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ABSTRACT

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Abstract

A001: Advanced melting technology in carbon dioxide reduction with large all-electric furnaces and superboosting

Stuart Hakes

F.I.C. (UK) Limited.

The paper will examine the advantages and current limitations of electric furnaces, particularly when compared to other technologies. It will briefly discuss alternatives to electric melting and in particular the use of hydrogen and will show the results of modelling large electric furnaces with pulls of greater than 350tpd for containers and greater than 600tpd for float furnaces. It will outline how to progressively move these larger furnaces to electric hybrid without incurring high capital costs.

Keywords: All-electric furnace; Hydrogen; Flat furnace.

Abstract

A002: Kinetics of E-Glass Batch-to-Melt Conversion: Effects of Natural Silicates and Detail FTIR Spectroscopic Investigation

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E-Glass fiber glass products have found a wide range of applications in composite markets, including automobile parts, printed circuit board, construction materials, wind turbine blades, pipes, etc. One of the commonly used major ingredients of E-Glass batch is kaolin, which provides sources of silica and alumina. This presentation focuses on the evaluation of alternative silicate minerals that may benefit fiber glass production in terms of kinetics of batch-to-melt (BtM) conversion, stable and lower impurity iron, and lower BtM conversion energy. Using kaolin (free quartz less than 1%) as a control, four new natural minerals are investigated, high-silica kaolin (quartz greater than 50%), pyrophyllite, anorthosite, and wollastonite. In our study, a newly established FTIR protocol has been applied to track intermediate phase formation and final glass melt conversion. Literature reported XRD results and limited XRD analysis are used in supporting the IR characterization. According to our study, for E-Glass of CaO-Al_2O_3-SiO_2 based system, independent of the source of the natural silicate minerals used, BtM kinetics is primarily controlled by the availability of "free silica" to react with "free calcium oxide" derived from limestone in the batch at high-temperature above 1000°C.

Key words: Fiber Glass; Batch Reaction; Silicate Minerals; FTIR spectroscopy

Abstract

A003: Analysis and Prospect of Energy Saving and Carbon Reduction Potential of Glass Furnace

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At present, the glass industry is in accordance with the national "double carbon" development strategy and related policy requirements, vigorously promote energy saving and carbon reduction. As the main energy-consuming equipment in glass production, it is of great significance to study and explore the energy-saving and carbon reduction potential of glass furnace. The authors of this paper theoretically analyse various possible means of energy saving and carbon reduction in conjunction with the heat balance table of glass furnace. Analyse existing feasible energy-saving and carbon reduction technologies in relation to the actual production of the glass industry. Looking ahead to future energy-saving and carbon-reducing technologies based on industry trends.

Keywords: Glass furnace; Energy-saving; Carbon reduction.

Abstract

A004: Cullet preheating device for application of the unused heat

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Solutions for materials and energy savings in glass industry (for example, furnace design optimization, technologies to preheat raw materials, heat recovery systems, technologies to improve combustion)

1) Introduction

The ceramics industry, which includes the glass industry, is the fourth largest producer of emissions in the entire Japanese industry. Though it appears to be contributing to the energy saving, it is still necessary to save more energy and reduce greenhouse gas emissions on a global scale.

Glass melting furnace is the most energy-consuming area of the whole glass manufacturing process, with its energy consumption accounting for 60~80%. At present, such technologies as air preheating, oxygen enrichment and oxygen combustion, as well as electric enhancing, all-electric melting and raw material preheating seem to be perspective in terms of energy saving.

2) Research objective

Among the above-mentioned energy-saving solutions, only air preheating and raw material preheating can actually re-use the exhaust heat from the glass melting furnace. Among these, the preheating of raw material uses low-temperature exhaust gas of 500°C or less, which allows to save the energy.

3) Task

At IFC we have studied a device which only preheats the cullet. The reason why the batch is not preheated is that if the batches are heated together, they solidify and might clog the device. Also, when the dried batch enters the glass furnace, it scatters around and provokes the erosion of the bricks. As a result, the life of the furnaces becomes shorter.

If we only preheat the cullet, there is no risk of malfunction due to clogging of the device as well as no concern about scattering of the fine powder of the raw material.

4) Distinctive features

The cullet preheating device developed by IFC is a hybrid structure divided into two heating zones – indirect and direct. First, in the indirect heating zone the moisture contained in the cullet is being removed. The reason why the moist cullet and the exhaust gas should no come into direct contact is that the moisture reacts with the gas, causing the metal corrosion of the equipment. The direct heating zone effectively heats up the dehydrated cullet.

5) **Summary**

By pre-heating the raw material before putting them inside the melting furnace, the amount of fossil fuel energy used for the melting process can be reduced, and, as a result, the amount of greenhouse gas emissions can also be minimized.

Abstract

A005: Application of Low pressure Oxy-fuel Combustion Technology in Glass Furnace

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Oxy-fuel combustion technology is applied in glass furnace to help glass manufacturers achieve economic and environmental goals such as fuels-saving, emissions reduction and glass quality improvement. After more than thirty years of development in glass industry, the benefits of oxy-fuel combustion technology for glass melting are well-known and acknowledged. This paper introduces the innovative low pressure oxy-fuel combustion technology, and its successful application in glass furnaces, it has improved the combustion efficiency and achieved sustainability performance including energy-saving and emission reduction.

Keywords: low pressure oxy-fuel combustion; glass furnace; low pressure oxy-fuel combustion burner; energy saving and emission reduction.

Abstract

A006: Low CO2 Emission Lining for Furnace Melter Crowns

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The necessity to reduce the CO2 emissions is forcing the glass industry to develop more efficient glass melting technologies. Possible solutions are offered by highly electrified melting furnaces, hydrogen fired furnaces and combined solutions like hybrid furnaces. The new melting technologies will change the furnace operations, which will lead to more corrosive conditions than in the past and a higher efficiency to reduce the cost impact of these two energy carriers. RHI Magnesita has developed a wide range of refractory materials to support its customers in this technologic transition in which the melting crown lining is playing an important role. A proper material selection has been done to preserve the furnace lifetime even in a more aggressive atmosphere. In combination with a smart crown design, the energy saving achieved can be significant. Highly corrosion resistant in a wide range of temperatures and furnace atmospheres, a Silica Based solution has been selected for the optimum lining of the combustion chamber crown: based on fused silica and a lime free bonding, this product has proven its excellent behavior in many different applications, maintaining its stability in terms of microstructure, corrosion resistance, thermal expansion, general performances. The application of fused Silica based material has been combined with RHIMs Honeycomb design, which allows to maximize the energy transfer from the melter crown to the glass bath. The lining concept is completed with the application of a Monolithic Insulation applied by gunning, which reduce the risk of rat hole formation significantly. The new lining concept is suitable for the expected operation conditions of hybrid furnaces and permits to achieve the highest insulation levels in a competitive asset, including a faster installation method that requires less manpower, providing its own contribute to the carbon footprint reduction.

Key words: Glass; Silica; Energy saving; CO_2 emissions reduction.

Abstract

A007:The Influence of Glass Liquid Flow Homogenization Quality on the Performance of Glass Products

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Inorganic glass materials must undergo a high-temperature melting process to form glass liquid, and then be made into corresponding glass materials through different forming methods according to their purposes. The common requirement is to use the formed glass liquid flow homogenization as much as possible, so as to ensure that the glass product has good physical and chemical consistency characteristics and is easy to process and use. This article introduces the homogenization process of glass liquid in different types of kilns and its impact on product performance.

Key words: Glass; Liquid; Homogenization; Products; Performance

Abstract

A008: Glass Ceramics with Continuous Innovation and Breakthroughs in the High-quality Development of the Glass Industry

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With the continuous progress of science and technology, the glass industry has entered a stage of high-quality development. As an important material in daily life and national defense construction, glass ceramic is also constantly innovating and breaking through. This article not only introduces the structure and characteristics of glass ceramic, but also compares the performance of glass ceramic with building stones and ceramics, and outlines the development trend of the Chinese glass ceramic market. The article introduces the development history, segmented market tracks, production process technology, and main manufacturers of glass ceramic technology, covering many aspects of glass ceramic technology, including process design, research and development innovation platforms and deep cultivation in the technical field, as well as the deepening of academic research and application expansion of technological innovation. It showcases the technological progress and application prospects of glass ceramic in different fields. By analyzing the application prospects of glass ceramic, a multi-dimensional and multi-dimensional approach has been provided for its industry development.

Keywords: Micro Crystallization; Subdivision Track; Composite Materials.

Abstract

A009: Hydrogen Combustion for Glass Melting

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With the continuous promotion of carbon neutralization, hydrogen is regarded as an ideal energy source because of its high energy density and no carbon, and combustion is one of the important ways of hydrogen energy utilization. By analyzing the combustion characteristics of hydrogen, it is concluded that there are three technical difficulties in the application of hydrogen replacing traditional energy sources in glass melting, including invisible flame shape, more foam on the molten glass surface and weak flame radiation penetration. For these three aspects, CFD analysis method, changing the flame atmosphere, and adding cullet to the flame were used to compensate for the defects of hydrogen combustion in glass melting.

Key words: Glass; Hydrogen Combustion; CFD; Flame Radiation; Oxygen-hydrogen Staging

Abstract

A010: How New Fused Cast Refractory Solutions Can Extend Glass Furnace Throat Lifetime

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Throat corrosion in specialty glass such as Borosilicate glass or Opal glass has often been a concern regarding furnace lifetime management. Moreover, glass furnace electrification dedicated to limit glass melting CO2 footprint will induce higher glass temperature at throat location, enhancing corrosion process that is quite complex at this furnace location, mixing different phenomenon. Based on our understanding through laboratory test and industrial experiences, SEFPRO developed an innovative fused cast refractory material able to face such harsh condition. We will discuss in detail the foundations of refractory composition evolution, associated microstructures, and also presented first industrial results.

Key words: Fused Cast Refractory; High Zirconia; Glass Corrosion; Throat Glass Furnace

Abstract

A011: The Recycling of Broken Glass Helps to Achieve the Two-Carbon Goal

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As green, low-carbon and recycling development becomes a global consensus, the effective management of recyclables is receiving increasing attention, and the market scale for recycling of broken glass will further expand. Most of the traditional recycling and disposal enterprises have low production and poor quality of glass clinker due to low technical level, and the proportion of glass products used by the enterprises is limited. Exploring the high-value use of glass, fulfilling corporate social responsibility and achieving the goal of "double carbon" is the significance of waste glass recycling.

Keywords: Shattered Glass; Recovery and Utilization; Social Security; Double Carbon Target.

Abstract

A012: Anhydrous Borate for Energy and CO2 Reduction

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Environmental, social and governance (ESG) issues are playing an increasing role in companies' decisions about choice of raw materials. Refined borates such as sodium borate and boric acid are commonly used in the production of in variety of glass. These borates do not contain carbon or carbonate, hence no direct CO_2 emission. However, choosing the right form (anhydrous instead of hydrous) reduces energy consumption of the melting process and hence carbon footprint. Our research, working closely with Celsian, aims to quantify the CO_2-emission reduction of anhydrous borate (both sodium or non-sodium) in the production processes of pharmaceutical glass, glass wool (c-glass) and specialty glass (LCD-TFT glass) respectively. Combination of Joule Meter measurement and Energy Balance Model (EBM) have been used to represent industrial central cases by applying typical furnaces settings in abovementioned glass applications. Results have shown that anhydrous sodium borate ($Na_2B_4O_7$) and anhydrous boric acid (B_2O_3) reduce carbon footprint significantly over hydrous sodium borate ($Na_2B_4O_7 \cdot 5H_2O$) and boric acid (H_3BO_3). Apart from CO2-emission during furnace melting, the report also briefly quantifies CO2-emission reduction during supply chain for anhydrous products.

Keywords：Anhydrous Borate; Energy Reduction; Carbon Footprint

Abstract

A013: Development of Hot State Maintenance Technology of Glass Furnace in China

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It mainly outlines the common damages in various parts of large cross-flame glass furnaces (mainly float and photovoltaic furnaces) in China at present, as well as the development of the corresponding hot state repair technology. Successful cases of restoration of severely damaged furnaces and innovations in repair methods are also presented. At the same time, it analyses the main problems existing in the use of various kinds of cross-flame glass furnaces, and jointly explores the feasibility of extending the service life of large-scale cross-flame glass furnaces.

Keywords: Glass Furnaces; Common Damages; Service Life; Restoration.

Abstract

A014: Technical Analysis of Environmental Protection and Energy Saving, High Quality and High Efficiency in Oxy-Fuel Combustion of Glass Furnace

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This paper provides a preliminary discussion on the characteristics and production capacity of the company's actual design of glass melting furnace oxyfuel and air combustion and energy saving, green environmental protection and other aspects. Calculation of the composition of exhaust gases shows the reasons for the environmentally friendly reduction of NOx emissions in the exhaust gas emissions of oxy-fuel glass furnace. The energy saving principle of oxy-fuel furnace is analyzed through the different melting capacities and heat dissipation of furnace of the same scale. The concept of effective melting rate is introduced through the characteristics of the lance arrangement, and the principle of high quality and high efficiency of oxy-fuel glass furnace is analyzed in terms of the comparison of effective melting rate of glass furnace of the same size, the influence on the stability of process production, etc. At the same time, it is pointed out that the special requirements for the use of refractories in the flame space of oxy-fuel glass furnace.

Key words: Furnace; Oxy-Fuel Firing; Flame Space; Refractory Materials

A015: Refractory Metals in the Glass Industry

Johnny Xuan

"$MoZrO_2$" – A NEW MATERIAL FOR GLASS MELTING ELECTRODES

The electrical heating of furnaces through the utilization of Molybdenum Glass Melting Electrodes (GME's) is state-of-the-art technology in today's production of glass. A new advanced material has been developed specifically for Glass Melting Electrodes. It offers superior corrosion resistance against molten glass as well as superior high temperature strength. This material is a doped grade of Molybdenum – Grade $MoZrO_2$. In addition to the improved corrosion resistance of this new material, particularly in Sb_2O_3- and SO_4^{2-} refined glasses, as well as in brown and green glasses, this material offers superior creep strength. In comparison to pure Molybdenum, the corrosion rate is reduced by between 25% and 50% depending upon the nature of the corrosive glass environment. The PLANSEE presentation will show actual test results from a small-scale investigation as well as from practical experiences with $MoZrO_2$ GME's in industrial glass tanks.

MOLYBDENUM GLASS TANK REINFORCEMENTS – Experiences and Insights

Glass producers are well aware of the features and benefits of using Molybdenum for such widely used products as glass melting electrodes, stirrers and nozzles. Now, there is an increasing demand from producers for Glass Tank Reinforcements (GTR's) which greatly contribute to productivity by prolonging the life of the glass tank. More than seventy (70) Glass Tank Reinforcement projects have been successfully completed within the last several years. The GTR's are designed to fit the specific furnace in critical areas such as the throat, doghouse, bubbler and wall areas; where the refractory bricks tend to be more severely attacked. The benefits achieved in addition to less corrosion and wear in the tank are significantly better quality of the glass due to stable melting conditions and sustained duration of the entire furnace campaign. Based on our wide experience in the glass industry, we have recently developed a new design principle for GTR's in highly corrosive glass melt applications, such as in borosilicate and opal glass. The PLANSEE presentation will cover project studies and this new GTR design approach in detail.

Abstract

A016: Research on Automation Technology for Sustainable Development in Flat Glass Factory

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This paper comprehensively discusses the key role of the automation technology of electromechanical equipment in the process of sustainable development of plate glass factory. Through in-depth study and understanding of the glass manufacturing process and the actual case of the factory, and in-depth discussion of the design scheme of the automation technology, this paper comprehensively analyzes the improvement effect of the electromechanical automation technology in the production process, the efficiency improvement of the whole process and the efficiency comparison of personnel technology and time. These studies show that the electromechanical automation technology has an important value in improving production accuracy, optimizing human resources, saving production time and promoting sustainable development. This study provides technical guidance for the plate glass industry, but also provides new perspectives and depth for further research and development in the field of automation technology, encouraging future research and development to continue to explore the potential applications and challenges of electromechanical automation technology in a broader industrial context.

Key words: Glass; Automation; Efficiency

Abstract

A017: Research and Development of Fiber Reinforced Zero Expansion Silicon Brick

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Silica materials have the advantages of high temperature resistance, corrosion resistance and low expansion, and are widely used in glass, metallurgy and chemical industry. In this paper, four kinds of silica brick samples such as silica brick for coke oven, high-quality silica brick for glass furnace, calcium-free silica brick and zero expansion silica brick were selected. The crystal structure and phase composition of four kinds of silica brick samples were studied by chemical analysis, microstructure analysis, X-ray diffraction analysis and apparent pore density analysis, and the corrosion resistance of four different silica bricks was studied by the molten soda ash, The results show that each of the four siliceous materials has its own feature. Among them, the high-quality silica brick of glass furnace has good temperature resistance, does not pollute the glass liquid, and the content of residual quartz of calcium free glass is the lowest. The load softening temperature of its products is very high, close to its fire resistance. After repeated calcination, the volume does not shrink, even slightly expands, and its alkali corrosion resistance is excellent. It can be mainly used in gas-fired glass kiln, full oxygen combustion furnace and high alkali glass furnace arch.

Keywords: Silica Brick; Low Expansion; Calcium-free Silica Brick; Zero Expansion Silica Brick; Resist Erosion.

Abstract

A018: Stability Study of Cured Glass from Arsenic-containing Wastes in Non-ferrous Metallurgy

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Non-ferrous metals, especially copper mining, smelting process, will produce a variety of arsenic-containing materials, arsenic and its compounds are not needed by the human body and has a strong toxicity, and arsenic and arsenic oxides are volatile. Currently used rigid landfill, cement curing, stinking onion petrochemical synthesis and arsenic ferroalloy methods have certain limitations, looking for new curing methods, and even resourceful application has been the research direction of arsenic-containing materials. In this paper, glass components with different arsenic contents were prepared by curing different glass components, the properties of arsenic-containing glass such as lattice structure and high-temperature viscosity were analysed, and the curing mode and migration mechanism of arsenic ions in the glass network body were clarified by testing the mechanism of arsenic precipitation at different concentrations and temperatures. The results show that: the arsenic material after glass curing is very stable, the precipitation rate of 5% arsenic-containing soda-lime glass at room temperature is only 0.12 mg/L, and the volatilisation rate of 5% arsenic-containing soda-lime glass at 1000 ℃ is less than 0.1mg/cm^2, which is far lower than the national relevant standard.

Keywords: Metallurgy; Arsenic Waste; Arsenic Glass; Chemical Stabilization.

Abstract

A019: The Elastic Modulus of High Performance Glass Fiber was Evaluated by Sound Velocity Method and Nano-indentation Method State

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With the country's vigorous development of high-performance fibers and their composites, high-strength and high-modulus glass fibers and basalt fibers play an extremely important role in electronic communications, military weapons, aerospace and other fields. The non-destructive testing of elastic modulus of glass fiber monofilament was carried out by adjusting the frequency and amplitude of the longitudinal and transverse acoustic waves by designing an acoustic transducer suitable for fiber sample. At the same time, the nano-indentation method is used to press the surface of the fiber sample with dot matrix, and the pressing depth is less than 500nm, which effectively reduces the test damage to the sample. In addition, weibull distribution was used to analyze the extreme value and discrete type of the two test methods for the modulus and hardness of fiber monofillion, and the effective error was less than 2GPa.

Key words: Glass Fiber, Modulus, Nondestructive Testing, Pulsed Sound Wave, Nano-indentation

Abstract

A020: Preparation and Properties of Enamel Coating Doped with Ceramic Fiber

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Composite enamel coating is widely used in the field of boiler pipelines due to its excellent performance, which can effectively improve its yield strength and service life in harsh environments. Mixing short fibers with the matrix material to evenly disperse the fibers into the matrix material can greatly enhance the strength and toughness of the material [1]. Ceramic fibers belong to inorganic non-metallic fiber materials, which have many advantages such as insulation, thermal shock resistance, and low thermal conductivity. Fiber reinforcement has been widely used in dense ceramic composite materials [2,3]. Enamel glazes with different ceramic fiber contents are pre placed on the surface of weathering steel, and ceramic fiber composite enamel coatings are prepared by high-temperature sintering. The microstructure, crystallization, and softening point of the coating were characterized using scanning electron microscopy, X-ray diffractometer, and synchronous thermal analyzer. At the same time, the impact resistance, acid corrosion resistance, and temperature sudden change resistance of the sample were tested. The results showed that the surface roughness of the enamel coating increased after doping ceramic fibers, but its amorphous structure did not change. The Tg of the enamel increased from 540 ℃ to 548 ℃, and the acid corrosion resistance slightly decreased. The impact strength of enamel coating increases with the increase of fiber doping amount, and the thermal shock temperature first increases and then decreases, reaching its maximum at a doping amount of 3%. As shown in Figure 1. In short, moderate doping of ceramic fibers can evenly distribute them in the coating, enhance the strength of the coating, and improve its temperature resistance to sudden changes.

Key words: Composite Enamel Coating; Ceramic Fiber; Temperature Sudden Change

Abstract

Resistance; Mechanical Property

Abstract

A021: Effect of Sintering on Mechanical Properties of Flexible Glass Coating

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Flexible glass is widely used in the protection of precision electronic devices due to its light weight, flexibility and high transmittance in the visible light range. However, the research on the preparation of flexible coatings by applying bismuth glass-based glaze to flexible glass is not deep enough. Meanwhile the ion migration which lead to changes of mechanical properties during the sintering needs quantitative analysis. In this paper, Bi_2O_3-B_2O_3-SiO_2 ternary system glass was selected as the glaze, TiO2 and lithium nepheline as grinding additive.The flexible glass with the thickness of 75 μm as the substrate was vac-sorbed on the embossed glass by ethanol, the coating was screen printed to the flexible glass, and the flexible coating was sintered in the Muffle furnace at 570℃-590℃.The results show that the coating is tightly bonded to the flexible glass with a thickness of 15±1 micron. The flexible coating has a strong UV intercepting ability. The maximum bending strength is 261.13MPa, the maximum modulus is 79.64GPa and the maximum hardness is 8.33Gpa. The law of potassium and sodium ion exchange in the sintering process accords with Arrhenius formula.

Key words: Flexible Glass Coating;Mechanical Properties;Ion exchange

Abstract

A022: Preparation and Properties of Alumina Fiber Reinforced LTCC Ceramic Coatings

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LTCC adopts multi-layer firing process to realize the high-density packaging of complex circuits and passive devices, which provides a new solution for the miniaturization and high integration of passive devices, and plays an important role in the fields of national defense and communication. As the bearing structure of the functional circuit, LTCC substrate plays the dual role of structural support and electrical shielding, which is the key to the development of LTCC technology. In this paper, CaO-MgO-B_2O_3-SiO_2/Al_2O_3 fiber system with good development potential was selected as the research object, and the effects of glass composition, glass particle size, glass/Al_2O_3 fiber ratio, fiber particle size and La/B on the dielectric and mechanical properties of glass/Al_2O_3 fiber composite materials were studied. The addition of Al_2O_3 ceramic fiber with different contents has little effect on the thermal expansion coefficient of LTCC base material, and the sintering temperature of the coating is 900℃, and the sintering density is good, and the melting point of silver is 961.93℃, indicating that the material has good co-firing performance with Ag, and the dielectric loss is between-0.02and0.16, which is in line with low dielectric constant. The requirement of low dielectric loss provides a certain reference for the regulation of mechanical and dielectric properties of LTCC substrate materials.

Key words: LTCC; CaO-MgO-B_2O_3-SiO_2; Al_2O_3 Fiber; Dielectric Property

Abstract

A023: Study of Volatilization of Cured Glass Containing Arsenic Waste at High Temperature Stage

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As_3O_2 is a highly volatile and toxic substance that poses a serious threat to the ecosystem and human life. In order to solve the problem of harmless treatment of arsenic containing waste, scientists have made various attempts. Among them, the glass curing method has shown great potential for converting arsenic wastes into glass materials with high curing capacity, excellent stability, low cost and resourcefulness. Previous studies on arsenic volatilization have focused on the volatilization behavior of arsenic during coal combustion and in copper slag. However, there is still a knowledge gap regarding the volatilization of arsenic glass after continued warming, especially in the high temperature stage.An in-depth study of the volatilization of arsenic glass in the high-temperature stage is of great significance for the realization of the harmless treatment and resource utilization of arsenic waste.This experiment was carried out under two different atmosphere conditions, and sodium-calcium silicate glass with different arsenic contents was selected as the material to investigate the effects of temperature, holding time, arsenic content and atmosphere on the volatilization of arsenic glass at high temperature stage by means of x-ray fluorescence spectroscopy, high-temperature synchronous thermal analyzer and Fourier infrared spectroscopy, and other analytical means. Experiments have shown that the volatilization of arsenic glass in air is less than 0.02% up to 1100 ℃.In addition, the volatile components of arsenic glass were analyzed, and the volatilization mechanism of arsenic glass at high temperatures was briefly analyzed. The results of this study are expected to provide key information to address the issue of environmentally sound treatment and resource utilization of arsenic wastes, contributing to better control and reduction of arsenic risks to the environment and health.

Abstract

Key words: Cured glass containing arsenic waste; Volatilization; Harmless treatment.

A024: Effects of Reducing Atmosphere and Iron Content on UV Transmission Property of Alkali-silicate and Alkali-borosilicate Glasses

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The effects of the reducing atmosphere during glass melting and the iron content in glass on the ultraviolet (UV) transmission property of borosilicate and silicate glasses were studied. The reducing atmosphere is controlled by the amount of citric acid in each glass batch. The effects of reducing atmosphere on the glass UV transmittance were examined in terms of the distribution of trigonal boron (BO3) and tetrahedral boron (BO4) units and iron reduction index (IRI). Our study reveals that the reducing atmospheres not only had a significant effect on the boron-oxygen structure of alkali-borosilicate glass, but also on the UV transmittance. In addition, IRI has a significant effect on the UV transmittance at a wavelength of 254 nm, with a relative change up to 461%. The iron oxidation state was found to affect the UV absorption coefficient of ferric ion (Fe(III) has about four times greater than that of ferrous ion (Fe(II)) at 254 nm.

Keywords: Borosilicate Glass, Ultraviolet Transmittance, Reducing Atmosphere, Iron Reduction Index, Boron Structure, Iron Oxide.

ABSTRACT

Session B

Advanced Testing and Characterization

Table of Contents

Session B:

Advanced Testing and Characterization Session

Abstract

B001: Advances in characterization of glass structure and its impact on property development

Madoka Ono[1*]

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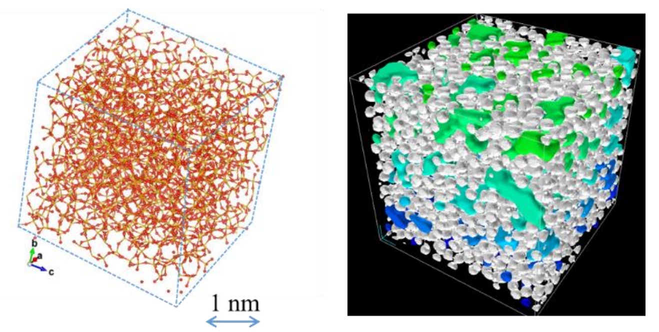
Remarkable progress has been made in the structural characterization of glass recently. In particular, structural analysis techniques combining quantum beams such as high-energy X-rays and neutrons with super computers have made it possible to find realistic structural models of glass that not only satisfy the energetic confinement provided by molecular dynamics but also comprehensively reproduce the experimental profiles[1][2]. There have been numerous reports of real observations of the atomic structures of thin glass films[3], which are overwhelmingly similar to what was predicted 80 years ago. However, how can the elucidated structures be used to improve the physical properties of glass? In this talk, I will introduce how the observation of structural voids by PALS (Positron Annihilation Lifetime Spectroscopy) has opened up new perspectives and led to new material design guidelines[4][5]. I will also discuss the relationship between glass structure and physical properties and what we should focus on in the future.

Key words: Glass; Structure; Void; Positron Annihilation Spectroscopy; MD simulation; High Energy X-ray Spectroscopy



(a) (b)

Fig.1 (a) Silica glass with atomic picture. (b) Silica glass with void picture.

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B002: Morphological and mechanical characterization on post-fracture laminated tempered glass

Jian Yang

Fracture morphology has insightful information which is vital in assessing the post-fracture performance of glass members. This study performed a morphological and mechanical characterization on fractured laminated tempered glass. It seeks to firstly find the relationship between the inherent properties of tempered glass (i.e., tempering level, glass thickness etc.) and the statistical, spatial features of fracture morphology. The morphology can hence be reconstructed with a Voronoi-based method, which can be combined to produce a refined numerical model of reconstructed fractured glass member with less computation cost. The numerical results indicate that the local debonding at the fragment edges significantly affects the post-fracture stiffness of glass members. Thus, random-crack tensile tests as well as the updated modellings were conducted to further investigate the effects due to the local debonding and the fragment overlap ratios. The variation limits of the post-fracture stiffness by those factors were identified.

B003:Microscopic characteristics of architectural glass and long-term strength prediction

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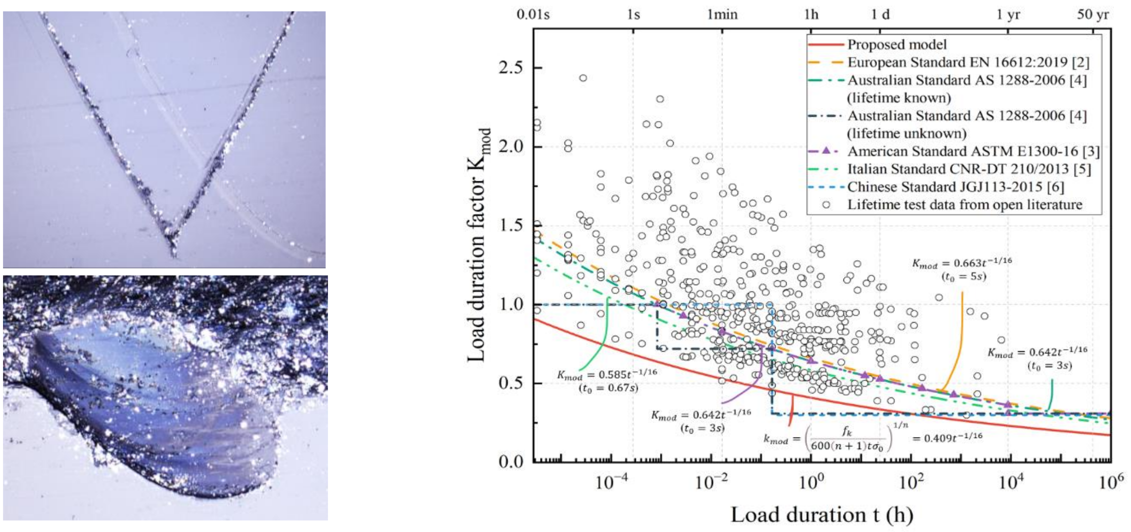
Architectural glass is a fundamental element in modern building design, contributing to aesthetics and functionality. The ever-increasing use of glass in load-bearing applications has led to concern about the glass strength over lifetimes. Due to the existence of the defects and the subcritical crack propagation induced by chemical reaction between glass around the crack tip and water, the long-term strength may decrease with time. Understanding the microscopic characteristics of architectural glass, especially the defects characteristics, is crucial for evaluating its mechanical property and ensuring the safety and durability of buildings. However, the existing knowledge regarding the defects characteristics in glass is limit, and the load duration factor $\mathrm{k_{mod}}$ proposed by standards has not consider the influence of different stress histories. This presentation aims to addresse this gap by observing and analyzing the microscopic characteristics of glass, considering comprehensive influence factors and then propose a long-term strength prediction model. To investigate the microscopic characteristics of architectural glass, the 3D laser confocal microscope was utilized to observe the surface topography and defects morphologies (Fig.1a), and measure the defect depth. To propose the long-term strength prediction model, the crack resistances under different stress histories (constant stress and constant stress rate) were derived respectively based on stress corrosion theory [1]. With the analysis and quantification of the influences of temperature, humidity and loading rate on crack growth parameters, it is available to compare the crack resistances under two different stress histories and modify the load duration factor $\mathrm{k_{mod}}$. The model is validated by a large set of available data for various load durations and is compared with international standards (Fig.1b). The results demonstrate that the proposed model is capable of accurately predicting the long-term strength of glass.

Key words: Architectural glass; Microscopic characteristics; Long-term strength; Load duration factor



a b

Fig.1 (a) Microscopic images of typical defects morphologies. (b) Proposed prediction model compared to lifetime test data and international standards

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Abstract

B004:Nanoindentation Induced Deformation and Structural Evolution of Silicate Glass

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Indentation has been widely used for investigating the mechanical behavior of glasses. However, the role of inelastic deformation during indentation of silicate glass is still debated. In this work, a 3D surface analysis method is developed to quantify the amplitude of the nanoindentation impression field. Based on this newly developed analysis approach, we have found that the shear flow and densification induced inelastic deformation of silicate glasses are visible as indentation, as pile-up close to the indent, and as lift-up far away from the indent. The lift-up mechanism is revealed for the first time, which complements the previous well-accepted pile-up description. The lift-up region is due to the increasing width of the indenter as it is pushed into the glass, which corresponds to the amount of glass volume pushed away laterally (lateral-pushing) and can contribute up to ~25% of the total volume above the original surface in soda-lime silicate glass. Using large-scale molecular dynamics simulations, we investigate the response of a prototypical sodium silicate glass under shape contact load up to an indentation depth of 25 nm. Both the short- and intermediate-range structures are found to exhibit notable changes below the indent, indicating that indentation deformation induces a more disordered and heterogeneous network structure. Our findings not only contribute to an atomistic understanding of the indentation response of silicate glasses but also pave the way towards rational design of damage-resistant glassy materials.

Key words: Silicate glass; Nanoindentation; Deformation mechanism; Structure.

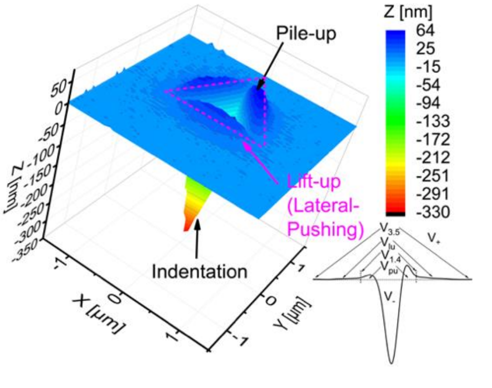

Fig.1 Nanoindentation deformation of a soda-lime silicate glass.

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Abstract

B005:Testing Technology of Mechanical Properties and Reliability Evaluation for Ultra-thin Glass

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The growing demand for thinner and more multifunctional electronic screens has driven the rapid development of ultra-thin glass technology, making it one of the key strategic developments in the glass industry today and in the future. Mechanical properties are critical indicators for characterizing the service suitability, durability, and reliability of ultra-thin glass materials. Due to the thickness effect in glass, the existing testing techniques and standards designed for conventional-thickness glass are challenging to apply accurately in assessing the mechanical properties of ultra-thin glass. In response to this challenge, testing techniques for the mechanical properties of ultra-thin glass, including flexural strength, elastic modulus, impact resistance, scratch resistance, hardness, and fracture toughness, have been proposed and national standards have been established. The mechanical properties of ultra-thin glass with thicknesses ranging from 0.1 to 1.1 mm have been evaluated, enabling an effective prediction of the reliability of ultra-thin glass in service.

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Abstract

B006:Evaluation and optimization of multiple insulating glass

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By borrowing the idea of “Ohm’s Law” into heat transfer mechanism, it is much easier to be understood the relationship between the heat flow, temperature and thermal resistance of any materials that are assessed with their thermal performances in use. In particular, a calculation of thermal transmittance of a multiple insulating glass is fully established and studied with the conditions as to what could be done on glass and the makeup to improve its U values of the thermal performance made more energy efficient in applications.

Key words: Glass; U value; Heat flow; Temperature; Thermal resistance; Thermal radiation

Abstract

B007:Mechanical properties of glasses at the micro scale: a case study of porous glasses by nanoindentation

Dong Wu[1*], Yinsheng Xu[2], Ping Lu[1,2], Zhuocheng Chen[3], Jin He[3,4], Long Zhang[3,4]

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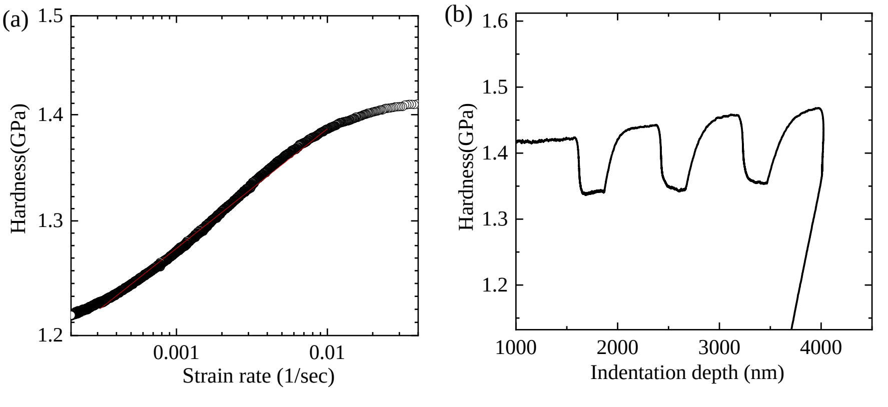
Mechanical properties (e.g. hardness, creep behavior, strain rate sensitivity) are essential to the application of functional glasses. Usually conventional tensile test is improper for glasses due to the difficulty in specimen fabrication as a result of the brittleness of glasses. However, the nanoindentation technique is versatile in obtaining diverse mechanical responses of materials, and therefore, it has been widely used in the field of glasses. So far, the viscous flow of glasses and responses of glasses to loading rates have been investigated using nanoindentation, and these properties were found to arise from some inherent features of glasses like strength of chemical bonding, structure of glass network etc. In this study, we reported the time-dependent deformation behavior of two sol-gel synthesized mesoporous glasses: AlPO4 and Al2O3-SiO2, both of which were found to be ideal carrier for luminescence center and catalyst. The influences of porous structure and chemical bonding on the creep rate have been analyzed and discussed, respectively.

Key words: Porous Glass; Nanoindentation; Time-dependent deformation; Strain rate sensitivity



a b

Fig.1 (a) The variation of hardness of porous Al-Si glass as a function of strain rate during creep (b) The jumps in hardness due to the jump of loading rate in Al-Si porous glass

References:

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Abstract

B008:Nanoscale Morphological Transformation and Electrical Conductivity of Silicate Glass Microchannel Plate

Cai Hua*, Liu Hui, Li Shangtong, Zhao Xuan, Jia Jinsheng, Ma Jing, Bo Tiezhu

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Lead silicate glasses are fundamental to a microchannel plate (MCP), a two-dimensional array of a microscopic channel charge particle multiplier. Hydrogen reduction is the core stage to determine the electrical conductivity of lead silicate glass MCP multipliers. The nanoscale morphologies and microscopic potential distributions of silicate glass at different reduction temperatures were investigated via atomic force microscope (AFM) and Kelvin force microscopy (KFM). We found that the bulk resistance of MCPs ballooned exponentially with the spacing of conducting islands. Elements composition and valence states of lead silicate glass were characterized by X-ray photoelectron spectroscopy (XPS). The results indicated that the conducting island was an assemblage of the Pb atom originating from the reduction of Pb2+ and Pb4+. Thus, this showed the critical influence of the hydrogen temperature and nanoscale morphological transformation on modulating the physical effects of MCPs and opened up new possibilities to characterize the nanoscale electronic performance of multiphase silicate glass.
Key words: Microchannel plate; Kelvin force microscopy; Nanoscale morphological transformation; Bulk resistance

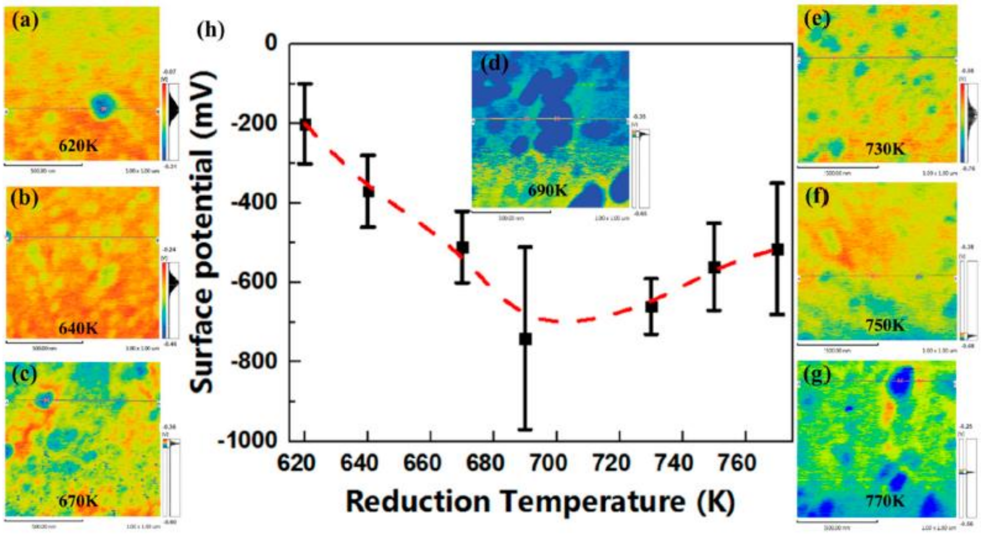

Fig. 1 The surface topographies and extrema of CPD of reduced lead silicate glasses at the reduction temperatures from 620 K to 770K.

References:

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B009:Theoretical investigation about thermal conductivity and thermal expansion coefficients of rare earth monosilicates

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Owing to the superior chemical and thermal compatibility with silicon-based ceramics, rare earth (RE) monosilicates are one of the most promising candidates for the next generation thermal and environmental barrier coating (T/EBC) materials for the applications in high-temperatures aero-engines. Herein, a comprehensive study of thermal and phonon behavior for the rare earth monosilicates RE_2SiO_5 (RE = Dy, Ho, Er, Tm, Yb and Lu) was conducted based on the first-principles and lattice dynamics calculations. Theoretical exploration predicts an anomalous increase of lattice thermal conductivity with increment of RE atomic number and the mechanism is explained by the stronger atomic bonding and weaker phonon anharmonicity. The thermal expansion coefficients were predicted as a function of temperature and ranged from 8.87 to 7.72×10^{-6} /K at 1600 K. The balance between negative contribution from distortion of RE polyhedrons and positive contribution from stretching of RE-O bonds is identified as the key to tune the thermal expansion coefficient. This theoretical study suggests an alternative approach towards the design of new thermal protection coatings.

Key words: Rare Earth Silicates; Thermal Conductivity; Thermal Expansion

References:

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Abstract

B010:Study on the Bending Performance of Flexible Ultra-thin Glass Based on the Theory of Large Deformation Elasticity

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2.School of Materials Science and Engineering, Wuhan University of Technology, Wuhan 430070, China

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Flexible glass refers to ultra-thin glass with a thickness equal to or less than 0.1mm. Due to thickness effects, its flexural strength far exceeds that of ordinary glass. Based on the theory of large deformation elasticity, theoretical curvature equations for the buckling longitudinal cross-section of flexible glass under two-point bending are derived. Furthermore, a simple fixture is designed to subject the samples to controlled bending, allowing for an analysis of the bending performance during the loading process.The relationship between deflection, curvature radius, applied force, and sample characteristics was established during this process. Experimental results demonstrate a high degree of agreement with the theoretical equations, providing a reference and foundational research support for the accurate testing and evaluation standards of the mechanical properties of flexible ultra-thin glass in the future.

Keyword： Flexible glass;Bending performance;Large deformation;Two-point bending

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Abstract

B011:Noble Metal Nanostructures Based Surface-enhanced Raman Scattering Fiber Probe for Trace Molecular Detection

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The detection performance of SERS fiber probes is highly determined by the geometries, morphologies, and components of noble metal nanostructures. In this research, different Ag, Au and alloy nanostructures were synthesized through chemical reduction method. The nanostructures were homogeneously coated on glass fiber end-tip for SERS fiber fabrication. The compositions, shapes, and sizes distributions of nanostructures were analyzed by XRD, TEM, and EDS.The stronger and larger areas of LSPR induced electromagnetic field from nanorod dimer and carbon dots decorated Ag nanoparticles implied better SERS behaviour. The lowest detection limit can reach 10-11 M for Au/Ag alloy nanorod fiber probes (Fig. 1 a), and 10-9 M for carbon dots decorated Ag nanoparticles fiber probes, using CV or R6G as an analyte. The relationship between Raman intensities and analyte concentrations showed well linear, for quantitative analysis, and the fiber probes showed excellent reproducibility and stability. Furthermore, carbon dots decorated Ag nanoparticles fiber probes were applied for trace Hg^{2+} ions detection, ranging from 10-5 to 10-11 M (Fig. 1b), from carbon dots reduced Hg meta surface wrapping on Ag nanoparticle surface, which decreased Raman intensities from CV analyte. The fiber probes can be applied for low-content chemical, biological molecules, and other detection.

Key words: Surface-enhanced Raman scattering; Noble metal nanoparticles; Optical fiber; LSPR

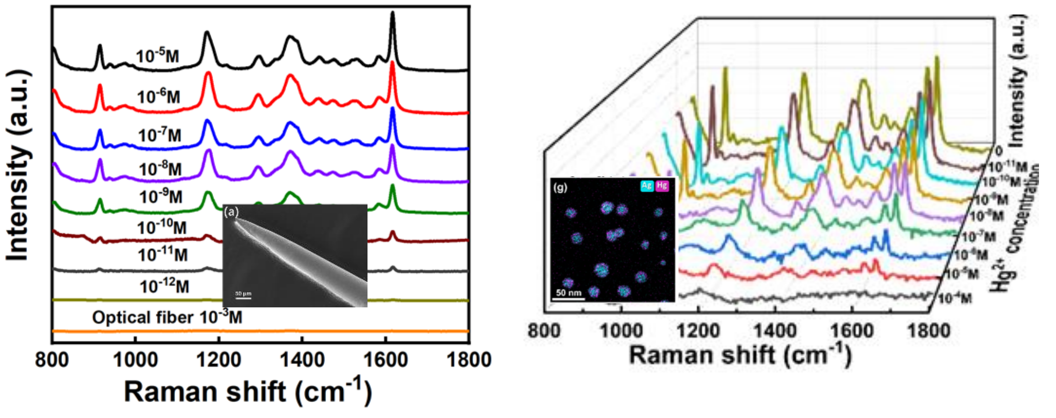

Fig.1 (a)The dependency of Raman intensities on CV concentrations (inset: SEM image of nanorod based fiber probe), (b) The relationship between Hg^{2+} concentrations and CV Raman intensities (inset: surface wraping of Hg metal on Ag nanoparticles)

Abstract

B012:Research on several factors affecting the test of expansion coefficient of glass materials

HAN Yu1, ZHANG Meilun1, CAO Zhenbo1*, YANG Shengyun1, ZHANG Yang1, WANG Ke1, LV Haifeng1, ZHOU You1, JIA Jinsheng1

1.China National Building Material Photonics Technology Co., Ltd., Zao zhuang 277000, China

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The coefficient of thermal expansion characterizes the size change of the material with the change of temperature. During the test, two temperatures will be involved, one is the temperature near the sample T1, and the other is the furnace temperature T2. The author studied the variation of expansion coefficient (30-300℃) by adjusting the furnace temperature. The results show that the higher the initial furnace temperature, the smaller the expansion coefficient of 30-300℃. The above problems are analyzed and discussed. At the same time, in order to improve the accuracy and consistency of the test results, the test standard that the furnace body temperature should be maintained below 35℃ before testing is formulated. In addition, in order to make the test results more accurate, the placement of the sample and the processing of the test data are discussed and studied. The process standard of the thermal expansion coefficient test is supplemented and improved, and the error in the test process is reduced.

Keywords: Furnace temperature; Coefficient of thermal expansion; Factor; Specification standards; Error

ABSTRACT

Session D

Advanced Functional Glass and Application

Session D：

Advanced Functional Glass and Application

Proposal of ICG2023 Annual Meeting

Session D：Advanced Functional Glass and Application

Functional glasses are those glasses that possess at least one or more inherent or inborn particular properties and functions independently based on this specific property. Moreover, some novel approaches are applied to prepare functional glasses to achieve certain designed properties. The ultimate destinations of the products of functional glasses are their use in various technological applications by the way of fabrication of different devices. These application areas include energy, display, health care, nuclear, defense, space, and so on.

The symposium will focus on the advanced functional glass and application. Topics include but not limited to the preparation, microstructure, structure-property relationships, thermal, electrical, optoelectronic, mechanical properties, and applications of these novel functional glasses.

Focused topics:

- Design and preparation of functional glasses and glass-ceramics
- Synthesis/production- techniques, new methods
- Glasses characterization: thermal, mechanical, structural and optical
- Computational modelling / simulation studies in functional glasses
- Glasses for Laser, optical, display applications
- Functional properties of glasses
- 3D print of functional glasses

Session Chairs:

Haizheng Tao, Wuhan University of Technology, China
Shibing Jiang, AdValue Photonics Inc., USA
Xianghua Zhang, University of Rennes 1, France

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Keynote Speakers:

(1) Yoshida Satoshi, AGC Inc., Japan.
Title: Dynamic indentation hardness of glass by using a blunt trigonal pyramid indenter.
(2) Shibin Jiang, University of Arizona, America.

Abstract

Title: High Peak Power Fiber Lasers and Applications

(3) Kiyoharu Tadanaga, Hokkaido University, Japan.

Title: Preparation of sulfide-based Li-ion conductive solid electrolytes using solution processes.

(4) Changgui Lin, Ningbo University, China.

Title: Chalcogenide Glasses: Novel Development and Applications.

Invited Speakers:

1. Morten M. Smedskjaer, Aalborg University, Denmark.

Title: Dependence of Glass Mechanical Properties on Structure at Varying Length Scales.

2. Johann Troles, University of Rennes I, France.

Title: Chalcogenide microstructured optical fibers: fabrication and applications.

3. Seungho Kim, Samsung Display Co. Ltd., Korea.

Title: Foldable Ultra-thin Glass for now and future.

4. Xin Jiang, Shanghai Institute of Optics and Fine Mechanics, China.

Title: Recent Advances in Microstructured Optical Fibres.

5. Zhenggang Lian, Yangtze Optical Electronic Co., Ltd., China.

Title: From doped quartz glass to special optical fiber based applications.

6. Lan Li, Westlake University, China

Title: Mechanically flexible photonics for on-chip sensing based on FSR-free cavities

7. Ang Qiao, Wuhan University of Technology, China.

Title: Medium-range structure in functional glasses.

8. Bin Zhang, Sun Yat-sen University, China.

Title: Integrated chalcogenide glass photonic devices for nonlinear photonics.

9. Pengfei Liu, City University of Hong Kong, Hong Kong.

Title: Progress and Challenges in Surface Enhancement Process on Oxide Glass.

10. KuenYao Lau, Ningbo University, China.

Title: O-, E- and S-band bismuth-doped fiber amplifier and laser.

11. Zhiyong Yang, Shanghai Institute of Optics and Fine Mechanics, China.

Title: Chalcogenide glass fiber bundles for infrared imaging.

12. Yinsheng Xu, Wuhan University of Technology, China.

Title: Infrared micro-nano fiber sensor for organic detection.

13. Qing Li, TUNGHSU GROUP Co.,LTD, China.

Title: Application and Future of Electronic Glass.

14. Ruichun Wang, YOFC co., Ltd, China.

Title: Manufacture and application of high-end optical quartz.

15. Yonggang Huang, China Building Materials Academy Co., LTD., China.

Title: Research progress in optical fiber imaging glass materials for weak photoelectric signal detection.

16. Qun Zu, Nanjing Fiberglass Research & Design Institute Co.Ltd., China.

Title: Process variables for the mechanical properties of high-strength glass fibers.

Abstract

Keynote speakers:

Satoshi Yoshida, AGC Inc., Japan.

Tentative Title: Dynamic indentation hardness of glass by using a blunt trigonal pyramid indenter.

Brief CV: Satoshi Yoshida graduated from Kyoto University, Japan, and got his B.E.(1993), M.E.(1995), and Ph. D.(2003) from Kyoto University. In 1995, he started to work as an assistant professor of Department of Materials Science in the University of Shiga Prefecture (USP), Japan. From 2007 to 2020, he worked as an associate professor at USP. During the year 2004-2005, he also worked as a visiting professor of the University of Rennes 1, France. Dr. Satoshi Yoshida was awarded the 14th Otto Schott Research Award (2016) from Ernst Abbe Fund and the CerSJ award for Academic Achievements in Ceramic Science and Technology from the Ceramic Society of Japan. His main research topic is deformation and fracture behavior of oxide glasses.

Shibin Jiang, University of Arizona, America.

Tentative Title: High Peak Power Fiber Lasers and Applications

Brief CV: Dr. Shibin Jiang is founder and Chair of Board of AdValue Photonics Inc. and Adjunct Research Professor at College of Optical Sciences, University of Arizona. He received Ph.D. degree from Universite de Rennes 1, France. He was Co-founder and CTO of NP Photonics Inc.

Dr. Jiang holds 87 issued patents, edited 36 proceeding books, authored 150 publications, has H index of 46, and has served as chairs of 42 international technical conferences including OPTO at Photonics West for SPIE and Advanced Solid-State Laser Congress for Optica. He served as many award committees for Optica, SPIE and The America Ceramic Society (ACerS), and associate editors for 4 scientific journals. He was the chair for Glass and Optical Materials Division of ACerS in 2014. Currently is the chair of technical committee of optical fibers and photonics glasses of International Commission on Glass (ICG), and a member of board of directors of ACerS.

Dr. Jiang was awarded with the Gottardi Prize in 2005 from ICG, 2012 and 2014 R&D 100 Awards, and 2018 R&D 100 Award Finalist. He received the 2018 Corporate Technical Achievement Award and the Medal for Leadership in the Advancement of Ceramic Technology in 2021 and was named as The Global Ambassador in 2019 by the ACerS. Dr. Jiang is a Fellow of SPIE, ACerS, and Optica. He is elected as an academician of the World Academy of Ceramics in 2020.

Kiyoharu Tadanaga, Hokkaido University, Japan.

Tentative Title: Preparation of sulfide-based Li-ion conductive solid electrolytes using solution processes.

Brief CV: Kiyoharu TADANAGA is Professor of Division of Applied Chemistry, Faculty of Engineering at Hokkaido University, Japan. Professor TADANAGA got Degree of Master from Kyoto University, Japan, and Degree of Doctor from Osaka Prefecture University, Japan in 1996. He started his academic career in Osaka Prefecture University, and moved to Hokkaido University in 2013, as professor of Inorganic Synthesis Laboratory.

Professor TADANAGA has made remarkable contributions in the field of sol-gel science and technology, especially in the formation of coating films on various substrates including glass substrates. He has also contributed in the field of the preparation of materials for fuel cells and lithium batteries using solution processes. Recently, he has joined several research projects on the development of all solid-state lithium secondary batteries and published many important papers in this field. He has published more than 250 research papers, which include a variety of studies on the new functional materials fabricated by solution processes.

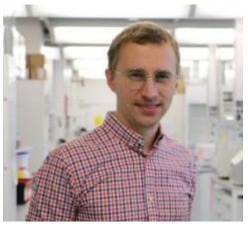
Professor TADANAGA won the "Young Ceramist Award" from the Ceramic Society of Japan in 2000. In 2006, he was given "Professor Vittorio Gottardi Memorial Prize 2006" from The International Commission on Glass. In 2013, he won the "Academic Achievements Award in Ceramic Science and Technology" from The Ceramic Society of Japan.

Changgui Lin, Ningbo University, China.

Tentative Title: Chalcogenide Glasses: Novel Development and Applications.

Brief CV: Prof. Changgui Lin is from Ningbo University. He has received the support from German Humboldt Scholarship and NSFC Excellent Youth Scientists Fund. His research activities are focused on chalcogenide glasses and their applications.

Abstract



Invited Speakers:

Morten M. Smedskjaer, Aalborg University, Denmark.

Tentative Title: Dependence of Glass Mechanical Properties on Structure at Varying Length Scales.

Johann Troles, University of Rennes I, France.

Tentative Title: Chalcogenide microstructured optical fibers: fabrication and applications.

Seungho Kim, Samsung Display Co. Ltd., Korea.

Tentative Title: Foldable Ultra-thin Glass for now and future.

Xin Jiang, Shanghai Institute of Optics and Fine Mechanics, China.

Tentative Title: Recent Advances in Microstructured Optical Fibres.

Zhenggang Lian, Yangtze Optical Electronic Co., Ltd., China.

Tentative Title: From doped quartz glass to special optical fiber based applications.

Lan Li, Westlake University, China.

Tentative Title: Mechanically flexible photonics for on-chip sensing based on FSR-free cavities

Abstract

Ang Qiao, Wuhan University of Technology, China.

Tentative Title: Medium-range structure in functional glasses.

Bin Zhang, Sun Yat-sen University, China.

Tentative Title: Integrated chalcogenide glass photonic devices for nonlinear photonics.

Pengfei Liu, City University of Hong Kong, Hong Kong.

Tentative Title: Progress and Challenges in Surface Enhancement Process on Oxide Glass.

KuenYao Lau, Ningbo University, China.

Tentative Title: O-, E- and S-band bismuth-doped fiber amplifier and laser.

Zhiyong Yang, Shanghai Institute of Optics and Fine Mechanics, China.

Tentative Title: Chalcogenide glass fiber bundles for infrared imaging.

Abstract

Yinsheng Xu, Wuhan University of Technology, China.

Tentative Title: Infrared micro-nano fiber sensor for organic detection.

Qing Li, TUNGHSU GROUP Co.,LTD, China.

Tentative Title: Application and Future of Electronic Glass.

Ruichun Wang, YOFC co., Ltd, China.

Tentative Title: Manufacture and application of high-end optical quartz.

Yonggang Huang, China Building Materials Academy Co., LTD., China.

Tentative Title: Research progress in optical fiber imaging glass materials for weak photoelectric signal detection.

Abstract

Qun Zu, Nanjing Fiberglass Research & Design Institute Co.Ltd., China.

Tentative Title: Process variables for the mechanical properties of high-strength glass fibers.

Abstract

Keynote

D001: Dynamic Indentation Hardness of Glass by using a Blunt Trigonal Pyramid Indenter

Satoshi Yoshida*, Shigeki Sawamura, Shusaku Akiba, Akio Koike

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Hardness is one of the most fundamental mechanical properties of glass, but deformation mechanisms of glass under an indenter are still unclear. Especially, strain rate dependence of permanent deformation in glass is little understood. In order to gain knowledge on mechanical response of glass during impact, machining, or sliding wear, it is of primary importance to investigate rate-dependent mechanical properties, such as hardness, of glass at higher strain rates. In this study, dynamic indentation hardness of soda-lime silicate (SLS) and Tempax (TPX) glasses were determined using a blunt trigonal pyramid indenter whose face angle (between the loading axis and an indenter face) 75°, which is larger than that (65°) of Berkovich indenter. The blunt indenter enabled us to create the indentation imprints without any severe cracks. From the results of both dynamic tests, which are pendulum and belt-slider tests, it is found that dynamic hardness of SLS and TPX glasses are lower than quasi-static hardness of the glasses. This is because the longer contact duration time results in the larger contribution of shear flow. Since the yield stress for shear deformation of glass may be larger than that for densification, quasi-static hardness should be larger than dynamic hardness. From the birefringence measurements of the indented glasses, in addition, it is found that the quasi-static indentation test induces higher residual stresses than the dynamic indentation tests. This result also suggests that deformation mechanism in glass varies with that strain rate during the indentation test.

Key words: Indentation, Hardness, Fracture, Deformation;

Abstract

D002: Preparation of sulfide-based Li-ion conductive solid electrolytes using solution processes

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All-solid-state lithium secondary batteries using inorganic solid electrolytes have been expected as next-generation batteries with higher energy density, safety, and reliability. Sulfide-based solid electrolytes have been used to fabricate all-solid-state lithium batteries because of their high lithium-ion conductivity (10^{-2}~10^{-4} S cm^{-1}).

The preparation of sulfide-based solid electrolytes using solution processes has been studied [1]. There are two approaches to preparing sulfide solid electrolytes from solution. One is dissolution-precipitation of sulfide solid electrolyte precursor, previously obtained by other processes such as solid-state or mechanical milling processes. The other is a suspension reaction of the precursors without any previous mechanochemical reactions. We reported that Li_6PS_5Cl solid electrolyte was prepared by a dissolution-precipitation process using ethanol as a solvent [2], and $Li_7P_3S_{11}$ was prepared by a suspension-reaction process using acetonitrile as a solvent [3,4]. We also reported an approach combining suspension reaction and subsequent dissolution-precipitation to prepare argyrodite-type Li_6PS_5Br [5] or lithium oxy-thiophosphate [6].

In this presentation, the preparation of Li-ion conductive sulfide-based solid electrolytes using solution processes and the application of these processes to the fabrication of all solid-state batteries will be reviewed.

Key words: All-solid-state batteries, solid electrolyte, solution process;

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Abstract

D003: Chalcogenide Glasses: Novel Development and Applications

Changgui Lin[1,2] *, Shiliang Kang[1,2], Chengwei Gao[1,2], Linlin Tan[1,2], Jinjin Chen[1,2], Shixun Dai[1,2]

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Among various infrared optical materials, chalcognide glass is the only amorphous material that is transparent from mid-wave infrared to long-wave infrared, occupying the optical applications of infrared thermal imaging, infrared photonic chip, infrared sensing and remote sensing that other optical glasses cannot enter into. Besides the excellent optical properties including wide transmission range, large linear/nonlinear refractive index, and low thermal coefficient of refractive index, chalcogenide glass also possesses intriguing thermoelectric and ionic conduction properties, which are promising for energy applications. The R&D of novel chalcogenide glasses and their applications has become one of the research hotspots both in infrared optics and energy fields. Here we would like to present a brief report concerning the recent advances of novel chalcogenide glasses and their applications in our research group.

Key words: Chalcogenide glass; Infrared optics; Gradient refractive index; Thermoelectric; Solid electrolyte ;

Abstract

D004： High Peak Power Fiber Lasers and Applications

Shibin Jiang

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Abstract: Rare-earth doped multicomponent glass fibers have been developed for the high power lasers at 1 micron, 1.55 micron and 2 micron wavelengths, especially for single frequency pulsed fiber lasers. Both nanosecond and picosecond lasers were demonstrated at green and UV wavelengths. These unique fiber lasers can be used for coherent lidar detections. Laser materials processing will be presented in this talk as well.

Key words: Rare-earth doped glasses, fibers, lasers

Abstract

Invited

D001: Dependence of Glass Mechanical Properties on Structure at Varying Length Scales

Morten M. Smedskjaer[1]

1.Aalborg University (Denmark)

Glasses tend to suffer from low fracture toughness, which limits their potential applications. In this talk, I will discuss our recent progress in understanding structure-mechanical property relations of oxide glasses as well as a recent family of organic-inorganic hybrid glasses, namely zeolitic imidazolate frameworks. Our aim is to design new glass compositions and microstructures with improved mechanical properties from the bottom-up. Such design is building on knowledge of the structural deformation mechanisms of the glasses under high local stress through a combination of experimental and simulation studies. We show that glass materials with improved resistance to both crack initiation and growth can be prepared by appropriately tailoring their structure at varying length scales, from coordination numbers and ring units to heterogeneous microstructures.

Abstract

D002: Chalcogenide microstructured optical fibers: fabrication and applications

Johann Troles[1]

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Johann.troles@univ-rennes1.fr

Chalcogenide glasses are known for their large transparency in the mid-infrared and their high linear refractive index (>2). They present also a high non-linear coefficient (n_2), 100 to 1000 times larger than for silica, depending on the composition. An original way to obtain fibers is to design microstructured optical fibers (MOFs). These fibers present unique optical properties thanks to the high degree of freedom in the design of their geometrical structure. Our group has prepared various chalcogenide MOFs operating in the IR range in order to associate the high non-linear properties of these glasses and the original MOF properties. Different glass compositions and different designs have been achieved depending on the intended application. Indeed, chalcogenide MOFs might lead to new devices with unique optical properties in the mid-infrared domain like multimode or endlessly single-mode transmission of light, small or large mode area fibers, non-linear properties for wavelength conversion or generation of supercontinuum sources. In the 1-12 μm window, single mode fibers, polarization maintaining fibers and exposed core fibers have been realized for Gaussian beams propagation and sensors applications.

Biography

Johann Troles was born in 1975. He has obtained his Ph.D. degree in Chemistry in 2002 at the University of Rennes. In 2003, he joined the Glasses and Ceramics team of the University of Rennes (UMR 6226 Institut des Sciences Chimiques de Rennes). In 2010, he obtained a full professor position. His research activities include the synthesis and characterizations of non-conventional glasses and fibers. Even if his main activity was about chalcogenide glasses, Johann Troles is also involved in numerous researches about other non-conventional glasses (fluoride glasses and fibers, phosphate glasses and fibres, heavy oxide glasses and fibers…). In 2015, he co-founded the SelenOptics company. Since 2019, he is developing a new activity about additive manufacturing of chalcogenide glasses.

Abstract

D003: Foldable Ultra-thin Glass for now and future

Seungho Kim[1]

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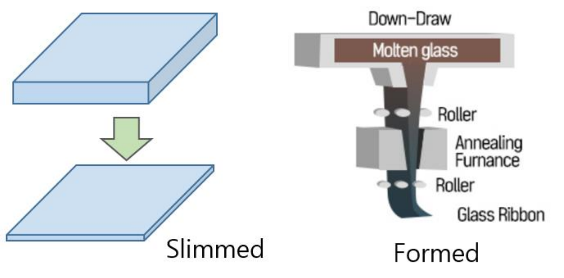
Email: seung-ho.kim@samsung.com

Flexible display products have recently shown the most competitive growth in the mobile technology sector. Flexible devices require materials and components with large deformation, to enable panels that partially or wholly bend. The ultra-thin glass (UTG) slimmed to less than 100 μm has been employed as cover window materials to protect modules including OLED panels and touch layers in flexible display products. In this presentation, the development history of UTG will be introduced in view of mother glass fabricaction and UTG manufacturing processes. In addition, the key issues of UTG as a cover material of flexible display applcation will be shared, and finally, required core technologies for future display application will be introduced.

Key words: Ultra-thin Glass; Foldable Cover Window;



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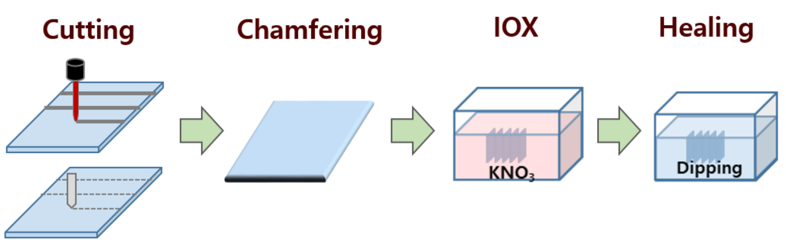

b

Fig.1 (a) UTG mother glass fabrication. (b) UTG manufacturing processes

Abstract

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Abstract

D004: Recent Advances in Microstructured Optical Fibres

Xin Jiang[1,*], Meng Pang[1,2], Zhuohao Luo[1,2,4], Jiapeng Huang1,2, Han Dong1,2, Yu Zheng3,4, Ruochen Yin3,1, Guojun Gao4, Haihu Yu4

1.Russell Centre for Advanced Lightwave Science, Shanghai Institute of Optics and Fine Mechanics and Hangzhou Institute of Optics and Fine Mechanics (HIOM), Hangzhou, 311421, China
2.Innovation and Integration Center of New Laser Technology, Shanghai Institute of Optics and Fine Mechanics (SIOM), Chinese Academy of Sciences (CAS), Shanghai, 201800, China
3.iFiber Optoelectronics Technology Co., Ltd., Ningbo, 315100, China
4.National Engineering Research Center of Fiber Optic Sensing Technology and Networks, Wuhan University of Technology, Wuhan, 430070, China

Ever since its first demonstration in 1996, Solid- and hollow-core photonic crystal fibres (PCFs), or micro-structured optical fibres (MOFs), have inspired a variety range of breakthroughs during the past 25-30 years. Both fundamental research and applications have been widely explored. Especially in the last few years, using PCFs for nonlinear optical frequency conversion, low-loss signal transmission, high-power laser delivery, sensing and imaging, and micro- to nano-manipulation has been well demonstrated. In this talk, I will briefly show the recent results achieved at the recently founded Russell Centre (RCALS) for Advanced Lightwave Science, using various PCFs as the research platforms. Details about ultrafast pulse delivery in hollow-core PCFs, enhanced short wavelength nonlinear frequency generation in cascaded photonic crystal fibres, NO2 chemical sensing in quantum dots modified hollow-core PCFs, ultrahigh mode purity by resonance-induced mode-filtering and mode coupling will be discussed.

Key words: Photonics crystal fibre;nonlinear optics;fibre sensing, mode-filtering

Abstract

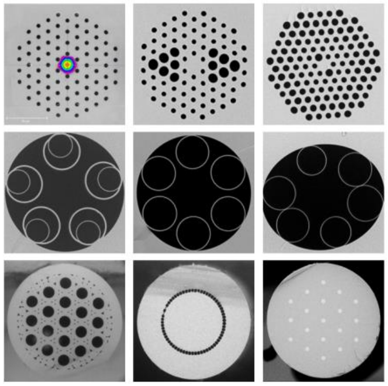

Fig.1 Vrious PCFs developed at RCALS.

Xin Jiang received his MS and PhD degrees from Chalmers University of Technology and University of Leeds in 2005 and 2009, respectively. After completing his PhD, he joined the research group led by Prof. Philip Russell at the Max-Planck-Institute for the Science of Light (Germany) in January 2010 as a group leader for fiber fabrication. Due to his outstanding contributions, Dr. Jiang was appointed to W2 Professor at the Max Planck Society in January 2017. Dr. Jiang's main research interests are in PCF fabrication technologies (fused silica, soft glasses and polymers) and related projects including supercontinuum light sources, photochemistry, quantum optics, fiber sensing, and optical tweezers. Recently Dr. Jiang joined the Russell Centre for Advanced Lightwave Science (RCALS) in Hangzhou as the deputy director and continues focusing on the fabrication and applications of PCFs.

Abstract

D005: From doped quartz glass to special optical fiber based applications

Zhenggang Lian [1]

The glass doping process is one of the important processes in the preparation of optical fibers. This technology provides the variation of the refractive index; facilitates the stress distribution inside the fiber; and also brings gain capability to the fiber. The report focuses on the manufacturing process and application technology of polarization maintaining optical fiber, square core optical fiber and multi-core optical fiber. The doping process of glass materials such as boron doping and fluorine doping in the manufacturing process of optical fiber preform will be introduced. Finally, the development and application of micro-structured optical fibers are also shown.

Zhenggang Lian, Ph.D., Professor, CTO of Yangtze Optical Electronic Co., Ltd. He has been working as a part-time professor at Huazhong University of Science and Technology; and part-time industrial professor at Southern University of Science and Technology, China. He obtained Ph.D. degree in Electronic Engineering from the University of Nottingham in 2009; then he joined the Optoelectronics Research Centre at the University of Southampton as a post-doc, in the field of design and fabrication of specialty optical fibers. He has over 15 years of experience in the synthesis and processing of special optical fiber materials and the preparation and testing of optical fibers. He has filed over 40 patents and published or co-authored more than 90 research articles. Yangtze Optical Electronic Co., Ltd. has more than 400 employees, located in Wuhan, mainly engaged in special optical fibers, optical devices, high-end equipment and provides customers with measurement calibration services. Various products are widely used in aerospace, high power lasers and marine monitoring.

Abstract

D006: Mechanically flexible photonics for on-chip sensing based on FSR-free cavities

Lan Li[1,2]

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In the past few years, flexible integrated photonics has emerged as a promising new technology that offers unique advantages over electronic devices in material sensing specificity, channel capacity, electromagnetic interference resistance, and noninvasive stimulation. Here, we present a new flexible photonic integrated sensor concept that utilizes cascaded one-dimensional (1D) photonic crystal (PhC) micro-cavities, which exhibit characteristics of large free-spectral-range (FSR), enabling high spatial resolution quasi-distributed sensing. Combining nanomechanical theory and device fabrication technology, we developed a universal and straightforward multimaterial integration approach incorporating passive and active components onto flexible platforms and demonstrated their potential applications for on-chip sensing.

Key words: Chalcogenide glasses;integrated photonics;flexible devices

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Abstract

D007: Medium-range structure in functional glasses

Ang Qiao[1], Haizheng Tao[1], Yuanzheng Yue[2]

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Email：qiaoang@whut.edu.cn

The understanding of structure-properties correlation in glassy materials is a long-standing puzzle, especially corncerning the role of medium-range structure (MRS) in the properties of functional glasses. In this presentation, we will report a series of studies on two types of functional glasses, i.e., metal-organic framework (MOF) glasses and amorphous chalcogenide conductors. A hypersensitivity of glass transition (Tg) to pressure history was found in a MOF glass. The structural analysis and molecular dynamics simulations revealed that the origin of the hypersensitivity of Tg to pressure history is ascribed to the MRS change. Furthermore, a new series of amorphous AgI-based chalcogenide conductors with considerablely high ionic conductivity and ultrahigh chemical stability were prepared. The existence and evolution of the MRS in the amorphous conductors were discovered using the solid-state NMR spectroscopy. The change in MRS, i.e., formation of the inter-connecting AgI clusters, contributes to the formation the percolative channels for superionic conducting. These findings provided a perspective for understanding the critical role of MRS in determing the properties of functional glasses.

Key words: Medium-range structure;MOF glasses;Ionic conductors; Glass properties.

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2. A. Qiao†, S. S. Sørensen†, M. Stepniewska, C. A. N. Biscio, L. Fajstrup, Z. Wang, X. Zhang, L. Calvez, I. Hung, Z. Gan, M. M. Smedskjaer*, Y. Z. Yue*, Hypersensitivity of the Glass Transition to Pressure History in a Metal−Organic Framework Glass. *Chemistry of Materials*, 2022, 34, 5030-5038.

Abstract

3. R. S. K. Madsen†, A. Qiao†, J. Sen, I. Hung, K. Chen, Z. Gan, S. Sen*, Y. Z. Yue*, Ultrahigh-Field ^{67}Zn NMR reveals short-range disorder in zeolitic imidazolate framework glasses. *Science*, 2020, 367, 1473–1476.

Abstract

D008: Integrated chalcogenide glass photonic devices for nonlinear photonics

Bin Zhang[1], Di Xia[1], Zifu Wang[1], Jingshun Pan[1], Zhaohui Li[1]

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Integrated nonlinear photonics combines state-of-the-art photonic integration with nonlinear optics to create high-performance laser sources. Recently, we have demonstrated a home-developed chalcogenide glass (GeSbS) for optical information processing chips and systems. Chip-integrated GeSbS microresonators and microresonator arrays with high quality factors and lithographically controlled fine structures were fabricated using a modified nanofabrication process. Moreover, considering the high Kerr nonlinearity of ChGs, we realised a novel ChG hybrid integrated chip, inspired by recent advances in optical frequency combs, quantum optics and optical interconnects.

Key words: Chalcogenide glass;Integrated photonic devices;Nonlinear photonics；

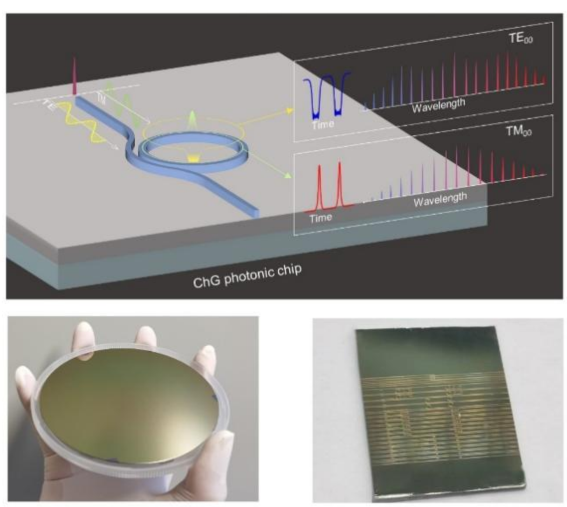

Figure 1. The nonlinear photonics based on integrated GeSbS photonic devices.

Abstract

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Abstract

D009: Progress and Challenges in Surface Enhancement Process on Oxide Glass

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2.Department of Chemistry and Bioscience, Aalborg University, Aalborg, Denmark

Oxide glasses are brittle materials, i.e., they cannot deform plastically on the macroscale without fracture, which seriously limits the scope of their applications.Therefore, it is very important to avoid the formation of surface damage (such as microcracks) that limits the practical strength of oxide glasses, but methods for ameliorating surface damage in these glass materials are still poorly understood. In this talk, we review recent advances and challenges in designing surface damage-resistant oxide glasses through surface strengthening processes. First, we report the use of surface aging in a humid atmosphere, to improve not the resistance to crack growth, but rather the resistance to crack initiation. Specifically, we demonstrate crack-free ultra-sharp cube-corner indents in an aged caesium aluminoborate glass at loads above 25 N.
This results indicate that the ultra-high crack resistance is due to the formation of surface hydration layer (more open structure, network with high freedom and Cs-OH groups with high mobility). Meanwhile, to search novel surface enhancement processes to design damage-resistant and potentially tough oxide glass compositions, we prepared hightransparency hard ceramic films on oxide glass by Physical Vapour Deposition sputtering process (PVD). We show that a bulk, transparent, melt-quenched oxide glass with this high-transparency hard ceramic film can survive Vickers indents at loads as high as 98 N without forming any strength-limiting cracks. Furthermore, this high-transparency hard ceramic film can also improve the hardness, strength and scratch resistance of oxide glass to a certain extent.

Abstract

D010: O-, E- and S-band bismuth-doped fiber amplifier and laser

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2.Prokhorov General Physics Institute of the Russian Academy of Sciences, Dianov Fiber Optics Research Center, 38 Vavilov str., Moscow, 119333, Russia
3.College of Optical Science and Engineering and State Key Lab of Modern Optical Instrumentation, Zhejiang University, Hangzhou 310027, China
(*Email: 0621072@zju.edu.cn)

The O-band fiber amplifier and laser are attractive for optical communications, whereas E- and S-band fiber amplifier and laser overlaps with the strong absorption band of water molecules for applications such as medical diagnoses and laser therapy. However, the fiber amplifier and laser working in these wavebands are inaccessible by most rare-earth-doped silica fibers. In contrary, the gain fibers doped with bismuth could exhibit broadband luminescence from 1100 to 1800 nm. Here, we fabricated two bismuth-doped fiber preforms with a small amount of P2O5 (~6 mol.%) and GeO2 (~4 to 5 mol.%) through modified chemical vapour deposition technique. The fiber preforms were drawn into bismuth-doped phosphosilicate fiber to generate O-band emission and germanosilicate fiber to generate E- and S-band emissions. The fiber amplifier was demonstrated to amplify a continuous wave laser with the highest gain of ~13 and ~20 dB at a wavelength of ~1310 and ~1450 nm, respectively. Furthermore, amplification of a tunable continuous wave laser that covers the O-, E-, and S-bands was performed from 1290 to 1520 nm. Next, the bismuth-doped fiber was employed to generate a continuous wave laser at ~1310 and ~1450 nm through a ring cavity. In addition, laser operation in mode-locking regime was designed to achieve high pulse energy through rectangular pulse emission. Here, we presented an O-, E- and S-band rectangular pulse emission with a pulse energy of ~170 to 200 nJ, which is three to four order of magnitudes higher than the other conventional mode-locked fiber lasers. Moreover, tunable rectangular pulse emission from ~1430 to 1470 nm was achieved to fulfil the current operation spectral gap from ~1406 to 1550 nm. This work presents the significance of bismuth-doped fibers to build a fiber amplifier and laser across O-, E- and S-bands for optical communications, medical diagnoses and laser therapy applications.

Abstract

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Abstract

D011: Chalcogenide glass fiber bundles for infrared imaging

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Infrared imaging fiber bunldes (FBs) are composed of multiple regularly arranged single infrared fibers. They have shown broad application prospects in the fields of national defense, medicine, and industry because of their small size, light weight, good flexibility, and excellent resistance to electromagnetic interference. Compard with infrared FBs made of polycrystalline silver halide fibers, hollow capillary fibers, or hollow core anti-resonant fibers, those made from chalcogenide fibers have advantages such as low crosstalk, low loss, easy fabrication, and low cost, making them highly promising in flexible infrared imaging applications. In rencet years, by using high-strength thermoplastics thermally matched with chalcogenide glasses as the outer cladding of the chalcogenide fibers, we have developed a number of high-perfromance imaging FBs working in the 2~12 μm. The fabricated chalcogenide FBs (see Fig.1) have single fibers as many as >1 million, resolutions as high as ⩾20 lp/mm, filling factors as high as >64%, crosstalk rates as low as <1%, and broken fiber rates as low as <0.5%. High-quality infrared images in the 3~5 μm and 8~12 μm spectral ranges have been delivered through the fabricated FBs.

Key words: Chalcogenide Glass; Infrared Fiber; Fiber Bundle; Thermal Imaging

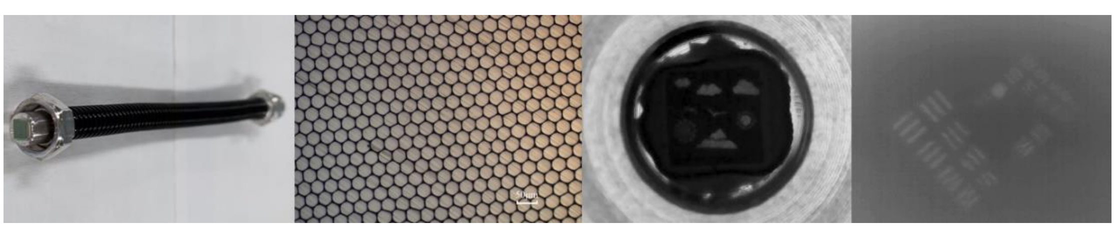

Fig.1 Fabricated representative chalcogenide FB and thermal images captured through the FB.

Abstract

D012: Infrared micro-nano fiber sensor for organic detection

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Infrared fiber has a wide transmission range of 1-15 μm, covering the molecular fingerprint region, so it has important applications in the field of organic detection. In this presentation, we will report the progress of the micro-nano infrared fiber, including the numerical simulation method, geometric structure optimization, fabrication technology, and applications in organic detection. Finally, a novel ring fiber sensor for qualitative and quantitative organic detection will be presented. Through the evanescent wave absorption spectra and Beer-Lambert law, the detection of CH3CH2OH, C6H5CH2OH, C6H5CHO, ascorbic acid, glucose, and triglycerides has been performed by infrared fiber sensor with high sensitivity and low Limit of detection (LoD). This sensor will find applications in environmental detection, food safety, chemical industry, and other fields.

Key words: Infrared fiber;fiber sensor;tapered fiber;organic detection

Abstract

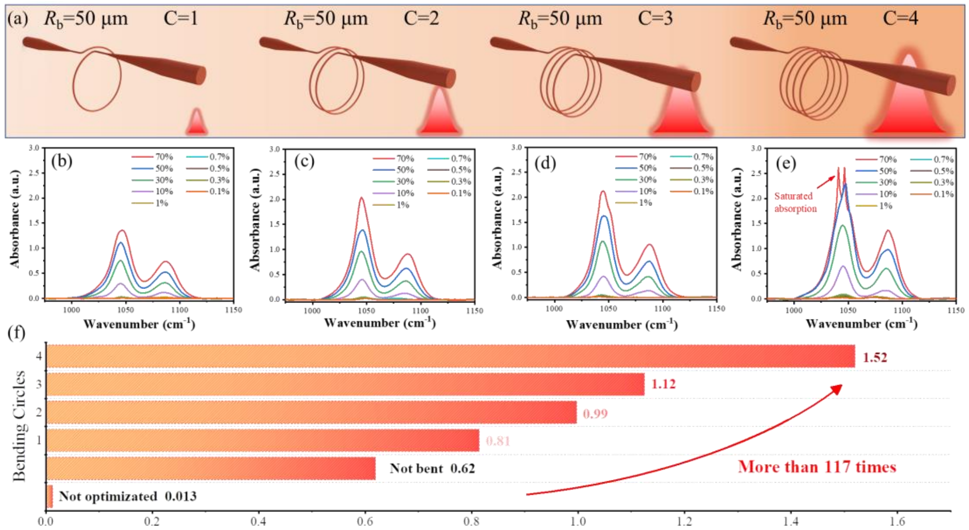

Fig. 1 Sensing performance of tapered fiber sensor with R_b of 0.5 mm and d_w of 50 μm. **(a)** Schematics of optical fibers with different bending circles and the corresponding evanescent wave absorption spectra **(b)-(e)**. Saturated absorption has been observed in **(e)** when the concentration of CH_3CH_2OH reaches 50 vol.%. **(f)** Sensitivity of fiber sensors with different bending circles.

Brief Biography

Yinsheng Xu, Professor. His research interests mainly focus on infrared optical materials, infrared fiber, and infrared fiber sensors. He received his undergraduate and PhD degrees in Material Science from the East China University of Science and Technology in 2006 and 2011, respectively. He also received PhD degree in Chemistry from the Universite of Rennes 1 in 2011. He has presided over 4 national research projects and has published more than 100 research papers.

Abstract

D013: Application and Future of Electronic Glass

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Which products do we spend the most time on every day? What are the indispensable components of these products? Which use-cases have the most profound and lasting impact on us? Display technology is ubiquitous—this presentation aims to highlight the various types, fundamental characteristics, and applications of electronic information display glass. It also outlines the current developmental landscape, the future opportunities and challenges facing electronic glass in China.
Key words: Electronic glass;Glass substrate;Cover glass;OLED glass

Brief Biography

Qing Li is a Professor-level Senior Engineer specializing in the development of electronic information display materials and equipment. With a long-standing presence at the forefront of the industry, she has focused on technological research and innovation in the realm of display glass and related equipment. Leading a dedicated team for over two decades, Li has achieved breakthroughs in a comprehensive range of technologies and equipment ranging from G4.5-G8.5 LCD glass substrates, screen protection glass (also known as cover glass), LTPS glass, and flexible OLED glass. These accomplishments have not only shattered foreign technological blockades and product monopolies but also transformed China's glass substrate industry from its nascent stages to a continually strengthening powerhouse, thereby reshaping the global market landscape for glass substrates. She has received numerous awards, including one first prize of National Science and Technology Progress Award, five first prizes of Provincial Science and Technology Progress Award, one Chinese Patent Gold Award, He Liang He Li Award, National Innovation Excellence Award, and 165 invention patents. She has published 59 academic papers, authored six scholarly works, and spearheaded the development of six national standards.

Abstract

D014: Manufacture and application of high-end optical quartz

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Quartz is inorganic non-metal and its main component is silicon dioxide. Quartz material is widely used in semiconductors, optical communications and optics due to its excellent properties such as high purity, high temperature resistance, low thermal expansion and strong chemical stability, and is an important raw material for high-end equipment manufacturing. Optical system is one of the most important components of photoetching machine. High-end synthetic optical quartz glass is an important raw material of lithography optical system. What are the specific performance requirements of this kind of quartz glass.

Key words: Synthetic quartz;Lithography optical system;Photomask quartz substrate

Abstract

D015: Research progress in optical fiber imaging glass materials for weak photoelectric signal detection

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Fiber optic imaging elements are hard fiber arrays composed of tens or even billions of micron scale glass fibers, each of which is a relatively independent unit for light and image transmission. The monofilaments are obtained by drawing optical glass rod and tube, and then arranged into rods in a regular manner. Two times of drawing are followed to prepare the primary and secondary multifilament, respectively. The multifilament is arranged in a directional manner and formed into dense plate segments through high-temperature melt pressing. The fiber optic plate (FOP) is prepared by optical processing of the plate segments. Fiber optic taper (FOT) and fiber optic inverters (FOI) can also be produced by high-temperature stretching and twisting the plate segments. As far as functions are concerned, FOP can transmit optical images with the same size, no distortion and high contrast. FOT proportionally enlarge or reduce images, while FOI transmit images by inverting 180°. The images could be transmitted with high fidelity and high-definition due to high light transmission efficiency, high resolution, high contrast, and optical zero thickness characteristics of fiber optic imaging elements. It is the core component of low light image intensifiers, image converter tubes, and particle detection imaging devices, and the material foundation for achieving device miniaturization and image digitization. It has been applied to various devices such as low light night vision, low light photography, and high-energy particle/ray detection in weapons. All of these devices have been widely used in the fields including electronics, aerospace, aviation, and nuclear. This article aims to systematically introduce the research status of optical glass materials, preparation processes, performance, and applications of fiber optic imaging components, as well as the bottle-neck issues that still need to be overcome at this stage. Finally, the development direction of fiber optic imaging functional glass and components is expected.

Key words: Fiber optic imaging elements; Weak photoelectric signal detection; Optical glass;

Abstract

Research progress

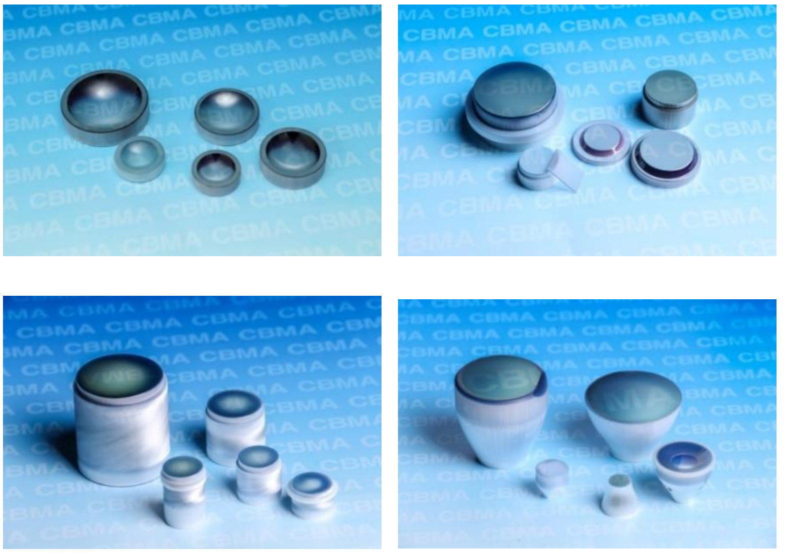

Fig.1 Fiber optic imaging glass materials and elements

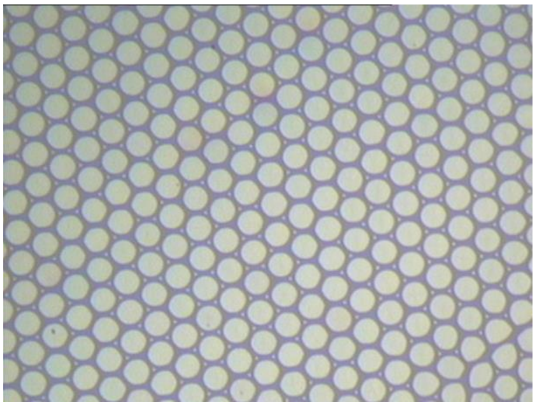

Fig.2 Microstructure of optical fiber imaging elements

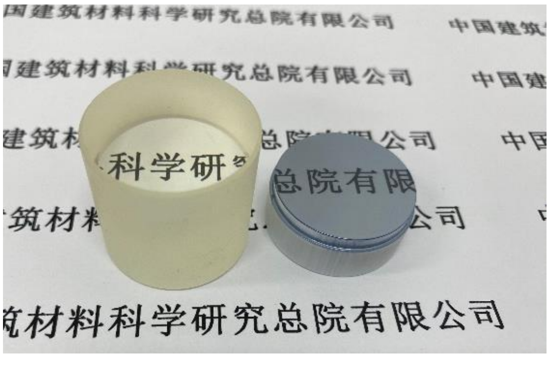

Fig.3 Comparison of imaging effects between fiber optic imaging elements and glass

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Abstract

D016: Process Variables for The Mechanical Properties of High-Strength Glass Fibers

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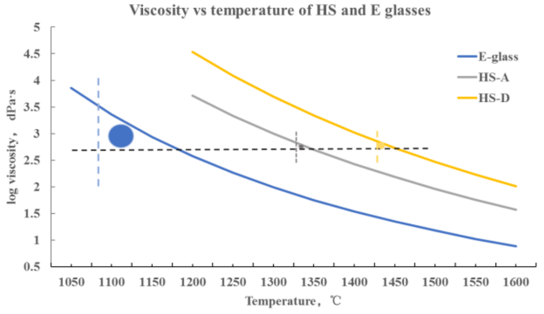
High-strength glass fibers have emerged as a cost-effective inorganic fiber material for a wide range of industrial applications due to their superior tensile strength and modulus compared to ordinary glass fibers. However, the production process of high-strength glass fibers is often hindered by inherent challenges such as high viscosity, easy crystallization, and limited fiber forming windows. Thus, precise control of the manufacturing process is crucial to ensure consistent mechanical properties and efficient production. This study employs statistical analysis models to comprehensively investigate the quantitative relationships between key production process variables, including glass composition, fiber forming temperature and rate, and the resulting mechanical properties of glass fibers. Additionally, the impact of variations in fiber diameter on the mechanical properties of unidirectional fiber composite laminates is explored. By elucidating the interrelationships between process parameters and mechanical properties, this research provides valuable insights for establishing control parameters in the production process of high-strength glass fibers. Implementing these findings will contribute to enhancing the performance and reliability of diverse glass fiber applications in industries such as aerospace, transportation and electronics.

Key words: high-strength glass fibers; mechanical properties; process variables; statistical models; production process control



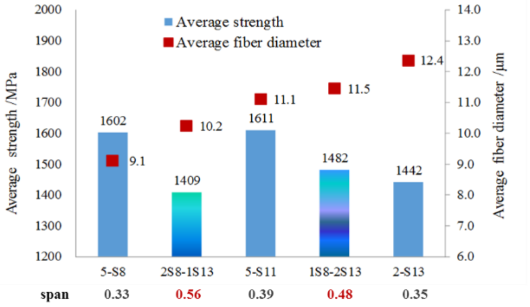


Fig.1 Temperature and viscosity of glass Fig.2 Average tensile strength and fiber diameter of raving

Abstract

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Abstract

D001: Investigation of Solar heat gain coefficiency and the application of CdTe Power glass

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CdTe power glass has aroused a widespread attention in building industry as a new green tech-building material due to its increasing photoelectric conversion efficiency and its reliable, safe, economical properties. It enables the building aesthetic value as well as the energy-saving value and has become the driving force for the zero-energy building. In order to weight the energy conservation of CdTe power glass, visible light transmittance, reflection, thermal transmission, solar heat gain coefficient (SHGC), shading coefficient (SC) have been discussed in the report. The effects of different film removal rates and different product structures on the optical and thermal properties of CdTe power glass have been systematically analyzed. The research results can help customers and architecture designers to make a best choice for the CdTe power glass. In addition, many successful practical projects of CdTe power glass will be shared in the report.

Key words: CdTe, energy-saving, SHGC, SC

Abstract

D002: The R&D of the high light yield and high density glass scintillator

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The future e+e− Higgs factory, whose main goal is to achieve a precise measurement of mass and properties of the Higgs boson, is the main development trend of the next-generation large collider. A big challenge for this goal is to fulfill an unprecedented jet energy resolution, and the scheme selection of hadronic calorimeter (HCAL) is one of the most important factors. Scintillation materials can convert high-energy rays into visible light. Generally, solid scintillator can be divided into crystal scintillator, plastic scintillator, glass scintillator and ceramic scintillator. Compared with crystal scintillator, the glass scintillator has many advantages, such as a simple preparation process, low cost and continuously adjustable components. Therefore, glass scintillator has long been conceived for application in the nuclear detection such as hadronic calorimeter. Given the deficiency of the crystal and the plastic scintillator, a new concept, Glass Scintillator Hadronic Calorimeter for CEPC (GS-HCAL), was proposed. In 2021, the researchers in the Institute of High Energy Physics (IHEP) have set up the Large Area Glass Scintillator Collaboration (GS group) to study the new glass scintillator with high density and high light yield. Currently, a series of high density and high light yield scintillation glasses have been successfully developed. The density of Ce3+ doped borosilicate and silicate glasses exceed 6 g/cm3 with a light yield of 1000 ph/MeV. And the fast component of scintillation decay time of silicate glass is less than 100 ns (44%). The GSHCAL conceptual design with preliminary detector optimization by simulation has been done. The physics potential and the R&D of the GSHCAL will be presented in this paper.

Keywords: Higgs factory, CEPC, HCAL, Glass Scintillator

Abstract

D003: Study on the Scintillation Properties of Ce3+-Doped Aluminum-silicate Glasses

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According to the Robbins model, there is a corresponding relationship between the light yield of scintillation materials and their photoluminescence quantum yield (PL QY), so the scintillation performance of glasses can be improved from the perspective of improving photoluminescence quantum yield. Ce3+-doped Gd2O3-Al2O3-SiO2 (GAS: xCe3+) glasses were prepared with a density of approximately 4.2 g/cm3. The PL QY of the glasses varies from 28.3% to 50.5%. Under the γ-ray radiation, its light yield can reach 1200 ph/MeV, and the energy resolution is 22.9%@662 keV. By adding B2O3 or Li2O to the glasses, the PL QY of the glasses was further improved, with a maximum PL QY exceeding 60%, and its scintillation performance was accordingly improved. The research results indicate that Ce3+-doped aluminum-silicate glasses have potential scintillation application.

Key words: Aluminosilicate glass; Photoluminescence quantum yield (PL QY); Light yield; Scintillation

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Abstract

D004: Development and Performance Study of Fluoride Glass Fiber

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Fluoride glass fibers have extremely low theoretical loss, excellent transmission performance and high solubility of rare earth ions in medium wave infrared. They show great prospects in fields such as optoelectronic countermeasures, fiber lasers, supercontinuum light sources, and clinical surgeries. However, the actual loss of fluoride fiber optic products is 2-3 orders of magnitude higher than the theoretical loss, greatly limiting their related applications. The preparation of high-quality fluoride optical fibers is a challenging technology in China. Our team designed and optimized the process from the purification of fluoride raw materials, deep water and oxygen removal of glass, preparation of low defect preforms, and fiber drawing, achieving a loss of 0.05 dB/m @ 2.4 μm. This achievement laying a preliminary foundation for the preparation of high-quality and industrialized fluoride optical fibers.

Key words: Fluoride glass fiber; Optical loss; Mid-infrared band

Abstract

D005: Design of optical fiber path for tapered optical fiber array and improvement of light transmission uniformity

Peng Jiao[a,b], Yonggang Huang [a,b *], Yang Fu [a], Yun Wang [a], Jiuwang Wang [a], Yajie Du[a], Jing Zhang [a], Jinsheng Jia [a,b]

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Tapered Optical Fiber Array (TOFA) is a type of fiber optic imaging element consisting of several million tapered optical fibers. TOFA is widely used for coupling with CCD/CMOS to achieve high-coupling efficiency and resolution. The inhomogeneity of light transmission is one of the pattern noises in a TOFA, which seriously affects the optical performance and reduces the detection efficiency and recognition accuracy of coupling devices. This is a problem that needs urgent improvement. In this study, the theoretical analysis of the light transmission loss of tapered optical fibers with various structures in TOFA was performed, and the geometric shape for the tapered transition region of a TOFA was designed as the distribution of a linear, parabolic, and cubic function, respectively. Ray-tracing software was used to numerically calculate the light transmission ability of tapered optical fibers in designed three types of TOFAs. It was concluded that the theoretical uniformity of light transmission is the best in the cubic model TOFA. Additionally, the linear, parabolic, and cubic model TOFA samples were manufactured by adjusting the stretching temperature and time, all of which are highly consistent with the designed geometric structure. The relative transmission curve from the axis to the edge of the TOFA was characterized using the fiber optic imaging element transmission detector. It is demonstrated that the light transmission uniformity of experimental linear, parabolic, and cubic model TOFA was 23.82%, 10.73% and 5.44%, respectively, which the experimental cubic model TOFA exhibits the highest uniformity agreeing with the trend of numerical calculation. Therefore, a TOFA with high homogeneity was manufactured by the specified results for the optical fiber path of the tapered transition section, which was created based on theoretical analysis and numerical calculation. The method and results provide a guideline for preparing a TOFA with high performance, large size and high taper ratio, which is of great significance for improving the performance of fiber optic imaging elements and the developing low level-light night vision fields.

Abstract

D006: Design, Fabrication and Properties of Mid-Infrared Fiber Combiners

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Mid-infrared fiber combiners can combine multiple low-power mid-infrared lasers to achieve higher power. In this study, we designed and manufactured 7×1 and 3×1 chalcogenide glass fiber combiners. The measurements show that the port transmission efficiencies of the fiber combiners at 3 μm and 4.6 μm are >75%, respectively. There is no obvious crosstalk between the fiber monofilaments at the output end of the fiber combiners. We further investigated the application of the fiber combiners in laser power superposition and laser spectral combining. The superposition efficiencies of the fiber combiners are >70%, and they can realize the multi-wavelength spectral combination at 3.4 μm and 4.6 μm. These results indicate that the fabricated fiber combiners are efficient laser combining devices and are promising in the fields of mid-infrared laser power enhancement and wide spectrum synthesis.

Key words: Chalcogenide Glass Fiber; Mid-infrared Fiber Combiner; Power Enhancement

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Abstract

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Abstract

D007: Preparation and Application of Chalcogenide Thermoelectric Fiber

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Fiber-based inorganic thermoelectric (TE) devices, owing to the small size, light-weight, flexibility, and high TE performance, are promising for applications in flexible thermoelectrics[1,2]. As a family of potential TE materials, semiconducting chalcogenide glasses exhibit unique characteristics of easy to draw fiber, high Seebeck coefficient, low thermal conductivity and tunable electrical conductivity, endowing them with promising applications in wearable electronics[3]. Based on preform-to-fiber drawing method, $Ag_2Te_{0.6}S_{0.4}$ and $Ge_{15}Ga_{10}Te_{75}$ TE fibers were successfully prepared, and their applications in power generation and thermal sensing were explored. For power generation, the $Ag_2Te_{0.6}S_{0.4}$ fibers were integrated into a wearable fabric, yielding a normalized power density of 0.4 μW m^{-1} K^{-2} under the temperature difference of 20 K. For thermal sensing, the prepared single TE fiber is capable of efficiently detecting thermal source with an accurate temperature resolution of 0.03 K and a fast response time of 4 s. Furthermore, the TE fibers enables effective monitoring of human respiration and body temperature when integrated into a mask and a wearable fabric.

Key words: Thermoelectric Fiber; Chalcogenide Glass; Wearable Electronics

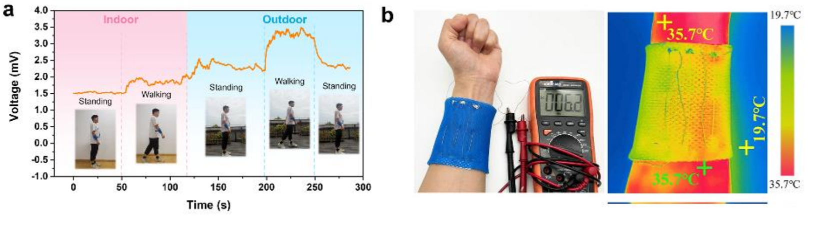

Fig.1 (a) Continuous monitoring on output voltage. (b) Output voltage of TE textile and temperature profile taken by infrared camera.

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Abstract

D008: Chemical Durability of Borosilicate Glasses

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Borosilicate glasses have wide application in pharmaceutical packaging, and the chemical durability of Borosilicate glasses is very important. Borosilicate pharmaceutical glasses typically contain a mixture of different modifier (alkali or alkaline earth) ions. A detailed understanding of the dependence of the chemical durability on alkaline earth oxide compositions is still largely lacking. Here we have designed a series of borosilicate glasses with systematic substitutions of calcium oxide with magnesium oxide, and investigated the influence of the substitution on the resistance to aqueous corrosion. Generally, the corrosion of the glasses can be divided into three stages. Stage I is the network breakdown region, where the dissolved layer thickness changes from ~100 nm to ~170 nm as R increases. All the element dissolve into the solution congruently. In stage II, the ion exchange between Na, Ca, Mg ions and H+ occurs. The leaching of magnesium and calcium ions only take place at the top ~25nm and ~50nm towards surface, and they seem less composition dependent. The leaching of Na ions mainly happens in stage III. The partial depletion of the Na increases monotonically from ~100 nm to ~200 nm as the R increases from 0 to 1. The glass with highest magnesium oxide is the least durable one against aqueous attack. The depletion of the ions is corelated with the degree of the network re-arrangement in the corroded layer proved by vibrational spectroscopy. The results are helpful to improve the chemical durability of Borosilicate glasses.

Key words: Borosilicate Glasses; Chemical durability; Corrosion

Abstract

D009: Amorphous tungsten bronze doped near-infrared-shielding glasses for energy-saving applications

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Tungsten bronze coatings and films have attracted global attention for their applications in near-infrared (NIR)-shielding windows. However, they are unstable in strong ultraviolet, humid heat, alkaline and/or oxidizing environments and are difficult to be coated on glass surfaces with complex shape. Here, we address these limitations by doping amorphous tungsten bronze into bulk glasses using a simple glass melting method. X-ray diffraction, Raman spectroscopy, X-ray photoelectron spectroscopy and TEM characterization confirmed the presence of amorphous sodium tungsten bronze functional units inside the SiO2-B2O3-NaF glass matrix. Because the functional units are well protected by the glass matrix, the fabricated glasses are stable under hot, humid, oxidizing conditions, as well as under ambient conditions, with no change after 1080 days. The NIR-shielding performance of these glasses can be adjusted to as high as 100% by varying WOx concentration (2-8 mol%) and quenching temperature (1000-1400 °C). With a content of 6 mol% WOx and a quenching temperature of 1000 °C, the bulk glass shows 63% transmission of visible light and only 11% transmission of NIR light at 1100 nm. Thermal insulation experiments show that the NIR-shielding performance of the glasses are far superior to commercial soda lime window glass or indium-doped tin oxide (ITO) glass, and comparable to cesium tungsten bronze coated glass. The novel bulk glasses have higher stability, simpler processing, and can be easily made into complex shapes, making them excellent alternative materials for energy-saving glasses.

Keywords：Amorphous tungsten bronze；energy-saving glasses；near-infrared (NIR)-shielding

Figure 1: (a) UV-Vis-NIR transmission spectra and (b) raman spectra of the glass samples doped with different amorphous tungsten bronze, (c) comparison of heat insulation effects, and (d) transmission spectra as a function of time.

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Abstract

D010: The application of metallic glass-based advanced oxidation processes (AOPs) in drinking water treatment

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The advanced oxidation processes (AOPs) drew great attention in the field of water treatment owing to their high efficiency and fast degradation rate towards organic pollutants. Metallic glasses, also known as amorphous alloys, are special metal alloy material with high conductivity, corrosion resistance and good biocompatibility, which have been successfully applied to the degradation of dye wastewater through amorphous alloys-based AOPs as environment-friendly catalysts in the past decade. Compared with azo dye in wastewater treatment, drinking water treatment which directly related with human health, worth further investigation. When disinfectants (chlorine) react with natural organic matter (NOM) and/or bromine/iodine ions in water, disinfection by-products (DBPs) which pose potential hazards to human health will be generated. More than 700 kinds of DBPs have been identified successively since its first identification in 1974. Therefore, how to effectively control the generation of DBPs while at the same time ensuring disinfection became a challenging topic during drinking water treatment process. The present study selected Fe-Si-B amorphous ribbons and introduced them into drinking water treatment (removal and control of DBPs). The amorphous alloys-based AOPs were carried out by Fe-Si-B amorphous ribbon reacting with hydrogen peroxide (hydrogen peroxide-based AOPs) and PDS/PMS (sulfate-based AOPs), respectively. The results indicated that both of two types of AOPs showed excellent performance in formation control of DBPs by successful abatement of NOM before disinfection. About 60%-90% DBPs can be reduced by the two types of AOPs. The mechanisms study indicated that high valent iron Fe (IV) which can be generated from the two types of AOPs was the reactive specie that accounted for the catalytic degradation of NOM, which as a result decrease the formation of DBPs. Our results showed that Fe-Si-B amorphous ribbon can be a promising catalyst for the formation control of DBPs in drinking water treatment.

Key words: metallic glass; high-valent iron; disinfection by-products; advanced

Abstract

oxidation processes

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Abstract

D011: Cu and Eu Doped Oxyfluoride Boroaluminosilicate Glasses and Glass-ceramics

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In the present study, Cu/Eu doped oxyfluoride boroaluminosilicate glasses and glass-ceramics prepared via a melt-quenching route in an air atmosphere are investigated. By precisely regulating the glass matrix compositions, the CaF2 crystals were spontaneously formed in the process of melt quenching and thus the corresponding glass-ceramics were obtained. The content of the formed CaF2 crystals depends on the proportions of the Al2O3 and B2O3 in the base glass compositions. The Cu2+ in the as-obtained materials can emit bluish green light upon ultraviolet (UV) light excitations. The Eu ions activated glasses and glass-ceramics simultaneously display the emissions originating from Eu2+ and Eu3+ ions, indicating the self-reduction of Eu3+ to Eu2+ occurs. The luminescence performances of the fabricated glasses and glass-ceramics are successfully tailored via a materials compositional design strategy and tuning excitation wavelengths. The superior photoluminescence features reveal the potential applications of the as-fabricated Cu/Eu doped oxyfluoride boroaluminosilicate glasses and glass-ceramics for light-emitting diodes (LEDs) devices.

Key words: Luminescence; Oxyfluoride boroaluminosilicate glass; Cu^{2+} ions; Eu^{3+} ions

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D012: New oxide optical functional glass materials

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With the development of science and technology, new oxide optical functional glass materials have been applied in more and more fields. Our work has been carried out around high-refractive optical glasses, high-performance scintillation glasses, infrared glasses and optical fibers. Containerless technology can suppress heterogeneous nucleation, obtain deep undercooling melt, and achieve ultrafast solidification. It is an effective method for the development of new oxide glass materials. High-refractive oxide glasses have been prepared by using aerodynamic method, with a refractive index exceeding 2.34, which can be used in laser coupling ball lenses to significantly improve the coupling efficiency. However, it is difficult to prepare large-size glasses by containerless processing. The compositions of containerless glasses have been optimized to improve the glass forming ability. Large-size, high-refractive glasses have been prepared by high-temperature melting method. The refractive index of the glasses is no less than 2.155. Through composition design and process optimization, the preparation of the infrared glass materials with large size and multi-band transmission has been developed. The internal transmittance is up to 99.5%. The glass transition temperature is 463 ℃, which is suitable for precision molding process. The glasses can be used to prepare aspheric lenses. Using the method of interlocking crucibles, colorless and transparent silicate glasses have been prepared successfully. The glass has good scintillation properties. The highest light yield reaches 941 ph/Mev, and the energy resolution is 26.7%, showing a good application prospect.

Abstract

D013: Sol-Gel Derived Multi-Layer Bulk Silicate Glass with Graded Refractive Index

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Glasses with graded or garadient refractive index have attracted much attention due to their potential applicaitions for planar lens, fibers, integrated optics, and micropgtonics[1.2]. The glasses can be prepared by ion-exchange, chemical vapor deposition, controlled crystallization, and others methods. In this research, SiO2-ZrO2, SiO2-Yb2O3, and SiO2-TiO2 binary components glasses were prepared through traditional sol-gel method, and bulk glasses with graded refractive index were fabricated by wet gel stacking, and subsequent sintering. The effect of pH value on the formation of wet gel and glass were discussed. The X-ray diffraction, FTIR, and X-ray microscope results confirm the formation of dense glass without porous. The refractive index (nd) changed from 1.465 to 1.514 for SiO2-Yb2O3 glass, and from 1.499 to 1.557 for SiO2-TiO2 glass (Fig. 1 a). Moreover, the transmittance in visible range can reach 75% (Fig. 1 b) . The elements distributions in muletilayer glass also confirm the refractive change in the bulk glass.

Key words: Sol-gel; Graded frarctive index; silicate glass; viscosity

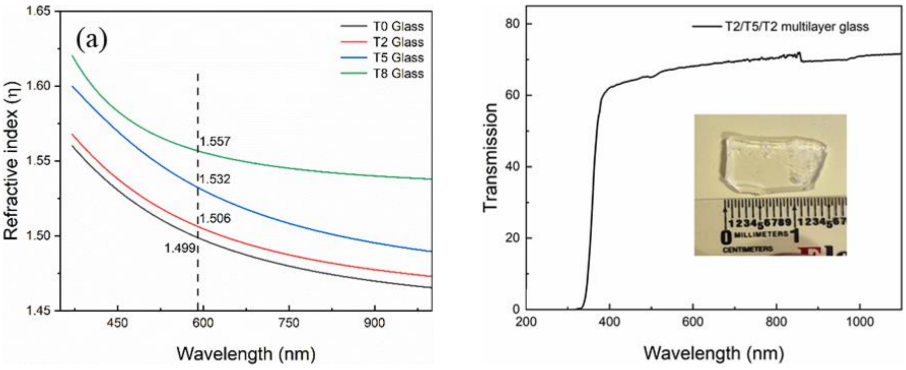

Fig. 1. (a)The dependency of refractive index of SiO_2-TiO_2 glass with different TiO_2

content on wavelength, and (b) the transmittance of multi-layer SiO_2-TIO_2 glass.

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Abstract

D014: Broadband NIR-emitting Te cluster-doped glass for smart light source towards multifunctional applications

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Broadband near-infrared (NIR)-emitting materials are crucial components of the next generation of smart NIR light sources based on blue light-emitting diodes (LEDs). Here, we report a Te cluster-doped glass, which exhibits ultra-broadband emission around 980 and 770 nm with a full-width at half-maximum (FWHM) of 306 nm under blue light excitation. We propose adjustments of glass chemistry and processing condition as a means for topochemical tailoring of the NIR photoemission characteristics in such materials. Through implementing strongly reducing conditions during glass melting, Te clusters with broad NIR photoluminescence can be generated and stabilized once the melt is vitrified to the glassy state. Tunability of the NIR emission peak over the wavelength range of 760 to 1026 nm is possible in this way, allowing for fine adjustments of spectral properties relative to the stretching vibrations of common chemical bonds, for example, in water, sugar, proteins, and fats. This potentially enables high sensitivity in NIR spectroscopy. We further demonstrate versatile application of glass-converted LEDs such as night-vision, information encryption, and non-destructive detection.

Reference

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Abstract

D015: Optical functional glass and glass-ceramics processed by spark plasma sintering

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Spark plasma sintering is an important technology for achieving rapid densification of powder materials. This technology can not only simplify the preparation process and shorten the preparation time but also expand the research field of optical glass-ceramics. Here, we summarize some novel optical functional glass and glass-ceramics prepared by spark plasma sintering technology. Based on the latest research progress, the effects of different sintering parameters such as temperature, pressure, and sintering holding time on glass shrinkage, final densification, and transparency are mainly introduced. In addition, the influence of these parameters on other properties of glass materials are illustrated. Some possible aspects in the future development were discussed, such as further study into the sintering mechanism, reducing or even avoiding carbon contamination, optimizing the preparation process, developing new optical functional composite glass, and exploring new applications.

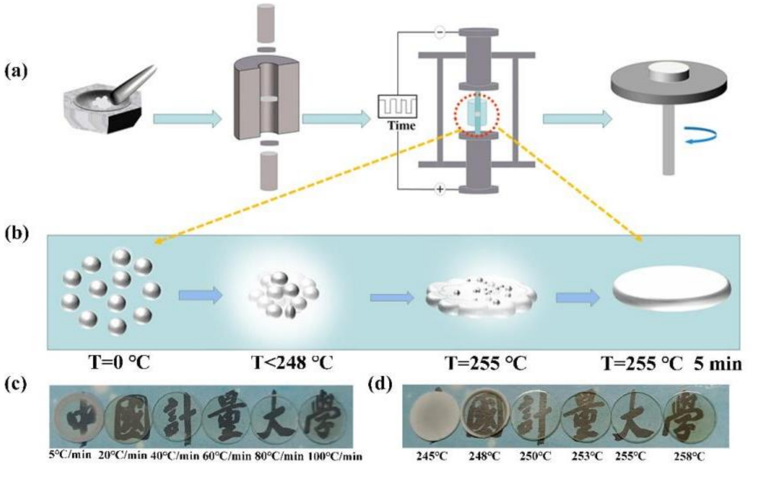

Fig. 1. (a) Process diagram illustrating the preparation of ZBLAN glass using SPS. (b) State of the glass powder at different temperatures. Photos of samples showing (c) different heating rates and (d) various sintering temperatures.

Abstract

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Abstract

D016: Advance in L-band Er^{3+} doped multi-component glass fibers

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With the development of Internet of Things and cloud computing, the next generation of optical communication places great demand for the dense wavelength division multiplexing (DWDM). L-band (1565–1625nm) Er doped fiber amplifier (EDFA) in the fiber communication system is the next generation of commercial EDFA. However, the Er-doped fiber lasers at wavelengths longer than 1600 nm face challenges of excited-state absorption (ESA) and low gain coefficient. Co-doping P in Er-doped silica fiber is a good way to enhance the L-band amplification. Unfortunately, the strong volatilization of phosphorus in heavy concentration during the high-temperature (near 2000°C) fiber drawing process has degraded the repeatability and vertical uniformity of Er-doped silica fibers. In this work, we have developed the L-band spectral shaping methodology of Er doped functional glasses through manipulating the glass network formers, glass modifiers, O/P atom ratios and Er concentrations in phosphate glass and silicate glasses. A L-band Er doped functional glass with excellent performance was fabricated into fibers with the propagation loss of <0.5 dB/m at 1.2μm through a modified rod-in-tube method. We obtained >10 dB net gain at L-band region in a 1-m long silicate fiber from an all-fiber configuration. Besides, we demonstrate for the first time an erbium doped phosphate fiber for extending the laser wavelength to 1630 nm with the maximum output powers and slope efficiencies of the lasers at 1627 nm and 1630 nm reached up to 44 mW/12.5% and 16.5 mW/5.6%, respectively, in an 30-cm phosphate fiber. Our approach provides a new solution for the next generation of EDFA and provides new glass materials support for the development of optical fiber communication.

Key words: L-band, Er doped functional glass, EDFA

D017: Design and fabrication of functional glass featured with electromagnetic stealth and optical transparency

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Radar detection and anti-electromagnetic interference are urgently needed in military and social life. The compatibility technology of optical transparency and electromagnetic stealth based on transparent applications has become one of the key research directions of this demand. We have designed electromagnetic absorbing multilayer-glass based on metamaterial via CST and fabricated entity with the dimension of 400 mm × 400 mm for testing. The transmittance of the overall glass is 80% and the absorptance is 85% in a wide waveband of 5.2-19.8 GHz and 33.1-38.9 GHz. We have the ability to manufacture absorbing glasses with large breadth of 1.5 m, which have wide applications in vehicle, ships and warships, etc.

Key words:

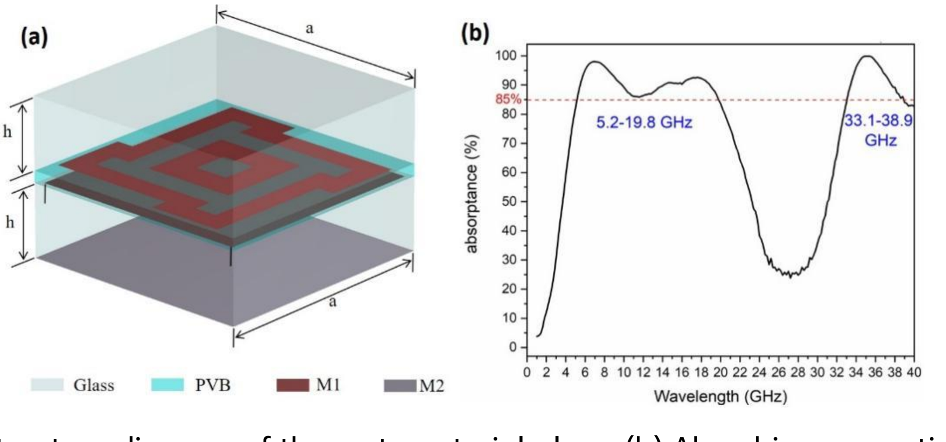

Fig.1 (a) Structure diagram of the metamaterial-glass. (b) Absorbing properties of the metamaterial-glass.

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Abstract

D018: Mechano-luminescent glass, glass ceramics and glass-crystal composites

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Light emission in response to mechanical stimulation-termed mechano-luminescence (ML)-enables the optical detection and visualization of mechanical strain. Most of today's MLmaterials are polycrystalline ceramics or ceramic particle composites, which puts constraintson their bulk processability,material homogeneity and optical transparency.Here,wedemonstrate mechanically induced luminescence from transparent glass,glass ceramics andglass-crystal composites by traditional melt-quenching methods and complementarycharacterization techniques.Mechanically responsive glasses and glass ceramics offer opportunitiesfor novel concepts in photodynamic therapy, theragnostic, stress sensing and local light delivery.

Abstract

D019: On the erasure of femtosecond laser imprinted nanogratings in optical glasses

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Self-assembled porous nanogratings (NGs) were imprinted by infrared femtosecond laser inside 8 commercial oxide glasses, and their thermal stability investigated through isochronal annealing experiments. As the annealing temperature is increased, NGs erase, which is ascertained by retardance measurements and corresponds to the collapse of nanopores composing the NGs. Additionally, this aspect is well predicted from the Rayleigh-Plesset equation, and the glass viscosity plays a preponderous role in it.[1] Combining both annealing or laser writing experiments, we can predict the erasure of nanopores during the laser irradiation process, since the later can also be viewed as a thermal process, i.e., a nearly instantaneous heating of the glass matrix induced by laser pulse absorption, followed by a cooling step. This approach enables one to find what maximum temperature nanopores can survive during the laser cooling timescale, ultimately defining an upper temperature limit to the existence of NGs. Consequently, for characteristic cooling timescales of 30 ns and 1 μs, the upper temperature limits of nanopores survival are reached when the glass viscosity values respectively equal log (η, Pa·s) ~ -0.75 and log (η, Pa·s) ~ 1. A higher temperature limit is correlated to a wider laser processing window to fabricate NGs (Fig. 1a). However, this temperature limit is lowered for much longer thermal processes with minutes / hours timescales corresponding to a glass viscosity typically of log (η, Pa·s) ~ 10.1. As an example, erasure time versus temperature is provided in Fig. 1b for the 8 glasses under consideration, and more details on establishing such relationship will be provided at the conference.

Overall, the time-temperature characteristics of any thermal process (irradiation, annealing, etc.), along with the temperature dependent glass viscosity, will inevitably impact the "survival" of the NGs.

Keyword: self-assembled porous nanogratings, commercial oxide glasses, femtosecond laser direct writing

Abstract

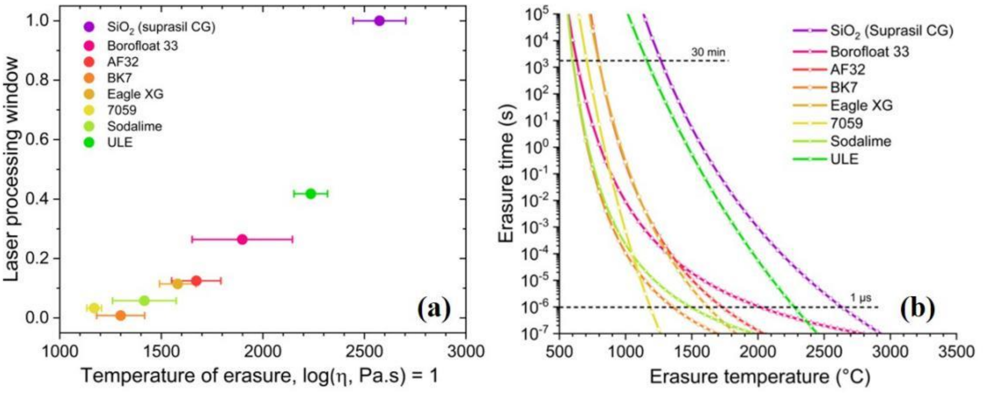

Fig. 1 (a) Erasure temperature defined as log (η, Pa.s) = 1 as an example, versus laser processing window (in a pulse energy -repetition rate landscape) related to existence of NGs.[2] (b) Calculated erasure time versus erasure temperature for 8 glasses investigated in this work.

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Abstract

D020: High-power lasing at ~900 nm in Nd^{3+}-doped fiber: a direct coordination engineering approach to enhance fluorescence

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Lasers at ~ 900 nm are of vital importance in various fields including material processing, underwater communications and strong-field physics. Although Nd^{3+}-doped materials have been employed for the ~ 900 nm laser, yet the ~ 900 nm emission is in strong competition with the often more dominating ~ 1060 nm emission, thus strongly limiting the output power and applications. Here, we propose a direct coordination engineering approach, which introduces halogen to the nearest coordination of Nd^{3+} in glass for increasing the bond covalency, leading to stronger emissions at ~ 900 nm than at ~ 1060 nm. Iodide-incorporated Nd^{3+}-doped silica fibers show prevailed ~ 900 nm emission rarely observed in Nd^{3+}-doped materials. Using the created fibers, a power (113.5 W) of 50 times higher than the current record is accomplished based on an all-fiber structure. Our approach holds potential for regulating spectroscopic properties of other rare earth doped laser materials.

Key words: silica glass, fiber laser, direct coordination engineering;

Abstract

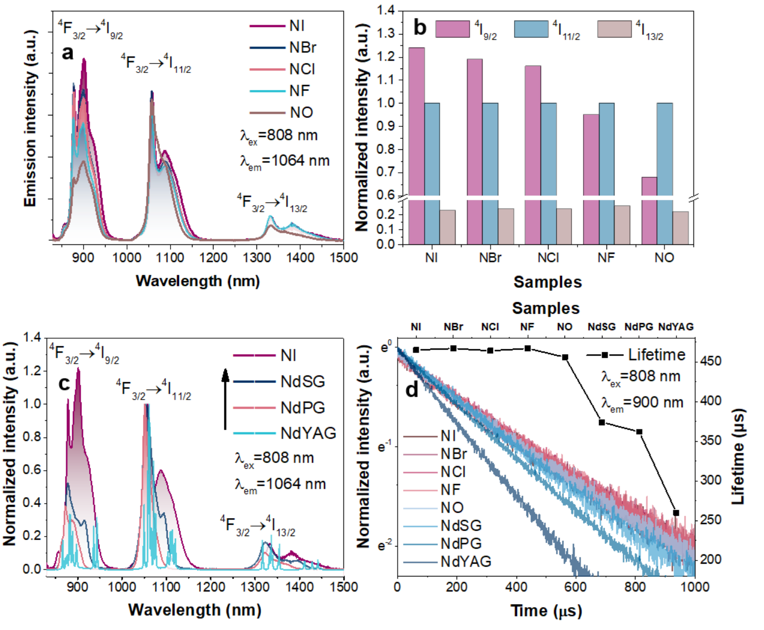

Fig. 1. Spectroscopic properties of Nd^{3+}-doped silica glass. a) Photoluminescence (PL) spectra of NO and NX. b) Integrated fluorescence intensities of the $^4F_{3/2}$ level to each lower level of NO and NX. All integrated fluorescence intensities are normalized to the same ~ 1060 nm emission intensity of each sample. c) PL spectra of NI, NdSG, NdPG, and NdYAG. d) PL decay curves and fluorescence lifetimes of NX, NdSG, NdPG, and NdYAG.

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[1] Yinggang Chen, Zhiquan Lin, Hongtao Sun, et al. Optica, 2023, 10(7): 905-912.

Abstract

D021: Transparent Long-lasting Phosphorescent Al_2O_3–CaO Glasses Activated by Cu^+

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A novel Cu^+ doped Al_2O_3-CaO transparent long-lasting phosphorescent glass was found by preparing under reduction conditions. The glasses not only showed double luminescence characteristic of Cu^+ at 457 nm and 480 nm after irradiated by ultraviolet light source or sunlight, but also emitted bright and lasting green phosphorescence after cutting off the excitation source. The afterglow lives of the glasses are positively correlated with the content of Al_2O_3, and the longest afterglow life can reach 10.5h. The spectral properties of the glasses were analyzed by absorption spectrum, fluorescence spectrum, thermoluminescence spectrum and EPR. Based on these results and the photochromic properties of the glass, the long afterglow luminescence is explained by a model of "storage" and "release" electrons generated by electronic defects in the glasses prepared in reducing atmosphere.

Key words: Al_2O_3-CaO glass; reduction preparation; Long-lasting phosphorescent glasses; Cu^+; transparent;

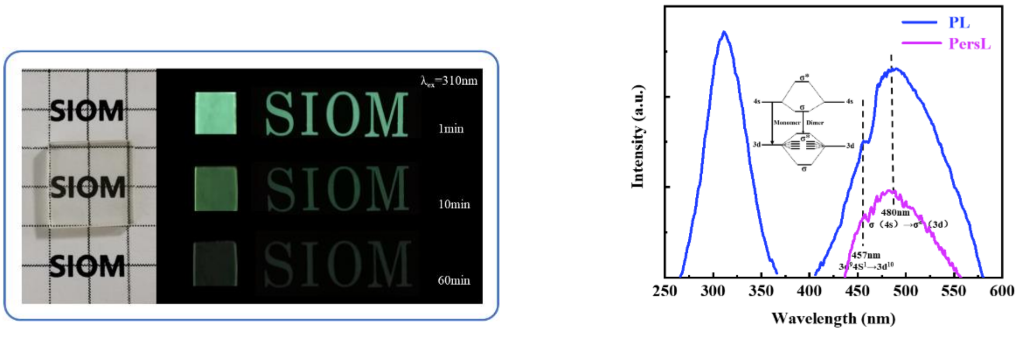

Fig.1 (a) Photo of transparent 37Al-r-1Cu glass and phosphorescence photos of 37Al-r-1Cu glass and glass powder. (b) PL spectrum, PLE spectrum and phosphorescence spectrum of 37Al-r-1Cu glass at room temperature.

Abstract

References:

Wang, P., Yan, S., Du, Y., Tao, Y. & Chen, D. Fabrication and photochromic properties of Al_2O_3–CaO binary glasses. Journal of Non-Crystalline Solids 576, 121257, doi:https://doi.org/10.1016/j.jnoncrysol.2021.121257 (2022).

Abstract

D022: Radiation-Induced Alterations in Zirconium-Doped Borosilicate Glasses: Implications for Long-Term Disposal of High-Level Radioactive Waste

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Borosilicate glasses are crucial in the containment and geological disposal of high-level radioactive waste (HLW) due to their ability to isolate highly toxic radionuclides from the biosphere. However, their long-term performance may degrade due to alpha decay and other radiation effects. Specifically, irradiation may alter both the mechanical properties and water resistance of these glasses, which are vital for ensuring the safe immobilization of HLW. A study conducted on zirconium-doped borosilicate glasses irradiated with 5 MeV Xe^{20+} ions analyzed the macroscopic and microstructural changes using various analytical techniques. The changes in hardness and Young's modulus were explored, and a relationship between glass composition and these mechanical properties was established. Molecular dynamics (MD) simulations of $ZrSiO_4$ were used to understand the coordination and structure changes upon irradiation, revealing that zirconium doping could influence the hardness and modulus trends post irradiation. On the other hand, a separate study on zirconium-containing borosilicate glass irradiated with a dose of 0.3 dpa aimed to understand the radiation effect on glass-water interaction, crucial for preventing groundwater corrosion and radioactive leaks. The investigation employed several analytical techniques to study the leaching behavior of both irradiated and non-irradiated samples. Post irradiation, the initial leaching rate was found to increase threefold, indicating a significant change in water resistance, with the impact of varying zirconium contents also being presented. These findings collectively underline the importance of understanding the radiation-induced alterations in borosilicate glasses to ensure the safe and effective long-term disposal of HLW.

Key words: borosilicate glass, heavy ion irradiation, hardness and modulus, leaching;

Abstract

D023: Self-luminescence of BaF2-B2O3 glass prepared by reduction

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This study discovered that a transparent BaF_2-B_2O_3 glass system without rare-earth ions prepared under CO-reducing atmosphere exhibited orange-red self-luminescence under near-UV light, generating broadband luminescence from 550~850 nm centered at 650 nm under broadband light excitation at about 397 nm. Based on the results of spectra, electron spin resonance, Raman, and X-ray photoelectron spectroscopy, it is proposed that the luminescence phenomenon is due to the s→p transition of B^{2+} generated inside the glass under the reducing atmosphere. This new luminescent glass has the potential to be an orange-red luminescent material excited by a light-emitting diode.

Key words: BaF_2-B_2O_3 glass; Reduction preparation; Self-luminescence; B^{2+} ion;

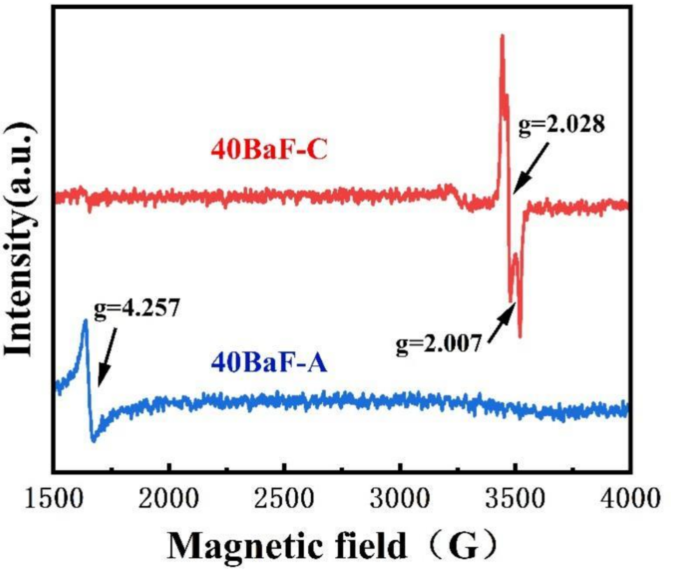

Fig. 1 ESR spectra of 40BaF-C and 40BaF-A glass samples

Binding energy(eV) **Binding energy(eV)**

Fig. 2 B 1s XPS spectra of (a) 40BaF-C and (b) 40BaF-A

Abstract

D024: Effect of modified cations on the spectra of Er-ion-doped silicate glasses

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The spectroscopic characteristics of Er-doped lead silicate glasses were investigated with respect to the effects of glass modifiers (Li^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+}, Sr^{2+}, and Ba^{2+}) with various optical basicities. Using the absorption spectra of the glasses, the Judd–Ofelt parameters of the glasses were calculated and examined, with an emphasis on the glass emission intensity ratio at 1572 nm. The spectra of the samples at low temperatures were examined, and the Stark splitting of Er was investigated. The McCumber method was used to determine the emission cross sections the glasses. The SPM glass exhibited high values of FHWM (51.24 nm) and the emission cross section at 1572 nm (1.908×10^{-21} cm^2), with potential applications for guiding component design of 1.5-μm fiber lasers and amplifiers.

Key words: Er3+ ions; Silicate glass; 1572 nm emission; Optical basicity;

Abstract

D025: Ultraflexible and High-sensitive Temperature-Strain Dual-Sensor Based on Chalcogenide Glass-PTFE Film for Human-Machine Interaction

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Skin-like thermoelectric (TE) films with temperature-strain sensing function are highly desirable due to their potential applications in human-machine interaction systems and wearable devices. However, existing TE films still face challenges in realizing high flexibility and excellent sensing performance simultaneously. Here, for the first time, we propose a rapid and facile roll-to-roll strategy for fabricating a chalcogenide glass-PTFE composite film with excellent temperature-strain sensing performance and mechanical flexibility, enabling repeated bending down to 5 mm radii without sensing performance degradation. The unique reticular construction endows the film with efficient Seebeck and strain-resistance effect, demonstrating high Seebeck coefficient (731 μV/K), rapid temperature response (~0.7 s), and excellent strain sensitivity. Given the outstanding features, a robot hand for intelligent action feedback and temperature alarm is created, exhibiting great potential in human-machine interaction and wearable device applications. This work provides useful insight on the development of flexible multifunction thermoelectric films and expands the practical applications of TE film in wearable electronic fields.

Key words: Thermoelectrics; Flexible films; Chalcogenide glass; Thermal sensor; Strain sensor;

Abstract

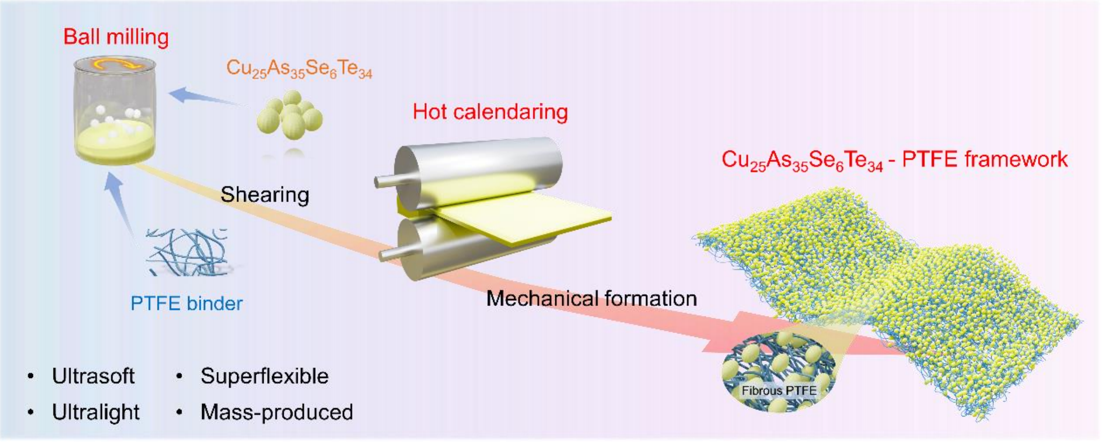

Fig.1 Schematic of the fabrication process for TE film.

References:

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Abstract

D026: Multilayered Chalcogenide Glass with Gradient Index for Reduced SWaP IR Optical System

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Gradient index (GRIN) lens could promote the lightweight and miniaturization of optical imaging system, but the development of IR GRIN lens is still in its infancy. A new series of As-S-Se chalcogenide glasses (ChGs) possessing similar glass transition temperature, excellent thermal stability, and large refractive index variation was developed, and these properties enabled them to become a good glass material catalog for co-molding multilayered GRIN IR lens. By employing precision molding, layer-stacked GRIN ChG was co-molded with a maximum refractive index variation of 0.47 at 4 μm, which was correlated to the variation of Raman intensity and elemental content. A mid-IR optical imaging system was designed and fabricated using the GRIN ChGs, and IR images were obtained. This multilayered GRIN ChG could lead to 18% smaller and 35% lighter SWaP IR optical system.

Key words: Chalcogenide glass; Gradient index; IR optical system;

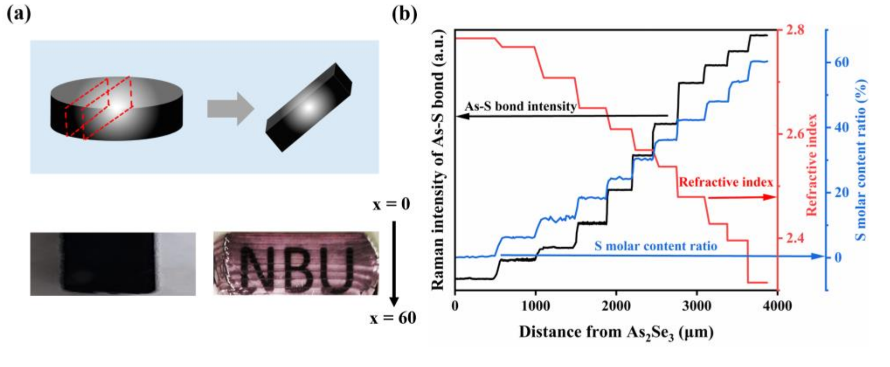

Fig.1 (a) Sectioning $As_{40}S_{60-x}Se_x$ GRIN ChG sample for Raman line-scanning measurement; (b) axial distribution of Raman intensity, S content, and refractive index (n @ 4 μm) of multilayered As40S60-xSex GRIN ChG.

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Abstract

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Abstract

D027: The energy storage mechanism of TeO_2-V_2O_5-P_2O_5 anode for lithium ion battery

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Recently it has been demonstrated that the electrochemical performances of semiconducting glass anodes for Li-ion batteries (LIBs) can be greatly enhanced by the discharging/charging induced nanocrystals [1-2]. However, the structural origin of those nano-domains remains elusive, although it is critically important for designing superior glass anodes for LIBs. In this work, we probe the local structural evolution in a TeO2-V_2O_5-P_2O_5 glass anode for LIBs during cycles by means of the state-of-the-art solid-state nuclear magnetic resonance (SSNMR). The structural evolution is manifested as the disassociation of the structural network into isolated units, followed by formation of different types of nano-domains with a high degree of order. These domains are highly favorable for rate capability and long-term cycling stability. From SSNMR and electrochemical characterizations, we have obtained a clear picture about the detailed redox reactions. Based on the finding, we incorporate water into the TeO_2-V_2O_5-P_2O_5 glass via humidity treatment due to its highly sensitive to moisture. The boosted electrochemical performances of glass anode should be ascribe to the abundant Li^+ diffusion channles provided by the depolymerized structural network and the enhanced pseudocapacitive behavior contributed by the derived hydrationinduced nanocrystals. These works provide facile strategy for designing the stable glass electrodes for high-performance LiBs.

Key words: Li-ion battery; Glass anode; Structure evolution; Nanodomains; Humidity treatment；

Abstract

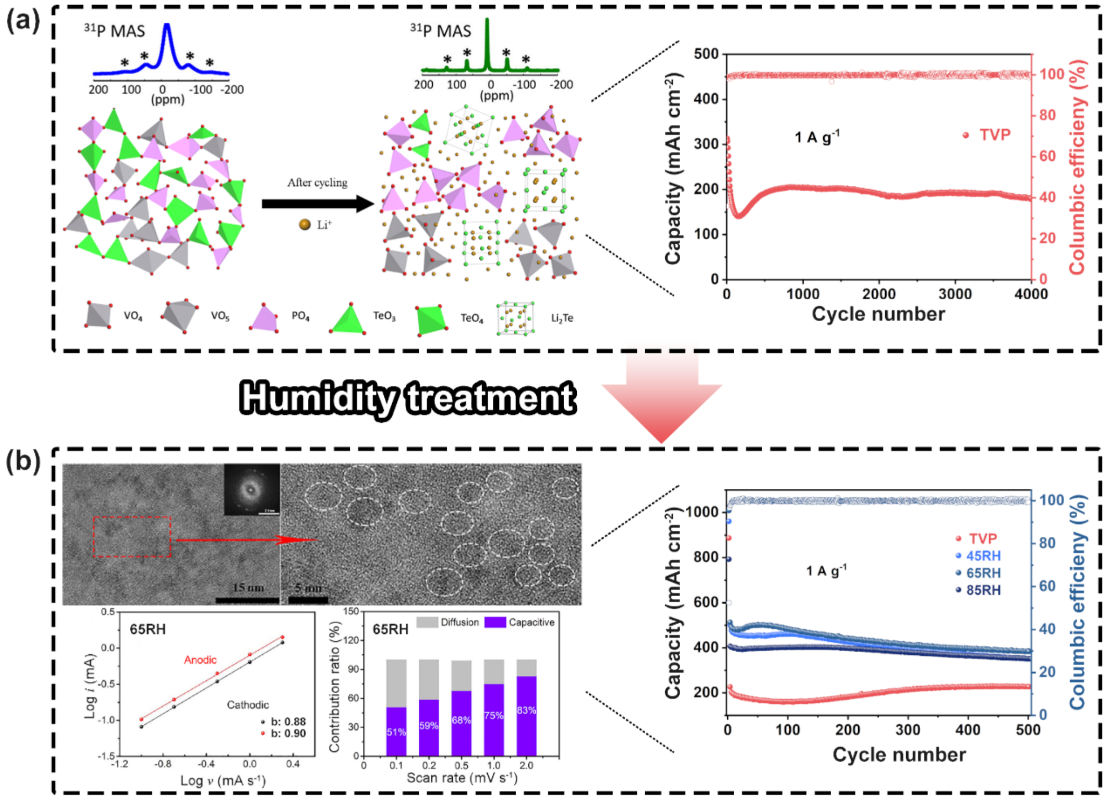

Fig.1 a) Clarify the local structural evolution in a TeO_2-V_2O_5-P_2O_5 glass anode for LIBs during cycles and its impact on electrochemical performace. b) Plenty of nanocrystals precipitate from the glass matrix through the humidity treatment, thus boosting the electrochemical performance when used as anode for LIBs.

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Abstract

D028: Mixed alkali-zinc effects on thermo-mechanical performances in borosilicate glasses

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Series of mixed alkali-zinc borosilicate glasses with the molar compositions of 70.65SiO_2•21.09B_2O_3•1.88Al_2O_3•1Li_2O•(5.38-x)R_2O•xZnO (x = 0, 0.34, 0.67, 1, 1.34, 2.69, 4.04, and 5.38) were fabricated to probe the mixed alkali-zinc effects on thermo-mechanical properties. The nonlinear evolution of glass transition temperature (Tg) with the addition of ZnO is ascribed to the competition of two converse factors, i.e., the Tg depression as one of the colligative properties for a solution on one hand, and the enhancement of Tg due to the higher field strength of zinc cations compared to that of alkali ions. However, the nonlinear evolution of elastic moduli and coefficients of thermal expansion with r is attributed to the variance of intermediate-range clusters, which is confirmed by infrared and Raman scattering spectra. These findings are very helpful to tailor the performances of borosilicate glasses.

Key words: Glass transition temperature; Elastic moduli; Coefficients of thermal expansion; Borosilicate glass;

Acknowledgments：This work was financially supported by Ph.D Program Fund of Non-Metallic Excellence and Innovation Center for Building Materials (2022SFP6-2).

Abstract

D029: Application of Glass Powder Surface Modification Technology in Electronic Pastes

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Glass is widely used as an inorganic binder in electronic pastes due to its adjustable composition dependent melting temperatures, excellent substrate adhesion and controllable powder size, etc. For insulating electronic pastes, a wet ball milling method is developed to modify the surface of lead aluminosilicate glass frit by using aliphatic chemicals with polyhydroxyl, carboxylic acid, phosphoric acid, and amine functionalities to eliminate surface hydroxyl groups and form a hydrophobic layer. The surface hydroxyl content of the prepared glass powder can be reduced to 0.10 mg/m2, and a uniform particle size distribution is obtained through the steric dislocation effect and hydrophobic effect formed by long carbon chains. The maximum contact angle can reach 153°, and the hemispheric point temperature can be reduced by up to 25 ℃ compared with the frit prepared by the conventional aqueous milling method. In the field of conductive silver pastes, the doping of silicates into tellurite glasses was used to improve water and alkaline resistance and corrode the wafer surface to enhance its contact with the silver. Furthermore, we have developed a wet milling process and employed lauryl gallate to remove the surface hydroxyl content of micro-scale silicate-containing tellurite low-melting glasses. This surface modification could effectively prevent agglomeration caused by hydroxyl condensation and eliminate defects in the sintered silver layer. This research provides a practical path-forward of improving the overall performance of metal conductive pastes from a new angle of innovating glassy adhesive.

Key words: Glass structure, Glass powder, Surface modification, Electrode;

Abstract

D030: Luminescence properties of Er-Yb co-doped phosphate glass

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Rare earth doped phosphate glass has the properties of large rare earth stimulated emission cross section, low thermal optical coefficient, high solubility of rare earth ions, moderate phonon energy and so on. Erbium doped phosphate glass is also often used as 1530 nm optical amplifier and ' eye-safe ' laser gain medium in long-distance communication system, which has attracted the attention of a group of researchers. However, due to the strong water absorption of phosphate glass, the properties and applications of glass are seriously affected. Therefore, it is necessary to study the influence of OH^- on the different properties of rare earth phosphate glass, and a certain water removal process is used to remove the residual OH^-. Compared with the commonly used reaction atmosphere method, we used a new type of secondary remelting water removal experiment and tested the physical and chemical properties and spectral properties of the glass before and after water removal to study the change of OH^- content under the water removal process and the influence of OH^- content on the structure, density, uniformity and spectral properties of the glass. At the same time, the changes of glass composition during the reaction were studied by ICP and XRF tests. Subsequently, the carbon doping of erbium-doped phosphate glass was also studied. Through physical property test and spectral test, the influence of C content on the properties and luminescence properties of the glass was investigated.

Key words: secondary remelting; Er-Yb co-doped phosphate glass; OH^- content;

Abstract

D031: Mg and Al mixed effects on thermal performances in aluminosilicate glasses

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The role of Mg cations in aluminosilicate glasses remains controversial. Depending on the glassy composition, the structural role of Mg cations in aluminosilicate glasses may change. In this presentation, using the aerodynamic levitation and laser melting technique, we successfully expanded the glass-forming region into Mg-rich and peraluminous regimes, fabricating a series of magnesium aluminosilicate glasses. This study focused on the mixed effects of Mg and Al on thermal performances. As Mg is gradually replaced by Al, glass transition temperature, configurational heat capacity and thermal stability exhibit two types of variations in two compositional regions separated by r = 0.57, where r is equal to the molar ratio of [Al_2O3]/([Al_2O_3] + [MgO]). High-field 27Al NMR and FTIR spectra are conducted to elucidate chemical and atomic-scale structural origin of the mixed effects of Mg and Al on thermal performances. These findings can be applied to tune the thermal properties of magnesium aluminosilicate glasses based on their composition.

Key words: Glass transition temperature; configurational heat capacity; thermal stability; magnesium aluminosilicate glasses;

Acknowledgments：

This work was financially supported by National Natural Science Foundation of China (No. 52172007).

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Abstract

D032: Transparent-to-gray electrochromic glass based on the nickel oxide

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Electrochromic smart windows offer a promising solution to enhance building energy efficiency. These windows can dynamically achieve reversible color changes and regulate indoor temperature and light intensity by applying voltage, thus reducing the heating and cooling energy consumption in buildings. They find broad applications in building glass, interior design, automotive sunroofs, and side windows. Inorganic electrochromic materials with exceptional thermal and chemical stability are commonly employed in smart windows. Among these materials, nickel oxide stands out due to its impressive electrochemical performance and distinctive brown-gray hue. However, the slow switching speeds and poor cycle stability usually hinder its practical application. Therefore, we developed a series of manufacturing strategies focused on nickel oxide materials. These strategies aim to enhance switching speed and cycle stability through structural design and component control. For instance, a novel stacked nanowire/nanoplate uniform structure was constructed recently, which can maintain 91% optical modulation after long cycles. Additionally, bicomponent nickel cobalt oxide materials were further fabricated, leveraging valence state transitions between elements, enable efficient electron and ion transfer, achieving significant optical modulation across a broad spectrum, rapid switching (6.8/6.7 s), and robust optical storage capacity. Furthermore, we provide insights into the electrochromic mechanism of nickel oxide, uncovering its multi-step electrochemical desorption mechanism and switching kinetics. These findings contribute to a deeper understanding of electrochromic processes, driving advancements in electrochromic materials and devices. Ultimately, this research can promote the application of electrochromic technology in multifunctional smart windows, anti-glare rearview mirrors, architectural glass, and revolutionizing sustainable building design.

Key words: Electrochromic glass; nickel oxide electrochromic materials;

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D033: Tuning the mechanical performances through phase separation in aluminosilicate glasses

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In this study, spinodal decomposition is used as a strategy to enhance the mechanical properties of the xAl_2O_3-$(1-x)SiO_2$ (x=25, 30, 35, 45 mol%) glasses. The melt-quenched glasses have exhibited a liquid-liquid phase separation with an interconnected snake-like or a doplet-type nano-structure. Through further heat treatment at 850℃ for different durations up to 40 hrs, we observed a continuous increase in hardness (H_v) and a gradual reduction in the slope of H_v elevation. However, the crack resistance (C_R) properties of the glasses exhibited different trends. Detailed calorimetric, morphological and compositional analysis is conducted to elucidate the tuning roles of thermal treatment time on hardness and crack resistance. These findings pave the way to utilize the spinodal phase separated phenomena to enhance the mechanical performances of glasses.

Key words: Spinodal Decomposition; aluminosilicate glass; hardness; crack resistance; phase interfaces;

Acknowledgments

This work was financially supported by National Natural Science Foundation of China (No. 52172007)

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（1）Xia FY, Wang XW, Wang YD, Ren XM, Qiao A, Tao HZ, Tuning the hardness and crack resistance through liquid-liquid phase separation in an aluminosilicate glass, Phys. Chem. Chem. Phys., 2023, 25(26),17619–17626.

Abstract

D034: Tailoring Thermo-Optic Coefficient of Selenide Glasses for Use as Thermal Imaging Lenses

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Abstract: As infrared camera capable of thermal imaging across the long-wavelength infrared (LWIR; 8~12 m) range has branched out into various civilian sectors, performance of the imaging lens assembly as well as its cost effectiveness becomes more critical. In the case of LWIR-transmitting lens materials, refractive index itself and its dispersion over the LWIR range need to be prioritized, and a group of lens elements are normally adopted to minimize optical aberrations such as chromatic and spherical ones. Temperature dependence of refractive index of a lens material also needs to be carefully adjusted in order to control the temperature aberration of a given lens assembly. It is widely known that single-crystalline Ge suffers from its high thermos-optic coefficient, which is one of its demerits. On the other hand, it is noteworthy that most of the commercially available chalcogenide glasses (ChGs) for use as LWIR-imaging lenses are containing As and/or Sb, which are considered toxic in many applications, and in addition fall into a limited range of thermo-optic coefficients. Based on these considerations, in this study, we have aimed to compositionally tailor selenide glasses containing neither As nor Sb, but featuring thermo-optic coefficient lower than 20×10^{-6} /K. As a result, selenide glass out of Ge-Sn-Bi-Se system is proposed, as shown in Fig. 1, which exhibits an excellent thermal stability and a significantly lower thermo-optic coefficient.

Key words: Chalcogenide glass; Ge-Sn-Se-Bi, Thermo-optic coefficient

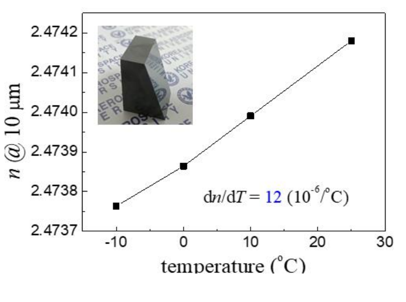

Fig.1 Temperature dependent refractive index of Ge-Sn-Se-Bi glass

Abstract

D035: Study on the structure and properties of La_2O_3-TiO_2-Nb_2O_5-B_2O_3 glass

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Abstract: Taking La_2O_3-TiO_2-Nb_2O_5-B_2O_3 as the basic system, the high refractive index optical glass of La_2O_3-TiO_2-Nb_2O_5-Gd_2O_3-ZrO_2-SiO_2-B_2O_3 system was successfully prepared by melting method, with the continuous increase of La_2O_3, TiO_2 or Nb_2O_5 content, the refractive index of glass continued to increase, up to 2.1, and the maximum Abbe number was close to 35. The effects of component changes on the structure and physical properties of this glass were studied using density measurement, high-temperature viscosity and linear expansion measurement. The oxygen bulk density also changes with the change of composition, resulting in a change in the properties of the glass. Raman spectroscopy shows that there are La-O, Ti-O and Ti-O-Nb bonds in the glass network, and when too many heavy metal oxides are added, the physical properties of the glass are greatly reduced, and even crystallization occurs.

Key words: Optical glass; Refractive index; Viscosity; Oxygen bulk density

Abstract

D036: Study on technological factors of the physical strengthening of glass

YANG Penghui, WANG Yanhang, HAN Tao, LI Xianzi, Shi Xiaofei

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Abstract: As glass is a typical kind of brittle material, improving the strength and toughening of glass is the key technology to be solved urgently. Studying the influencing factors of physical toughening of glass is an important basis for further exploration of toughening mechanism and development of new toughened glass. In this paper, the glass with elastic modulus of 85 GPa and expansion coefficient of 48.2×10^{-7} /K was optimized, and the relationship between the tempering process parameters and mechanical properties of aluminosilicate glass was studied. The results showed that after physical tempering, the bending strength of glass was significantly improved, and the Vickers hardness was slightly reduced. The bending strength increased by 1.4 times with the increase of tempering temperature, tempering time and cooling wind pressure, and the bending strength increased by 1.5 times with the increase of thickness. The surface compressive stress of tempered glass was tested by GlasStress SCALP, and it was found that there was a positive linear relationship between the surface compressive stress and the tempered strength. Compared with the glass thickness as a variable, the surface stress value had a greater influence on the tempered strength when the tempered temperature was a variable.

Key words: Tempered glass; Physical tempering; Tempering process; Bending strength; Strengthen

ABSTRACT

Session E

Session E Glass Crystallization and Glass Ceramics

ICG Annual Meeting 2023
November 12-15, 2023, Hangzhou · China

Session E：

Glass Crystallization and Glass Ceramics

Proposal of ICG Annual Meeting 2023 Sessions

Session E：Glass Crystallization & Glass-Ceramics

Brief Introduction:

Glass crystallization is a fundamental process of glass under stimulation of external fields. Glass-ceramics are innovative materials with crystalline phases dispersed in a glass matrix. Glass-ceramics combine the unique features of glasses, such as easy shaping/forming, with the specific properties of crystals. Since their discovery in the 1950s, numerous studies have been focused on the glass crystallization and glass-ceramics. Excitingly, some of them have been found practical applications in various fields. In this session, the recent progresses on the glass crystallization and glass-ceramics are expected to be presented

Focused topics:

The topics will include, but are not limited to: Fundamental processes about nucleation and crystal growth; experimental studies on the glass crystallization; advanced methods, techniques and characterization tools; role of nucleation agents; thermal, mechanical, electrical, optical or chemical properties of glass-ceramics; processing and glass crystallization phenomena; microstructure/property relationships in glass-ceramics; novel processing techniques; commercial and new glass-ceramic applications.

Session Chairs:

1. **Shifeng Zhou,** South China University of Technology, China
2. **Laurent Cormier**, Sorbonne Université, CNRS, France
3. **María Jesús Pascual,** Ceramics and Glass Institute (CSIC), Spain

Point of Contact:

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Keynote speakers:

1. **Xianghua Zhang,** Institute of chemistry, Lab. Glasses and ceramics, CNRS/University of Rennes, France
2. **Mathieu Allix,** CEMHTI laboratory-CNRS, France

Invited Speakers:

1. **Koichi Kajihara**, Tokyo Metropolitan University, Japan
2. **Tetsuya Murata**, Nippon Electric Glass Co., Ltd, Japan
3. **Taehoon Lee**, Kyungpook National University, Korea
4. **Jianbei Qiu,** Kunming University of Science and Technology, China
5. **Chao Liu**, Wuhan University of Technology, China
6. **Guoping Dong**, South China University of Technology, China

7. **Zhiwei Luo**, Central South University, China
8. **Xiaofeng Liu**, Zhejiang University, China
9. **Weichao Wang**, South China University of Technology, China
10. **Olga Dymshits**, Ioffe Institute, Russian Academy of Sciences, Russian Federation

Keynote Speakers

Xianghua Zhang, Institute of chemistry, Lab. Glasses and ceramics, CNRS/University of Rennes, Rennes, France

Tentative Title: Crystallization in chalcogenide glasses

Brief CV (<150 words): XiangHua Zhang is Research director of the CNRS (French National center for scientific research) and the director of the laboratory of glasses and ceramics. He got his bachelor in Zhejiang University, China in 1983 and PhD degree in University of Rennes, France in 1988. He worked in the laboratory of glasses and ceramics, a joint laboratory CNRS-University of Rennes until 1996 when he left to found the Umicore IR glass company, for producing chalcogenide glass optics. He came back to the laboratory in 2002. He is mainly specialized in chalcogenide glasses and ceramics for thermal imaging. He is co-inventor of 22 patents and co-author of more than 450 peer-reviewed publications.

Mathieu Allix, CEMHTI laboratory-CNRS, Orléans, France

Tentative Title: New out-of-equilibrium oxides elaborated by crystallization from glass/melt

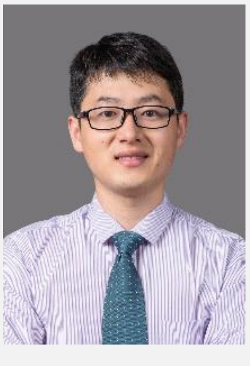
Brief CV (<150 words): Mathieu Allix is a CNRS researcher at the CEMHTI laboratory in Orléans, France. His current research interests include (i) the crystallization processes in oxide glasses with an application to the elaboration of new transparent (glass-)ceramics and (ii) the synthesis and structure

	determination of new inorganic materials.

Invited Speakers

	**Koichi Kajihara,** Tokyo Metropolitan University, Japan **Tentative Title**: Synthesis and characterization of lithium ion-conducting boracite and sodalite glass-ceramics
	**Tetsuya Murata,** Nippon Electric Glass Co., Ltd, Japan **Tentative Title**: In-situ observation on heterogeneous crystallization
	**Taehoon Lee,** Kyungpook National University, Korea **Tentative Title**: Intimate correlation between structure, chemistry, and crystallization in glasses
	**Jianbei Qiu,** Kunming University of Science and Technology, China **Tentative Title**: Glass-Ceramics with Eu^{2+}/Eu^{3+} Selective Distribution in Oxide/Fluoride Crystalline Phases for UV-Pumped Warm White Light-Emitting Diodes

Abstract

	**Chao Liu,** Wuhan University of Technology, China **Tentative Title**: Transforming Sodium Silicate Glasses into Transparent Ceramics
	**Guoping Dong,** South China University of Technology, China **Tentative Title**: Luminescent Nanocrystal-doped Glass and Fiber
	**Zhiwei Luo,** Central South University, China **Tentative Title**: Crystal growth and near-infrared luminescence of spinel-type transparent glass-ceramics
	**Xiaofeng Liu,** Zhejiang University, China **Tentative Title**: Linear and nonlinear optical properties of glass-ceramics containing plasmonic metal oxide nanoparticles
	**Weichao Wang,** South China University of Technology, China **Tentative Title**: Fluoro-sulfo-phosphate glass and glass ceramic as hosts for broadband optical amplification and fiber laser

Abstract

	**Olga Dymshits**, Ioffe Institute, Russian Academy of Sciences, Russian Federation **Tentative Title**: Structure and Spectral Properties of Fe:$ZnAl_2O_4$, Fe:$MgAl_2O_4$, and Fe:γ-Al_2O_3 transparent glass-ceramics

Abstract

E001: Crystallization in chalcogenide glasses

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Chalcogenide glasses are particularly interesting for middle and far infrared applications. They are usually fabricated in sealed silica ampoule because of their sensitivity to oxygen and their relatively high vapor pressure when melted. This fabrication technique which does not allow high cooling rate, demands glass composition with high resistance towards crystallization. The crystallization behavior is one of the key parameters for composition selection. At the same time, controlled crystallization is also an efficient way to create glass ceramics with original properties such as improved mechanic properties, enhanced photo-luminescence and unusual optical properties. The key for achieving these performances without destroying the infrared transparency of chalcogenide glasses is to develop appropriate glass compositions and thermal annealing process in order to generate crystals with optimized composition and size. The challenge and results of controlled crystallization in chalcogenide glasses will be discussed.

Key words: Chalcogenide glasses, glass ceramics, controlled crystallization

Abstract

E002: New out-of-equilibrium oxides elaborated by crystallisation from glass/melt

Mathieu Allix1,*, Cécile Genevois1, Emmanuel Véron1, Weiwei Cao1, Xue Fang1, Haytem Bazzaoui1, Ana Becerro2, Victor Castaing2, Pierre Florian1, Franck Fayon1, Didier Zanghi1, Michael Pitcher1

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Chalcogenide glasses are particularly interesting for middle and far infrared applications. They are usually fabricated in sealed silica ampoule because of their sensitivity to oxygen and their relatively high vapor pressure when melted. This fabrication technique which does not allow high cooling rate, demands glass composition with high resistance towards crystallization. The crystallization behavior is one of the key parameters for composition selection. At the same time, controlled crystallization is also an efficient way to create glass ceramics with original properties such as improved mechanic properties, enhanced photo-luminescence and unusual optical properties. The key for achieving these performances without destroying the infrared transparency of chalcogenide glasses is to develop appropriate glass compositions and thermal annealing process in order to generate crystals with optimized composition and size. The challenge and results of controlled crystallization in chalcogenide glasses will be discussed.

Key words: Chalcogenide glasses, glass ceramics, controlled crystallization

Abstract

E003: Synthesis and characterization of lithium-ion-conducting boracite and sodalite glass-ceramics

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Almost fully crystallized lithium-ion-conducting boracite and sodalite glass-ceramics were successfully prepared by conventional melt-quenching-crystallization methods. The glass-ceramics of lithium boracites, $Li_{4+x}B_7O_{12+x/2}Cl$, have been prepared for the first time [1], and new lithium boracites $Li_4B_4M_3O_{12}Cl$ (M = Al, Ga) (Fig. 1, left) were discovered as the first boracites with substituted boron sites [2]. The lithium ion conductivities of $Li_4B_4M_3O_{12}Cl$-based glass-ceramics were ~1×10^{-5} S cm^{-1} at room temperature and an order of magnitude higher than the glass-ceramics of $Li_4B_7O_{12}Cl$. The lithium sodalite $Li_8B_6Si_6O_{24}Cl_2$ (Fig. 1, right) was discovered as the first alkali sodalite containing boron as the main framework cation [3], and its glass-ceramics are probably the first sodalite glass-ceramics derived from uniform melts. The glass-ceramics of $Li_4B_4Al_3O_{12}Cl$ and $Li_8B_6Si_6O_{24}Cl_2$ were stable in contact with Li metal (Fig. 2), and the former ones were even resistant to immersion in water up to 1 h [4]. Solid-state rechargeable test cells consisting of a $Li_4B_4Al_3O_{12}Cl$-based glass-ceramic solid electrolyte, a $LiCoO_2$-based composite cathode, and Li-rich Li–Au alloy anode delivered an initial discharge capacity of ~135 mAh g^{-1} and good average Coulombic efficiency of ~99.3% under operation at 60 °C, demonstrating that $Li_4B_4Al_3O_{12}Cl$-based glass-ceramics are compatible with solid-state rechargeable lithium metal batteries employing 4 V-class transition metal oxide cathodes [4].

Key words: Lithium-Ion-Conducting Glass-Ceramics, Boracite, Sodalite, Solid-State Lithium Metal Battery

Abstract

E004: In-situ observation on heterogeneous crystallization

Tetsuya Murata[1], Shingo Nakane[1], Hiroki Yamazaki[1], Raschid Al-Mukadam[2], Joachim Deubener[2]

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The crystallization kinetics of binary alkali glasses such as lithium disilicate and sodium disilicate have been widely investigated. Particularly, lithium disilicate is of importance, as it forms the basis for typical commercial glass-ceramics. Therefore, detailed analyzes of their nucleation and crystal growth kinetics have been carried out. Recently, a probabilistic method was introduced to evaluate the heterogeneous crystal nucleation rate of undercooled liquids [1-3]. In this method, the glass melt was heated and cooled repeatedly, and the time for crystal nucleation was measured using a differential scanning calorimeter (DSC). In this work, nucleation events were repeatedly observed in-situ using a high temperature optical microscope (HTOM). This microscopic technique allowed direct observation of the position of the nascent crystallite at each cooling run. It was found that the events occurred randomly in time confirming the stochastic nature of the transformation process and estimated heterogeneous nucleation rate using the HTOM showed similar values with the one by the DSC measurement.

Key words: Glass, Crystallization, Heterogeneous crystal nucleation

E005: Intimate correlation between structure, chemistry, and crystallization in glasses

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Understanding the structure of glasses, especially chalcogenides, remains a significant challenge in the realm of glass science. This complexity largely stems from the intricate arrangement of atoms within these materials. However, recent research suggests that these structural complexities may be influenced by the nature of chemical bonds between the constituent atoms. Various properties of glass, such as phase transition behaviours, are also closely related to the types of chemical bonds present. In this talk, we will explore the latest discoveries that link a new type of chemical bond, i.e., multi-center hyperbonding, to both the static and dynamic properties of glasses, offering a new perspective on these complex materials.

Key words: glass structure; chemical bonding; phase transitions; DFT

Abstract

E006: Glass-Ceramics with Eu^{2+}/Eu^{3+} Selective Distribution in Oxide/Fluoride Crystalline Phases for UV-Pumped Warm White Light-Emitting Diodes

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White light emitting diodes (WLEDs) are particularly desirable illumination due to their high efficiency, long lifetime and small size. At the moment, commercial WLEDs are mainly realized by combining a GaN-based blue LED chip with $Y_3Al_5O_{12}$:Ce^{3+} (YAG:Ce) yellow phosphor. Since YAG:Ce provides insufficient red light, the obtained output cannot meet the requirements for indoor lightings and displays which need warm white light with an excellent color rendering. In this study, we made glass-ceramics where Eu^{2+} and Eu^{3+} are selectively incorporated in $NaAlSiO_4$ and $Na_5Gd_9F_{32}$ crystalline phases precipitated in glass matrix. Upon the excitation with 393 nm light, the glass-ceramics phosphor exhibits broad green-yellow and sharp red emissions with good thermal stability. A white light-emitting diode (W-LED) that consists of an ultraviolet LED chip (~ 395 nm) and a glass-ceramic phosphor is made to demonstrate the generation of white light (Fig.1). The correlated color temperature (CCT) is 2250 K, the color rendering index (Ra) is 72, and the luminous efficacy of this W-LED is 6.85 lm/W at room temperature and with a forward-bias current of 100 mA.

Key words: Oxy-fluoride glass-ceramics; Selective distribution; Low correlated color temperature

Abstract

E007: Transforming sodium silicate glasses into transparent ceramics

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Transparent ceramics have many important applications in the fields of optics, communications and laser technologies due to their particular properties. Even though high-quality transparent ceramics have been synthesized through methods such as hot pressure sintering, hot iso-pressure sintering, vacuum sintering, and spark plasma sintering, development of new methods is still needed to fabricate large-sized transparent ceramics with low cost and high production efficiency. Glasses are amorphous, transparent, and isotropic materials, and converting glasses into transparent ceramics has potential to fabricate large-sized and high-quality transparent ceramics. Herein, transparent ceramics with composition of $Na_2Ca_2Si_3O_9$ are prepared from Na_2O-CaO-SiO_2 glasses. Glasses are prepared through conventional melt-quenching and converted into transparent ceramics through thermal treatment. By adjusting the compositions of the glasses, nucleation agents, and thermal treatment conditions, growth of the grains and microstructure of the ceramics are well controlled, leading to transformation of glasses into ceramics with transmittance as high as ~90% and ~16% enhancement of Vickers hardness. These results provide new insight into the formation of transparent ceramics from glasses, and have potential for the development of large-size transparent ceramics.

Abstract

E008: Luminescent Nanocrystal-Doped Glasses and Fibers

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Combining the merits of the low phonon nature of nanocrystals and the excellent fiber-drawing ability of glass matrix, nanocrystal-doped glasses have been considered as potential candidates for various optical applications. Herein, the nanocrystal-doped glass fibers are fabricated by the modified fiber-drawing method, which provides an ingenious way to break through the bottleneck problem of uncontrollable rapid growth of nanocrystal existing in traditional fiber-drawing method. The obtained nanocrystal-doped glass fibers with excellent optical properties and well-preserved structure are expected as potential gain materials for near/mid-infrared fiber lasers. Importantly, we have obtained enhanced 1.55 μm and 2 μm laser output in nanocrystal-doped glass fibers, manifesting that the obtained nanocrystal-doped glass fiber is a promising gain fiber material. This work also expands the potential applications of nanocrystal-doped glasses and fibers in fields of optical amplification, sensing, detection, imaging, etc.

Key words: Nanocrystal-doped glass; Fibers; Photoluminescence; Laser

Abstract

E009: Crystal growth and near-infrared luminescence of spinel-type transparent glass-ceramics

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The spinel compound zinc galliate ($ZnGa_2O_4$) is a typical wide-band compound with optical band-gap in the range of 4.4~4.5 eV. Due to its good chemical stability, cathodoluminescence, and photoluminescence properties, $ZnGa_2O_4$ has become a particularly attractive candidate material for display devices based on vacuum fluorescence, field emission, and electroluminescence, and has received wide attention. In this work, transparent glass-ceramics containing $ZnGa_2O_4$ nanocrystals were prepared by using silicate glass with excellent physical and chemical properties as matrix material, and the crystallization kinetics, microstructure, and photoluminescence properties of $ZnGa_2O_4$ transparent glass-ceramics were further analyzed. Under the excitation of 440 nm, Cr^{3+} ions in borophosphate glass emit a broadband NIR emission ($^4T_2 \rightarrow {^4A_2}$) with the spanning wavelength of 600-1400 nm and FWHM of ~210 nm. In addition, the NIR emission intensity of Cr^{3+} ion tends to increase initially and then decrease, the optimal concentration was determined to be 0.30 mol. The above results indicate that as-prepared broadband NIR borophosphate glasses might be a potential candidate material for NIR spectroscopy techniques and device applications.

E010: Glass ceramics containing metal oxide plasmonic nanoparticles

Xiaofeng Liu

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Noble metal nanoparticles (NPs) have been employed to color oxide glasses used for decoration for nearly 2000 years. The precipitation of plasmonic noble metal NP, like Au and Ag, is relatively easy as they do not form strong bond with the oxide glass network, while the crystallization of plasmonic oxide NPs which is electronically doped have been rarely explored. In this talk, we report our recent work on the crystallization of plasmonic oxide NPs in oxide glass matrix. Two examples of such glass ceramics with precipitated oxide plasmonic NPs of RuO2 and ITO, will be introduced. The formation of these plasmonic NPs results in strong localized surface plasmon resonance which can be tuned in a wide spectral region in the visible and infrared region. Based on comprehensive measurement using Z-scan method and ultrafast pump-probe techniques, these plasmonic NPs contribute to a dramatic enhancement of ultrafast nonlinear optical response in the sub-ps scale, which can be further exploited for application in nonlinear photonics.

Abstract

E011: Fluoro-sulfo-phosphate glass and glass ceramic as hosts for broadband optical amplification and fiber laser

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At present, fiber lasers have occupied an important position in the fields of communication, sensing, laser processing, and laser medical treatment, and have rapidly expanded to other broader application fields such as gravitational wave detection, geomagnetism detection, and satellite laser communications [1]. Fluoro-sulfo-phosphate (FSP) glass is a new type of laser glass developed based on traditional phosphate glass, which can be used as the core gain medium for fiber lasers and fiber amplifiers [2-3]. In this work, a series of new FSP glass systems were predicted and verified from the perspective of thermodynamics. Tailored through chemical composition, internally nucleated precipitation of a nanocrystalline fluoride phase enables switching between high-field and low-field configurations of the transition metal activators, resulting in the specific emission properties and setting the path towards FPS-based optical devices. Moreover, two types of high-gain FSP optical fibers (more than 3 times higher than the current commercial erbium-doped silica fiber) were developed and kHz ultra-narrow line-width laser with low threshold and GHz high-repetition femtosecond laser were achieved. Such advanced fiber lasers have important potential applications in high-precision fiber sensing, coherent lidar, biomedical diagnosis, and other fields.

Keywords: Fluoro-sulfo-phosphate glass; glass ceramic; glass formation; fiber laser

Abstract

E012: Structure and Spectral Properties of Fe:$ZnAl_2O_4$, Fe:$MgAl_2O_4$, and Fe:γ-Al_2O_3 transparent glass-ceramics

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We present the results of a comparative study of the structure and spectral properties of new Fe^{2+}-doped transparent glass-ceramics based on nanocrystals of $ZnAl_2O_4$, $MgAl_2O_4$, and γ-Al_2O_3 with spinel structure, Fig. 1(a). Their absorption spectra are formed by absorption of Fe^{2+} ions in spinel crystals in O_h and T_d positions and by intervalent charge transfer transitions between Fe^{2+}, Fe^{3+}, Ti^{3+}, and Ti^{4+} ions in spinel and titanium-containing nanocrystals, Fig. 1(b). A broadband absorption in the spectral range of 1.8-2.4 μm is due to the $^5E \rightarrow {}^5T_2$ (^5D) transition of Fe^{2+} ions in T_d sites in spinel nanocrystals. The glass-ceramics are intended for saturable absorbers of lasers emitting in this spectral range.

Key words: Glass-ceramics; Spinel; Ferrous ions

Abstract

E013: Formation and crystallization behavior of Rb_2O-Nb_2O_5-SiO_2 glass

Minghui Sun, Jiangkun Cao, Roman Sajzew, René Limbach, Yang Xia, Falko Langenhorst, and Lothar Wondraczek*

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Niobium-containing glasses and glass ceramics are of potential interest for their optical and electrical properties. Here, a series of rubidium silicate glasses with a large amount of Niobium was prepared by melt-quenching method, and the corresponding glass ceramics (GCs) were prepared from these glasses by iso-thermal treatment. Depending on transformation conditions, the GCs exhibit pronounced nucleation activity leading to very high crystal number density, accompanied by dramatic changes in the material's mechanical properties. Details of the crystallization behavior are investigated by non-isothermal DSC analysis, iso-thermal in situ HT-XRD and polarized Raman spectroscopy.

Keywords: Niobium; Glass ceramics; Mechanical; HT-XRD.

Abstract

E014: Oxysulfide Glass-Ceramics Containing Alkaline-Earth Metal Sulfide Nanocrystals

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Alkaline-earth metal sulfides are one kind of important optical materials, and have broad application prospects in bioimaging, spectral conversion, etc. However, alkaline-earth metal sulfides suffer from the weak chemical stability and mechanical properties, and can be easily oxidized. Incorporation of alkaline-earth metal sulfide nanocrystals into oxysulfide glasses is expected to overcome those inherent limitation. In this work, a new type of oxysulfide glass-ceramics is developed using the melt-quenching and subsequent thermal treatment. Alkaline-earth metal sulfide nanocrystals such as CaS, SrS, BaS, $Ca_{1-x}Sr_xS$, and $Sr_{1-x}Ba_xS$ nanocrystals are precipitated in glasses. By controlling the heat-treatment condition, average diameters of these alkaline-earth metal sulfide nanocrystals are tuned in the range of 3~15 nm. Precipitation of alkaline-earth metal sulfide nanocrystals not only improves the mechanical properties of glasses, but also maintains high transmittance in the spectral range of 1~4.3 μm. Results reported in this work provide one interesting optical glass materials, which provide new opportunity to developed optically functional materials and devices.

Key words: alkaline-earth metal sulfide nanocrystals; oxysulfide glass-ceramics; high transmittance

Abstract

E015: Broadband NIR luminescence of subnano Te cluster in glass

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We propose a strategy for the in situ generation and stabilization of Te clusters by tuning the cluster evolution in glass for generating NIR optical reponse. A novel active photonic glass embedded with a Te cluster exhibited intense and broadband NIR emission with a peak at 1030 nm and a bandwidth exceeding 330 nm. Interestingly, the glass exhibited a full visible-spectrum conversion ability from 300 nm to 800 nm. We demonstrated the application of this broadband excitation feature for night vision and tissue penetration using a smartphone as the excitation source. These findings demonstrate a fundamental principle of cluster design in glass for creating new properties and provide a new direction for developing novel cluster-derived functional composite materials.

Key words: Cluster in glass; Optical active materials; NIR luminescence

Abstract

E016: Correlations between Oxidation States of Ti Ions and Optical Transmittance in TiO_2-SiO_2 Glasses

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Addition of a proper amount of Ti into the silica network is known to present an exceptionally low thermal expansion coefficient, which is even lower than that of silica glass, thus enabling the TiO_2-SiO_2 glass to be employed as a substrate material for the extreme-ultraviolet (EUV) lithography process. Titanium ions are supposed to exist either as trivalent (Ti^{3+}) or as tetravalent (Ti^{4+}) states in this uqique glass. Relative proportion of these two states is then influenced not only by impurities but also by synthesis conditions. Achieving a proper balance between these two states of Ti ions is crucial for producing high-quality TiO_2-SiO_2 glass. In this study, TiO_2-SiO_2 glasses were synthesized via the vapor axial deposition (VAD) technique. Thermal expansion coefficient and optical transmittance of the resulting glasses were measured and analyzed in connection with the $[Ti^{4+}]/[Ti^{3+}]$ ratio and relative amount of $TiCl_4$ precursor. In addition, hardness of the glass specimens was empirically correlated with TiO_2 concentration.

Key words: TiO_2-SiO_2 glass, VAD, Thermal expansion, EUV lithography

Abstract

E017: New insights into the High Temperature Stability of stone wool fibres

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Stone wool (SW) is widely used for thermal insulation and well known for its fire resistance. The fire resistance, or high temperature stability (HTS) describes the ability of SW to maintain its geometrical integrity at elevated temperatures (≈1000°C). HTS is important for slowing down the spread of construction fires. Pre-oxidizing SW at temperatures around the glass transition temperatures (T_g) has beneficial effects on the HTS [1-2] through the formation of a nanocrystalline surface layer consisting of MgO. Using a newly developed method for quantifying HTS [3], our research provides interesting new information about the details of the HTS improvement through pre-oxidation. We used hot stage microscopy to quantify the HTS of SW pre-oxidized at various temperatures for 15 min, and various durations at T_g (677°C).
Our work reveals that pre-oxidation of SW does not lead to a continuous improvement in HTS. Pre-oxidation of SW initially leads to an improvement in HTS (i.e., an increase in A_2/A_0 in Fig. 1) followed by as decrease as shown by the dependence of HTS with increasing temperature of pre-oxidation (Fig. 1a) and duration (Fig. 1b). We link the initial increase in HTS to the formation of the nanocrystalline surface layer, and the following decrease to a mechanical break-down of the nanocrystalline layer. This hitherto unknown aspect of HTS is important in relation to fire-protection as it can lead to various HTS of SW, depending on the development of a fire. Heating rate and maximum temperature of the fire can affect the HTS through the described effect of breakdown of the nanocrystalline surface layer.

Key words: Stone wool; high temperature stability; nanocrystals

Abstract

E018: Rare-earth-doped nanostructured glass-ceramics: processing and properties

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The growing field of photonics demands the design of new rare-earth (RE)-based optical materials for their use in efficient optical telecommunications, solid-state lasers and other applications. Oxyfluoride glass-ceramics (GCs) combine the transparency and both mechanical and chemical resistance of aluminosilicate glasses with the low phonon energy and facile incorporation of RE ions in the fluoride crystals. The incorporation of RE ions in the crystalline phases enhances the optical emission intensity, a major property of these materials [1]. Moreover, the additional presence of metallic nanoparticles (Ag, Au, Pt) in the RE-doped glass-ceramics can further enhance the luminescent response.

These materials are suitable for the preparation of preforms as precursors for the drawing of optical fibers and as substrates for waveguides written using laser radiation and some examples of the materials preparation and its possible applications will be provided in this presentation.

By the other hand, transparent GC materials have also been obtained by spark plasma sintering (SPS) [2]. This approach combines thermal action with simultaneous compression of the material to reach full densification and high homogeneity in a short time [3]. The structural, mechanical, and optical properties have been characterized and compared with GCs of the same composition prepared by conventional heat treatment. The results confirm the suitability of the SPS processing for the preparation of highly dense and transparent oxyfluoride glass-ceramics containing nanocrystals.

Keywords: oxyfluoride glass-ceramics; transparent; rare earths, metallic

nanoparticles, spark plasma sintering

E019: Ultrasound-Induced Luminescence from Cr^{3+}-Doped $ZnGa_2O_4$ Glass–Ceramic Composites

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Stimulus-responsive materials are of great interest for modern communication, bio-treatment, and smart sensors. Here, we report an intense ultrasound-induced luminescence (USL) from Cr^{3+}-activated glass–ceramic composites, obtained by direct precipitation of nanoscale $ZnGa_2O_4$ from silicate melts upon cooling. The USL band overlaps with the first near-infrared transmission window of biological tissue and spans further into the visible red spectral range, generating interest for visible data encryption and labeling as well as for photophysical stimulation with a remote, non-optical energy source. Time-resolved observations of luminescence build-up and decay, US heating, and persistent luminescence reveal thermal de-trapping as the origin of the observed US sensitivity. The fabrication process leads to a robust, dense, and biocompatible composite without requiring secondary encapsulation.

E020: Photoionic Effect Imposed by Photoresponsive Local Field in a Tellurate Glass with Lanthanide Ions and Ag Nanoparticles

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Understanding the photoionic mechanism in optoelectronic materials offers significant potential for various applications in the fields of laser, data/energy storage, signal processing, and ionic batteries. However, the research on such light-matter interaction using photons of sub-bandgap energy is scarce, especially for those transparent materials with photoactive centers that would generate a local field upon photoillumination. This research investigates the photoionic effect in Yb3+/Er3+ doped tellurate glass with Ag nanoparticles (NPs) embedded. It is found that the photogenerated electric dipole of Yb3+/ Er3+ ions and local field of Ag NPs could block the Ag+ migration in an external electric field. The blocking phenomenon of Ag NPs is the so-called Coulomb blocking effect (ascribed to its quantum confinement effect), which would be further enhanced by the additional photoinduced localized surface plasmon resonance (LSPR) effect. Interestingly, the photoresponsive electric dipole of lanthanide ions could cause plasmon oscillation of Ag NPs, resulting in a partial release of the blockade of lanthanide ions and enhanced blockade via quantum confinement of Ag NPs. A model device is proposed according to the photoresistive behavior. The research gives another perspective on the photoionic effect via the photoresponsive local field generated by photoactive centers in optofunctional materials.

Abstract

Keywords: ionic movement, blockade, photoresponsive, local field, lanthanide ions

Abstract

E021: Preparation and optimization of optical properties of $CsPbX_3$ perovskite quantum dot glass

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$CsPbX_3$ perovskite quantum dots (PQDs) glasses were prepared by conventional melt-quenching followed by a thermal treatment process. The optical properties of PQDs glasses were optimized by glass network structure modulation. For example, by adjusting the ratio of B_2O_3 and SiO_2 to control the ratio of two-dimensional and three-dimensional glass network structures, the photoluminescence (PL) quantum yield of $CsPbI_3$ PQD-doped glasses could be increased to 50.5%, as shown in Figure 1(a). The crystallization behavior and optical properties of PQD-doped glass could also be regulated by modulating the network structures through the introduction of a glass network intermediate ZnO, as shown in Figure 1(b). The PQD-doped glasses could have potential application in the field of optoelectronic devices due to their excellent optical properties and stability.

Key words: $CsPbX_3$ perovskite; glass network; quantum dot glass; optical properties

Abstract

E022: Mid-infrared Emission of Cobalt Doped Chalcogenide Glass Ceramics

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Novel mid-infrared (mid-IR) gain materials are of great significance for the development of mid-IR tunable lasers and amplifiers. Herein, we found that Ga_2S_3 nanocrystals distributed in chalcogenide glass ceramics are new tetrahedral-coordinated sites that can be used to activate the mid-IR emission of divalent transition metal ions, like Co^{2+}. Under the excitation at 808 nm or 1550 nm, transparent glass ceramics doped with different concentrations of Co^{2+} showed 2.5-5.0 μm broadband emission. The peak wavelengths were located at ~3.4 μm and the full widths at half-maximum exceeded 1 μm. Such emission properties are superior to those of the Co^{2+}: ZnS nanocrystals embedded transparent chalcogenide glass ceramics. Therefore, the active Co^{2+}: Ga_2S_3 embedded glass ceramic has great potential in mid-IR tunable lasers and amplifiers.

Key words: Chalcogenide glasses; Glass ceramics; Mid-infrared emission; Nanocrystals

Abstract

E023: Single-shot photon recording for permanent optical data storage based on photoluminescent glass

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Long-term optical data storage technology is essential to break the bottleneck of high energy consumption for information storage in the current era of big data, and femtosecond laser-induced modification in the glass has drawn considerable interest due to its widespread superiority in the applications of multi-dimensional optical storage. Here, we report that a single pulse could be used in optical memory with super-high writing speed and optical data storage with an ultralong lifetime of 2×10^7 years is attained with single ultrafast laser pulse induced reduction of Eu^{3+} ions and tailoring of optical properties inside the Eu-doped photoluminescent glasses. Consequently, strong emission contrast is obtained, which is used for optical storage. By regulating the fabrication conditions, the fluorescent diameter could be controlled to approximately 600 nm, which demonstrates the feasibility in super-high density optical storage. We demonstrate that the induced local modifications in the glass can stand against the temperature of up to 970 K and strong ultraviolet light irradiation with the power density of 100 kW/cm^2. Furthermore, the active ions of Eu^{2+} exhibit strong and broadband emission with the full width at half maximum reaching 190 nm, and the photoluminescence is flexibly tunable in the whole visible region by regulating the alkaline earth metal ions in the glasses. The developed technology and materials will be of great significance in photonic applications such as long-term optical data storage.

Key words: Optical data storage; Femtosecond laser; Photoluminescent glass; Photoluminescence tailoring.

Abstract

E024: Ultrafast laser-induced self-organized nanostructuring for all-inorganic photonic devices

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Inscribing functional micro-nano-structures in transparent dielectrics enables constructing all-inorganic photonic devices with excellent integration, robustness, and durability, but remains a great challenge for conventional fabrication techniques. Recently, ultrafast laser-induced self-organization engineering has emerged as a promising rapid prototyping platform that opens up facile and universal approaches for constructing various advanced nanophotonic elements and attracted tremendous attention all over the world. This presentation summarizes the history and important milestones in the development of ultrafast laser-induced self-organized nanostructuring (ULSN) in transparent dielectrics and reviews our recent research progresses by introducing newly reported physical phenomena, theoretical mechanisms/models, regulation techniques, and engineering applications, where representative works related to next-generation light manipulation, data storage, optical detecting are discussed in detail. We also present an outlook on the challenges and future trends of ULSN, and important issues merit further exploration.

Keywords ultrafast laser, self-organization, nanostructuring, transparent dielectrics

Abstract

E025: Preparation and luminescence properties of $MgO\text{-}Al_2O_3\text{-}SiO_2$ transparent glass-ceramics containing metastable phase

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In this work, a novel $MgO\text{-}Al_2O_3\text{-}SiO_2$ transparent glass-ceramics (MAS TGCs) containing metastable $MgAl_2Si_3O_{10}$ phase was prepared by the melting crystallization method. The precipitation of $MgAl_2Si_3O_{10}$ was helpful in promoting the crystallization mechanism of MAS glass from surface crystallization to volume crystallization, and the Vickers hardness of the TGCs could reach 9.5 GPa. In addition, a series of $Ce^{3+}/Tb^{3+}/Sm^{3+}$ co-doped MAS TGCs containing $MgAl_2Si_3O_{10}$ have been designed. Under ultraviolet irradiation, the prepared TGCs emit bright white light and exhibit good thermal stability. The 365 nm UV chip and MAS TGCs were assembled into a white LED device, showing a color temperature of 3335 K and a color rendering index of 90.6. The results show that the synthesized MAS TGCs can be used not only for display covers of terminal devices, but also for the construction of white LED devices with high color rendering index and low color temperature.

Key words: Transparent glass-ceramics; Metastable phase; Luminescence properties

Abstract

E026: ErF_3 microcrystals deposited in perfluoride glass for up-conversion red emission

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In the research of Er^{3+} concentraion affects properties of fluoroziconate glass, we found the changes of glass crystallzation tendency in ZBLAN glass. Through the x-ray diffraction (XRD) and differential thermal analysis (DTA) curves, and analyzed by phase-separation engineering techinque, we designed a glass ceramic composed by $62ZrF_4$-$15BaF_2$-$2AlF_3$-2NaF-$19ErF_3$. The crystals among the glass matrix are mainly ErF_3, and the sample exhibited a red/green ratio of up to 18.6, a long red-light fluorescence lifetime (3.18 ms @660 nm) and good color saturation (0.6255, 0.3707). This glass ceramic may has potential applications in multiple fields, such as color display, visible laser and lighting. Morever, the research of devitrification in rare-earth-doped fluoride glass can be the guidance toward high power mid-infrared fiber laser and multicolour display.

Key words: Fluoride glass ceramic; Rare-earth; Luminescence.

Abstract

E027: Glass ceramics containing mullite type $Al_4B_2O_9$ crystal phase for broadband near-infrared luminescence

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Mullite is one of the most important phases in many traditional or high performance ceramics due to its excellent properties, such as low heat capacity, low thermal expansion, high thermal stability, excellent creep resistance, and high corrosion resistance[1]. In the past decades, research on mullite mainly focuses on improving the mechanical properties of advanced ceramics or refractory linings based on the mullite phase, while only in few reports mullite was studied as a luminescent medium. Mullite is able to dissolve a large number of transition metals or foreign ions, and one of the structural characteristics of mullite type crystals is the abundant edge-sharing [AlO_6] octahedron forming chains parallel to the crystallographic axis. Therefore, the potential of some mullite crystal phases in near-infrared luminescence applications is underestimated.

In our recent research, we found that boron mullite crystal Cr:$Al_4B_2O_9$ can stably precipitate in a serises of multi-component aluminumborosilicate glasses, When excited by a 450 nm light source, broadband emission from 650 to 1200 nm is observed from the crystallized glass-ceramic samples, which are attribute to Cr^{3+} centers located at two different crystallographic site in the precipitated $Al_4B_2O_9$ grains[2]. In addition, NIR luminescence of mullite type Cr:$Al_4B_2O_9$ glass ceramics show a flexible customizability through oriented growth introduced by adding small mount of ZrO_2 as nucleating agent. This method can be further explored as a general strategy for the manipulation of the transition metal ion activated NIR luminescence in crystals with mullite type structure.

Key words: mullite type crystal; glass ceramics ; NIR luminescence

Abstract

E028: Transparent Fluoride Glass-Ceramics with Phase-Selective Crystallization for Middle IR Photonics

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Crystallization in glass is a fundamental topic in materials science. Controlling the crystallization in fluoride glasses remains a challenge owing to their low glass-forming ability. We fabricate transparent fluoroindinate glass-ceramics (FGCs) with phase-selective crystallization (SrF_2, CaF_2 and MgF_2) by a general one-step strategy. The alkaline-earth cations with high field strength is utilized to engineer the phase separation which induce subsequent phase-selective crystallization. The ab initio molecular dynamics revealed the heterogeneous distribution of Sr/Y-F regions and diverse diffusion rates of different elements in fluoride glass melt, providing fundamental insights into phase-separation at the atomic scale. Rapid quenching is employed to regulate the crystal growth in spontaneous crystallization during cooling stage. The crystal morphology, element distribution, lattice parameters and simulated atomic structure in FGCs further elucidate the phase-separation mechanism, thermodynamics and kinetics in rapid quenching. The new FGCs manifest enhanced mechanical and chemical stability and do not sacrifice the excellent optical performance compared to parent fluoroindinate glass. Numerous optical applications with superior properties in MIR photonics have been demonstrated.

Key words: Transparent fluoride glass-ceramics; Phase-Selective Crystallization; Mid-infrared band

E029: Enhanced luminescence of self-crystallized Cs_4PbBr_6 quantum dots via regulating glass ceramic network structure

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In this work, Cs_4PbBr_6 QDs are obtained in glass matrix through self-crystallization method. The results elucidate that with the increase of Na_2O, glass network structure transforms from three-dimensional framework structure to two dimensional layered structure and phase separation process of glass is aggravated. The looser network structure facilitates atoms rearrangement, and the presence of phase interface reduces activation energy of nucleation. Both of the two aspects can promote the self-crystallization of Cs_4PbBr_6 QDs. Importantly, the PLQY of PG3 is 81.24 %, which is much higher than the heat treated one (CG3:11.89 %). Our work puts forward a new perspective to investigate QDs glass ceramic and brings QDs glass ceramic significant prospect in the optoelectronic applications.

Key words: Quantum Dots Glass; High-temperature Metting; Phase-Separate

Abstract

E030: Impact of Fe_2O_3 content on performance of ferrosilicate glasses and glass fibers

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Glass can exhibit unique and excellent properties through crystallization, so we can add Fe_2O_3 to glass to generate Fe_3O_4 crystals with magnetic properties, and obtain ferrimagnetic glass and glass fibers. The influence of ferric oxide content on the performance of ferrimagnetic glass and glass fibers was investigated. Ferrimagnetic glass fibers within ferrosilicate glass system were prepared by spinning method. The effect of ferric oxide content on the microstructure and mechanical properties of the glass fibers were examined. The X-ray diffraction analysis showed the presence of magnetite with spontaneous crystallization for all investigated samples. Transmission electron microscopy (TEM) analysis indicated that the size of magnetite is less than 30 nm in diameter. The surface microstructure, density, magnetic hysteresis circles, thermal expansion performance, hardness, and elastic modulus of the glasses were studied systematically.

Key words: Ferrosilicate glasss; Crystallization; Glass fibers

Abstract

E031: Crystallization properties of $BaAl_2Si_2O_8$ in the $40SiO_2$-$25Al_2O_3$-$20BaF_2$-$15Na_2O$ glass

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Crystallization behavior is an important aspect of the functional glass materials. Heat treatment is an imperative method in crystallization. Thus, to study the effect of devitrification temperature on the transformation of barium feldspar ($BaAl_2Si_2O_8$) hexagonal phase and monoclinic phase in SiO_2-Al_2O_3-BaF_2-Na_2O glass system, the crystalline phases of the devitrified crystals were explored by X-ray diffraction (XRD) and high-resolution transmission electron microscopy (HRTEM). The results show that, after heating 30 minutes between 700 °C to 950 °C, respectively, hexacelsian (Hexagonal) can be successfully produced, and as the heat treatment temperature increases, celsian (Monoclinic) is precipitated successfully. Interestingly, heating for different time at 810 °C and 950 °C, respectively, it was found that the hexacelsian content decreases, however, the celsian did not increase significantly with the increasing crystallization time.

Key words: Oxyfluoride aluminosilicate; Glass ceramic; $BaAl_2Si_2O_8$; Heat treatment; Phase transformation

Abstract

E032: Layered array Al_2O_3-LuAG: Ce composite ceramic phosphors for high-brightness display

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Thermally robust and highly efficient green-emitting luminescent ceramics are gradually attracting great attention as promising phosphors in high-brightness laser phosphor display. Especially, composite ceramic phosphors (CCPs) combined both the merits of matrix and phosphor have received growing interests. Nevertheless, high matrix content brings diluted activated ion concentration and dropped photoluminescence (PL) quantum yield (QY). Here, novel layered array Al_2O_3-LuAG: Ce CCPs, where Al_2O_3 and LuAG: Ce thin layers (10-250μm) are alternately arranged, was presented. The thermal phonons and photons are respectively routed into Al_2O_3 layers and LuAG: Ce layers, which weakens the influence of Al_2O_3 and heat accumulation on PL properties. Consequently, it exhibits high PLQY (84%), good thermal conductivity (17 W/m·K), and extremely high lumen-density (5994 lm/mm^2) under high-power density (27 W/mm^2) blue laser excitation. This work provides a promising new microstructure in developing novel phosphor converters.

Key words: high-brightness display; composite ceramic phosphor; LuAG: Ce

Abstract

E033: New Generation of Optical Information Storage: Efficient Tunable Persistent Luminescence in XAl_2O_4: Eu^{2+} (X=Ca, Sr) Doped Borate Glass

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Eu^{2+} doped XAl_2O_4 (X=Ca, Sr) phosphor with polycrystal fields for realizing the tunable persistent luminescence has been seldom explored. In this work, by fine-tuning the ratio of calcium carbonate to strontium carbonate in the borate matrix, Eu^{2+} ions were introduced into $CaAl_2O_4$ and $SrAl_2O_4$ crystals in different concentrations, with reductive-induced oxygen vacancy defects distributing shallow or deep near Eu^{2+} 5d state to obtain the tunable polychromatic afterglow emission from green to indigo to dark blue. Also, the additional red emission from Eu^{3+} in the glass matrix further enriched the luminescence characteristic by equipping the samples with tunable photoluminescence from yellow, white to purple. Ultimately, such material has been proved to be stably applied in optical information storage applications.

Key words: Tunable Persistent Luminescence; Polycrystal Field; Oxygen Vacancy Defects; Information Storage; Sr/$CaAl_2O_4$: Eu^{2+}

Abstract

E034: Preparation and luminescent properties of Sm^{2+}-heavily-doped fluorosilicate glass

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Fluorosilicate glass doped with Sm^{2+} ions has many unique optical properties and can be used in a variety of optoelectronic devices. However, high-efficiency Sm^{2+} reduction has always faced challenges for the lower reduction potential of Sm^{3+}/Sm^{2+}. In this study, Sm^{2+}-doped fluorosilicate glass was successfully prepared by taking advantage of the strong reducing property of Al elemental substance and under a weak reducing atmosphere. Under the condition of Sm doping of 1 mol%, as the Al content increases, the Sm^{2+} characteristic emission increases while the Sm^{3+} emission weakens. When Al reaches 0.4wt%, the Sm^{3+} emission completely disappears. The results show that the reduction of Al element leads to efficient conversion of Sm^{3+}. The material is expected to be used in fields such as infrared lasers, fiber amplifiers and luminescent displays.

Key words: Sm^{2+} doped fluorosilicate glass; Al element reduction; Sm^{3+}/Sm^{2+} conversion; Infrared luminescence

Abstract

E035: Study on the optimum nucleation temperature of niobate glass

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Niobate glass with different Nb2O5 content was prepared by melting quenching method. The glass transition temperature Tg and glass crystallization temperature Tc were obtained by DSC scanning. The results show that as the increase of Nb content in the glass, the Tg of the glass gradually decreases. The required temperature for glass heat treatment is determined according to the glass transition temperature obtained by DSC scanning. The glasses are heat treated at 10 ° C, 20 ° C, 30 ° C and 40 ° C above the glass transition temperature. The Tc after heat treatment can be obtained by DSC high temperature scanning after heat treatment at different temperatures. The temperature at which glass crystallization peak first appears is the best nucleation temperature of glass. With the increase of Nb content, the best nucleation temperature of glass first increases and then decreases.

Key words: Niobate glass; nucleation; heat treatments

Abstract

E036: Controllable microstructure and crystallization of germanate glass

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The controllable crystallization is a pivotal property of glass ceramics, allowing for precise control over the type and average size of the precipitated nanocrystals. Oxide nanocrystals, such as spinel crystals, exhibit unique properties, including high crystal field symmetry, making them ideal for doping and luminescence of rare earth ions and transition metal ions. It is worth noting that different oxide nanocrystals have distinct crystallization properties, and regulating the glass microstructure enables the precipitation of various nanocrystal types. In this work, the composition and structure of germanate glass were systematically modified by altering the type of intermediate and modifier oxides. This modification to the glass structure, particularly the manipulation of bridging oxygen (BO) and GeO_4-membered rings, resulted in the successful precipitation of four distinct oxide nanocrystals—$ZnAl_2O_4$, $LiGa_5O_8$, $ZnGa_2O_4$, and Zn_2GeO_4—in the corresponding germanate glass. The results show that the type of precipitated crystals is related to the number of BO and GeO_4-membered rings presented in germanate glass. This has a certain guiding significance for the investigation of germanate glass ceramics that contain oxide nanocrystals.

Key words: Germanate glass ceramic; Glass structure; Oxide nanocrystals

Abstract

E037: Atomistic simulation of interfacial dynamics in nanocrystal-in-glass composites

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Nanocrystal-in-glass composite (NGC) doped with rare earth ions (REI) exhibits excellent optical properties by combining the spectroscopic quality of a crystalline phase and the outstanding thermal and chemical stability of matrix glass. The strong interfacial reactions and thermal erosion that occur during high-temperature encapsulation have detrimental effects on the final performance and can be alleviated by employing glass matrices with low melting points and chemical inertness. However, the control of interfacial reactions is often based on empirical approaches, and the underlying physical mechanisms remain largely unknown. Herein, by atomic simulation and experimental verification, we build more realistic models of NGCs, unveil the dynamic characteristics of the interface, and elucidate how the crystal and glass phases can regulate the interface reaction. Finally, we show how to realize a tunable interface by composition adjustment of the glass matrix.

Key words: Nanocrystal-in-glass composite; Interfacial dynamics; Atomistic modelling

Abstract

E038: The mechanism of water-induced enhanced green emission in Cs_4PbBr_6 PQDs glass ceramic

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The special luminescence properties of lead halide perovskite make it an ideal material for efficient and low-cost light-emitting devices. However, the green emission observed in Cs_4PbBr_6 nanocrystals is still controversial, whether it originates from the inherent point defects or only the $CsPbBr_3$ impurities. In this work, Cs_4PbBr_6 perovskite quantum dots glass was synthesized and the mechanism of green emission in Cs_4PbBr_6 nanocrystals was systematically studied. The results show that the green emission of Cs_4PbBr_6 nanocrystals comes from the defect energy level, and the passivation of partial nonradiative recombination defects of Cs_4PbBr_6 nanocrystals by PbBr(OH), resulting in water-induced enhancement of luminescence. The PLQYs of the quantum dots glass is increased 28 times with the assistance of water. This work provides evidence for defect-induced green emission of 0D Cs_4PbBr_6 nanocrystals, which has significant value to related work and helps to extend the application range of zero-dimensional perovskite materials in optoelectronic devices.

Key words: Cs_4PbBr_6 PQDs; glass ceramic; PLQYs; PbBr(OH)

Abstract

E039: Preparation of Na_2O-Al_2O_3-SiO_2 Transparent Nanocrystalline Glass-ceramic by Cooperating Phosphorus and Zirconium

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How to prepare excellent Na_2O-Al_2O_3-SiO_2 (NAS) transparent nanocrystalline glass-ceramic remains a challenge, as research on NAS transparent nanocrystalline glass is limited. In this study, we propose a new strategy for preparing NAS transparent nanocrystalline glass-ceramic, focusing on studying the crystallization process. On the one hand, phosphorus is used to promote the phase separation and crystallization of NAS glass. On the other hand, the presence of zirconium separates the crystallization of nepheline and carnegieite crystals. At the same time, a diffusion barrier was formed and the crystal size was limited. We have selected the appropriate phosphorus and zirconium content, prepared transparent nanocrystalline glass-ceramics with the high mean optical transmittance (over 86%). The hardness of glass-ceramic has a significant increase of compared to untreated glass, increased from 5.18 GPa to 7.15 GPa (increased by 38%). We hope that this work can provide new ideas and methods for the preparation of transparent NAS glass-ceramics.

Key words: Transparent nanocrystalline glass-ceramic; Na_2O-Al_2O_3-SiO_2; zirconium;

Abstract

E040: Quantitatively calculating the physical and spectroscopic properties of Nd^{3+}-doped laser glasses

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Predicting the properties of glass based on compositional and structural information is a fundamental issue with enormous practical and industrial significance for the study of laser glass. Here we address this problem and demonstrate the application of phase diagram method in predicting the spectroscopic properties of Nd3+-doped binary and ternary silicate, binary phosphate and borate laser glasses from their initial congruently melting compounds (CMCs). In particular, spectroscopic properties such as effective linewidth ($\Delta\lambda_{eff}$) and fluorescence branching ratio (β) can be precisely predicted in all glass systems with an error less than 5%. Furthermore, a composition-structure-property (CSP) database of Nd^{3+}-doped ternary silicate glass system is established and preliminarily applied to the composition design and explanation of commercial glass. This study provides interpretable predictions of the optical and spectroscopic properties for Nd^{3+}-doped laser glasses.

Key words: Laser glass, Structure, Spectroscopic, Quantitative prediction, Congruently melting compounds

E041: Effect of CaO on the formation of Te_2^- color center and CdTe quantum dots in glasses

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Embedding CdTe QDs into glass can improve the thermal and chemical stability of QDs, which facilitates their wide and endurable applications such nonlinear optical devices, optical filters, light-emitting diodes, and other optical emitters. However, the tunable spectral range of emission from CdTe QDs is narrow, the quantum efficiency is low and the full width at half of maximum is large, which hinder its practical application. In this work, effect of CaO concentration on the precipitation and optical properties of CdTe QDs on glasses are investigated. It is found that CaO has large effect on the formation of Te_2^- color centers, and the with the increase in CaO concentration in glass, Te_2^- color centers in the glass decreases. By adjusting the heat-treatment temperature, average diameters of nanocrystals are tuned in the range of 2.5~9.0 nm and the photoluminescence bands are tuned from 550 nm to 800 nm. More importantly, the photoluminescence quantum efficiency is improved to 41.9%. Results reported in this work indicate that CdTe quantum dots embedded glasses are promising for applications in light-emitting devices.

E042: Effect of ZrO_2 crystallization on ion-exchange properties in aluminosilicate glass

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Transparent glass-ceramics have gained much attention and interest due to the combination of high optical transparency and good mechanical properties. Ion-exchange has the potential to improve the mechanical properties of glass-ceramics. In this work, ZrO_2 nanocrystals embedded transparent glass-ceramics were prepared and effects of ZrO_2 crystallization on ion-exchange properties were investigated. The crystallization of ZrO_2 did not affect the transmittance and Vickers hardness due to the small nanocrystal size and the low crystallinity, but significantly enhanced the ion-exchange depth of layer (DOL). X-ray diffraction, high resolution transmission electron microscope, Raman spectra and nuclear magnetic resonance analysis demonstrated that with the crystallization of ZrO_2, the charge compensator (Na^+) used to charge balance for $[ZrO_6]^{2-}$ was released. Part of Na^+ is transferred to connect with NBOs, and the other part is transferred to the vicinity of high coordinated Al, which promoted the transformation of highly coordinated Al into $[AlO_4]^-$ tetrahedral units, leading to the expansion of glass network. The change of the glass structure leads to the increase the mobility of Na^+ and the consequently DOL. The hardness of the glass-ceramics is obviously improved after ion-exchange. Results reported here may be useful for the development of glass-ceramic materials with good ion-exchange abilities.

Keywords: Glass-ceramic, ZrO_2, Ion-exchange, Nanocrystal, Glass Structure

Abstract

E043: Multi-phase Glass-Ceramics containing MF2:Yb^{3+}/Er^{3+} (M=Ca, Sr) and $ZnAl_2O_4$:Cr^{3+} crystalline phases for Optical Temperature Sensing

Abhishek Wadhwa[1], Xusheng Qiao*[,1], Zhiyu Wang[1], Guodong Qian[1] and Xianping Fan[1]

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A multi-phase glass ceramic have the added advantage of lanthanide (Ln^{3+}) and transition metal (TM) ions co-doped into a single host material which realizes both the FIR for Ln^{3+} and luminescence lifetime for TM ions together for effective temperature sensing. However, doping both Ln^{3+} and TM ions into same host material results into quenching of the luminescence, due to adverse energy transfers between the different active centers. Here, two different glass formulations, (44+x) SiO2-(26.95-x) Al2O3- 10ZnF2- 20CaF2- 3ErF3- 0.05CrF3, (42+x) SiO2- (24.90-x) Al2O3- 10ZnF2- 20SrF2-2YbF3-1ErF3-0.10CrF3, were studied to get well balanced performances, respectively. We investigate the phase separation and nanocrystallization through a combination of molecular dynamics (MD) simulations and experimental investigations. Through the luminescence emission spectrum and luminescence lifetime test methods, the element partition of Yb3+/Er3+/Cr3+ was revealed in the glass matrix. By fitting a series of luminescence intensity ratio and luminescence lifetimes to the corresponding temperatures, the temperature dependent luminescence parameters of thesamples are determined to show double mode temperature sensing performances.

Key words: Lifetime Temperature Sensing, Luminescence Temperature Sensing, Molecular Dynamics Simulation, Oxy-fluoride glass and glass sceramics

E044: Intimate correlation between structure, chemistry, and crystallization in glasses

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[2]Physical and Theoretical Chemistry Laboratory, University of Oxford, South Parks Road, Oxford OX1 3QZ, UK
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Understanding the structure of glasses, especially chalcogenides, remains a significant challenge in the realm of glass science. This complexity largely stems from the intricate arrangement of atoms within these materials. However, recent research suggests that these structural complexities may be influenced by the nature of chemical bonds between the constituent atoms. Various properties of glass, such as phase transition behaviours, are also closely related to the types of chemical bonds present. In this talk, we will explore the latest discoveries that link a new type of chemical bond, i.e., multi-center hyperbonding, to both the static and dynamic properties of glasses, offering a new perspective on these complex materials.

Key words: glass structure; chemical bonding; phase transitions; DFT

Abstract

E045: Effect of thermocompression on properties of transparent glass-ceramics containing quantum dots

Yiting Tao [12], Panting Wang [12], Ting Wu [12], Mingjun Zhao [12], and Danping Chen[1*]

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A novel strategy for preparing transparent glass-ceramics with a uniform quantum-dot size and high transparency via thermocompression is reported. Borophosphate glass containing the Cs-Pb-Br component is prepared using the conventional melting method. The glass is then pressed with a piece of stainless steel to generate thermocompression during the crystallization heat treatment, by which small and uniform-sized nanocrystals of $CsPbBr_3$ quantum dots are produced in glass. Thermocompression reduces the specific surface energy of the nanocrystals and inhibits the abnormal growth of microcrystals, thereby reducing the average particle size from 7 nm to 4 nm and completing the growth of microcrystals. This significantly increases the transmittance of the glass-ceramics and enhances the luminescence intensity by approximately threefold. The experimental results show that low-intensity pressure can control the structure and properties of glass-ceramics during the growth of microcrystals in glass, which is a new process for preparing transparent microcrystalline glass.

Key words: Transparent glass ceramics; thermocompression; surface energy; nanocrystals; crystal size

Abstract

E046: Lithum aluminosilicate glass-ceramics with ultra-high fracture strength induced by amophozation

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The chemical strengthened transparent glass-ceramics by ion-exchange had been widely used for protective covers of mobile displays due to their excellent mechanical properties, such as high elastic modulus, high microhardness and good impact resistance. The ion-exchange in glass-ceramics is much more complex than in glasses because of their polycrystalline nature, which can be taken place in crystalline phase or residual glassy phase. In this work, the lithium aluminum silicate (LAS) glass-ceramics with eucryptite ($LiAlSiO_4$) were ion-exchanged with a mixture molten salts of 85 *wt*% $NaNO_3$:15 *wt*% KNO_3 at different conditions. During the ion-exchange, the eucryptite on the surface tend to be amophozation, which is more significant at higher ion-exchange temperature. After ion-exchange, the three-point bending strength is significantly increased from about 178 MPa to about 735 MPa for eucryptite glass-ceramics, which is even higher than that of sapphire crystal (~550 MPa).

Keywords: LAS glass-ceramics; Ion-exchange; Microstructures; Mechanical properties

E047: Investigation on the Luminescent Glass Ceramics Potentially Applicable to Laser-Driven Lightings and Displays

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The lighting sources of lightings and displays are developing towards higher brightness and more energy saving. The laser-driven lightings and displays has been the latest hotspot, in virtue of the overwhelmed advantages of no “efficiency droop”, small volume, wonderful monochromaticity and high directionality, whose most common technology is based on the combination of blue laser diode (LD) with color converters. However, there is the shortage of satisfactory color converters to meet the stringent requirements in high brightness lightings and displays. Correspodingly, great endeavors have been employed to research the design, fabriation, structure and performance of luminescent glass ceramics. Taking consideration of the urgent needs from lightings and displays, we choose the luminescent glass ceramics as the research object. A serious of luminescent glass ceramics are obtained, which have independent intellectual property rights, low cost and excellent performance. These findings suggest a step toward developing the admirable laser-driven color converters for next-generation lighting sources of lightings and displays.

Key words: Luminescent Glass Ceramics; Lightings and Displays

E048: Effect of phase separation of a phosphosilicate glass on self-limited crystallization and slow crack growth

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Following the percolation theory, the self-limited crystallization behavior of a phosphosilicate glass was systematically investigated by heat-treatment at both the low and the high temperatures, respectively. The metastable amorphous phase separation leads to phosphate-rich droplet phase and silicate-rich matrix, the former belongs to the floppy region with low network connectivity. Crystallization of Na3PO4 was limited in the droplets during heat-treatments, endowing the glasses with high transparency. The heat-treatment temperature and time have strong effect on the evolution of droplets including average size, distribution and number density, however, the content of crystallite is determined by the number density of droplets regardless of droplet size and distribution. On the other hand, slow crack growth behavior was investigated by measuring the wedging residual stresses at radial indentation cracks. With prolonging heat-treatment time, the mismatch of thermal expansion coefficient between the droplets and the matrix causes compressive stress in the latter, which is responsible for the improvement in crack growth resistance. However, coarsening process of the droplets should be avoided, since this impairs the transparency and crack growth resistance.

ABSTRACT

Session F

MOF glass, Perovskite glass, and other new glasses

Session F：

MOF Glass, Perovskite Glass, and Other New Glasses

Proposal of ICG2023 Annual Meeting

Session F：MOF Glass, Perovskite Glass, and Other New Glasses

New glasses and glass-ceramics afford new functionality to conventional glasses. Recently, MOF glass and perovskites glasses have attracted a lot of attentions for scientists owing to their particular properties and wide applications.

This symposium will focus on the MOF glasses, glasses containing perovskite nanocrystals, and other new glasses. Topics includes but not limited to chemical design and controlled synthesis, formation mechanisms, computational simulation, structure-property relationship and regulation, device applications, etc.

Focused topics:

- Chemical design and synthesis of MOF and hybrid glasses, glass formation or vitrification mechanism in MOF glass
- Computational simulation studies in MOF glasses
- Structural, mechanical, and optical properties of MOF glasses
- MOF glasses for membrane, battery, and electrochemistry applications
- Composites of MOF glasses and applications
- Lead halide perovskite and lead-free perovskite nanocrystals embedded in glasses
- Precipitation and manipulation of perovskite nanocrystals in glasses
- Glasses containing perovskite nanocrystals for detection, imaging, anti-counterfeiting, information processing, (mini-/micro-) light-emitting diodes, and miniaturized devices
- New glasses and glass-ceramics with special compositions, microstructures, and functionalities

Session Chairs:

Chao Liu, Wuhan University of Technology, China

YuanZheng Yue, Aalborg University, Denmark

Junjie Zhang, China Jiliang University, China

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Keynote Speakers:

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(1) Yuanzheng Yue, Aalborg University, Denmark

Structure, Relaxation and Functionality in Metal-Organic Framework Glasses

(2) Daqin Chen, Fujian Normal University, China

Perovskite quantum dots glasses for backlit displays

Invited Speakers:

MOF Glass

(1) Minghua Zeng, Guangxi Normal University, China

Systematic designing, sequential perturbation, muti-phase evolution and properties tuning of MOF glasses

(2) Mohamed Ali, Zhejiang University, China

Vitrification of metal coordination compounds and their applications

(3) Wenqian Chen, Shanghai University

Synthesis and applications of ordered to disordered MOFs

(4) Chengwei Gao, Ningbo University

MOF glass preparation and their applications in Li-ion batteries

(5) Yanfei Zhang, Qilu University of Technology, China

MOF Glass Anode for Li-Ion Batteries

Perovskite Glass

(1) Dezhi Tan, Zhejiang Lab, China

Photonic Glass: Structure Regulation and Applications

(2) Xuhui Xu, Kunming University of Science and Technology, China

The Optical Properties and Application of Perovskite QDs Glass

(3) Hang Lin, Fujian Institute of Research on the Structure of Matter, CAS

Stress-induced $CsPbBr_3$ Nano-crystallization on Glass Surface: Mechanism Study and Application Exploration

(4) Woon Jin Chuang, Kongju National University, South Korea

Improved stability of $CsPbBr_3$ perovskite embedded glasses for white LED color converter with wide color gamut

(5) Ruilin Zheng, Nanjing University of Posts and Telecommunications, China

A new insight into the structural evolution of halide perovskite in glasses

(6) Jing Ren, Harbin Engineering University, China

Sunlight excitable perovskite quantum dots sensitized near-infrared emitting glasses

Abstract

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<tr><td colspan="2">Keynote Speaker</td></tr>
<tr><td></td><td>Yuanzheng Yue, Aalborg University, Denmark
Tentative Title: Structure, Relaxation and Functionality in Metal-Organic Framework Glasses
Brief CV: Yuanzheng Yue is Professor of Chemistry at Aalborg University (AAU), Denmark. In 1995, he obtained his Ph.D. degree in Materials Science from Berlin University of Berlin, Germany. In 1998, he founded the inorganic glass research field at AAU. In 2003, he established the research laboratory for disordered materials at AAU. Since then, he has been leading the functional amorphous materials group. He is author/coauthor of >360 papers in peer-refereed journals including Nature, Science and Nature Materials.
He is Fellow of the European Academy of Sciences, Royal Society of Chemistry, European Ceramic Society, and Society of Glass Technology. He holds Knight's Cross of the Order of the Dannebrog (Denmark). He is a council member of the International Commission on Glass (ICG) and the chair of the ICG Technical Committee for Glass Fibers. He is editor of European Journal of Glass Science and Technology and editorial board member for six international journals.</td></tr>
<tr><td colspan="2">Invited Speakers</td></tr>
<tr><td></td><td>Minghua Zeng, Guangxi Normal University, China
Tentative Title: Systematic designing, sequential perturbation, multi-phase evolution and properties tuning of MOF glasses
Brief CV:</td></tr>
<tr><td></td><td>Mohamed Ali, Zhejiang University, China
Tentative Title: Vitrification of metal coordination compounds and their applications
Brief CV: Dr. Mohamed Ali is a postdoctoral researcher in Prof, Jianrong Qiu's group at the College of Optical Science and Engineering, Zhejiang University, China. He is currently working as an assistant professor at the Department of Physics, Suez</td></tr>
</table>

	University, Egypt. He received his Ph.D. in Materials Science and Engineering from Zhejiang University in June 2019. He received his M.S. and B.S. degrees in Physics from Cairo University in 2014 and 2009, respectively. His research work focuses on the photonic applications of glassy materials such as MOF glasses and the discovery of new glasses and new vitrification approaches. He has published 16 papers in journals such as Angewandte Chemie, Chemistry of Materials, ACS Materials Letters, and Inorganic Chemistry, and has contributed one Elsevier chapter in English.
	**Wenqian Chen**, Shanghai University, China **Tentative Title:** Synthesis and applications of ordered to disordered MOFs **Brief CV:** Wen-Qian Chen is currently an Associate Professor at Shanghai University. She obtained her PhD from Kyoto University in 2015 and was selected for the Shanghai Overseas High-level Talent Program in 2019. Since 2023, she has held an adjunct position at NSFC. Her main research focus on the application of disordered MOFs. In recent years, she has published nearly 40 academic papers in high-level journals such as E. E. R., Angew. Chem. Int. Ed., Coord. Chem. Rev., Adv. Energy Mater., Chem. Eng. J., Engineering, et al. as first/corresponding author. She was honored with the Young Talent Award at the "10th International Symposium on Advanced Glass" and received the Second Prize for the Shanghai Science and Technology Award.
	**Chengwei Gao**, Ningbo University, China **Tentative Title:** MOF glass preparation and their applications in Li-ion batteries **Brief CV:** Dr. Chengwei Gao received his Bachelor's degree and Master ' s degree in Applied Chemistry from Zhengzhou University, P. R. China in 2015 and 2017, respectively. He was then a Ph.D. student at the Department of Chemistry and Bioscience, Aalborg University (2017-2021) supervised by Prof. Yuanzheng Yue and Prof. Yanfei Zhang. After his graduation, he has been working as a Research Associate at Ningbo University

	since 2022. His research interests range from the MOF glass, chalcogenide glass and their applications in secondary batteries.
	**Yanfei Zhang**, Qilu University of Technology, China **Tentative Title:** MOF Glass Anode for Li-Ion Batteries **Brief CV:** Yanfei Zhang is now Professor at the Qilu University of Technology, Jinan, China. She received her Ph.D. degree in Physics from Shandong University, China, in 2009. From 2011 to 2012, she worked as a Postdoctoral fellow at Aalborg University, Denmark. Through her professional carrier, her research interests focus on glass electrode materials for lithium-ion batteries, and glass relaxation, glass transition, structure and properties of oxide glasses and glass fibers. She has published more than 60 scientific papers and conference proceedings in the research field.
Perovskite Glass Session	
Keynote Speaker	
	**Daqin Chen**, Fujian Normal University, China **Tentative Title:** Perovskite quantum dots glasses for backlit displays **Brief CV:** My research interests focus on optoelectronic materials (QDs, QDs glasses, and lanthanide-doped luminescent materials) and devices, which have been supported by National Key Research and Development Program of China and National Natural Science Foundation of China. I am serving as a young editor for *Chinese Journal of Luminescence* and associate editor for *Journal of the American Ceramic Society*.
Invited Speakers	
	**Dezhi Tan**, Zhejiang Lab. China **Tentative Title:** Photonic Glass: Structure Regulation and Applications **Brief CV:** Dezhi Tan is a full professor in the Zhejiang Lab. He received his BS and PhD degrees in materials science and engineering from Zhejiang University in 2009 and 2014, respectively. He previously worked in the Zhejiang University (China), Kyoto University (Japan, JSPS Fellow), and Institute for Basic Science (Korea, research professor). His current research

	interest is focused on fabrication of photonic micro/nanostructures and devices, and ultrafast laser–matter interaction. He has published 40 papers as the first author or corresponding author in the top journals such as Science, Adv. Mater., Light Sci. Appl., Prog. Mater. Sci., Adv. Photonics, and Laser Photonics Rev. The results have been selected as one of the top 10 Chinese scientific advances for 2022, the top 10 Chinese optical advances for 2022.
	**Xuhui Xu**, Kunming University of Science and Technology, China **Tentative Title:** The Optical Properties and Application of Perovskite QDs Glass **Brief CV:** Xuhui Xu, male, born in June 1986, Professor, Ph.D. supervisor. Prof. Xu is mainly engaged in the application research of rare earth doped inorganic solid luminescence materials in LED, long afterglow, upconversion laser, X-Ray detection and realized the phenomenon of upconversion high power laser emission in microcrystalline glass for the first time. In recent years, more than 70 SCI papers have been published in renowned international authoritative journals such as Adv. Mater, ACS Nano, ADV. Fuct. Mater, Nanoscale, ACS Photonics, J. Phys. Chem. C, Inorg. Chem and others, with a total of more than 3900 citations and H factor of 33. 16 patents have been applied and 4 national invention patents have been authorized. He also presided over 2 national funds and 7 provincial and ministerial projects.
	**Hang Lin**, Fujian Institute of Research on the Structure of Matter, CAS, China **Tentative Title:** Stress-induced $CsPbBr_3$ Nano-crystallization on Glass Surface: Mechanism Study and Application Exploration **Brief CV:** Hang Lin received his bachelor, and master degrees from Fuzhou University (China), and PhD degree from FJIRSM, CAS, in the years of 2005, 2008, 2011, respectively. His research interest focuses on the oriented preparation of luminescent glass ceramic for opto-functional application, and aims to understand the fundamental issues of glass crystallization kinetics, controllable crystal growth of specific nanocrystals in

	glass, distribution of doping activators, and microstructure-property relationship in glass ceramic. In recent years, he has published more than 80 papers in Light: Sci. Appl., Laser Photon. Rev., Chem. Mater. J. Am. Ceram. J. Europ. Ceram. J. Adv. Ceram. et al., which receive citations of more than 5000 times by others (H index 41). He has been granted more than 10 invention patents in China and has made more than 20 invited presentations in various domestic/international conferences.
	**Woon Jin Chung**, Kongju National University, South Korea **Tentative title:** Improved stability of $CsPbBr_3$ perovskite embedded glasses for white LED color converter with wide color gamut **Brief CV:** Prof. Woon Jin Chung got his Ph.D in 2001 in Pohang University of Science and Technology (POSTECH), South Korea and worked as a post-doc in University of Leeds, UK in 2002. He joined Electronics and Telecommunications Research Institute (ETRI), South Korea in 2003 as a senior researcher. He moved to Kongju National University, South Korea in 2006 and is working there as a professor till now. He worked as a visiting scholar in University of Washington, USA in 2018. He's research interest includes alumino-silicate glasses and chemical strengthening of glasses for display and industrial applications; quantum-dot embedded and nano-structured glasses for photo-electronic applications such as display, photo-voltaic cell or LEDs; glass frit materials for sealing: lead-free sealing (or frit) materials for AM-OLED, LED and SOFC; glass and glass ceramic materials for Li-secondary battery.
	**Ruilin Zheng**, Nanjing University of Posts and Telecommunications, China **Tentative Title:** A new insight into the structural evolution of halide perovskite in glasses **Brief CV:** Dr. Zheng is currently a professor of optics at Nanjing University of Posts & Telecommunications (NJUPT). In 2015, Dr. Zheng joined NJUPT as a research assistant professor of optoelectronics, then promoted to research associate professor

	(2020). He was a JSPS researcher at Kyoto University, Japan (2020-2022), a visiting researcher at the University of Central Florida, USA (2014-2015), and Nanyang Technological University, Singapore (2014). His current research focuses on photonic glasses and their applications in energy conversion. Dr. Zheng has published over 70 journal papers and has frequently been serving as a referee for many peer-review journals, including Chem. Mater., J. Phys. Chem. Lett., Adv. Opt. Mater., etc.
	**Jing Ren**, Harbin Engineering University, China **Tentative Title:** Sunlight excitable Perovskite quantum dots sensitized near-infrared emitting glasses **Brief CV:** Ren Jing, professor, PhD supervisor, head of the laser materials and devices group at Harbin Engineering University, a member of the Specialty Glass Branch of the Chinese Ceramic Society, and a young editorial board member of the Journal of Rare Earth and Journal of Luminescence. He has published over 200 peer-review papers on the design, preparation, and performance regulation of optical functional glasses and fiber devices. He has been invited to write 6 review articles of optical materials, and his research has been selected as journal covers and hotspots, and highlighted by Optica. He has given more than 20 invited talks, serving as a technical guidance for optoelectronic enterprises. He has undertaken and completed more than 20 projects funded by the National Natural Science Foundation of China, the Ministry of Science and Technology of China, and optoelectronic industry. He has been awarded the first prize in the science and technology category in Heilongjiang Province.

Abstract

F001: Systematic Designing, Sequential Perturbation, Muti-Phase Evolution and Properties Tuning of MOF Glasses

Zheng Yin, Jian Li, Yi-Hang Guo, Ming-Zhu Chen, Wei-Dong Liu, Ming-Hua Zeng*

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The emerging metal-organic framework (MOF) glasses, that are brand-new comers to the traditional noncrystalline physics world, was viewed as Holy Grail of future porous chemistry and the key direction of MOF derived functional materials.[1,2] Though a few ZIF or 1D/2D CP glasses are prepared through melt-quenching method, the vast majority of MOFs undergo thermal decomposition prior to melting, thereby preventing their glass-formation. It is of key importance to develop new methods to prepare MOF glasses. A new strategy of sequential perturbation based on dynamic chemistry was established to widely prepare MOF glass. A series of MOF glasses with relative low glass transition temperatures were created,[3,4] including a 4-fold interpenetrated dia-net cobalt-based MOF glass generated through perturbation of hydration and thermal dehydration, the first glass generated form 3D MOF precursors that incorporating metal cluster building unit, as well as a [Co_{15}] metal-carboxylate cluster-node MOF. Several important MOF glass properties such as GFA, Tg, liquid fragility can be systematically regulated. Uniform, transparent and large size MOF glass film can be prepared with effective maintenance of target physicochemical properties. Physical phenomena like β-relaxation and liquid-liquid transition were observed and confirmed in MOF glasses.

Key words: Metal-organic framework; Glass; Liquid; Structure transformation

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[4] YIN Z, YU HB, ZHANG YB, ZENG MH, et al. J Am Chem Soc, 2022, 144: 13021-

Abstract

13025.

F002: Vitrification of metal coordination compounds and their applications

Mohamed Ali

The vitrification of metal coordination compounds (MCC) leads to the emerging of a new family of glass with unique structures and properties. In this lecture, we discuss the recent progress in MCC glasses with focus on their synthesis, structure, and functionalities. First, we highlight the structural differences between MCC crystals and how these hybrid networks possess stable liquids at elevated temperatures, forming bulk and fiber glasses after quenching. In the later sections, we summarize the reported experimental investigations for the local structure differences between MCC crystals and their corresponding glasses in order to understand the melting and amorphization mechanisms. This lecture presents the properties of MCC glasses and their potential applications in various fields. Finally, we discuss the recent achievements, current challenges and future perspectives of MCC glasses and give suggestions for future directions of these new hybrid glassy materials.

Abstract

F003: Synthesis and Applications of Ordered to Disordered MOFs

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The amorphous state of crystalline Metal Organic Frameworks (MOFs, constructed from metal ions and molecular bridging ligands via coordination bonds), has received a lot of attention as an emerging class of materials. Among them, only a few undergo vitrification and demonstrate glassy behavior. Opportunities for discovering unique functionality in amorphous and glassy MOFs have been demonstrated with potential advantages of isotropic structure, grain-boundary free structure, variable pore distribution, defect engineering and transparency. The amorphization method and essential characterization techniques are discussed for understanding the structure and functionality of amorphous and glassy MOFs.

Key words: Glass; MOFs; Amorphous; Disorder

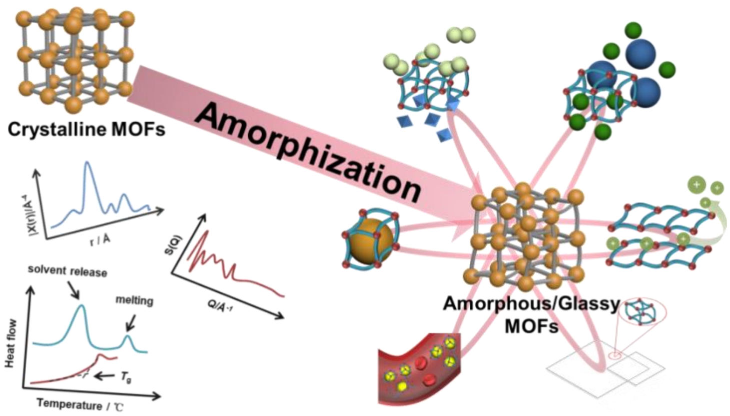

Fig.1 Amorphization from Crystalline MOFs to Glassy MOFs.

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[1] X. Han, R. Su, WQ Chen, *et al.*, *Nanoscale*, **2023**, *15*, 7703-7709.
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Abstract

F004: MOF glass preparation and their applications in Li-ion batteries

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Metal organic framework (MOF) glass, as one new kind of glass, hold great promise as both high-energy anode materials and solid-state electrolyte for next-generation lithium-ion batteries (LIBs) due to their tunable chemistry, unique porous structure and abundant active sites. However, their applications are still retards by the high melting temperature and lacking of proper modifications. Thus, functional group modification strategy is propsed to regulate the melting temperature, which is vital for low the energy consumption during MOF glass and maintain the pore/channel for ion/proton conduction.When acting as electrode, MOF glass and Si@MOF glass composite demonstrate better Li storage performance than their crystalline counterparts (Figure 1a)[1,2]. As for solid-state electrolyte, the open site of metal nodes could work act "binding and hoping site" for ion conduction. While, MOF glass is still in its early state for pragmatic applications, and it is worth more thorough investigation and exploration.

Key words: MOF Glass; Lithium ion battery; anode, solid-state electrolyte

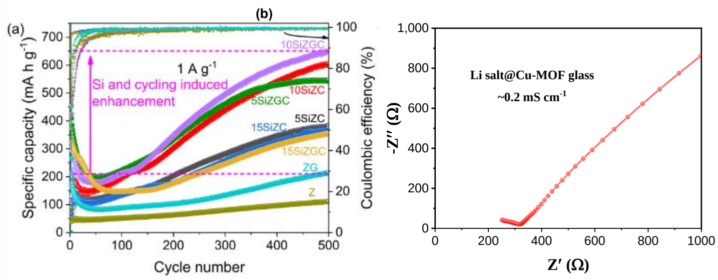

Fig.1 (a) Li storage performance of Si@MOF glass. (b) Li$^+$ conduction in MOF glass.

References:

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F005: Medium-range order structure controls thermal stability of pores in zeolitic imidazolate frameworks

Rasmus Christensen, Yossi B. Bleile, Søren S. Sørensen, Christophe A. N. Biscio, Lisbeth Fajstrup, Morten M. Smedskjær

Metal-organic framework (MOF) glasses have multiple potential applications as they combine advantages of traditional glasses with those of MOFs. The melt-quenching process used to form MOF glasses typically leads to a significant decrease in porosity, but the structural origin of this thermally-induced pore collapse remains largely unknown. Here, we study the melting process of three zeolitic imidazolate frameworks (ZIFs), namely ZIF-4, ZIF-62, and ZIF-76, using ab initio molecular dynamics (MD) simulations. By analyzing the MD data using topological data analysis, we show that while the three ZIF systems exhibit similar short-range order structural changes upon heating, they exhibit significant differences in their medium-range order structure. Specifically, ZIF-76 retains more of its medium-range order structures in the liquid state compared to the other glass-forming ZIF systems, which allows it to remain more porous than ZIF-4 and ZIF-62. As such, our results may aid in understanding what structural features govern the ability to maintain porosity in the melt-quenched glassy state.

F006: Metal-organic Framework Glass Anodes for Li-ion Batteries

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Metal-organic frameworks (MOFs) hold great promise as high-energy anode materials for advanced lithium-ion batteries (LIBs) owing to their great porosity, abundant reaction sites, tunable structures [1]. However, the pore structure of crystalline MOFs tends to collapse during the charge-discharge cycling, significantly degradating their electrochemical performances. In contrast, the recently discovered zeolitic imidazolate framework (ZIF) glasses exhibit different structural features, e.g., high degree of short-range disorder [2], with retained porosity. As a critical breakthrough, we prepared the first MOF (Cobalt-ZIF-62) glass anode by melt-quenching for LIBs, which exhibits high specific capacity (306 mAh g^{-1} after 1000 cycles at 2 A g^{-1}), outstanding cycling stability, and superior rate performance compared with the crystalline Cobalt-ZIF-62 and the amorphous one prepared by high-energy ball-milling [3]. To further improve the electrochemical performances of Cobalt-ZIF-62 glass anode, we present a strategy to in situ grow it on the surface of Si nano particles, and then to transform the thus-derived material into Si@ZIF-glass composite (SiZGC) through melt-quenching. The electrochemical characterizations of SiZGC show that proper tuning the Si loading in cobalt-ZIF-62 can lead to a considerable enhancement in discharge capacity up to ~650 mA h g^{-1}, which is about three times that of ptistine ZIF glass at 1 A g^{-1} after 500 cycles [4]. More impressively, the capacities of both the pristine ZIF glass and the SiZGC anodes continuously rise with charge-discharge cycling and even tripled after 1000 cycles. Through both the structural characterizations and density functional theory calculations, we revealed that their cycling-induced enhancement of the performances originate from the

Abstract

increased distortion and local breakage of the Co-N coordination bonds, making the Li-ion intercalation sites more accessible. Additionally, the ZIF glass phase in SiZGC can not only contribute to lithium storage, but also buffer the volume changes and prevent the aggregation of Si nano particles during lithiation/delithiation processes.

Key words: Metal-organic framework glass; Anode; Silicon; Lithium-ion batteries

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Abstract

F007: Deciphering the Structure and Mechanical Properties of Glassy Zeolitic Imidazolate Frameworks by a Transferable Deep Learning Force Field

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The glassy state of metal-organic frameworks (MOFs) offers unique features, such as combining nano-porosity with lack of grain boundaries. Zeolitic imidazolate frameworks (ZIFs) are an important subset of MOFs that can form glasses through melt-quenching, but their detailed structural features and mechanical properties remain elusive due to the difficulty to characterize experimentally. To overcome this challenge, we here develop a deep learning-based force field (DLFF) for molecular dynamics (MD) simulations, which is able to reproduce both the structure and mechanical properties of ZIF glass with an accuracy comparable to ab initio MD, yet at a much lower computational cost. Based on the large-size, yet accurate simulations, we reveal the structural changes of ZIF-4 glasses under different temperatures and pressures mainly originate from the reorientation process of imidazole rings. This DLFF is transferable to functionalized derivative ZIF glasses outside the training sets, which allows the study of the structural features of ZIF-62 glasses with different compositions. By correlating the local structural fingerprints with the fracture behaviors, we established the structure-properties relations of ZIF glasses which can guide the future design of MOF glasses with higher fracture resistance.

Abstract

F008: In situ detection of glass phase transition of zif-62

Shurong Shi

MOF glasses are widely used in gas storage/separation, catalysis, and nanostructure manufacturing. ZIF-62, as a subclass of MOFs, exhibits strong hydrothermal and chemical stability, as well as high designability.

Thermal-induced atomic displacement and the resulting framework deformation/collapse significantly affect the application of MOF crystals/glasses. In this study, a micro-region heating system was developed to perform real-time in situ temperature-dependent measurements of the Fourier-transform infrared spectroscopy and Raman spectroscopy of samples. The changing trends and reaction mechanisms such as solvent desorption, lattice expansion, deformation, molecular vibrations, and oxidative collapse during the thermal melting of ZIF crystal and the glass transition process were summarized and analyzed. Moreover, a single-particle F-P cavity was constructed in fiber end-face to measure the interference spectra of ZIF-62 crystal and glass particle at changing temperatures in real-time, correlating the refractive index of the sample with molecular structural change. This report provides a new approach for studying MOF materials, and the test results are of significant importance for a deeper understanding of network structures and phase transition processes of MOF crystal and glass.

Abstract

F009: Effect of Zn/Co node ratio on the glass transition in the high-density amorphous ZIF-4

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Zeolitic imidazolate frameworks (ZIFs) are an important subset of Metal-organic framework (MOF) glasses, which have been utilized for various applications. Upon heating, ZIF-4 crystals experience a polyamorphic transition, i.e., the transformation of a super-strong (i.e., very low liquid fragility in Angell's sense) low-density liquid into a relatively "fragile" high-density liquid.[1] Upon cooling, the latter transforms into the high-density amorphous phase (HDA). Understanding the connection between the glass transition temperature (T_g) and structural factors is crucial for processing the ZIF liquid phase with desired properties. By reheating the quenched HDA, the glass-to-liquid transition occurs. Despite notable progress in studying ZIF glasses, the nature of the HDA of ZIFs remains to be revealed. Particularly, the influence of metal node substitution on T_g of the ZIF-4 HDA has not yet been investigated. Here, we report the preparation of bimetallic Zn/Co-ZIF-4 HDAs and their T_g values [2]. The temperature dependence of the isobaric heat capacity (C_p) of ZIF-4 HDAs was measured to determine the T_g. The T_g non-linearly decreases with the molar ratio R, where R is Co/(Co+Zn), indicating the presence of a mixed-metal node effect [3]. The mixed-metal node effect on T_g is attributed to the difference in the degree of configurational freedom owing to the difference in tetrahedral symmetry. The degree of configurational freedom is influenced by the electronic structure and metal-nitrogen bonding nature [2]. Our study provides insight into the mixed-metal node effect on the glass transition in the HDA of ZIFs. The insight also helps design meltable ZIFs.

Key words: Zeolitic imidazolate frameworks; Mixed-metal node effect; High-density

amorphous phases; Glass transition

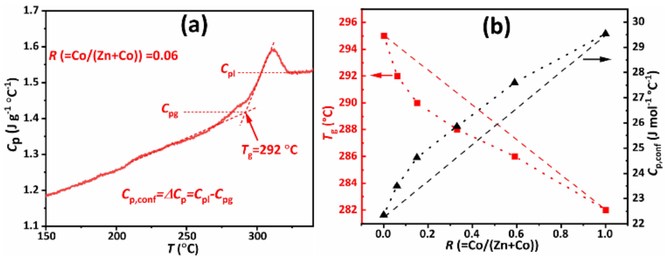

Fig. 1 (a) Isobaric heat capacity (C_p) curve for $Zn_{0.94}Co_{0.06}$-HDA at the heating rate of 10 °C min^{-1} in argon. (b) The molar ratio R dependence of T_g and $C_{p,conf}$. Dotted lines: guide for the eyes. Dashed lines: Linear lines connecting the two end-member compositions.

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F010: Synthesis of Glassy Metal-organic Frameworks Through Coordination Perturbation and Their Application for Solid-state Electrolytes

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Glassy metal-organic frameworks (MOFs) combine the processibility of glasses and the modular designability of MOFs and are promising for gas separation and electrolyte applications. Most known MOFs cannot be vitrified by melt-quenching, as they would thermally decompose before melting. In this research, we developed bottom-up synthesis for MOF glasses starting from metal-oxo clusters and bisphenol linkers, which can give glassy MOFs with surface area beyond 300 m^2/g and void portion of 30%.[1] In this synthesis, cresol was used as solvent, which can coordinatively compete with bisphenol and prevent the MOF network from phase separation. The gradual removal of cresol result in network formation, which lead to increase in viscosity and the eventual vitrification of the material. Following a similar strategy, we synthesized MOF glasses using polyethylene glycols as linkers, which can incorporate Li salt to give solid state electrolytes with ionic conductivity exceeding 1E-4 S/cm and have good interfacial contact and stability.[2] We also worked on the development of MOF glasses synthesis using coordination perturbation methods.[3]

Key words: Metal-orgaic framework; Porosity; Solid-state electrolyte

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Abstract

Cai, X., Li, H., Deng, Y., Zhao, L., Zeng, M.-H., Jiang, S., Zhao, Y*., Xie, J.,* *Nano Lett*, 23 *(9),* 4066.

Abstract

F011: Perovskite quantum dots glasses for backlit displays

Daqin Chen

High-quality backlit display puts forward urgent demand for color-converting materials. Recently, metal halide perovskites (MHPs) with full spectral tunability, high photoluminescence quantum yields (PLQYs) and high color purity have found potential application in wide-color-gamut display. Regrettably, naked MHPs suffer from long-term instable issue and cannot pass harsh stability tests. Recently, we successfully prepared amorphous-glass-protected green/red $CsPbX_3$ quantum dots (QDs) with PLQYs of ~90% by elaborately optimizing glass structure, perovskite concentration and in-situ crystallization. Benefited from complete isolation of QDs from external environment by glass network, $CsPbX_3$@glass can endure harsh commercial standard aging tests of 85°C/85%RH and blue-light-irradiation, which are applied to construct high-quality QDs-based films and white light-emitting diodes (wLEDs). Accordingly, the perovskite backlit units and prototype display devices are designed, showing more vivid and wide-color-gamut feature benefited from narrowband emissions of $CsPbX_3$ QDs. The results highlight practical application of $CsPbX_3$@glass composite as an efficient and stable light color converter in backlit display.

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Abstract

Prof. Daqin Chen

Fujian Normal University

My research interests focus on optoelectronic materials (QDs, QDs glasses, and lanthanide-doped luminescent materials) and devices, which have been supported by National Key Research and Development Program of China and National Natural Science Foundation of China. I am serving as a young editor for *Chinese Journal of Luminescence* and associate editor for *Journal of the American Ceramic Society*.

Abstract

F012: Ultrafast laser direct writing of bandgap-tunable perovskite nanocrystals in glass

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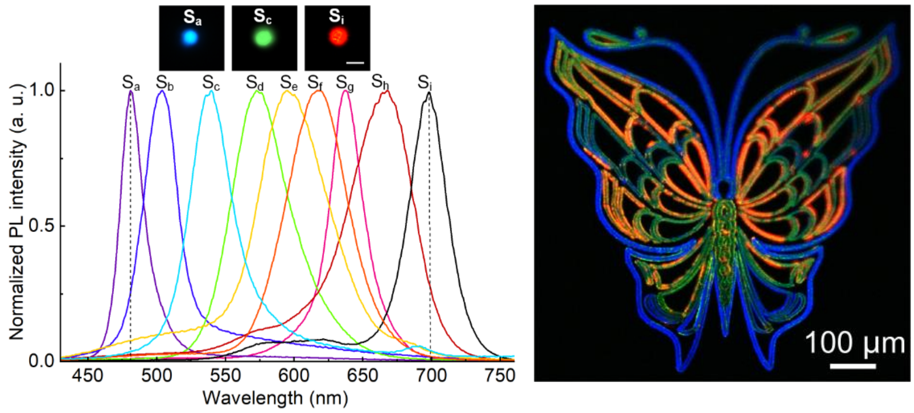
Compositional tuning of the optical properties of perovskites is usually performed in solution to create materials for high-performance devices with long-term stability.[1,2] Despite recent advances in optoelectrical performance, low structural stability has been an obstacle for practical perovskite devices, and numerous strategies such as surface passivation or device encapsulation have been developed. In these approaches, stabilization requires additional processing steps at the thin film or device level and is not integral to tuning the nanocrystal properties. We demonstrated three-dimensional (3D) direct lithography of perovskite nanocrystals (PNCs) with tunable composition and bandgap in glass by using ultrafast laser direct writing.[3,4] The halide ion distribution was controlled at the nanoscale with ultrafast laser-induced liquid nanophase separation. Thus, the full-color printing of PNCs with PL tuned in a range from 480 to 700 nm was achieved and reflected the transformation of $CsPb(Cl_{1-x}Br_x)_3$ into $CsPbI_3$, and hence, confirmed the PNC composition engineering.[3] Because liquid nanophase separation only occurs at a local position inside glass, the 3D direct lithography represents completely dry fabrication technique that advances the fabrication of structures and devices with high throughput, high scalability. It excludes contamination with organic components (reagents and solvents) during material synthesis and device processing. The PNCs exhibit remarkable stability against ultraviolet irradiation, organic solution, and high temperatures (up to 250 Celsius). Printed 3D structures in glass were used for optical storage, micro-light emitting diodes, and holographic displays.

Abstract

Key words:
Perovskite, glass, tunable bandgap, ultrafast laser direct writing



Ultrafast laser direct writing of bandgap-tunable perovskite nanocrystals in glass

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Biography:
Dezhi Tan is a full professor in the Zhejiang Lab. He previously worked in Zhejiang University (China), Kyoto University (JSPS Fellow, Japan), and Institute for Basic Science (research professor, Korea). His current research interest is focused on the study of fabrication of photonic micro/nanostructures, materials and devices, and ultrafast laser–matter interaction. He has published 40 papers as the first author or corresponding author in the top journals such as Science, Adv. Mater., Light Sci. Appl., Prog. Mater. Sci., Adv. Photonics, and Laser Photonics Rev.. The results have been selected as one of the top 10 Chinese scientific advances for 2022, and the top 10 Chinese optical advances for 2022.

Abstract

F013: Optical Properties and Applications of Perovskite Quantum Dot Glass-ceramic

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Perovskite quantum dot glass, due to its excellent optical properties, has been widely used in fields, such as OLED displays, laser technology, and biomedical applications. However, the nucleation and growth process of perovskite quantum dots and traditional nanoparticles in amorphous glass media, which serve as the basis for subjective governance methods of optical performance and the expansion of applications, are not yet clear. Here, we utilize the real-time in situ TEM to investigate the nucleation and growth dynamics of perovskite quantum dots and traditional nanoparticles in amorphous glass media. The research reveals the nucleation dynamics of amorphous nanoclusters. By directly observing the nucleation and crystallization process of perovskite quantum dots and traditional nanoparticles, the coexistence of non-classical nucleation theory and classical nucleation theory has been verified. In addition, we find that rare-earth doping not only facilitates the nucleation and crystallization process of perovskite quantum dots in amorphous glass media, but also exhibits excellent optical performance. Based on the optimization of perovskite quantum dot glass with excellent optical properties, further research has been conducted in the areas of upconversion lasers, shortwave shielding, and low-temperature persistent luminescence. In recent studies, in the fields of X-ray imaging and mechano-luminescence, a series of studies have been carried out by embedding well-performing scintillating perovskite quantum dots in

Abstract

glass, resulting in transparent and homogeneous composite materials with good scintillation performance as well as excellent physical and chemical stability, achieving low-dose and high-resolution X-ray imaging. In addition, the encapsulation of perovskite quantum dot glass in an organic polymer matrix has realized the mechanical luminescence of ultra-short-lived perovskite quantum dots for the first time, which can be used for high-resolution dynamic stress imaging.

Key words: Perovskite; Glass-ceramic; X-ray imaging; Stress distribution

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F014: Stress-induced $CsPbBr_3$ Nano-crystallization on Glass Surface: Mechanism Study and Application Exploration

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Glass could be thought of as a super-cooled liquid on thermodynamically metastable state with extremely long relaxation time, thus it inclines to crystallize when supplied with energy, particularly in the form of heat, to go beyond the energy barrier against crystallization. In this work, we found a new force-driven moisture-mediated glass crystallization phenomenon in P_2O_5-$PbBr_2$-NaBr-Cs_2O-PbO glass. Upon the action of dynamical force, such as, fracture or friction, $CsPbBr_3$ nanocrystals (NCs) precipitates on glass surface. Advanced micromechanical analyses were adopted to reveal the close relationship between the damage degree of glass network and the phase transformation of $CsPbBr_3$ NCs. Some new optical sensing applications based on the mechanism of force-driven humidity-assisted crystallization of $CsPbBr_3$ NCs were explored.

Key words: Glass; $CsPbBr_3$; Nanocrystallization

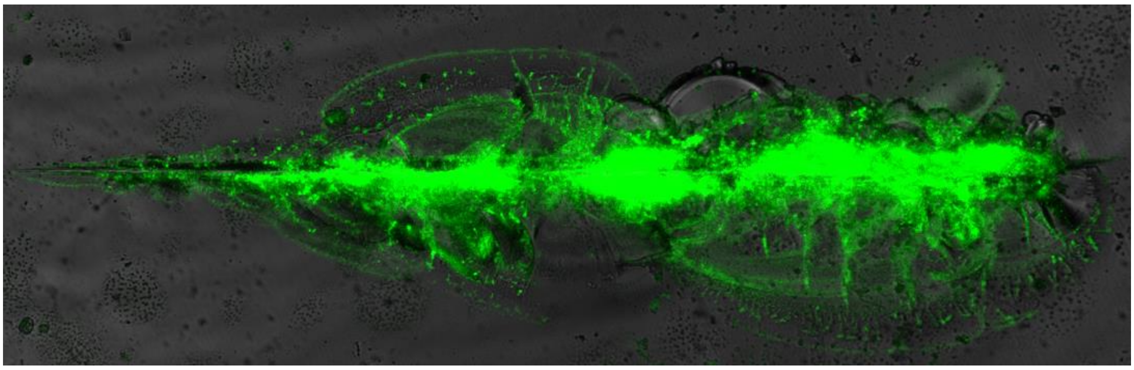

Fig.1 Confocal laser scanning microscope image on the scratched surface of P_2O_5-$PbBr_2$-NaBr-Cs_2O-PbO glass.

Abstract

F015: Improved stability of $CsPbBr_3$ perovskite embedded glasses for white LED color converter with wide color gamut

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Perovskite nanocrystals (PNCs) based on cesium lead halide ($CsPbX_3$, X=Cl, Br, I) have been extensively studied due to their superior spectral properties, including high quantum yield up to 100% and a very narrow emission bandwidth down to 20 nm, which is suitable for high-definition displays. However, they suffer from inherently weak thermal, chemical, and photonic stabilities, which could be dramatically improved by the introduction of inorganic glass matrices. PNC-embedded glasses (PNEGs) can provide a solution for practical applications due to their significantly improved stability and excellent color conversion properties for white LED (wLED) fabrication. Nevertheless, most of the previously reported PNEGs were based on borate or germanate glasses, which possess relatively weak chemical and thermal stabilities. Thus, further enhancement in stability is required for the practical application of PNEGs.

In this study, we introduced and discussed our recent approaches to enhance the stability of CsPbBr3 PNEGs. A germanate-based CsPbBr3 PNEG was synthesized as a green phosphor and applied onto a glass substrate with $K_2SiF_6:Mn^{4+}$ (KSF) to create a white LED (wLED) using a remote phosphor in silicone (PiS) structure. The PNEG was also sintered with a transparent glass to form a phosphor in glass (PiG) structure, with KSF additionally applied on the PiG to create a wLED. Furthermore, we explored a boro-silicate glass matrix to find a PNEG composition that is chemically more stable than conventional germanate glasses. After fabrication of wLEDs, all samples exhibited white emission with a wide color gamut of up to ~130% of NTSC, demonstrating their practical feasibility.

Abstract

Key words: Perovskite, Nanocrystal, Glass, Stability

Abstract

F016: A new insight into the structural evolution of halide perovskite in glasses

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Metal halide perovskite $CsPbX_3$ (X = Cl, Br, I) nanocrystals (NCs) have attracted great attention due to their excellent properties, including high photoluminescence quantum yields (up to 90%), extremely narrow emission width (FWHM <20 nm), and tunable emissions extending the entire visible spectral region. However, the poor stability of $CsPbX_3$ NCs is still the major matter which hinders their practical applications. The key to resolving this problem is to develop a novel method for improving stability beyond the ion doping or/and the construction of heterostructure. Compared with the ex-situ embedding in hosts, the in situ growth of $CsPbX_3$ NCs in glass matrices improves their stability and opens them up to more potential applications in three-dimensional optical storage devices. Although trial-and-error experiments have improved the performance of the $CsPbX_3$ NCs in glass matrices in the past few years, it is still difficult to design and control the properties of the $CsPbX_3$ NCs in amorphous matrices based on the variety of contradictory mechanisms. Therefore, it is very urgent and important to elucidate the formation and structural evolution of halide perovskite NCs in glass matrices. More importantly, understanding multi-physical variables (temperature, pressure, light irradiation) co-induced structural evolution of $CsPbX_3$ NCs in glass matrices has guiding significance for designing and applying devices with heterostructures.

Abstract

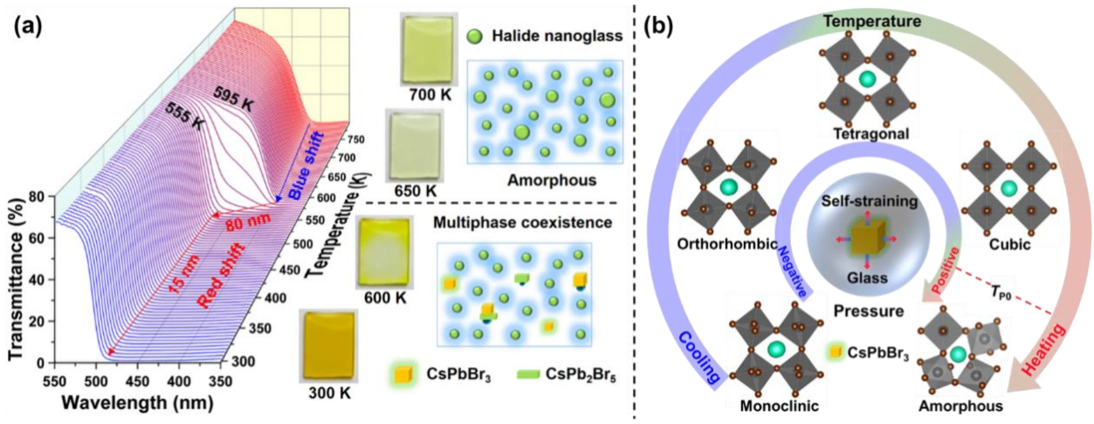

Figure 1. (a) Formation and (b) structural evolution of halide perovskite nanocrystals in glasses

In this work, we clarified the in-situ growth mechanism of halide perovskite NCs in amorphous matrices and proposed an adjustable self-straining strategy to control their temperature and pressure co-induced phase transitions. The synchronous pressure regulation, based on the thermal expansion mismatch between the NCs and the glass matrix, can be achieved by changing a single temperature variable. Two new phase transition processes of $CsPbBr_3$ NCs, including monoclinic-orthorhombic and reversible amorphization, are clarified for the first time using the proposed self-straining strategy. All the phase transition temperatures of the self-straining NCs show a high sensitivity response to the pressure regulation. Most importantly, the encapsulation of $CsPbBr_3$ NCs in a glass matrix excludes the effect of external environments allowing us to elucidate the widely existing "self-straining effect" for heterostructured NCs and phase segregation for mixed-halide perovskite. We proved that there are five phases (monoclinic, orthorhombic, tetragonal, cubic, and amorphous) for $CsPbBr_3$ NCs in glasses, and there is a dynamical process combining compositional segregation (mixing) and structural disorder (order) for mixed-halide $CsPbX_3$. This work provides a better fundamental understanding of the phase transitions of halide perovskite NCs and paves the way toward the development of an in situ method to predict the multi-physical variables co-induced structural evolution of halide perovskite NCs in optoelectronic devices.

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Abstract

F017: Sunlight excitable Perovskite quantum dots sensitized near-infrared emitting glasses

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$CsPbBr_3$ perovskite quantum dots (PQDs) and Nd^{3+} co-doped tellurite glass ceramic (GC) phosphor is designed to significantly upgrade the NIR photoluminescence (PL) performance of Nd^{3+}. Benefiting from the sensitization effect of the PQDs on Nd^{3+}, the PL excitation band of Nd^{3+} is greatly extended in the visible spectral region, permitting far more excitation channels that are impossible for conventional Nd^{3+}-doped glass phosphors. Consequently, we demonstrate the first sunlight pumped NIR emitting GC phosphor. A proof-of-concept demonstration for nigh vision application is given using the designed NIR pc-LED. The implications of the present study are enormous considering diverse combinations of PQDs and rare earth ions in GCs.

Key words: perovskte glass; near-infrared phosphor; sensitization

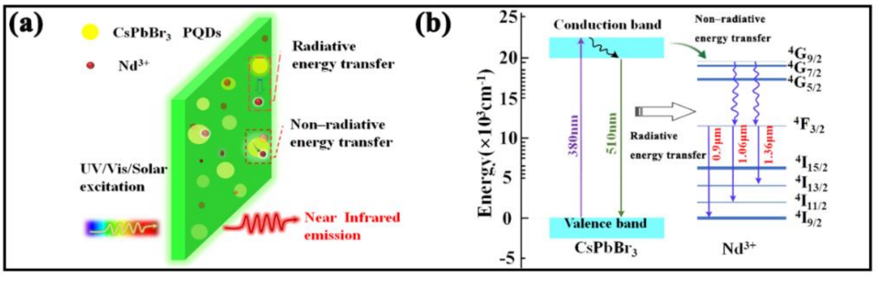

Fig.1 Conceptual graph of NIR emission from the $CsPbBr_3$ PQDs-sensitized Nd^{3+} doped glasses

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Abstract

F018: Preparation and optimization of optical properties of $CsPbX_3$ perovskite quantum dot glass

Zhousu Xu[1,3], Yijian Yang[1], Peng Wang[1], Xiaofeng Liu[2], Zhongjie Li[3]

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$CsPbX_3$ perovskite quantum dots (PQDs) glasses were prepared by conventional melt-quenching followed by a thermal treatment process. The optical properties of PQDs glasses were optimized by glass network structure modulation. For example, by adjusting the ratio of B_2O_3 and SiO_2 to control the ratio of two-dimensional and three-dimensional glass network structures, the photoluminescence (PL) quantum yield of $CsPbI_3$ PQD-doped glasses could be increased to 50.5%, as shown in Figure 1(a). The crystallization behavior and optical properties of PQD-doped glass could also be regulated by modulating the network structures through the introduction of a glass network intermediate ZnO, as shown in Figure 1(b). The PQD-doped glasses could have potential application in the field of optoelectronic devices due to their excellent optical properties and stability.

Key words: $CsPbX_3$ perovskite; glass network; quantum dot glass; optical properties

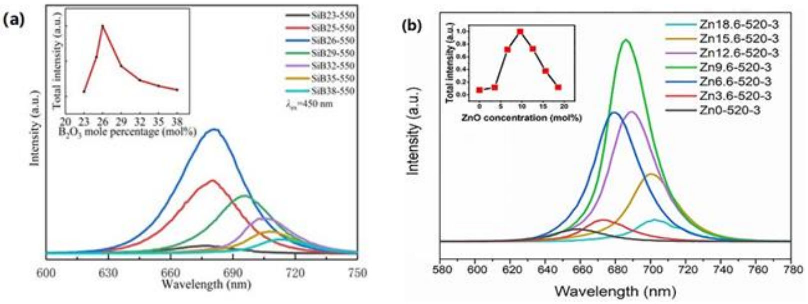

Fig.1 PL spectra of PQD-doped glasses with different (a) B_2O_3 and (b) ZnO concentrations.

Abstract

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ABSTRACT

Session G

Modeling, simulation and artificial intelligence of Glasses

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Abstract

Abstract

Session G:

Modeling, simulation and artificial intelligence of glasses

Symposium G: Modeling, Simulation and Artificial Intelligence of Glasses

To advance the field of glass science and technology, an unprecedented level of understanding is required on glass materials. This symposium will address the contribution of **Modeling, Simulation and Artificial Intelligence of Glasses** on the fundamental principles and applications of glass physics and chemistry, across a variety of chemistries (oxide, metallic, organic, chalcogenide, etc.), physics (photonic, electric, thermodynamics, etc.), phase changes (nucleation, crystallization and phase separation), as well as length scales (from the atomistic glass structure to large-scale behaviors). Session topics will cover fundamentals of glass structure and properties, as well as changes in various macroscopic properties as a function of chemistry and processing. It also involves the most recent emerging topics, such as machine learning, big data and their applications in predictive modeling of glass properties, as well as the other modeling and theory development.

Focused topics:

- Molecular dynamics and Monte Carlo simulation of glass
- First-principle and DFT calculation of glass
- Mechanical modelling on glass
- Machine learning and modelling of glass
- Material genome of glass structures and properties
- Quantitative structure-property relationship (QSPR) study on glass
- Modeling and simulation on glass furnaces and kilns
- Other glass modeling and theory development

Session Chairs:

Jincheng Du, University of North Texas, USA
Alastair N. Cormack, Alfred University, USA
Xusheng Qiao, Zhejiang University, China

Point of Contact

Xusheng Qiao, Zhejiang University, China; Phone: +86-571-8795-1234; E-mail: qiaoxus@zju.edu.cn

Keynote speakers :

1. Alastair N. Cormack, Alfred University, USA
Atomic Scale Melting Mechanisms in Silicate Glasses

2. Walter Kob, Université de Montpellier, France
The medium-range order in silicate glass-formers: From standard two-body indicators to many-body correlations

Abstract

Invited Speakers :

1. Jincheng Du, University of North Texas, USA
Composition effect on ion-exchange strengthening in borosilicate glasses from molecular dynamics simulations and QSPR analysis

2. Liping Huang, Rensselaer Polytechnic Institute, USA
Molecular Dynamics Study on the Viscosity of Glass-forming Systems

3. Pengfei Guan, Beijing Computational Science Research Center, China
Large-scale simulation of multi-component metallic glasses

4. Shingo Urata, AGC company, Japan
Force-matching potential for investigating an effect of Al2O3 addition on the thermal expansion of sodium alkaline-earth silicate glasses

5. Hong Li, Nippon Electric Glass (NEG-US), USA
Raman spectroscopic study of MgO-CaO-Al2O3-SiO2 glasses and statistical modeling of composition-structure-property relationships

6. Hiroyuki Inoue, Institute of Industrial Science, The University of Tokyo, Japan
Structural simulations of RO-B2O3 (R=Mg, Ca, Sr, and Ba) glasses by the first principle molecular dynamics technique

7. Huidan Zeng, East China University of Science and Technology, China
Molecular dynamics simulations study on structure and properties of aluminosilicate glasses

8. Xusheng Qiao, Zhejiang University, China
Structural Simulation and Spectroscopic Computation of Rare Earth Doped Multi-component Glasses

9. Neng Li, Wuhan University of Technology, China
The Atomic Structures and Optical Properties: From Silicate Glass to MOF Glass

10. Liyan Zhang, Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, China
The application of statistical glass structure gene modeling in laser glass and HLW glass

11. Lu Deng, Shanghai Institute of Optics Fine Mechanics, Chinese Academy of Science, China
Composition-structure-property relationship of phosphate glasses: A combination of experiment, simulation, and QSPR analysis

12. Wenke Li, Wuhan University of Technology, China
Carrier Recombination Dynamics of PbS Quantum-Dot-In-Glasses by Time-Dependent Density Functional Theory and Nonadiabatic Molecular Dynamics

13. Han Liu, Sichuan University, China
Deciphering a structural signature of glass dynamics by machine learning

14. Zhen Zhang, College of Materials Science and Engineering, Chongqing University, China
Understanding the deformation and fracture of silicate glasses from atomistic simulations

15. Haishen Ren, Shanghai Institute of Ceramics, Chinese Academy of Sciences, China
Molecular dynamics simulations to structure-properties relationship of $MgO-BaO-CaO-Al_2O_3-B_2O_3-SiO_2$ glass-ceramic for intermediate temperature solid oxide fuel cell

Oral Speakers :

1. Linfeng Ding, State Key Laboratory for Modification of Chemical Fibers and Polymer Materials, Engineering Research Center of Advanced Glass Manufacturing Technology, Ministry of Education, Donghua University,China
Nanoindentation-induced evolution of atomic-level properties in silicate glass: Insights from molecular dynamics simulations

2. Shiqing Xu, Yanshan University, China
Structural response to densification of Na2O-Al2O3-SiO2 glasses with different load indentation centers

3. Zeshi Guo, Xinjiang Institute of Physical and Chemical Technology, Chinese Academy of Sciences, China
Study on the Influence of Chemical Composition and Fiber-forming Process on the Atomic Structure of Basalt Fiber: An experiment and molecular dynamics study

4. Yong Yang, China Building Materials Glass New Materials Research Institute Group Co., Ltd, China
Application of digital technology in research and development of new glass materials

5. Ying Tian, China Jiliang University, China
Simulation prediction of thermal properties and spectral characteristics of Er3+ doped fluorotellurite glasses

6. Yiping Huang, Zhejiang University, China
Molecular Dynamics Simulation Study on the Structure of Fluorosilicate Glass

7. Bozhao Ying, East China University of Science and Technology, China
Influence of glass structure units on the electronic structure of cesium lead halide perovskite quantum dots

8. Xiaodi Liu, Shenzhen University, China
Understanding Glass formation Ability and Origin of Plasticity in Metallic Glasses Through Machine Learning Techniques

9. Rasmus Christensen, Aalborg University, Denmark
Predicting dynamics in sodium silicate glasses using graph neural networks

10. Seok Jin Hong, Kongju National University, Korea
Machine Learning Based Prediction of Refractive Index and Glass transition temperature of B2O3-

Abstract

La_2O_3-Ta_2O_5-ZnO Glasses for High Refractive Index Optical Lens

11. Yuanqing Lu, Otto schott institute of materials research, Germany
Machine learning for predicting the distribution of multiple Al_2O_3 phases synthesized by plasma-assisted aerosol

12. Du Tao, Aalborg University, Denmark
Predicting *Fracture and Conduction Propensity in Glassy Electrolytes Using Classification-Based Machine Learning*

13. Taygun Akar, SISECAM, Turkey
Enhancing Production Efficiency: A Statistical Approach to Glass Coloring and Optical Performance

14. BURCIN GUL ARSLANOGLU, ÅžÄ°ÅžECAM, Turkey
Pushing the Limits of Production in Float Furnaces

15. Ci Wang, Harbin Engineering University, China
Theoretical Insights into Band Gap and Defect Engineering for Enhanced properties in Glass-Ceramics Scintillators

Abstract

Brief introduction of speakers

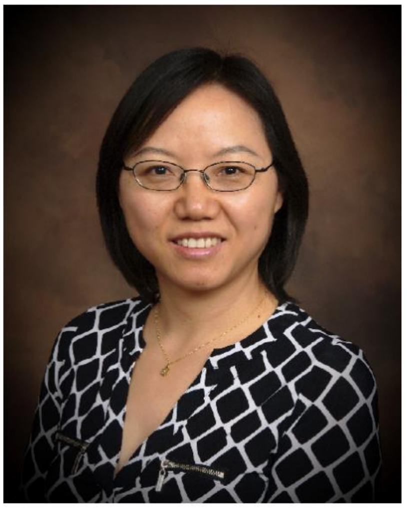
Keynote speakers:

Alastair N. Cormack, PhD, Professor at the New York State College of Ceramics at Alfred University. He is a leading authority in the field of computer modeling of materials, focusing on the atomic-scale physics and chemistry of ceramics and glass.

WALTER KOB, Full Professor (classe exceptionnelle), D´epartement de Physique, Uni-versit´e Montpellier. Research in statistical mechanical properties of disordered systems (supercooled liquids, glasses, granular materials, gels, oxide glasses). He is the recipient of George W. Morey Award from the American Ceramic Society; Senior member of the Institut Universitaire de France; Darshana and Arun Varshneya Frontiers of Glass Science Lecture by the Amer-ican Ceramic Society; Ivan Peych`es Award of the French Academy of Science; Otto Schott Research Award for "Outstanding research achievements in glass science".

Invited speakers:

Dr. Jincheng Du is a Professor of materials science and engineering at the University of North Texas in USA. After obtaining his B.E. in material science and M.E. in inorganic materials from Wuhan University of Technology, he studied at the New York State College of Ceramics at Alfred University and obtained Ph.D. in ceramic science in 2004. He then did postdoctoral research at the Pacific Northwest National Laboratory and University of Virginia in U.S.A. before joining University of North Texas as a faculty member in 2007. His research focus on atomistic simulations of materials, particularly the structure, structure-property relation, defect and interfaces, corrosion and environment interactions of glass and ceramic materials for energy storage, nuclear waste disposal, microelectronics and other applications. He has published 2 books, 12 book chapters, and over 210 peer reviewed papers. As one of the leading experts in his field, he has given over 100 invited talks and seminars in international conferences and at universities around the world. Prof. Du currently serves as the Chair of TC27 atomistic modeling of International Commission of Glass (ICG) and Editor of the Journal of the American Ceramic Society. He is the past chair of the Glass and Optical Materials Division of the American Ceramic Society. Among other distinctions, he is an elected Fellow of the American Ceramic Society and American Society of Materials (ASM International). He is also the recipient of Research Leadership Award, Early Career Award of Research and Creativity of UNT, Fulbright US Scholar Award, Gordon Fulcher Distinguished Scholar of Corning Inc., and the W.E.S Turner Award of ICG.



Dr. Liping Huang is a Professor of Materials Science and Engineering at Rensselaer Polytechnic Institute (RPI). She obtained her B.E. and M.S. degree in Materials Science and Engineering from Zhejiang University, China, and her Ph.D. degree from the University of Illinois at Urbana-Champaign, USA. After several years of postdoctoral research experience at the University of Michigan and North Carolina State University, she joined RPI as a tenure-track faculty in 2008. Her primary research interest is to investigate the structure-property relationships at the atomic level in amorphous materials by using a combination of *in-situ* light scattering techniques and multi-scale computer simulation methods. She was elected as a fellow of the American Ceramic Society (ACerS) in 2020. She is a member of TC 27 on "Atomistic Modeling and Simulation of Glass" in the ICG, currently also serves as an editor for the Journal of Non-Crystalline Solids.

Abstract

Hong Li, Ph.D. in Metallurgical Engineering (University of Nevada, Reno, USA, 1992), Senior Scientist in the field of fiber glass research and technology development with a combined 22 years of experience working at Nippon Electric Glass and PPG Industries. His major R&D activities include new fiber glass product development for a wide range of market applications, covering high-modulus fiber for wind turbine blades, corrosion resistant fiber for chemical protection, low dielectric fiber for high end print circuit board, etc. Dr. Li also worked in the fields of vitrification of high-level radioactive waste glass and high-power laser glass in various roles at Pacific Northwest National Laboratory and SCHOTT Norther America, Inc., respectively.

Dr. Li is a recipient of PPG Industries INNOVA AWARD and a Distinguished Member of PPG Collegium. Dr. Li is the Fellow of the American Ceramic Society (ACerS) and formerly chaired the Glass and Optical Materials Division (GOMD, ACerS). He also served as a Council Member of the International Commission on Glass for 11 years. Dr. Li has co-authored more than 100 journal publications and published two monographs on Fiberglass as an editor-in-chief, and Specialty Glass as co-editor, respectively. Recently Dr. Li served as a chief translator, in charge of the publication of an English version of History of Ancient Chinese Glass Technology Development (中国古代玻璃技术发展史) edited by Fuxi Gan. Dr. Li is an inventor or co-inventor of more than 100 patents/patent applications worldwide in the fields of fiberglass and laser glass worldwide.

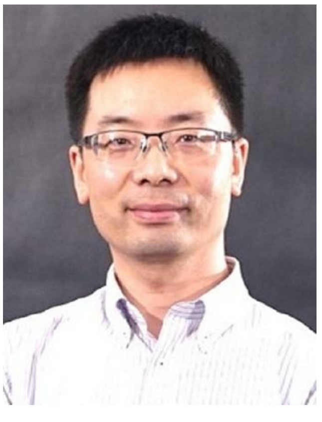
Abstract

Pengfei Guan, professor at the Beijing Computational Science Research Center. He focuses on the microscopic mechanisms and theoretical design of advanced material properties, conducting interdisciplinary research that integrates knowledge and methods from various disciplines such as physics, materials science, mathematics, computer science, and data science. His research explores the structure and property relationships of amorphous materials, performance-driven design of disordered alloys, and multiscale simulations & performance predictions of materials in special service environments. He has published more than 120 papers in SCI journals, including 10 in Nature sub-journals, 10 in Phys. Rev. Lett., and 10 in Acta Mater. His papers have been cited over 6000 times in total. He has led projects funded by the National Natural Science Foundation of China, including the Distinguished Young Scholars Program and General Programs. He serves as a member of the Computational Materials Division of the Chinese Materials Research Society and a member of the Non-crystalline Alloys and Applications Division of the Chinese Society for Metals. He is also an associate editor/editorial board member of academic journals such as National Science Open and Materials Future.

Hiroyuki Inoue, Professor at Institute of Industrial Science, the University of Tokyo, Japan. His research is primarily focused on investigating the fundamental problems related to glass structure and computer simulations.

Liyan Zhang received her PhD in material science in 2005 from Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences. She has been working in SIOM since 2008 on the basic research of near-infrared and mid-infrared laser glass and fibers. She established the statistical glass structure gene modeling (GSgM) methodology, and has been leading the development of the Nd:phosphate glass and nuclear waste glass simulation database.

Huidan Zeng is a full professor at School of Materials Science and Engineering, East China University of Science and Technology. Her research interests are functional glass design and processing combined with molecular dynamics simulation for advanced applications, such as photonic devices, semiconductors, passivation/sealing glass for electronics devices, glass fiber, and metal pastes (e.g., silver, copper). Until now, she has applied 10 patents and published more than 100 peer-reviewed papers in international Journal, including Chem. Mater.，J Am Ceram Soc， Ceram International, J Euro Ceram Soc, J Non-crystal Solids, Appl Phys Lett. Besides, she has served as editorial board for several Journals, such as Journal of Chinese Ceramic Society, Journal of Luminescence. she is the board of directors of the Chinese Ceramic Society and the Shanghai Ceramic Society. She also received fundings from governments and corporations, such as Marie Curie fellowship, National Natural Science Foundation of China (5), National Science and Technology Department Foundation.



Xusheng Qiao, Ph. D., Associate Professor at Zhejiang University. He received his Ph.D. degree in 2007 at Zhejiang University. His research is mainly focused on luminescent glass and glass-ceramics, simulation on glass structures, as well as functional nanomaterials and microspheres. He serves as members of the Specialty Glass Division and the Electronic Glass Division of the Chinese Ceramic Society, members of the Optoeletronic Materials and Devices Devision and the Crystal Materials Division of the Chinese Society of Rare Earths. He also serves as the Secretary General of the Hangzhou Ceramic Society as well as the Head of Zhejiang University – Assure Biotech Collaborative R&D Center. He has published more than 200 peer-reviewed papers on international Journals, including ACS nano, Advanced Functional Materials, Advanced Science, etc. He serves as editorial board for several Journals, such as Journal of Rare Earths. He has received 20+ research funds from governments and corporations, such as National Natural Science Foundation of China and Zhejiang Province.

Neng Li, Fellow of Royal Society of Chemistry (FRSC), Fellow of IAAM, Full professor in the State Key Laboratory of Silicate Materials for Architectures, Wuhan University of Technology, He received Ph.D. degree in 2011 from the Huazhong University of Science and Technology. He worked at University of Cambridge as a visiting professor in 2016–2017. His current research interests focus on amorphous materials, silicate-based materials, such as cement, concrete and so on. He has published >250 peer-reviewed papers, and be cited over 15000 times, with H-index of 65. He serves on the editorial boards/young advisory board of *Materials Horizons*, *Advanced Powder Materials*, *Nano-Micro Letter*, *Journal of Inorganic Materials*, *Acta Physico-Chimica Sinica*, etc.

Lu Deng is a professor in the Laboratory of High Power Laser Optical Components at Shanghai Institute of Optics and Fine Mechanics (SIOM), Chinese Academy of Sciences. Dr. Deng received his Ph.D. in Materials Sciences and Engineering from the Department of Materials Science and Engineering at University of North Texas (UNT), USA in 2017. Dr. Deng's research expertise lies in atomistic computer simulations of glass and amorphous materials. He develops empirical potentials and computational tools to understand the structure, properties, and their relationships of the glass and amorphous materials. His current research topics include composition-structure-property relationships, nuclear waste immobilization, corrosion behavior, crystallization behavior, and other glass material related topics using multi-scale computational modeling and machine learning techniques. Dr. Deng's research has been funded by projects from NSF, DOE, SRC, AGC, Corning, and national projects from China. He has published over 30 peer reviewed papers and two book chapters, with Google Scholar citation over 1000 (h index 23, i10 index 26). He is a recipient of the talent program of Chinese Academy Sciences and Shanghai, as well as the Young Scholar Award from the Chinese Ceramic Society.

Abstract

Wenke Li obtained her PhD degree in PSL university and Wuhan University of Technology. Her research is focused on exploring the luminescence mechanism of optoelectronic materials, particularly on quantum dots(QDs) doped glasses, through combining molecular dynamics(MD), density functional theory(DFT), time-dependent DFT and nonadiabatic MD. To improve the understanding of optical properties of QDs doped glasses, she used multiscale simulations to investigate the structure and electronic structure of QD/glass interface. Some of her studies were published on Journal of American Chemical Society and Journal of the American Ceramic Society.

Han LIU is a materials physicist who is combining computational simulations and machine learning techniques to accelerate the design of disordered materials, including glassy materials, porous materials, and mechanical metamaterials. He obtained his Ph.D. from the Department of Civil and Environmental Engineering at University of California, Los Angeles (UCLA) in 2021, and concurrently obtained a master's degree from the Department of Electrical and Computer Engineering at UCLA in 2020. Prior to UCLA, he obtained his bachelor's and master's degrees from the College of Polymer Science and Engineering at Sichuan University (SCU, CHINA). Since 2022, he continued to work as a Postdoc at UCLA and now join SCU as a faculty, establishing the SOlids inFormaTics AI-Laboratory (SOFT-AI-Lab). As the Lab header, his present research interest lies in the intersection between machine learning and computational materials, toward an advanced AI-computing platform for disordered materials modeling and inverse design.

Zhen Zhang obtained his PhD degree in Physics from the University of Montpellier in 2020 and subsequently worked as a postdoctoral researcher at Xi'an Jiaotong University (China). He is currently an Associate Professor at the Department of Materials Science, Chongqing University (China). His research focuses on the microstructure-property relationships in disordered materials, notably glasses. He is expertised in developing and using state-of-the-art computational and numerical methods to probe and understand the physics behind the intriguing properties of these materials. He has published 17 peer-reviewed articles, including 4 PNAS, 2 PRL, and 1 Acta Materialia.

Abstract

Haishen Ren, Ph. D., Associate Researcher of the Shanghai Institute of Ceramics, Chinese Academy of Sciences. He has been engaged in basic research on the application of special glass materials for a long time, especially in the design and application of high-temperature resistant microcrystalline glass sealing materials for solid oxide fuel cells, oxygen sensors, aviation engine sensors, and other fields. He is currently hosting 7 projects, including the National Natural Science Foundation Youth Science Foundation and National Defense and Enterprise Commissioned Projects. He has published 15 SCI papers, got authorization with 6 Chinese invention patents, and published 2 enterprise standards. He also received the "Excellent Award" at the 4th China Innovation Challenge and the 3rd Zhongguancun Emerging Field Special Competition in 2019.

G001: Atomic Scale Melting Mechanisms in Silicate Glasses

Alastair N. Cormack

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Melting has been called the single most important phase transition in materials science. For millennia, the production of glass, particularly silicate glass, has required the melting of a set of raw materials (known as the batch) into a homogeneous melt. Sometimes, silica particles do not completely dissolve, leading to inclusions, such as seeds or knots, in the resulting glass. Since the atomic scale mechanisms underlying batch melting are poorly understood, optimization of the melting process, including silica dissolution, is limited.

Over the last couple of decades or so, atomistic simulations, primarily molecular dynamics, have been shown to be an indispensable tool for the characterization of silica based glasses such as used commercially for a wide range of applications such as containers and architecture.

We have thus undertaken a series of molecular dynamics simulations in an effort to improve our understanding of the melting mechanisms in silicate glasses. In this presentation, we will focus on the dissolution of silica grains in a soda-lime silicate melt, typical of the compositions used in commercial glasses such as used for containers or window glass.

Key words: Molecular Dynamics; Batch Melting; Silica Dissolution

Abstract

G002: The medium-range order in silicate glass-formers: From standardtwo-body indicators to many-body correlations

Walter KOB[1], Zhen ZHANG[2]

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2. Department of Physics, Chengdu University of Technology, Chengdu, China

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Recent studies have shown that many features of glasses depend on the properties of their medium range order. Using large scale computer simulations, we probe the medium-range order in silica and sodium silicate glass-formers as a function of composition and temperature. This order is characterized by means of a variety of structural indicators that include standard two-point correlation function but also novel higher order correlators(1). We find that the standard structural indicators show no remarkable behavior on the temperature and alkali concentrations. However, by monitoring a recently introduced four-point correlation function one discovers that in these glasses the intermediate range order is very pronounced on the scale of nanometers and shows a surprisingly complex dependence on temperature and alkali concentration. We demonstrate that the structural decay lengths as obtained from these correlation functions are correlated with the macroscopic observables related to the kinetic fragility of the supercooled liquids as well as the elastic properties of the glasses.

Key words: Glass; Computer simulations; Structure; Medium range order

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G003: Molecular Dynamics Study on the Viscosity of Glass-forming Systems

Yanming Zhang, Liping Huang, Yunfeng Shi

Department of Materials Science and Engineering, Rensselaer Polytechnic Institute, Troy, NY

Email: huangL5@rpi.edu

Temperature-dependent viscosity is critical to deciphering two profound questions in condensed matter physics, namely the glass transition and the relaxation of glassy solids. In this work, we derived an analytical model to show that the shear viscosity in a logarithmic scale changes linearly with the shear-induced variation in shear modulus or potential energy of the glass-forming system. The shear viscosity as a function of the steady-state potential energy of liquid under different shear strain rates can be directly calculated in molecular dynamic (MD) simulations; together with its equilibrium potential energy, one can extrapolate the zero-strain-rate equilibrium viscosity of liquids at different temperatures. Furthermore, this model can predict the nonequilibrium viscosity of glass given the corresponding potential energy that is thermal history dependent. From the nonequilibrium viscosity of 20 glass-forming systems calculated in MD simulations, we identified a universal nonequilibrium viscosity value at the high-temperature limit for superheated glasses, which substantially simplifies the Mazurin model to reproduce the temperature- and time-dependent nonequilibrium viscosity measured in experiments. Our study reveals a close connection between the nonequilibrium viscosity and the nonexponential relaxation of glass..

Key words: Viscosity; Glass-forming systems; Potential energy; Molecular dynamics simulations

References：

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Abstract

G004: Molecular dynamics simulations study on structure and properties of aluminosilicate glasses

Rui Yang, Chunyu Chen, Cong Zhong, Liangzhu Zhang, Huidan Zeng*

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Email: hdzeng@ecust.edu.cn

Molecular dynamics (MD) simulation has been one of the effective tools for predicting the properties of glass, such as structural, mechanical, thermophysical properties. In our study, we studied the structural properties of Lead aluminosilicate glass and alkali-earth aluminosilicate glass glasses by applying MD simulation. Pb^{2+} plays the role of both charge compensators and network modifiers at a low PbO content. When the PbO content exceeds 30 mol%, some Pb^{2+} ions will be incorporated into the network that leads to rearranging of the network structures. After entering the glass network, Pb^{2+} ions first break the Al-O-Si linkages to form the Si-O-Pb and Al-O-Pb bonds. Then the remaining Pb^{2+} ions preferentially form the Pb-O-Pb bonds. In CaO-MgO-B_2O_3-Al_2O_3-SiO_2 glass system, we discovered that four-coordination aluminum is the major coordination in the aluminum structural units when the molar ratio of B_2O_3/MgO is increased. While the boron coordination environment does not change significantly with the substitution, and the three -fold boron remains at a high level. Furthermore, the glass stability is enhanced with the increase structural units of bridge oxygen. There is only about 10% difference between the Young's moduli calculated by MD simulation and the experimental values. High content of MgO can increase the atomic packing density and improve the elastic moduli.

Key words: Glass; Molecular dynamics (MD) simulation; aluminosilicate glasses

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[5] C. CHEN, C. ZHONG , A. LI , et al. Materials Today Communications， 2022, 32:103945

Abstract

G005: Molecular Dynamics Simulations to Structure-Properties Relationship of MgO–BaO–CaO–Al2O3–B2O3–SiO2 Glass-ceramic for Intermediate Temperature Solid Oxide Fuel Cell

Haishen Ren, Huixing Lin

Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai 201899, P R China
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The sealing material is one of the key materials of intermediate temperature solid oxide fuel cell (ITSOFC). The stability of the material structure and the stability of the performance seriously affect the service life of ITSOFC. Therefore, it is of great significance to study the ideal sealing material for the development of SOFC. As a suitable sealing material, glass-ceramic has the advantages of low cost, good sealing performance and adjustable performance. BCABS (BaO-CaO-Al_2O_3-B_2O_3-SiO_2) glass–ceramic has good sealing performance. However, when used at high temperature, the structure of the material will change over time, resulting in a decrease in the coefficient of thermal expansion and a mismatch with other components.

In order to improve the thermal stability of BCABS, the MBCABS (MgO-BaO-CaO-Al_2O_3-B_2O_3-SiO_2) system was designed by adding MgO to the original system formula to improve the sealing performance by adjusting the material structure. In this work, the mechanism of magnesium oxide (MgO) inhibiting phase precipitation and phase transformation of $BaAl_2Si_2O_8$ in BaO-CaO-Al_2O_3-SiO_2-B_2O_3 glass-ceramic is systematically investigated and analyzed by Molecular Dynamics Simulations and glass structure analysis (FTIR and Raman). The simulation results show that the addition of MgO will change the coordination number of B from 3-coordinated ([BO_3]) to 4-coordinated ([BO_4]), the transition of bridge oxygen to non-bridge oxygen and Qn distribution of the [SiO_4] tetrahedron from Q3 to Q1 in the MBCASB glass structure, which are confirmed by IR and Raman analysis of the melt-quenching MgO-BaO-CaO-Al_2O_3-B_2O_3-SiO_2 glass. Consequently, the precipitation process of $BaAl_2Si_2O_8$ phase is inhibited by the silicate structure transform from pyrosilicate (SiO_3^{2-}) to protosilicate (SiO_4^{4-}), resulting in that the $BaAl_2Si_2O_8$ phase is gradually replaced with $MgSiO_3$, Mg_2SiO_4, $BaMgSiO_4$ and $BaCa_2Mg(SiO_4)_2$ phase with increasement of the MgO in the MBCASB glass. Hence, the coefficient of thermal expansion of the sealant BaO-CaO-Al_2O_3-B_2O_3-SiO_2-MgO glass-ceramic decreases from $11.75\times10^{-6}K^{-1}$ to $10.70\times10^{-6}K^{-1}$ and rise to $12.37\times10^{-6}K^{-1}$ with the increasement of MgO content.

Abstract

G006: Data-Driven Simulation and Design of Metallic Glasses

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The interplay of disorderly characteristics and structural heterogeneity in metallic glasses presents a formidable challenge for experimental endeavors aimed at characterizing their atomic-scale attributes and their connections with physical properties. Current experimental techniques are still hampered by insufficient spatiotemporal resolution, impeding the ability to capture their atomic-scale attributes and their responses to external influences. Theoretical research, grounded in computational simulations, has emerged as an effective means to surmount this challenge. However, a substantial chasm still exists between theoretical model systems and real-world amorphous alloy materials, stemming from issues related to the precision in describing multi-element cooperative behavior, computational methodologies, and computing capabilities. In recent years, we've harnessed and amalgamated knowledge from various disciplines and incorporated the latest research advancements to explore and develop research methods with atomic-level precision. These techniques have proven successful in shedding light on the structural and performance correlations within intricate amorphous alloy systems. These works offer a potential avenue toward establishing a theoretical framework for disordered alloys and the intelligent design of material properties.

Abstract

G007: The application of statistical glass structure gene modeling in laser glass and HLW glass

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Composition-structure-property (C-S-P) modeling, named as "glass structural gene modeling (GSgM), is a method that threads composition-structure (C-S) and structure-property (S-P) modeling together to carry out accurate simulation. High accuracy of GSgM comes from the transformation of the nonlinear relationship of C-P to two linear relationships of C-S and S-P (cf. Fig.1a). The combination of C-S and S-P models produced the modeling platform to carry out the bi-directional C↔S↔P modeling, revealing the relationship between glass composition, structure and property in depth. Furthermore, S-P modeling alone can be used independently to simulate glass property.

C-S-P method has been successfully applied to laser glass and HLW solidification glass in SIOM. Non-linearly varied properties, such as the spectroscopic properties, chemical durability and liquidus temperature (T_L), are difficult to achieve accurate simulation with limited data by C-P modeling, while C-S-P method is proved to be a valuable alternative to solve this problem. Integral area of Gaussian peaks derived from FTIR or Raman peak fitting was used as the structural data to build S-P and C-S models. C-S-P modeling platform based on C-S and S-P models was then established to simulate glass property or design glass composition (cf. Fig.1b). GSgM is highly suitable for the initial glass composition screening and property prediction purpose with limited data and future database development.

Key words: GSgM modeling, non-linearly varied property, modeling platform

Abstract

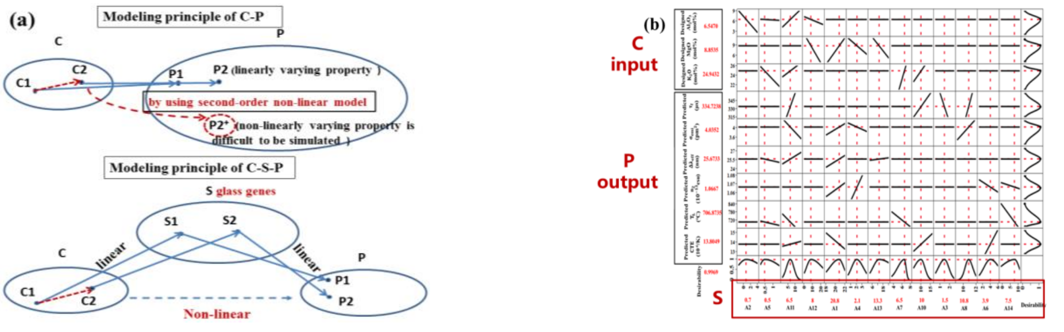

Fig.1 (a) Modeling principle of C-P and C-S-P; (b) C-S-P modeling platform

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Abstract

G008: Composition-structure-property Relationship of Phosphate Glasses: A combination of Experiment, Simulation, and QSPR Analysis

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Phosphate glasses have various applications in fields including biomedical materials, optical components, and sealing materials. In addition, its ability, containing more rare-earth elements than the borosilicate glass, makes it become a potential candidate of the high-level nuclear waste virtrification for those with high rare-earth content. Therefore, it is important to understand the composition-structure-property relationship of the phosphate glasses. In this paper, an architype of multi-component phosphate glasses, sodium aluminophosphate (SAP) glasses, has been investigated by using molecular dynamics (MD) simulations. In addition, experiments of Raman and synchrotron X-ray total scattering have been performed to characterize the glass structures and validate the simulation results. Moreover, the Quantitative Structure-Property Relationship (QSPR) analysis was performed to correlate the simulated glass structures with the experimentally measured properties, such as the density, T_g, CTE, and hardness. Results show that additional aluminum content will lead to a gradual replacement of the P-O-P linkages by the P-O-Al linkages, and it will also modify the long chains of the SAP glass into three-dimensional ring structures. The QSPR models show linear relationships between the structural descriptors from simulations and the measured properties; in addition, its ability to predict certain glass properties based on the simulated glass structures has also been validated.

Key words: Phosphate glass; QSPR analysis; Composition-structure-property relationship

Abstract

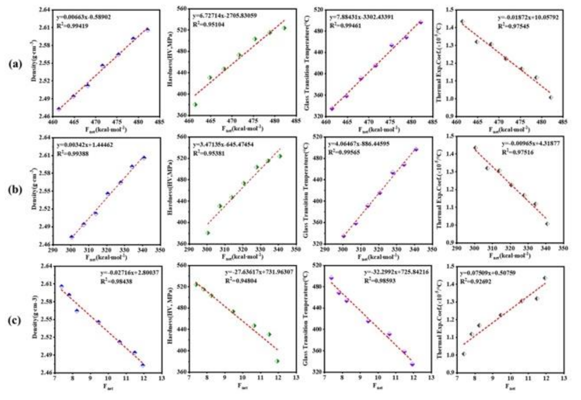

Fig. 1 QSPR analyses on the density, hardness, glass transition temperature, and thermal expansion coefficient with different descriptors.

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Abstract

G009: Composition effect on ion-exchange strengthening in borosilicate glasses from molecular dynamics simulations and QSPR analysis

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Atomistic computer simulations have evolved as an important tool to understand the structures and structure-property relations of glass materials, as well as in designing glasses for various functional applications. In this talk, I will introduce the development of interatomic potentials of borosilicate glasses, the Quantitative Structure-Property Relationship (QSPR) approaches and their application in studying ion-exchange strengthening in borosilicate glasses. Ion-exchange (IOX) strengthening is a widely used method to enhance mechanical properties of glass materials and find wide industrial and technological applications. Although widely studied experimentally, the fundamental understanding of the IOX strengthening process is still rather limited that hinders effective design of glass compositions for chemical strengthening. Effect of boron oxide for silica and alumina for silica substitutions on the mechanical properties of different levels of K^+ to Na^+ ion exchanges were studied by using molecular dynamics (MD) simulations with a set of recently developed effective partial charge potentials. The linear network dilation coefficient (LNDC), a common measure of IOX behaviors, was calculated for each of the glass compositions. Quantitative structural property relationship (QSPR) analysis based on the MD-generated structural features was used to establish the structure–property correlations of mechanical and other properties. The results show strong composition dependence of the LNDC, hence the suitability of IOX strengthening. This behavior is discussed based on glass structure features of the glasses. It was found that glass compositions with a higher amount of mixed glass formers, higher network connectivity, and less complex components tend to show higher calculated LNDC and higher surface compressive stress. MD simulations in combination with QSPR analysis can thus provide atomistic insights into how the glass composition and structural characteristics affect IOX behaviors and can be an effective tool to design glass compositions for IOX strengthening.

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Abstract

G010: Structural simulations of RO-B2O3 (R=Mg, Ca, Sr, and Ba) glasses by the first principle molecular dynamics technique

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The Raman scattering spectrum of RO-B_2O_3 glass (R is an alkaline earth element) shows different atomic arrangements depending on the alkaline earth element even if the alkali metal oxide content is the same. In particular, Ca, Sr, and Ba borates show similar Raman spectra, while Mg borate is different from the others. Moreover, the proportion of four-coordinated boron N4 evaluated by NMR is also found to be lower in Mg borate than in others.

In this study, I investigated the difference in atomic arrangement between borate glasses containing different alkali metal oxides by structural models using molecular dynamics simulations. The structural model was created using classical molecular dynamics methods by melting and quenching, and then first principle molecular dynamics techniques were used to further optimize the structural models.

For some compositions, the total correlation functions were calculated and compared with the experimental total correlation functions obtained from X-ray diffraction measurements. As for structural characteristics, for example, when containing 50 mol% alkali metal oxide, the N4 value for Mg borate was 0.28, which was lower than 0.36-0.38 for other systems. Furthermore, in the six-membered ring (B_3O_3) structure, it was found that Mg borate has the least number of rings, Ca borate has the most, and the number decreases in the order of Sr borate and Ba borate. Furthermore, the formation of triborate groups, pentaborate, and diborate was confirmed in the structure models.

Abstract

G011: Structural Simulation and Spectroscopic Computation of Rare Earth Doped Multi-component Glasses

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Rare-earth-doped multi-component luminescent glasses are of great importance as optical and photonic materials, but the simulation of such glass networks and the theoretical prediction on the spectral band of rare earth activators are still kept as challenges. To address this, we established a simulation model of such multi-component glass systems with the traditional or ab initio molecular dynamic (MD) methods, and calculated the spectroscopic properties of Er^{3+} in glasses with involving the 4f spin-orbit coupling (SOC). First, we simulated different Al/Na ratio Er^{3+} doped sodium aluminosilicate glasses by molecular dynamics, revealing the dependence relationships between glass structure, local environment of Er^{3+} ions and glass composition. Second, we calculated the SOC corrected absorption spectra of Er^{3+} ions in the glass networks with balancing time cost and accuracy. It revealed the influence of the local environment of Er^{3+} ions on their absorption spectra, and agreed well with experimental absorption spectra of Er^{3+} ions. Third, through summing the SOC corrected absorption spectra of all Er^{3+} ions in the glass systems, we fitted out the absorption spectra of Er^{3+} doped glasses. It revealed the correlations among glass composition-structure-spectroscopic properties. This provides new insights into the structural and spectroscopic calculations on rare earth doped glass materials.

Key words: glass structures; rare earth ions; molecular dynamic simulation; spectroscopic calculation

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Abstract

G012: The Atomic Structures and Optical Properties: From Silicate Glass to MOF Glass

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Atomic Structure, Electronic structure; Optical properties, Molecular Dynamic; Machine Learning.

Atomic simulations around glasses are both intriguing and challenging, due to the lack of long-range order. In recent years, our research group has engaged in atomic-level simulations of various inorganic glass systems, including silicate glasses, germanate glasses, and novel organic-inorganic metal-organic framework (MOF) glass structures. Employing first-principles methods, we have addressed several key issues: 1) The impact of mixed alkali effects on the electronic structure of traditional inorganic glasses; 2) The structural evolution during the glass fabrication process of MOFs; 3) Structure-property relationships in silicate glasses and MOF glasses, particularly focusing on their mechanical properties. Furthermore, by combining larger-scale molecular dynamics and machine learning techniques, we have conducted research into the correlation between local structures and the glass-forming ability during the formation of MOF glasses. Our works indicate that attempting to comprehend the glass formation process in terms of functional building blocks at the super-atomic level is a viable approach, as well as shedding light on optical and mechanical aspects.

Abstract

G013: Understanding the deformation and fracture of silicate glasses from atomistic simulations

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Silicate glasses are generally known to be brittle but many of their unusual mechanical properties are so far not well understood, especially from a microscopic perspective. Here, we use atomistic computer simulations to reveal the microscopic mechanisms that are responsible for the non-linear elasticity and the fracture of silica and alkali silicate glasses under uniaxial tension. Our results show that the complex (non-linear) dependence of stress on strain can be attributed to the mobility of the modifiers which, without leaving their cage or modifying the topology of the network, are able to relieve the local stresses. Furthermore, we find that the nature of the dynamical fracture of silicate glass strongly depends on composition. Upon increasing Na concentration, the glass becomes progressively more ductile on the nanoscale which is manifested in the reduced crack velocity, the roughened fracture surface, and the formation of very irregular cavities ahead of the crack front. The dynamical correlations between various atomic-level properties are also discussed. Our results are expected be helpful for understanding the complex mechanical response of disordered materials that consist of atomic species with distinctive mobilities.

Key words: Silicate glasses; Deformation; Fracture; Molecular dynamics simulations

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G014: Carrier Recombination Dynamics of PbS Quantum-Dot-In-Glasses by Time-Dependent Density Functional Theory and Nonadiabatic Molecular Dynamics

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Quantum dot(QD)-in-glasses have attracted enormous attention for their potential application in lighting, lasers and solar cells. The performance of this material is still below the expectations with one main limiting factor being the poor emissive properties, severely hindering its commercial applications. In this work, we combine time-dependent density functional theory and nonadiabatic molecular dynamics to study the effect of glass matrices and chlorine atoms on the carrier recombination dynamics of PbS QDs embedded glasses. The presence of glass matrices weakens the oscillator strength of lowest-energy transitions of QDs and promote nonradiative recombination by introducing multiple high-energy phonons coupled to electronic transitions and undercoordinated interfacial atoms. Nonadiabatic coupling are found to play a more predominant role than decoherence in deciding the nonradiative electron-hole recombination. We also provide computational evidence that chlorine atoms enhance the optical performance by decreasing radiative recombination time, nonadiabatic coupling and accelerating loss of coherence, in excellent agreement with the experimental findings. The results of this study draw a complete picture of the charge recombination dynamics of QDs in glasses and promote mutual understanding that would benefit the fabrication of highly luminescence glasses.

Abstract

G015: Force-matching potential for investigating an effect of Al2O3 addition on the thermal expansion of sodium alkaline-earth silicate glasses

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Coefficient of thermal expansion (CTE) is an important property when utilizing oxide glasses in thermal treatment processes. It is thus important to know the effect of additives on CTE for designing glass compositions. Alumina-doping efficiently improves chemical and mechanical durability of oxide glasses while maintaining the functionality and productivity; however, alumina often induces nonlinear variation of CTE. In this work, we therefore tried to investigate the relationship between CTE and the microstructure of sodium alkaline-earth aluminosilicate glasses using classical molecular dynamics (MD) simulations. To accurately model the glasses, we extended our force field, namely force-matching potential, which has been developed to reproduce force and energy calculated by density functional theory. New parameter sets for Ca–O, Mg–O, and Na–O pair interactions were optimized using Bayesian optimization. The MD simulations reproduced the nonlinear variation of CTE as a function of alumina content, and detailed structural analyses identified inhomogeneous expansion in the glasses. It was found that the nonuniform CTE change at the nanoscale was related to the formation of an alumina-rich region, in which more fivefold-coordinated aluminum exist, when alumina content exceeded Na_2O content. Accordingly, the microstructural change by alumina-doping was identified as the origin of the nonlinear variation in the CTE of the glasses.

Abstract

G016: Raman spectroscopic study of MgO-CaO-Al2O3-SiO2 glasses and statistical modeling of composition-structure-property relationships

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Coninuous greinforcement glass fiber has a broad composition range, covering E-Glass of CaO-Al_2O_3-SiO_2 system and R-Glass of MgO-CaO-Al_2O_3-SiO_2 system. The latter offers significantly higher modulus and strength and is commonly used for manufacturing longer turbine blade for renable wind energy generation. Statistical composition – property modeling (C-P) has been commonly used in designing complex silicate and borosilicate glasses. Statistical structure – property (S-P) modeling approach has been recently proposed/demonstrated for optical glasses of phosphate glasses. We recently performed a study covering E-Glass and R-Glass space, investigating relationships of composition, structure, and properties (melting temperature, T_M at 100dPa.s, fiber forming temperature, T_F at 1000 dPas, and fiber sonic modulus, E). Raman spectroscopic measurements (Fig 1) reaveal evolution of the structure distirbutions as a function of composition. Statistical modeling, S-P (Fig 2) and C-P (not shown), were carried out. The modeling outcome enables the construction of new glass design platform, C-S-P, detailed in our presetantion.

Key words: Fiber Glass, Raman spectroscopy, Statistical property modeling

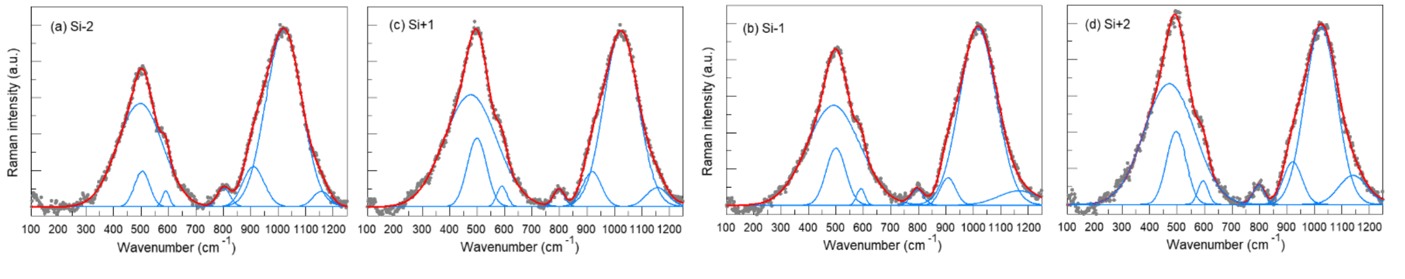

Fig. 1 Raman spectra and deconvolution analysis of Si-series, illustrating effect of SiO_2 on intensity of characteristic bands (peak height) near 500 cm^{-1} (T-O-T) and 1000 cm^{-1} (Q^n, n=4, 3, 2)

Abstract

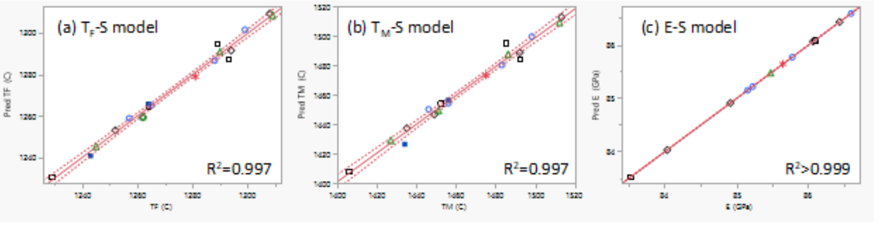

Fig. 2 Statistical structure – property modeling (X-measured value, Y-predicted value)

Abstract

G017: Deciphering a Structural Signature of Glass Dynamics by Machine Learning

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The dynamics of atoms plays a key role in governing various dynamical and transport properties of glasses. However, it remains elusive which structural features (if any) control atom dynamics in glasses. Here, based on million-atom molecular dynamics simulations and classification-based machine learning, we extract a "needle-in-a-haystack" by identifying a local, non-intuitive structural signature (a revised version of the recently developed softness metric) that governs glass dynamics. We do so by investigating the ion mobility in sodium silicate glasses—a realistic, archetypal glass—finding that the sodium ion mobility is largely encoded in its initial softness, wherein "softer" Na atoms exhibit higher mobility. Importantly, our approach allows us to interpret the machine-learned softness metric and thus elucidate the atomistic origin of the ion mobility. Namely, we find that Na mobility is anticorrelated with the local density of "defect" oxygen neighbors that are located in between the nearest two coordination shells. This local packing order offers a potential path to develop new glass formulations with tailored dynamical properties. Finally, we demonstrate that the softness is strongly anticorrelated with the activation energy for Na atom reorganization.

Abstract

G018: Nanoindentation-induced evolution of atomic-level properties in silicate glass: Insights from molecular dynamics simulations

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Indentation has been widely used for investigating the mechanical behavior of glasses. However, how the various microscopic properties of glass evolve from the immediate contact with the indenter to the far-field regions, and how these observables are correlated to each other remain largely unknown. Here, using large-scale molecular dynamics simulations, we investigate the response of a prototypical sodium silicate glass under shape contact load up to an indentation depth of 25 nm. Both the short- and intermediate-range structures are found to exhibit notable changes below the indent, indicating that indentation deformation induces a more disordered and heterogeneous network structure. The decay of densification is considerably slower than that of shear strain, implying that the former might contribute more to the deformation at the far-field regions. Our findings not only contribute to an atomistic understanding of the indentation response of silicate glasses but also pave the way towards rational design of damage-resistant glassy materials.

Key words: Silicate glass; Nanoindentation; Molecular dynamics simulations

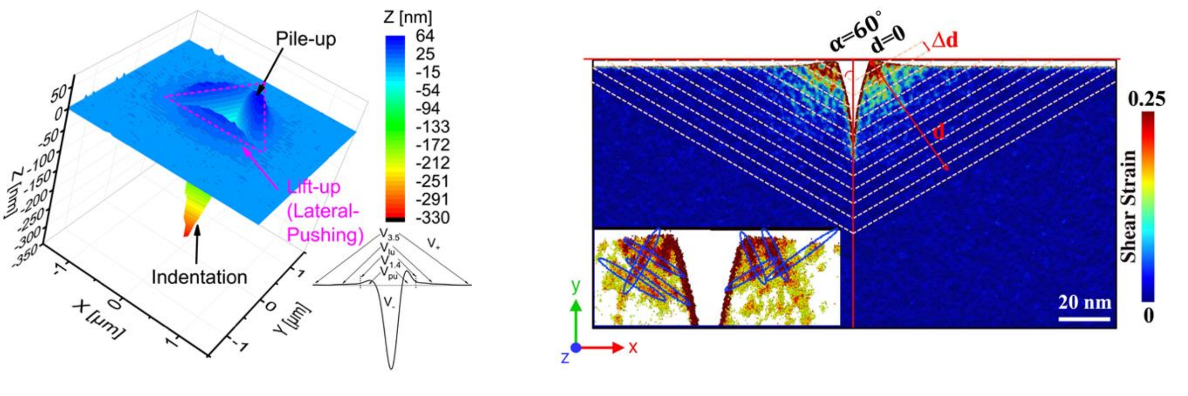

Fig.1 (a) Nanoindentation deformation of a soda-lime silicate glass. (b) Large-scale molecular dynamics simulations of the nanoindentation process

Abstract

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Abstract

G019: Study on the Influence of Chemical Composition and Fiber-forming Process on the Atomic Structure of Basalt Fiber: An experiment and molecular dynamics study

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The mechanical properties of basalt fiber depend on the surface defects and atomic structure. Due to the difficulty in characterizing the atomic structure of glassy materials, current research has focused chiefly on the impact of surface defects on mechanical properties, with less research on the atomic structure of fiber. This study utilized molecular dynamics simulation combined with neutron scattering and Raman spectra experiments to investigate the effects of chemical composition and process parameters on the atomic structure of basalt fiber. Firstly, this study demonstrated that the atomic structure of basalt fiber can be qualitatively analyzed using BKS potential by comparing the results of neutron scattering and molecular dynamics simulations. Based on this, using response surface methodology (RSM) combined with molecular dynamics simulation, we found that within the suitable chemical composition range for continuous fiber production, the content of network formers is positively correlated with the degree of polymerization of the fiber atomic network. At the same time, Al, Fe, Ti are more conducive to forming a tight network. The network modification volume is negatively correlated with the degree of polymerization of the fiber atomic network. Furthermore, neutron scattering and Raman spectra were used to demonstrate a negative correlation between winding speed and fiber atomic network strength, and simulations were used to reveal the effect of temperature on fiber atomic network strength. Finally, the molecular dynamics model was used to verify the theoretical strength of basalt fiber in the order of 10 GPa. We also found that the local deformation mode in the underconstrained region of the glass during the stretching process causes plastic deformation and reconnection at the nanoscale in the network, resulting in non-brittle fracture modes at the nanoscale, confirming the nano ductility of multi-component silicate glass with nanoscale heterogeneity. The results provide theoretical guidance for developing high-strength, high-modulus, and high-ductility basalt fiber in the future.

Key words: Basalt fiber; Glass structure; Molecular dynamics simulation; Neutron scattering; Theoretical strength

Abstract

G020: Simulation prediction of thermal properties and spectral characteristics of Er3+ doped fluorotellurite glasses

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Fluorotellurite glass is a key material for mid-infrared windows and laser gain media with its wide infrared transmission range, low maximum photon energy, excellent mechanical properties, and high solubility of rare earth ions. Previous researches force on glass systems have been based on a large number of experiments to search for suitable glass hosts, but the data obtained are very restricted. The commonly used statistical and additive prediction methods are limited to the calculation of glass physical properties, which is difficult to effectively guide the exploration of new laser glasses. Compared with the traditional C(component)-P(property) statistical simulation method, the C(component)-S(structure)-P(property) statistical simulation method can provide more accurate property assessment of complex glass systems and facilitate the development of new glasses. Taking simulated fluorotellurite glasses as an example, the application of the statistical structure simulation method to the performance prediction of fluorotellurite glass systems is investigated using the effective linewidth glass transition temperature Tg, fluorescence lifetime, and optical band gap as target properties. The results show that the Tg and fluorescence properties of fluorotellurite glasses can be simulated more accurately by using the Raman and infrared structural data of the samples. The model validation results show that the predicted and measured values of the validated samples fit well with a simulation willingness of 0.9994. The statistical structure simulation method can assist in building a database of glass formulations.

Key words: Fluorotellurite glass; Spectral characteristics; Simulation

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Abstract

G021: Molecular Dynamics Simulation Study on the Structure of Fluorosilicate Glass

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There are great challenges in the observation and design of fluosilicate glass,[1,2] so the relationship of composition-structure-performance was studied using molecular dynamics (MD) simualtions. The simulation results not only can provide microscopic information on the fluosilicate glass structure at the atomic level, but also establish a structural model of immiscible fluorosilicate glass. And the effectiveness of the obtained structural model was verified through the EXAFS, neutron diffraction, and NMR. Additionally, we also revealed the influence of glass composition, system size, melting and insulation time, cooling rate and other parameters on the structure and phase separation behavior of fluorosilicate glass, explained the formation and morphology evolution of fluoride phase separation in fluorosilicate glass, and obtained the optimal simulation parameters for this type of glass structure. More importantly, a class of rare earth doped transparent fluorosilicate glass ceramics, with high UV absorption, visible transmittance, and UV visible spectral conversion efficiency, were successfully designed and prepared by using the method of "phase separation simulation-predicting crystallization".

Key words: Fluosilicate glass; molecular dynamics simualtions; phase separation

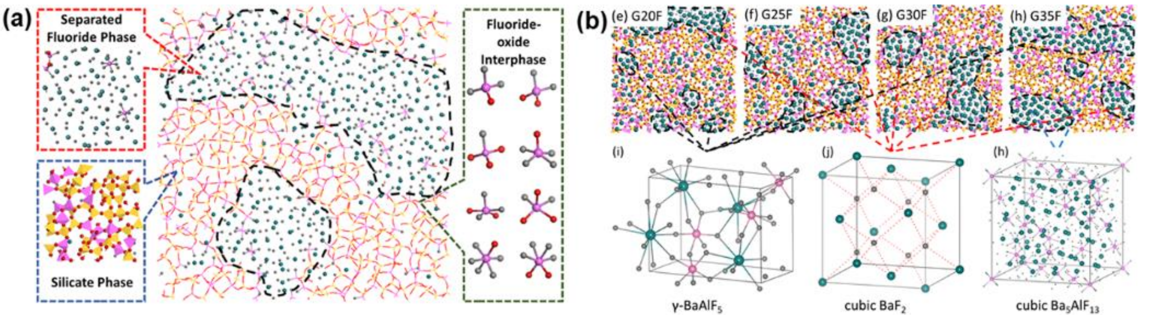

Fig.1 (a) Structural model of immiscible fluorosilicate glass. (b) The snapshot of phase separation simulation-predicting crystallization

Abstract

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Abstract

G022: Structural response to densification of Na2O-Al2O3-SiO2 glasses with different load indentation centers

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The Vickers indentation centers of glass have a general densification effect, and their ability to dissipate stress significantly influences the crack resistance and toughness of the glass. In this study, we used Raman spectroscopy and molecular dynamics simulations focused on the Vickers indentation center of Na_2O-Al_2O_3-SiO_2 glass to investigate its structural contribution to densification. The indentation load and depth were both controlled. Results showed that as the loading increases, the structure of the glass densification zone shrinks (decreased spacing of silica-oxygen tetrahedra close to each other and Si-O-Si bond angles) and reorganizes (by ring distribution, or bridging oxygen distribution). The non-bridging oxygen(NBO) content increases with increasing degree of densification, and the corresponding modifier ions fill the original void space, indicating the occurrence of shear behavior during densification. Furthermore, Al tetrahedra inhibits NBO production during indentation. These findings jointly contribute to the study of the cracking behavior of glass.

G023: Influence of glass structure units on the electronic structure of cesium lead halide perovskite quantum dots

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Cesium lead halide perovskite quantum dots have garnered widespread attention from researchers due to their outstanding optoelectronic and luminescent properties. Embedding these quantum dots within a glass matrix leads to a significant enhancement in their stability. Furthermore, the precise control over the quantum dot nucleation process can be achieved through the application of femtosecond laser-induced techniques. This technology holds considerable promise for potential applications in the fields of displays and anti-counterfeiting measures. However, it is imperative to acknowledge that the glass matrix exerts a discernible influence on the electronic structure of cesium lead halide perovskite quantum dots, consequently affecting their luminescent performance. To conduct an in-depth investigation into the specific ramifications of the glass matrix on the electronic structure, we conducted first-principles calculations. Our analysis encompassed the influence of different glass matrix constituents on cesium lead halide perovskite quantum dots, and we subsequently discussed the corresponding electronic structure information, along with its relevance to luminescent performance.

Key words: Quantum dot glass; First-principles calculations

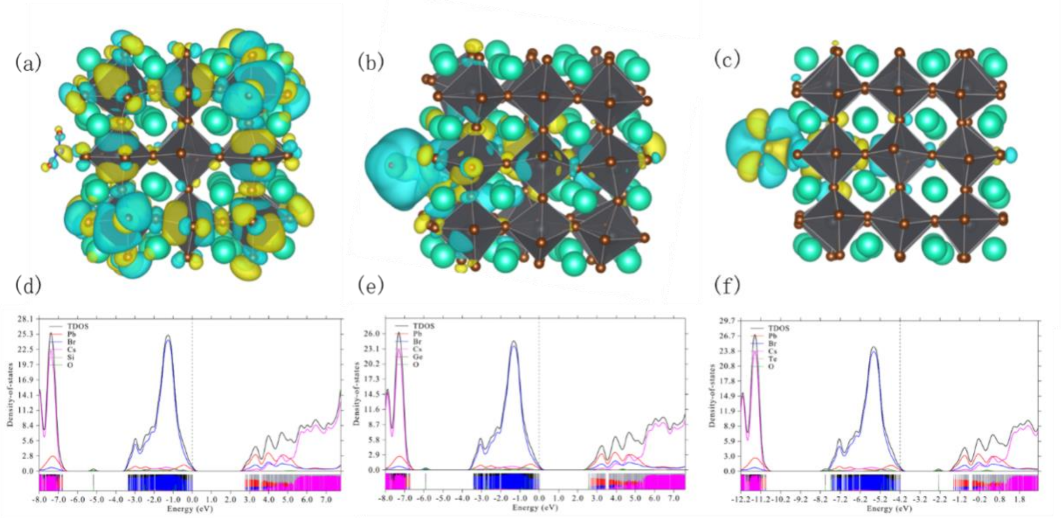

Fig. 1: Electron cloud distribution of LUMO orbitals for $CsPbBr_3$ quantum dots with surface additions of (a) SiO_2, (b) GeO_2, and (c) TeO_2 molecule; Corresponding density of states (DOS) for $CsPbBr_3$ Quantum Dots with surface additions (d) SiO_2, (e) GeO_2, and (f) TeO_2 molecule.

Abstract

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Abstract

G024: Application of digital technology in research and development of new glass materials

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The design of novel glass materials has been plagued by inefficient Edisonian "trial-and-error" discovery approaches. The machine learning (ML) algorithm was combined with molecular dynamics method to predict the properties of glass overcome the defect of single method. In this paper, six ML algorithms were systematically studied using the data set generated by molecular dynamics. The ML model and the hyperparameter suitable for glass property prediction were selected by comparing the performance of the model after tuning the hyperparameter. This study can readily be extended to anticipate various compositional-property combinations, thus replacing empirical approaches of glass property prediction with related properties and applications.

Key words: Molecular dynamics simulation; Machine learning; Composition-property relationship

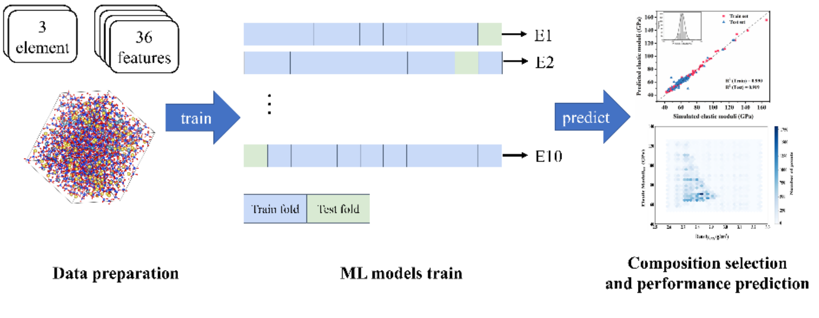

Fig.1 Machine learning flow diagram

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Abstract

G025: Theoretical Insights into Band Gap and Defect Engineering for Enhanced properties in Glass-Ceramics Scintillators

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This work explores theoretical strategies to enhance scintillation in glass-ceramics through band gap and defect engineering, which show promise for radiation detection and imaging due to their tunable properties. Here, band gap engineering entails the precise alignment of the material's electronic structure with incident radiation, while the synergistic effects of doping aim to suppress defects and optimize defect types and concentrations for efficient radiative recombination. Furthermore, the study investigates the intrinsic defect properties in scintillators, providing a theoretical foundation for donor-acceptor pair recombination processes. In summary, this work highlights the importance of theoretical insights in optimizing scintillation in glass-ceramics through band gap and defect engineering, with potential applications in radiation detection and imaging.

Key words: glass ceramic scintillator; first-principles calculation; defect engineering

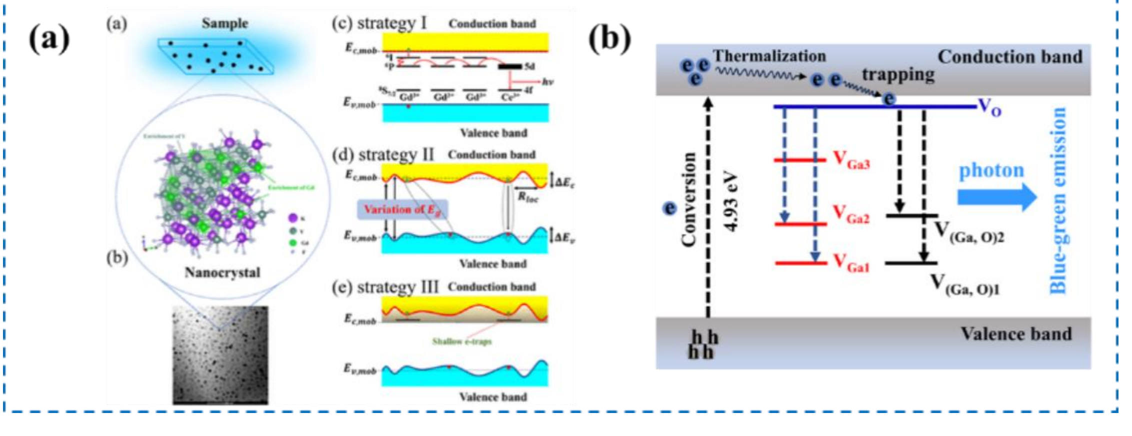

Fig.1 (a) Strategies to improve scintillation performance. (b) The scintillation process

Abstract

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Abstract

G026: Enhancing Production Efficiency: A Statistical Approach to Glass Coloring and Optical Performance

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Glass is a versatile and widely favored material in numerous applications due to its exceptional optical properties, particularly its ability to transmit light. Additionally, its capacity to be colored for aesthetic purposes further elevates its desirability. Notably, in sectors like automotive glass, where stringent regulatory standards are commonplace, the emphasis typically centers on optimizing optical characteristics. However, designers often introduce a unique dimension by seeking specific color requirements. This same dual priority for optical excellence and customizable coloration is mirrored in architectural glass applications.

Presently, Sisecam boasts an extensive product portfolio featuring nine distinct color options for automotive and architectural glass. To delve deeper into the intricate mechanisms of coloring and optical properties, Sisecam is actively exploring diverse approaches. An impressive dataset of approximately 45,000 records has been meticulously compiled through routine measurements conducted across a network of 13 flat glass manufacturing facilities and 6 regional laboratories. These datasets encompass a wealth of information, including chemical analysis results (XRF) detailing colorant oxide compositions, as well as comprehensive optical properties (both direct and solar transmittance) and color parameters (utilizing CIE 1964, L-a-b color space) obtained through meticulous spectrophotometric analysis of identical samples.

Leveraging these comprehensive datasets, statistical modeling has been undertaken to discern the intricate relationships between glass composition and its resultant properties. The resultant model's primary objective is to expedite reverse engineering efforts, enabling the development of more efficient methods for achieving desired colors while diminishing the reliance on labor-intensive laboratory procedures. This innovative initiative by Sisecam seeks to advance the glass industry by bridging the gap between science and art, enhancing the versatility and desirability of glass in various applications.

Key words: composition-properties, statistical modelling, color modelling, optical performance

G027: Pushing the Limits of Production in Float Furnaces

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Over the years, advancements in float glass furnace technology have been driven by various factors, including the improvement of glass quality, the enhancement of energy efficiency, and the response to environmental concerns. Today, the growing demand in key sectors such as automotive and construction, alongside increased government investments in solar energy, is exerting significant pressure on the capacity limits of float glass furnaces. Undoubtedly, designing and commissioning a high-capacity flat glass furnace with precise operational tuning to address the increasing need for premium products like mirrors, automotive glasses, and low-E glass undeniably enhances a company's competitive edge in the global marketplace.

In alignment with this vision, Şişecam declared its plans to invest in a new float line in Turkey, which will boast a nominal capacity of 1200 tons per day for clear glass production to meet the expanding demand for high-quality float glass. Based on a modelling study carried out by Şişecam Furnace Model developed within the company, together with extensive engineering expertise, a float furnace with a capacity of 1200tpd clear glass has been designed and projected by Şişecam Science, Technology and Design Centre. The scope of the modelling study was expanded to investigate potential opportunities for design and operational improvements in the current design allowing for enhancing both the design and operational aspects, enabling adaptability to future scenarios with increased furnace capacity demands or elevated standards for glass quality.

The primary focus of this modeling study is to tackle the challenge of enhancing the melting capacity in float furnaces without the obligation for substantial expansion of the melting area. Specifically, it focuses on investigating the relationship between glass depth and waist cooler submersion and their impact on effectively managing convection currents and temperature profiles in large capacity float furnaces. The findings of this modelling study offer valuable guidance for potential improvements, enhancing the melting capacity in float furnaces.

Key words: High-capacity float glass furnace; mathematical modelling; capacity limits; design improvements

G028: Machine-aided optimization of plasma-assisted aggregate deposition implementing multi-parameter output and process resilience analysis

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Machine learning is nowadays a popular tool for glass science research because of its powerful predicting abilities. It accelerates the process of scientists constructing and understanding the relationship between the experimental design and different properties. In this study, we build a machine-learning model for predicting the highly correlated phase distribution of Al_2O_3 synthesized by plasma-assisted aerosol deposition. This demonstration exhibits the importance of considering the correlations of the properties when building a model with high dimensional and correlated inputs and output features. Moreover, the model extrapolated the experimental data to the limitation of the physical setup. It suggests the optimization path for tuning the experimental parameters toward energy efficiency. It also offers an insight into the trade-off between system resilience and optimization extended to other experiments.

Key words: machine learning; high dimensional outputs; processing optimization; system resilience; multiple phases

Abstract

G029: Predicting dynamics in sodium silicate glasses using graph neural networks

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Understanding the dynamics of atoms in glasses is crucial for unraveling their transport and dynamical properties, but it is challenging to identify the underlying structural features controlling atom dynamics. Recent studies have used machine learning models such as graph neural networks (GNNs) to predict long-term dynamics, but the focus has so far been on model systems like Kob-Andersen-type Lennard-Jones mixtures. This study extends this approach by using GNNs and molecular dynamics simulations to investigate the dynamics across varying timescales in a realistic system that forms the basis for most industrial glasses, namely sodium silicate glasses. By harnessing the capabilities of graph neural networks, our method provides an effective means for predicting the long-term dynamics of ions in glassy systems based solely on initial atom positions, without relying on handcrafted features. We compare our predictions with those of previously proposed methods. Our findings pave the way for designing glass formulations with tailored dynamical properties.

Abstract

G030: Machine Learning Based Prediction of Refractive Index and Glass transition temperature of B2O3-La2O3-Ta2O5-ZnO Glasses for High Refractive Index Optical Lens

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Recently, as the demand for precision optics such as telecommunications and high resolution cameras increases, research on high refractive glass lenses that can be applied to glass mold press (GMP) is being actively conducted. Glass compositions for high refractive optical lenses are mainly composed of oxides with heavy metals such as Ta_2O_5 and La_2O_3, and are prepared by combining other compositions to adjust refractive index, dispersion and thermal properties. [1-3] However, finding a proper glass composition with multi-component glass system is a rigorous job if they are synthesized and measured. On the other hand, machine learning (ML) can give variable-based prediction via classification and regression analysis. [4-5] In particular, in the case of supervised machine learning, it is possible to learn and predict variables with a small data-set of 200 to 300, and predict physical properties according to glass composition and use them to design glass with specific physical properties. Thus, the development time and cost can be significantly reduced via the application of the learned ML model.

In this study, in order to predict refractive index and glass transition temperature based on the glass composition, ML was carried out based on about 300 compositions of which data were collected from the existing literature. Polarizability, density, and average bond energy of the glass composition were considered as additional factors to increase fitting accuracy. Four algorithms (Linear Regression, Bayesian Ridge Regression, Nearest Neighbour, and Random Forest) were applied to train and predict the refractive index and the glass transition temperature, and the algorithm with the highest R^2 value was selected. To confirm the validity of the selected model, B_2O_3-La_2O_3-Ta_2O_5-ZnO based glasses were fabricated and their refractive index and glass transition temperature were measured and compared with the predicted ones.

Key words: Glass-Lens, Refractive Index, Machine Learning, Refractive Index Predict, Ascends

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Abstract

G031: Predicting Fracture and Ionic Conduction of Glassy Electrolytes Using Classification-Based Machine Learning

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Glasses are promising candidates as solid electrolytes for all-solid-state batteries due to their isotropic ionic conduction, formability, as well as high chemical, thermal and electrochemical stability. However, the lack of well-established composition-structure-property relations hinders the design of new glassy electrolytes with tunable functionalities. Here, we combine molecular dynamics simulations with classification-based machine-learning based to clarify the relation between structure and properties in lithium borophosphate glassy electrolytes. Specifically, we focus on the machine learning derived “softness” metric. By isolating the relative effects of Li and B contents on the electrolyte performance, we correlate the fracture behavior and ionic conduction with the bond switching activities of B and the mobility of Li atoms, respectively. Based on the interpretable features of the machine learning model, we identify the most influential structural parameters of the radial order function controlling the atomic behaviors. These results enable finding the optimum chemical compositions for glassy solid electrolytes with high mechanical stability and high ionic conductivity.

Abstract

G032: Understanding Glass Formation Ability and Origin of Plasticity in Metallic Glasses Through Machine Learning Techniques

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The compositional design of metallic glasses is a long-standing issue in materials science and engineering. However, traditional experimental approaches based on empirical rules are time consuming with a low efficiency. In this work, we successfully developed several machine learning models to address this issue. The computational framework herein established is expected to accelerate the design of MG compositions and expand their applications by probing the complex and multi-dimensional compositional space that has never been explored before.

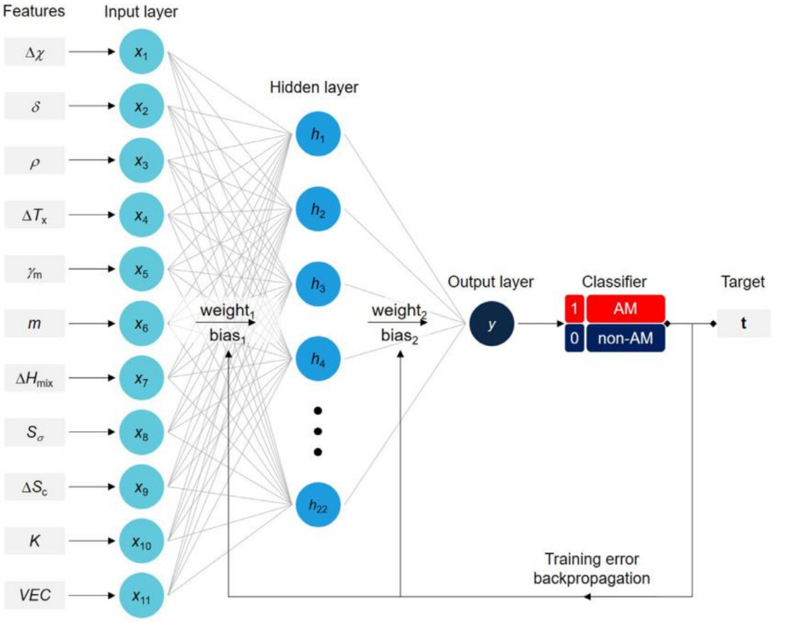

Fig.1 –Schematic of the backpropagation neural network model.[1]

Abstract

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Abstract

G033: Insight into the structure and crystallization of SiO2-Al2O3-P2O5-Na2O-MgO/CaO glass-ceramic system with Mg-Ca substitution: A molecular dynamics study

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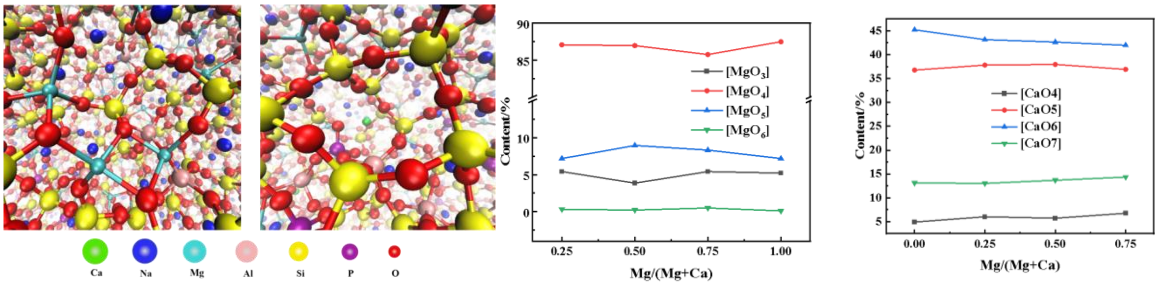
NCMPAS glass system is a complex and very significant glass-ceramic system, in which the relative content of Ca and Mg greatly affects the network structure and crystallization behavior of the glass. This study selected a six component system of $18Na_2O \cdot (16-x)CaO \cdot xMgO \cdot 3P_2O_5 \cdot 2.5Al_2O_3 \cdot 60.5SiO_2$ (mol%, x=0,4,8,12,16) and obtained the glass structure using molecular dynamics simulation. Statistically, it was found that Mg ions mainly exist in the form of [MgO4], while Ca ions exhibit a highly coordinated state as a typical modifier. Based on this, this study for the first time adopted a statistical method considering MgO as network former. The overall connectivity of the network increases with the substitution of MgO for CaO. MgO as network former behaves similarly to Al_2O_3. Mg ions tend to connect in both phosphorus-rich and silicon-rich phases, and the presence of Mg ions promote the formation of TBOs, especially 2Mg1Si. 'Coordination priority' principle was proposed to explain the selection of glass crystallization and the formation of energetically unfavorable TBOs and Mg_4-O-Mg_4 linkages may be favorable nucleation sites for the nucleation of Na_2MgSiO_4 crystals.

Key words: Glass-ceramic; Molecular dynamics simulation; Calcium and magnesium content; Network structure; Crystallization



(a) (b) (c)

Fig.1 (a) Visualization of NC8M8PAS glass network structure. (b, c) Statistics of coordination number of Mg^{2+} and Ca^{2+} in glass network with the change of calcium magnesium content ratio.

Abstract

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Abstract

G034: Structural simulation and spectral calculation of silver quantum cluster activated borate glasses: A spin-orbit coupling involved first-principles study

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Silver quantum clusters (Ag QCs) composed of a few silver atoms exhibit unique optical properties arising from quantum confinement effects. However, in amorphous networks, silver clusters possess diverse configurations and complex coordination environments. Elucidating their structures in such environments remains challenging. To address this, density functional theory (DFT) calculations are performed to optimize geometries and compute vibrational frequencies of neutral and cationic Ag_n clusters (n=2-8) to determine their stable configurations. Furthermore, time-dependent DFT with spin-orbit coupling is utilized to simulate the UV-vis absorption spectra of these Ag QCs in the visible range (200-800 nm). The simulated spectra are then combined with experimental spectra of Ag QCs in activated borate glasses to enable prediction of potential weight distributions for differently sized neutral and charged Ag QCs for specific glass compositions. Overall, this work establishes a computational spectroscopic approach to probe elusive cluster structures in complex amorphous solids and provides a viable route to investigate the evolution behavior and optical properties of Ag QCs in microcrystalline glass-ceramics.

Key words: TD-DFT; Spin-orbit Coupling; UV-vis; Silver Cluster; Borate Glass

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Abstract

G035: Investigations on Mo rich Simulated HLW Borosilicate Glass by Statistical Glass Structure Gene Modeling

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Mo-yellow phase is difficult to be handling in HLW solidification process. It affects the chemical durability of the product seriously and tends to accumulate on the surface of the molten glass. This work studied a simulated HLW with high Mo (2.6~3.3wt%) by using Glass Structure gene Modeling (GSgM), focusing on chemical stability and accumulation of Mo yellow phases in borosilicate glass, establishing the structural models of Na, Li, B, Mo leaching rate, T_g and Mo-yellow phase accumulation. Results show that Mo-yellow phase in our studied glass composition range is mainly $CsLiMoO_4$, and Si-B phase separation exists universally, leading to relatively larger errors on property and FTIR measurements. Analysis on the S-P and S-C models indicated that certain compositions have statistically significant influences on yellow phase and $r_{Na,Li,B,Mo}$.

Key words: Mo-yellow phase; structural modeling; HLW borosilicate glass

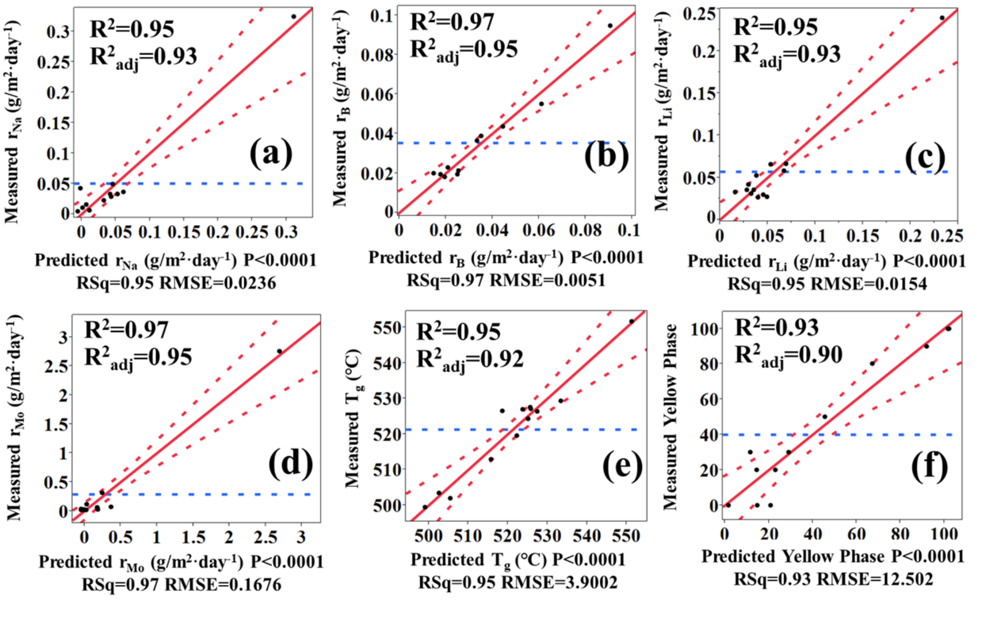

Fig.1 S-P models of glass properties (a) r_{Na} (b) r_B (c) r_{Li} (d) r_{Mo} (e) T_g (f) yellow phase

Abstract

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Abstract

G036: Machine learning-based accelerated design of glasses with targeted young's modulus

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Enhancing glass mechanical properties is pivotal for tackling energy, communication, and infrastructure challenges. Here, we propose a machine learning-based approach to predict the Young's modulus of silicate glasses. Four categories of machine learning methods, namely linear regression, support vector machine regression, random forest, and artificial neural networks, were explored. Linear methods fall short in describing Young's modulus, whereas artificial neural networks excel due to their nonlinear data handling capability. Incorporating physics-informed machine learning significantly boosts predictive performance in poorly-performing methods. This combined approach reduces computational costs and predicts untrained compositions' responses efficiently. In summary, we advocate for widespread utilization of machine learning to expedite the design of novel glasses with tailored properties.

Key words: machine learning; silicate glasses; Young’s modulus

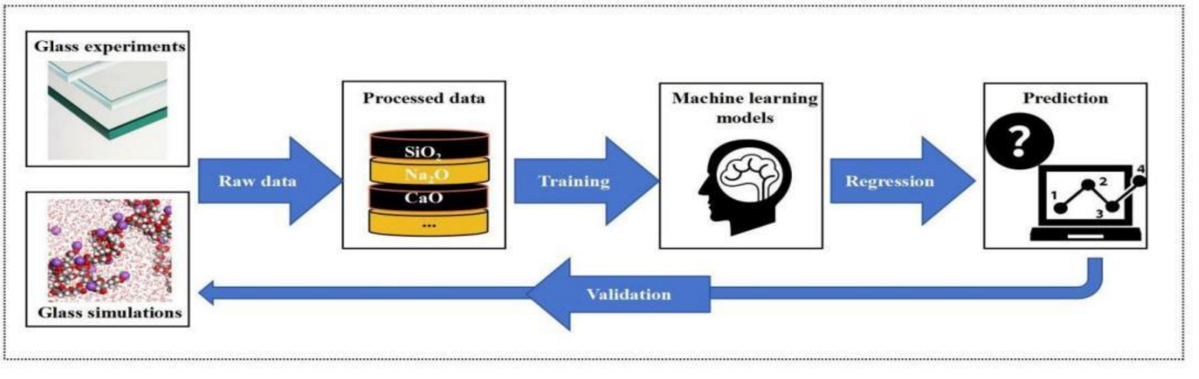

Fig.1 A flowchart of the data processing and machine learning method.

References：

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Abstract

G037: Gaussian process regression for predicting the electrical conductivity of complex ionic glasses

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Machine learning can provide a powerful tool for glass formulation [1]. Here, we focus on the possibility of using Gaussian regression analysis to predict glasses' ionic conductivity. To provide for the highest complexity, we use glasses that implement complex anion mixtures, for which neither the conduction species nor the conduction mechanism are known in straightforward ways. We developed a machine learning model and built quantitative relationships between glass composition and the respective ionic conductivity, using consistent experimental data for training and testing. In this way, we demonstrate how variations in conducting species, non-linear mixing effects (such as the alkali mixing effect) and structural features can be detected.

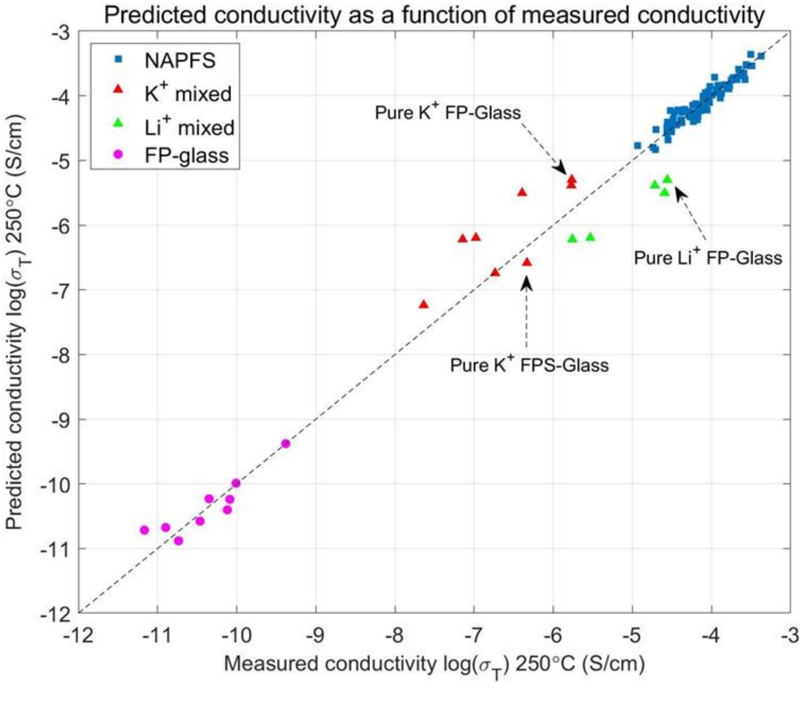

Fig 1. The predicted conductivity is a function of measured conductivity from the backtest for the extended model.

Key words: Gaussian process regression, ionic conductivity, ionic glasses

Abstract

Reference

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Abstract

G038: Machine Learning Driven Model on the Glass Forming Ability of Nuclear Waste Glasses

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The traditional trial and error method has been widely used in glass technology, however, is challenge to meet the demand of developing new glass materials. Particularly, glass materials like nuclear waste glasses are with more than 20 different components, which makes it difficult to fast design qualified compositions. On the other hand, the machine learning based method combining with experiments and molecular dynamics simulations provides a new way to predict glass compositions with target properties. In this work, we have applied neural network algorithm to develop a model for predicting the glass forming ability of nuclear waste glasses. Among the 620 predicted compositions, 143 compositions have been experimentally verified over all six generations of model evolution. The prediction accuracy of glass forming ability of the sixth model has been significantly improved (100%) comparing with the original model (10%). This study is a critical step forward in establishing models of composition-structure-property relationships.

Key words: Machine Learning; Nuclear Waste Glass; Composition-property Relationship

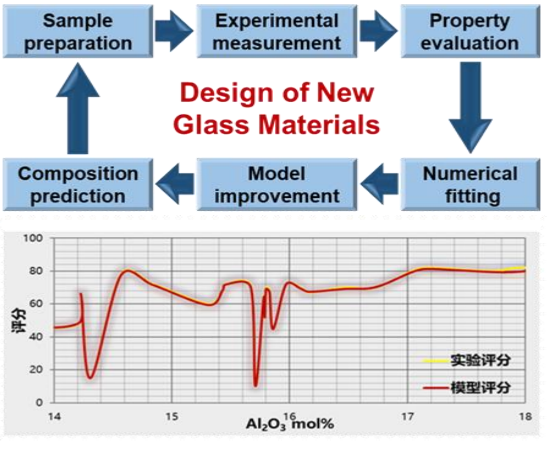

Fig.1 Illustration of machine learning based method in design new glass materials.

Abstract

References:

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Abstract

G039: Development of bromine-related potentials for molecular dynamics simulations of the oxyhalide photo-thermo-refractive glass

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The oxyhalide photo-thermo-refractive (PTR) glass has found various applications in optical devices. In this work, we applied molecular dynamics (MD) simulations to investigate the structure of the classic PTR glass (excluding Ce, Ag, Sb, and Sn). A set of bromine-related potential parameters has been developed and tested by comparing the simulated crystal structures with those from experiments or ab initio calculations. The PTR glass has then been simulated by using MD simulations with the newly developed potentials. It is found that the bromine prefers to stay around the fluorine-rich regions and form the phase boundary between the fluorine-rich phase and the oxygen-rich glass matrix. The results show that the newly developed bromine/fluorine-related potential parameters can describe the PTR glass structures thus provide a new method to help design and improve new applications.

Key words: photo-thermo-refractive glass; phase separation; molecular dynamics simulations; potential development

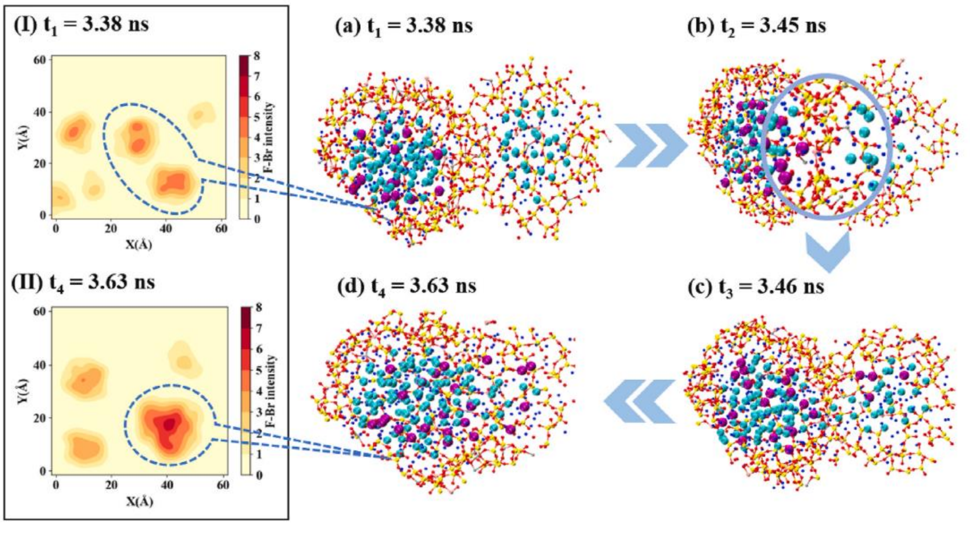

Fig.1 The fusion process of F-Br clusters in PTR glass, where F (cyan), Br (purple), Na (blue), Si

(yellow), and O (red)[1]

References：

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Abstract

G040: Study on element evolution of SiO2-Al2O3-P2O5 glass micrometer fiber during stretching to nanometer fiber

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In this work, glass nanofibers were prepared at one end of glass microfibers by the secondary drawing method. The compositional analysis of different sizes fibers was carried out. Ab-initio molecular dynamics were used to simulate the glass nanofibers forming process. The results show that there is an element gradation phenomenon in the transition region of glass fibers from micrometer to nanometer. The content of Al increases gradually, while the content of Si gradually decreases, and the contents of P and Na remain unchanged. When the glass fiber is stressed on one side, the silicon changes from five-coordination to four-coordination, accompanied by the formation of SiO molecules and new bonds Si-O-Si. The migration direction of aluminum atoms is consistent with the direction of stress. Compared to silicon atoms, aluminum atoms have higher mobility. In addition, P atoms also play an important role in the formation of glass nanofibers, which can introduce more free volume energy into the glass network and promote the generation of more bond conversion events.

Key words: SiO_2-Al_2O_3-P_2O_5 glass; glass nanofibers; element gradation

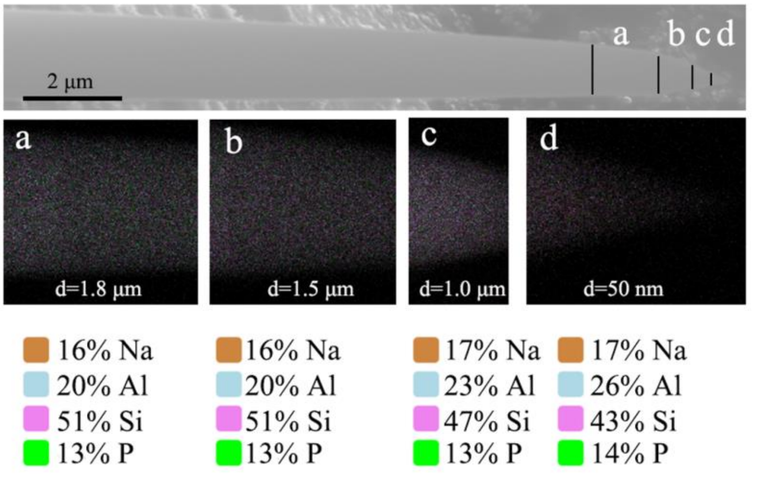

Fig.1 Scanned view of segment surface of 69.22SiO_2 - 12.55Al_2O_3 - 6.76P_2O_5 – 11.47Na_2O (mol%) glass fiber.

Abstract

Acknowledgements

This work is supported by the National Natural Science Foundation (grant no. 52072335).

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ABSTRACT

Session H

Thin film and Coating

Session H：

Thin film and Coating

Abstract

H001: Functional Coatings on Glass with Sol-gel Technology

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The glass used in various area like buildings, houses, display and automotives are usually manufactured by float process to make flat glass. Various functionality is also required to provide light, electrical, and wettability control with glass. Coating technology is widely used as a means of adding various functions to the glass sheets. Although there are a couple of application method including vacuum film formation method such as sputtering, Chemical Vapor Deposition and sol-gel technology, each of which has its own characteristics. Sol-gel technology is the way to form glassy material at a considerably low temperature by utilizing a chemical reaction in liquid that accompanies a sol-gel transition. By making good use of the liquid starting material and its feature of low temperature process, it enables to create functional material in various forms, such as bulk, fibre and powder in addition to coatings. Besides as there are many sources material including organic and inorganic usable, various functions depending on requirement could be realizable. NSG group has been developing various functional coating on glass in various area and productionalized since early 1990. Here, the feature of sol-gel coating technology and functional coatings on glass sheets with practical examples is reviewed.

Key words: Sol-gel technology; Functional coating;

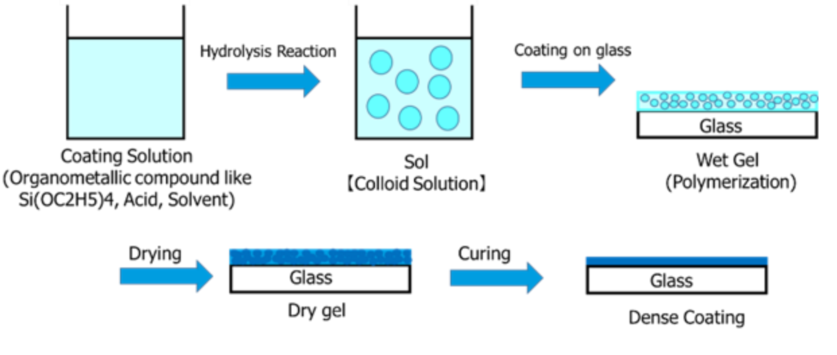

Fig.1 Diagram of representative sol-gel reaction on glass.

H002: Organic Thin Film Solar Cells: Pathways toward High Performance and Semitransparency

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Thin film solar cells, which convert the energy of sunlight into electricity, are a promising type of device to generate renewable energy. Organic thin film solar cells are flexible, light-weight and can be made semitransparent. In this talk, I will present pathways to fabricate high performance toward 20% power conversion efficiency, including materials design and molecular aggregation control, as well as technologies to realize semitransparency.

Key words: Organic solar cells; Performance; Semitransparency;

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H003: Low Carbon Aesthetic New Material under the Carbon Peaking and Carbon Neutrality Goals-CdTe Power Glass

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By analyzing about the current status of worldwide energy consumption, put forth insights into future construction system development. By discussing the relationship between studies on CdTe materials and power glass, put forth the advantages of CdTe materials and difficulties addressed amid research and exploration. Detailed descriptions of strengths of large-area cadmium telluride power glass in construction application and case study analysis.

Abstract

H004: Printing Technology for Highly Efficient and Stable Perovskite Solar Cells

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Controlling the crystallization process of perovskite thin films to obtain a high-quality material is one of the most challenging aspects for upscaling perovskite solar cell (PSC) technology. Here, we expand the lead acetate precursor route to form mixed A-cation perovskites, namely, formamidinium–caesium lead perovskite. High-quality large-area formamidinium–caesium mixed-cation perovskite films were produced by blade-coating a lead acetate-based precursor formulation in an ambient laboratory environment, with the use of NH4+ as a volatile cation to drive off acetate during annealing, leading to formation of PSCs with a power conversion efficiency (PCE) of up to 21.0%. Blade coated mini-modules with an aperture area of 10 cm2 displayed PCEs of up to 18.8%. The encapsulated PSCs showed excellent thermal stability, with no evidence of efficiency loss after 3300 hours at 65 degree.

Key words: Blade printing; Thin film; Perovskite solar cells;

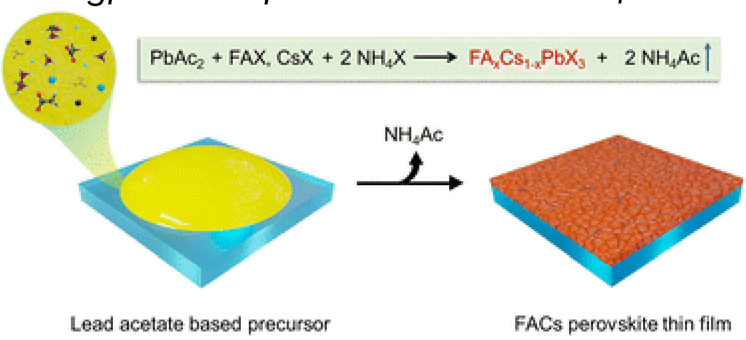

Fig.1 Printing efficient and stable perovskite solar cells with $PbAc_2$-based precursors

References:

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Abstract

H005: Subwavelength Photonic Devices Based on Chalcogenide Glass

Wei Zhang[1,2,*], Zhiyong Li[1,2], Chenfeng Zhou[1,2], and Xuelei Zhang[1,2]

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Chalcogenide glasses (ChGs) are widely recognized as the material of choice for sensing, integrated photonics and all-optical signal processing due to their broad transparency window, large linear and nonlinear refractive indices, low two-photon absorption and negligible free carrier absorption. Here we introduce high-quality subwavelength Bragg grating (BG) filters, as well as slot Bragg grating sensor and slot microring resonator sensor, based on Ge-Sb-Se ternary ChGs using dry etching techniques.

BG filters play important roles in integrated photonics such as signal processing and optical sensing. In silicon-based counterpart photonic platforms, the application of narrow-bandwidth filters is often restrained by fabrication limitations. Here, narrow-bandwidth BG filters based on Ge-Sb-Se chalcogenide materials are investigated. The structure of the filter is designed by optimizing the grating period, corrugation height, and grating number. The large corrugation of chalcogenide BG is more friendly and convenient for manufacturing process. The symmetric and asymmetric corrugation filters are then fabricated and characterized. Experimental results show a half-maximum bandwidth of 0.97 nm and 0.32 nm for symmetric and asymmetric filters, respectively, which demonstrates excellent narrow-bandwidth filtering performance of chalcogenide BG.

As for sensor device, traditional sensor with a strip structure has a limited sensitivity because the effective mode is confined to a high refractive index waveguide core layer, resulting in a feeble evanescent field making contact with the analyte. Slot Bragg grating sensor and slot waveguide microring resonator, manufactured by

Abstract

electron beam lithography and inductively coupled plasma etching, which confine the effective mode in the low index slot region, could increase the interaction between the effective mode and the analyte, and improve the sensitivity of the sensor. The obtained chalcogenide SBG has a minimum feature size of 150 nm, which makes it easier to manufacture than silicon photonics Bragg grating devices. Measurement results show a high sensitivity of 325 nm/RIU, compared to the conventional evanescent field waveguide sensor in the sensing experiment. Meanwhile, the chalcogenide slot waveguide microring resonator has achieved a quality factor of 1×10^4, one of the highest quality factors reported for chalcogenide slot microring resonators. The sensitivity of the sensor is measured to be 471 nm/RIU, which leads to an intrinsic limit of detection of 3.3×10^{-4} RIU.

Our research works illustrate the feasibility of Ge-Sb-Se glasses as materials for integrated photonics, especially for optical filtering and sensing applications.

Key words: Chalcogenide glasses; Microring resonator; Slot Bragg grating;

Abstract

H006: Hydrolysis and Condensation of Monobutyltin Chloride: Reaction Process Analysis with DFT

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As the initial process of preparing transparent conductive oxide materials from monobutyltin chloride (MBTC) to tin oxide, the hydrolysis and condensation of MBTC to form a dimer Sn_2 play a critical role. However, the specific mechanism of this process is still unclear. Here we develop a step-by-step searching method based on density functional theory calculation and empirical chemical criteria to determine possible reaction pathways and reveal the most likely reaction mechanism. The wave function analyses of various intermediate species provide more insights into the changes of atomic charge population, chemical bond strength, and coordination situation of central tin in the reaction process. Further investigation on the ring-containing Sn_2 reveals the existence of unique three-center four-electron (3c-4e) interactions to stabilize the four-membered Sn_2O_2 ring structure, which serves as the true driving force for dimerization reaction. These results provide a more detailed understanding of the hydrolysis and condensation process of MBTC and would be helpful for the future optimization of the preparation process of tin oxide films.

Key words: Monobutyltin chloride; DFT; Reaction mechanism; Wave function analysis;

Abstract

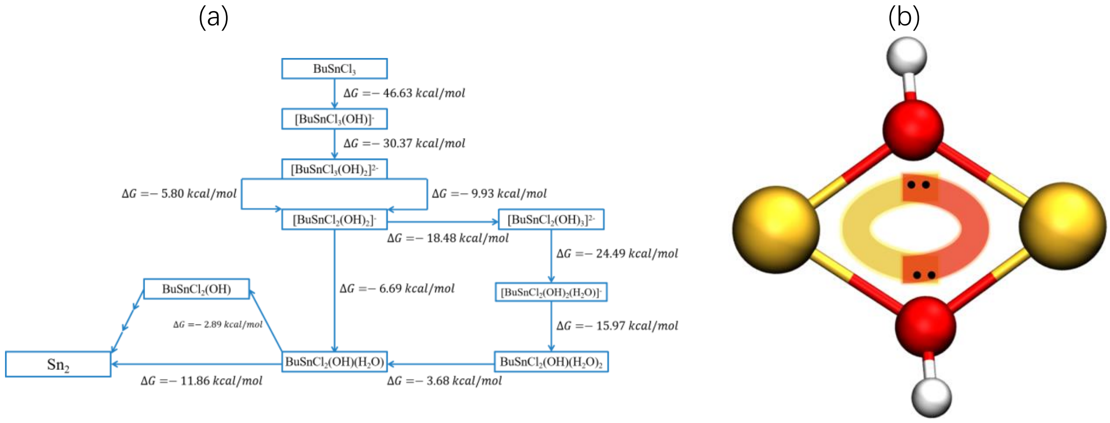

Fig. 1 (a) All reaction pathways connecting MBTC and Sn_2 (b) The 3c-4e interactions within the Sn_2O_2 unit of Sn_2.

References:

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Abstract

H007: Carbon Dots Integrated Luminescent Solar Concentrators for Building Integrated Photovoltaics

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Luminescent solar concentrators (LSCs) are large-area sunlight collectors coupled to small area solar cells, for efficient solar-to-electricity conversion. LSCs can utilize incident solar light at any angle without the use of solar tracking system. Benefited their light weight, semi-transmittance, and low-cost, they have the great potential for use as building integrated photovoltaics (BIPVs). The three key points for successful market penetration of LSCs are: (i) removal of light losses due to reabsorption during light collection; (ii) high light-to-electrical power conversion efficiency of the final device; (iii) long term stability of the LSC structure related to the stability of both the matrix and the luminophores. Among various types of fluorophores, carbon quantum dots (C-dots) offer wide absorption spectrum, high quantum yield, non-toxicity, environmental friendliness, low-cost and eco-friendly synthetic methods. However, they are characterized by a relatively small Stokes shift, compared to inorganic quantum dots, which limits the highest external optical efficiency for large-area single-layer LSC (>100 cm^2) based on C-dots below 2%. In this talk, we reported highly efficient large-area LSCs (100-225 cm^2) based on several types colloidal C-dots with different colors via wet-chemistry approach. We can produce gram-scale C-dots with a high quantum yield (QY) (50-70%) and large Stokes shift. The large-area LSC ($15\times15\times0.5$ cm^3) prepared by using polyvinyl pyrrolidone (PVP) polymer as a matrix exhibits a power conversion efficiency (PCE) of 1-5% under natural sunlight illumination. These findings demonstrated the possibility to obtain eco-friendly, high efficiency, large area LSCs through scalable production techniques, paving the way to the use of the LSC for BIPVs.

Key words: Thin film; BIPVs; Luminescent solar concentrators; Cabon dots;

Abstract

H008: Synthesis of Ultra-bright Emission Carbon Dots for High-performance Luminescent Solar Concentrators

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Carbon dots (CDs), a new class of fluorescent carbon-based nanomaterials, have become a research hotspot in recent years due to their unique and excellent properties, such as tunable fluorescence excitation and emission, high photoluminescence quantum yield, greenness, low cost, and excellent biocompatibility, which have outstanding application prospects in the fields of biology, sensing, catalysis, and optoelectronics. However, CDs usually suffer from aggregation-induced quenching problem, which seriously hinders their development in the field of optoelectronic devices. In our study, the efficient preparation, properties, and applications of ultra-bright luminescent CDs were developed and investigated in detail. The employment of bright-emitting CDs enables the fabrication of high-performance luminescent solar concentrator devices and the realization of high photovoltaic conversion efficiencies. These experimental results show that eco-friendly CDs can be an ideal candidate for the fabrication of high-performance optoelectronic devices.

Key words: Carbon dots; Aggregation-induced quenching; Luminescent solar concentrator;

Abstract

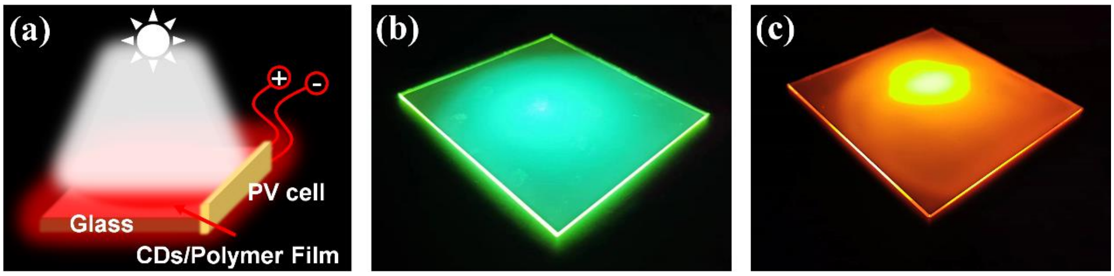

Fig.1 (a) Schematic diagram of the LSC device. (b) Optical picture of ultra-green emission CDs based on LSC devices. (c) Optical picture of bright yellow emission CDs based on LSC devices.

References:

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Abstract

H009: Room Temperature Preparation and Lead Leakage Suppression of Perovskite Thin Film Solar Cells

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Organic inorganic perovskite solar cells, due to their high absorption coefficient, can be prepared into opaque solar cells with a thickness of less than 1 micrometer. Such a small thickness cannot be prepared through top-down methods. The existing preparation methods mainly use one-step or two-step solutions. The nano tin dioxide electron transport layer and active layer of the battery require heat treatment at 180 ° C and 150 ° C respectively. If titanium dioxide is used as the electron transport layer, it needs to undergo heat treatment at a temperature above 400 ° C. These heat treatment temperatures are significantly higher than the heat treatment temperatures of polymer flexible substrates such as PET/ITO or PEN/ITO, which limits the development of flexible solar cells. For this reason, we propose a method of using ultrasonic vibration instead of heat treatment. The basic principle is that the nucleation of grains occurs quickly after solvent evaporation, but impurities such as solvent molecules and inorganic ions remaining on the surface of the grains inhibit the surface energy driven grain growth process. Using ultrasonic vibration can achieve cold sintering of nano tin dioxide films and perovskite precursor wet films at a power of 10W and a time of as little as 3 minutes [1], respectively, And a perovskite solar cell prepared at full room temperature was obtained, with an efficiency of over 17.0% for flexible cells [2]. In order to suppress potential lead leakage in perovskite solar cells, we introduced polymer monomers thermally polymerized at 60 ° C into the absorption layer solution of perovskite solar cells [3,4], which formed an amorphous polymer network. This can reduce lead ion leakage by more than 70%, resulting in a glass based rigid MAPbI3 battery with an efficiency of over 23%.

Abstract

Key words: Perovskite solar cell; Glass transition temperature; Cold sintering; Polymer encapsulation;

References：

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Abstract

H010: Phosphorylation Constructs Ion Channels to Improved Reactivity And Electrochromic Performance of Nickel Oxide

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As an anodic electrochromic material, nickel oxide (NiO) has attracted much attention due to its neutral coloring feature and wide optical modulation in visible light.[1] However, the electrochromic performance of nickel oxide has been unsatisfactory due to the dense cubic phase structure that hinders the insertion of ions.[2] Developing rational crystal structures of NiO to improve electrochromic performance remains a challenge till now. Herein, we enhanced the electrochromic performance of NiO by introducing phosphorus to construct ion transport channels. Experimental and theoretical analyses illustrated that the introduction of P generates P-O tetrahedra in nickel oxide crystals, transforming the NiO with dense crystal structure into a porous structure with large number of cavities. The continuous cavities provide new channels for the ions transporting, which significantly improved the electrochromic performance of nickel oxide. Especially, a large optical modulation range of 90.7%, high coloration efficiency of 81.1 $cm^2\ C^{-1}$, and short coloring / bleaching time of 6 s/7.3 s were achieved (at 500 nm) after phosphorylation of the NiO. In addition, the designed P-NiO-based electrochromic devices simultaneously achieved large optical modulation, fast response, and high coloration efficiency. Therefore, the strategy of introducing non-metallic elements to construct ion transport channels would be a judicious way to construct high performance electrochromic devices.

Key words: Metal oxide; Phosphorylation; Ion channels; Optical modulation;

Abstract

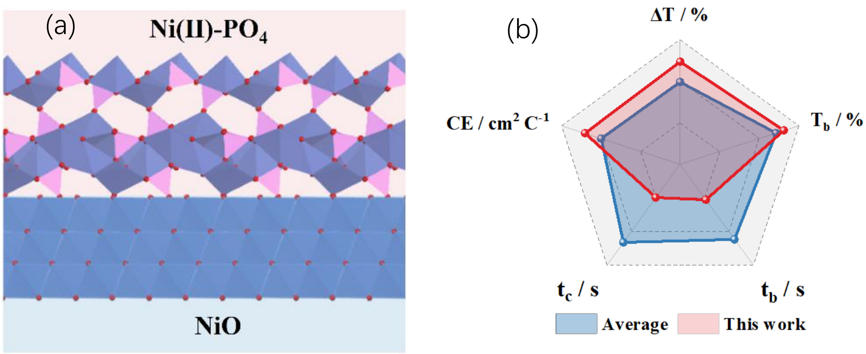

Fig.1 (a) Crystal model of P-NiO. (b) Average electrochromic performance of the P-NiO device compared to other process NiO devices.

References:

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Abstract

H011: Progress in Thermochromic Smart Windows

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Windows associated energy consumption in buildings was estimated at about 4% of primary energy in some developed countries. Thermochromic material responds to solar spectrum differently at the stimulus of heat which makes it attractive in the energy saving smart windows application. The most studied inorganic VO_2 has the intrinsic problems of low luminous transmission (T_{lum}) and low solar modulation (ΔTsol the transmission difference between high and low temperatures). Numerous efforts such as employing dopings, nanoparticle-based composites, and nano-porous structuring have been widely studied. Our group have developed some new approaches to tackle this veritable challenge, namely, biomimetic nanostructuring including photonic structure and moth eye, gridded structures, tunable plasmonic structures, organic and hybrid structures. In addition, new active controls have also been applied to thermochromic material to generate a new electro-thermochromics or mechanical-thermochromic materials. The more recent work on radiative cooling regulated smart window suggested the inefficiency of the traditional performance index. The perspective of next generation of smart window will be discussed.

Abstract

H012: Intelligent Photothermal Regulation Materials and Devices for Energy-efficient Application

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Faced with the higher requirements of building energy conservation for comprehensive regulation of solar light and heat, it is necessary to meet the dual functions of summer heat insulation/winter heat preservation; Focusing on the research of inorganic intelligent light and heat regulation materials and devices, the speed of active intelligent light and heat comprehensive regulation is slow, poor stability and other problems, a new method of proton relay transmission is proposed to achieve ultra-fast transfer of proton in the solid electrolyte, greatly improving the discoloration speed and stability of the device. Aiming at the problem of adaptive photothermal comprehensive regulation, a new structure of multi-layer composite film system is proposed to achieve dual improvement of visible light and solar energy regulation rate. Vanadium dioxide (VO_2) is a representative material for typical adaptive photothermal regulation. Optical performance tuning and stability are basic scientific issues and problems that restrict its application. Elucidate the degradation mechanism of VO_2 films and establish a long-life film preparation plan; develop a high-performance VO_2 self-rolling multi-level control structure; provide theoretical and technical support for the application of photothermal materials.

Abstract

H013: VO_2 Emissivity Regulation

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VO_2 thin films have been developed for over 70 years. Many milestone works have been reported in past 3 decades [1]. Most of these works are the synthesis, visible transparency, solar energy control and phase transition temperature of VO_2 thin films and nanocrystals. In this talk, we present the control of the emissivity of VO_2 thin films with special emphasis on the practice and progress (Figure 1).

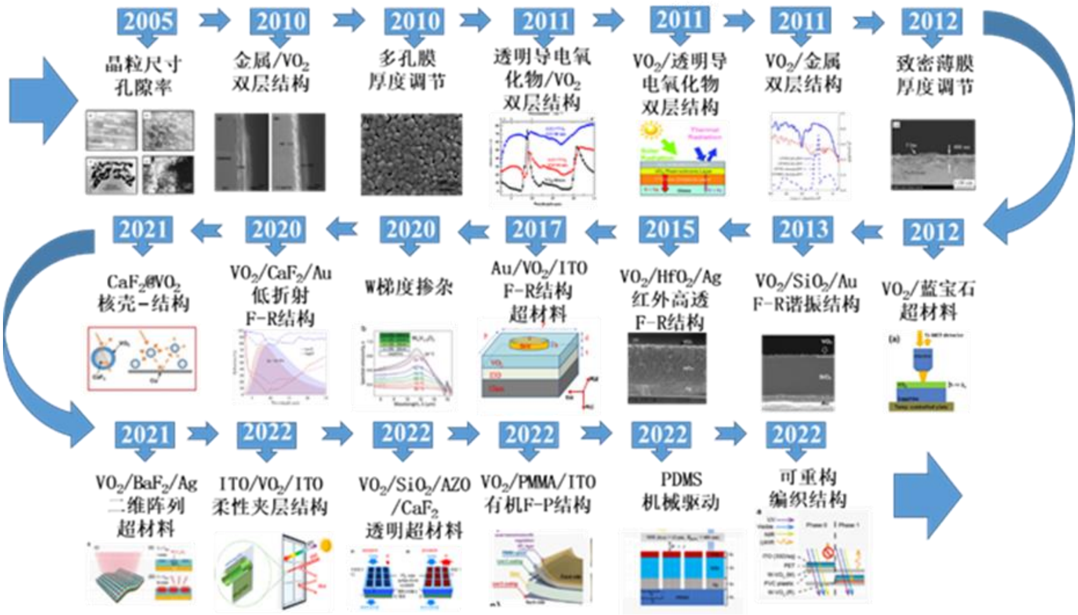

Fig.1 Schematic description of the regulation methods and representative works for VO_2 emissivity control

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Abstract

H014: Objective-orientated Automatic Optimization Guided Fast Fabrications of High-property VO2-based Multilayered Thermochromic Smart Coatings

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VO_2-based thermochromic coatings had drawn much attention in energy-saving smart glazes. High visible light luminance transmittance (T_{lum},) and solar light modulation (ΔT_{sol}) are needed for practical applications of the VO_2-based smart glazes. However, the trade-off between the high T_{lum} and high ΔT_{sol} cannot be obtained for the single-layer dense VO_2 film. Fabrications of multilayered film structures is the widely used way; selecting suitable multilayered combinations through optical designs is important to realize the trade-off. The current research reported experimental preparations of VO_2-based multilayered film systems under the guidance of the so-called objective-orientated automatic optimization method developed by us. Fast optimizations can be realized among various multilayer structures to screen out the most suitable film system. Based on the designs, the multilayered film systems that have both high T_{lum} and ΔT_{sol} were prepared with SiO_2, TiO_2, and VO_2 layers. The novel methodology presenting here can realize fast designs and fabrications of multi-layered VO_2-based film systems according to the different demands; it is believed that this can promote the research progress and reduce its costs.

Abstract

H015: Effect and mechanism of W dopant on thermochromism properties of VO_2 thin films by magnetron sputtering and post-oxidation

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VO_2 is an ideal material for preparation of "warm in winter, cool in summer" smart windows. At present, there are still some difficulties in practical applications. The first problem is the high phase transition temperature. In this paper, a series of researches are carried out on the issue of reducing the phase transition temperature of VO_2 thin films, which are prepared on quartz glass by magnetron sputtering-post-oxidation. The thermal hysteresis loop is drawn by testing the variable temperature transmission curve, the crystal structures and peak drifts of the films are characterized by XRD, and the micro morphologies of the films are observed by SEM. The experimental results show that a reasonable amount of W dopant can significantly reduce the phase transition temperature of the VO_2 film, and maintain a good near-infrared switching efficiency. But excessive W dopant has a series of negative effects on the thermochromism performance and optical properties of VO_2 film. Models of electron doping and energy band theory are utilized to analyze and discuss this problem.

Key words: VO_2; Magnetron sputtering; Post oxidation; W dopant;

Abstract

H016: Photochromic $W_{18}O_{49}$ Nanoparticles Dispersed Films for Smart Window

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Photochromic smart window is a promising method to save building energy and thus reduce carbon emissions. Among photochromic materials, $W_{18}O_{49}$ has widely used due to its strong localized surface resonance effect and unique oxygen-deficient structure. In this work, the bleached $W_{18}O_{49}$ obtained by mild-heating the solvothermal-synthesized blue $W_{18}O_{49}$ nanoparticles in air exhibited considerable reversible photochromic feature, which can be colored in 1 min under UV irradiation. The photochromic mechanism of $W_{18}O_{49}$ was revealed through the XRD, XPS and FTIR results. The chromic process was mainly attributed to the changed W^{5+} content under different conditions. The photochromic performance was systematically investigated on the $W_{18}O_{49}$ nanoparticles dispersed film and which can be significantly improved by Ti doping. Finally, the great potential of the films in the energy-saving smart window application has verified, and a 10 at.% Ti-doped $W_{18}O_{49}$ film delivered outstanding optical performance with luminous transmittance (T_{lum}) of 87.53% and solar energy modulation efficiency (ΔT_{sol}) of 30.13%.

Key words: Tungsten oxide; Photochromic; Smart window;

Abstract

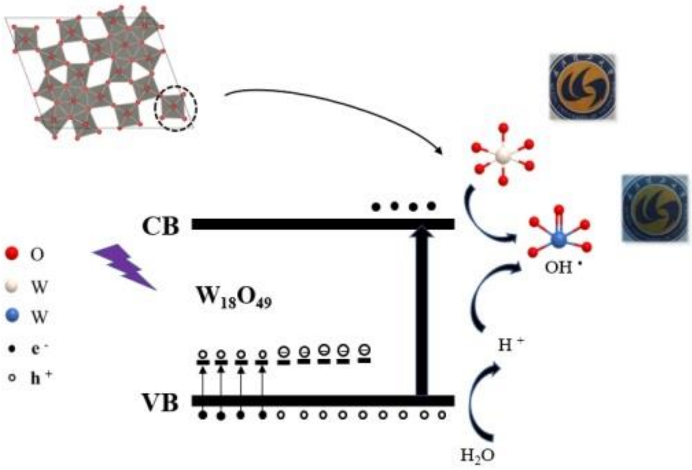

Fig. 1 The photochromic phenomenon and mechanism of $W_{18}O_{49}$ nanoparticles dispersed films.

References:

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[2] Qian J, Li B, Tian S, et al. Appl Surf Sci, 2022, 605, 154680.

Abstract

H017: Multifunctional Inorganic All-Solid-State Electrochromic Glasses and Energy Saving Window Applications

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Two types of transmissive and reflective electrochromic thin film devices with tungsten oxide and nickel oxide-based all-inorganic films and inorganic-organic laminated all-solid-state multilayered structures were fabricated and investigated through vacuum magnetron sputtering coating technology. The devices show excellent intelligent modulation properties of spectrum selective transmittance and reflectance of ultraviolet, visible, near-infrared and mid-infrared light regions. Electrochromic thin film devices have great potential application prospects in the fields of building energy-saving smart windows, spacecraft intelligent thermal control, military camouflage and stealth. The industrial scale-up production and potential applications of large size electrochromic glasses and flexible thin film devices in China are to be briefly introduced.

Abstract

H018: Large-Area Electrochromic Smart Glas

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Electrochromic glass has broad application prospects in many important fields such as energy-saving buildings, information displays, national defense industry, etc. However, its development is limited by some problems such as small optical modulation range, poor cycle stability, small device size and relatively single function. Herein, we illustrate current state-of-art strategies for the fabrication of nanostructured electrochromic materials, rational design of multifunctional devices, and the characterization of their performance. By analyzing the coupling mechanism between the electrochromic layers and the electrolyte, we proposed a new interface regulation strategy to improve the compatibility of ion and electron transport rate, and developed an electrochromic material with optical modulation of up to 97.7%. By adjusting the interaction between the ink components and the electrode, a novel technology of large-area film formation was established with the compatible feature of the electrochromic layer and the electrode, and a large-size (50 × 50 cm^2) electrochromic device was constructed for the first time. A novel system of multifunctional and flexible devices was demonstrated by precisely designing the matching relationship between each functional layer. The application of electrochromism was extended to the fields of wearable intelligent optoelectronic devices and other fields.

Key words: Electrochromic glass; Multifunctional device;

References：

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Abstract

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H019: Long Lifetime and High Stability Space Laser Coatings

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With the continuous development of space technology and exploration, space laser has been used in a wider range of applications, such as space communications, meteorological and geological exploration, height measurement and so on. As one of the weakest points in the optical system, the reliability and stability of thin-film components are crucial for space laser systems. Once optical coatings are damaged in the space environment, coatings cannot be repaired or replaced. In addition, there are environmental effects such as vacuum, radiation, and pollution in the space. The damage mechanism of laser coatings for space applications under laser irradiation was investigated. The effects of structural defects on coatings were explored by microscopic morphological analysis and combined with electric and temperature field models. The effects of space environmental factors on the lifetime and stability of the films were also simulated, including the timeliness of the spectra under long-time storage, the stability under vacuum, and the reliability of the space coatings under gamma-ray radiation.

Key words: Laser coating; Space laser coatings; Laser induced damage;

Abstract

H020: Key Preparation Technology and Large-scale Production of Highly Transparent and Conductive Tin Oxide Films

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SnO_2 nanocrystals (NCs) are wide band gap semiconductors (the band gap at nanoscale with more than 4.0 eV). The lose oxygen of SnO_2 NCs at high temperature or low-pressure environment will result in the certain conductive properties due to the generated oxygen vacancies. As an alternative material with the greatest development potential for TiO_2, the SnO_2 NCs have been widely used in perovskite solar cells, new inorganic compound solar cells and other fields. These applications have demonstrated the superior photostability, high electrical conductivity, high anti-reflection and other characteristics of SnO_2 NCs.

Based on the preparation of SnO_2 NCs by combining coprecipitation with hydrothermal crystallization, the research team has conducted many years of research and exploration in the dissolution of raw materials, coprecipitation and hydrothermal crystallization. All the aspects of experiment have been optimized and improved for many times, and the preparation process is very mature. Each of SnO_2 NCs sols has the good dispersibility, processability of low-temperature solution, and film-formation, and the deposited SnO_2 films have the superior photoelectric properties. Moreover, the prepared SnO_2 NCs and the deposited transparent and conductive films also show the superior repeatability. The preparation of SnO_2 NCs has fully equipped with the industrial pilot ripening conditions.

The prepared SnO_2 NCs with the mature scheme have the following properties: (1) crystal structure of rutile phase, (2) grain sizes of 3 ~ 6 nm, (3) good thermal stability, (4) superior mechanical stability, (5) preferred hard materials, and (6) good electrical conductivity. The deposited SnO_2 films present the following photoelectric properties: (1) excellent electrical parameters (carrier concentration: > 1.75×10^{17} cm^{-3}, electron mobility: > 2.81×10^{-3} cm^2 $V^{-1}s^{-1}$, conductivity: > 7.87×10^{-3} S m^{-1}), (2) high optical

Abstract

transmittance (transmittance at visible light > 95%, as supplied in Fig. 1), (3) good anti-reflection characteristics, (4) small refractive index difference with substrate, etc.

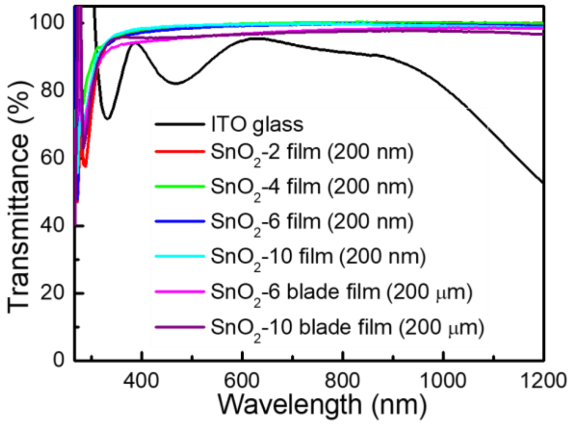

Fig. 1 Optical transmittance of ITO conductive glass and SnO_2 films (ordinary glass as substrate) under different optimization conditions (slide as the transmission reference).

Abstract

H021: Designing V_2O_5/MXene van der Waals Heterostructure for Multifunctional Color Glass

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Developing highly efficient electrochromic multifunctional color glass is essential for generating ample color changes and large electrochemical capacity, from the perspective of practical energy conservation.[1] However, slow ion diffusion and poor electron transport speed is one significant limited factor for the transition metal oxide film.[2] MXene exhibts good conductivity which is a promising candidate for electrochromic materials that require rapid ion insertion/extraction. Herein, we designed a two dimensional (2D) van der Waals heterostructure with face-to-face hybridization of MXene and V_2O_5 via self-assembly. These heterointerfaces serve as highly "active" sites that favor the ion diffusion in this region. Meanwhile, the prepared V_2O_5/MXene thin film have a macroporous structure, which is beneficial to the improvement infiltration of electrolyte and the rapid ion transportion . Benefiting from the fast and efficient ion/electron transport kinetics, heterostructured V_2O_5/MXene films exhibit large optical modulation (57%), short switching time (6.8/7.4 s), high coloration efficiency (92.3 cm^2 C^{-1}) and multicolor variation from yellow, olive, and dark green to brownish-red. In addition, MXenes can serve as an interlayer scaffold to alleviate the volume expansion during the insertion/extraction of Li^+, resulting in an excellent cyclic stability (over 2000 cycles). Finally, the patterned film is designed with a help of masks, which provides a new avenues for the construction of multicolor patterned displays.

Key words: Electrochromism; Van der Waals heterostructure; Multifunctional color glass;

Abstract

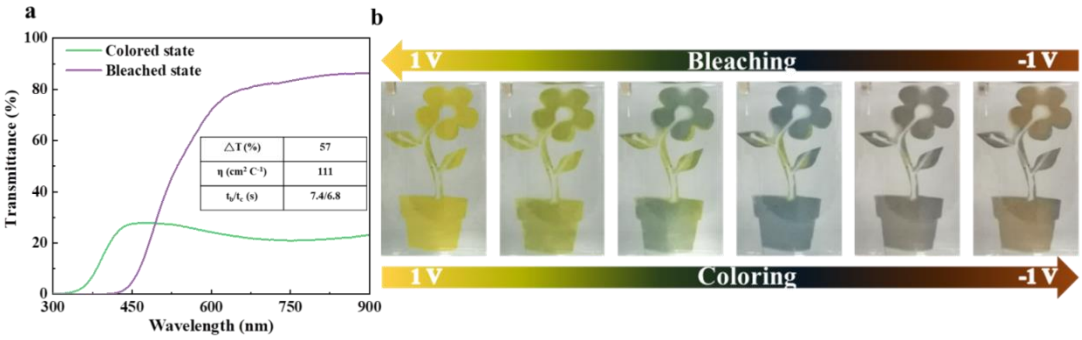

Fig.1 (a) Transmittance spectra of V_2O_5/MXenen thin film baed on Van der Waals heterostructure at colored state and bleached state (inserted table exhibts electrochromic performance parameters). (b) The digital photos of patterned V_2O_5/MXene thin film under different applied potentials.

References:

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Abstract

H022: A facile Electrochemical Lithiation Method to Prepare Porous Nickel Oxide Electrodes with High Electrochromic Performance

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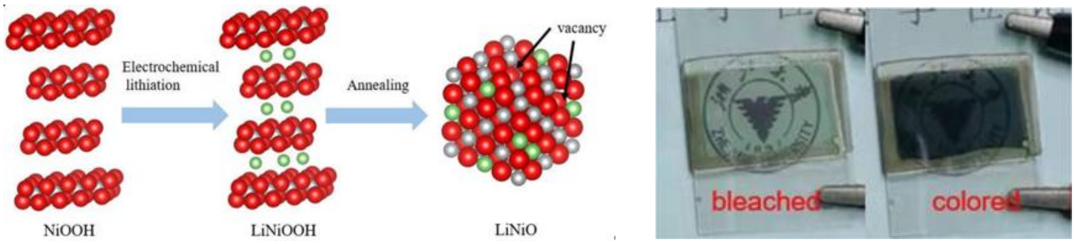
As an ion storage layer for electrochromic devices (ECDs), nickel oxide (NiO) is crucial for maintaining the charge balance of the ECDs. The modification of NiO through doping can effectively enhance the charge storage capacity performance, but the traditional "one pot method" in the wet chemical route cannot control the content of doped elements effectively. In the present work, a facile electrochemical lithiation method was developed in the framework of the wet chemical route, and Li-doped NiO (Li-NiO) films have been successfully prepared. The structure and morphology were characterized by using SEM, HRTEM, XRD, XPS, etc. The electrochromic performance and electrochemical reaction kinetics of NiO films were tested by combining CV, CA, EIS, and UV-Vis. The results indicate that the lithium content in NiO exhibits a linear relationship with the amount of charge injected during electrochemical lithiation. The optimized NiO electrode was obtained by injecting a charge of 25 mC and exhibited an excellent storage capacity of 6.4 mC/cm^2 and transmittance modulation of 35.7% at 550 nm, which can be attributed to the improved p-type characteristics, ion storage, and diffusion capabilities. The ECDs with the structure of Glass/FTO/WO_3/PC-$LiClO_4$/Li-NiO/FTO/Glass was assembled here, has a transmittance modulation of 55.7% at 550 nm and a coloring efficiency of 89.4 cm^2/C.

Key words: Electrochemical lithiation; Nickel oxide; Electrochromic; Porous film; Chemical bath deposition;

Abstract



(a) (b)

Figure 1. (a) Schematic diagram of crystal structure evolution during electrochemical lithiation process, and (b) Digital photos of electrochromic devices before and after color change.

Reference

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[2] F. Zhao, H. He, Z. Cheng, Y. Tang, G. Li, G. Xu, Y. Liu, G. Han, Improving electrochromic performance of porous nickel oxide electrode via Cu doping, Electrochim. Acta, 417 (2022) 140332.

Abstract

H023: Inorganic Multi-color Transmissive-type Electrochromic Electrodes Based on Fabry-Perot Interferometer for Full-solid Smart Window

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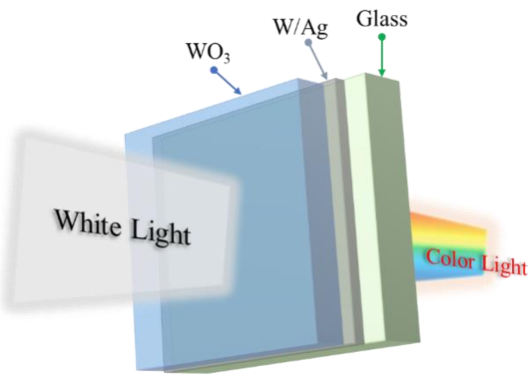
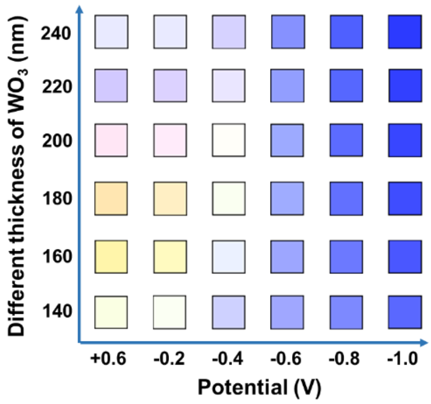
Recent inorganic multi-color electrochromic electrodes frequently contain thick reflecting coatings, sacrificing transparency and limiting their applications. In the present work, a strategy for creating inorganic multi-color transmissive-type electrochromic electrodes (MCTEEs) is proposed within the context of an asymmetric Fabry-Perot interferometer, which satisfies the aesthetic requirement for color variation while maintaining adequate transmittance. Based on the optimized design, a prototype MCTEE was successfully created using the magnetron co-sputtering technique, which has a high potential for use in transparent display and decorating applications because of its good cycle stability (72.4% optical modulation remained after over 600 cycles), the fast response time (6.5 s/3.8 s for coloration/bleaching process), and the good color tunability (pink, colorless, light blue, and dark blue with various applied voltages).

Key words: Electrochromism; Tungsten oxide; Multi-color; Smart window;

Abstract



(a)



(b)

Fig.1 (a) Schematic diagram of MCTEE with the structure Glass-Ag-W-WO_3. (b) Calculated transmittance color of MCTEE with various applied potentials and WO_3 thicknesses.

References:

[1] Z. Wang, et al., Towards full-colour tunability of inorganic electrochromic devices using ultracompact fabry-perot nanocavities, Nat. Commun. 11 (1) (2020) 302.

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Abstract

H024: A Facile Hydrothermal Method for Preparing Niobium-tungsten Bimetallic Oxide Rlectrodes with High Dual-band Electrochromic Performance

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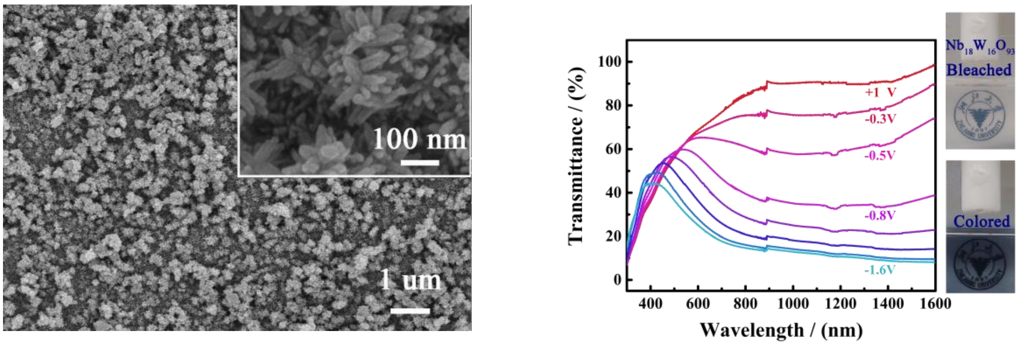
The dual-band electrochromic (EC) smart window, which are capable of selectively regulating visible (VIS) and near-infrared light (NIR), are considered one of the most attractive options of building for significantly reducing the energy consumption of buildings. This work successfully synthesized niobium tungsten bimetallic oxide ($Nb_{18}W_{16}O_{93}$) films with tungsten bronze like phases using a simple hydrothermal method, and studied their microstructure and dual-band electrochromic properties. The prepared niobium tungsten bimetallic oxide film is formed by disorderly stacking of nanorods. Based on this morphology, the $Nb_{18}W_{16}O_{93}$ films exhibits impressive dual-band EC performance, including high optical tuning (49.4% at 633nm and 90.5% at 1600nm), short bleaching/coloring time (2.6s/12s at 633nm and 6.1s/6.5s at 1600nm), and satisfactory cyclic stability. This work, not only, demonstrates that niobium tungsten oxygen bimetallic oxide is a high performance dual-band electrochromic material, but also, provides a strategy with potential for large-scale synthetic materials.

Key words: Niobium tungsten bimetallic oxide, Hydrothermal method, Nanorods, Dual-band electrochromism;

Abstract



(a) (b)

Fig. 1 (a) SEM images of NWO films, (b) Transmittance variation of NWO films at bleached and colored states (in inset digital photos of NWO films for the bleaching (+1 V) and coloring (-1.6 V) states).

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Abstract

H025: Study on Preparation and Self-cleaning Properties of Biomimetic $AlPO_4$ Array Coated Glass

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Fogging and dusting of glass surfaces is a common problem in life. In nature, the leaves and flowers of many plants, the wings and legs of insects have unusual self cleaning characteristics. This gives us the inspiration for glass anti-fog research. Here, we provide a simple method to prepare a bionic anti-fogging $AlPO_4$ array with superhydrophilic properties. The size of $AlPO_4$ array can be adjusted by the concentration of the coating solution, the environmental humidity during the drying self-assembly process and the drying time. Nano $AlPO_4$ array imitating cicada wing structure has great application value in the anti-fog field because of its high transparency, low haze, superspreadability and wear resistance. In addition, the roselike $AlPO_4$ arrays may be a good choice in the field of photovoltaic cover, because of its superhydrophilic and anti-glare properties.

Key words: Aluminum phosphate; Array structure; Bionics; Superhydrophilic;

Abstract

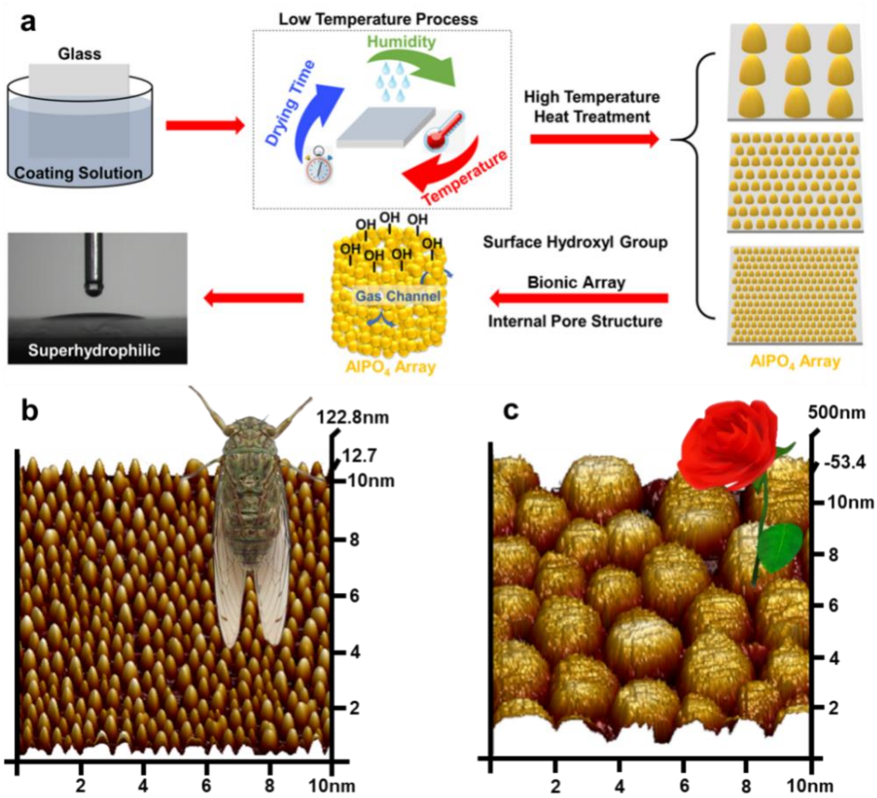

Fig.1 (a) Schematic diagram of the preparation process and water contact Angle test of $AlPO_4$ array. (b-c) AFM images of $AlPO_4$ nanoarray and microarray, respectively.

Abstract

H026: Monolayer Thermochromic VO_2 Films with Superior Durability Fabricated by A Facile Chemical Method

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Monolayer VO_2 thin films were fabricated by a facile sol-gel method, and then were deposited under normal environmental conditions. UV-vis-NIR spectra results show that the aged VO_2 film still keeps the modulation efficiency of approximately 54% at 2000 nm, while the visible transmittance retains at 40%~45%, after the film aged in ambient air for 8 years. The XRD patterns also demonstrate that the characteristic peaks of the samples match well with the VO_2 (M1) phase. Presumably, the cause could be that VO_2 embedded in the hypervalent vanadium oxides avoids being oxidized. This good thermochromic stability in ambient air indicates the practical applications of VO_2 film in smart window or other devices.

Key words: VO_2 thin film; Durability; Sol-gel method; Thermochromic property;

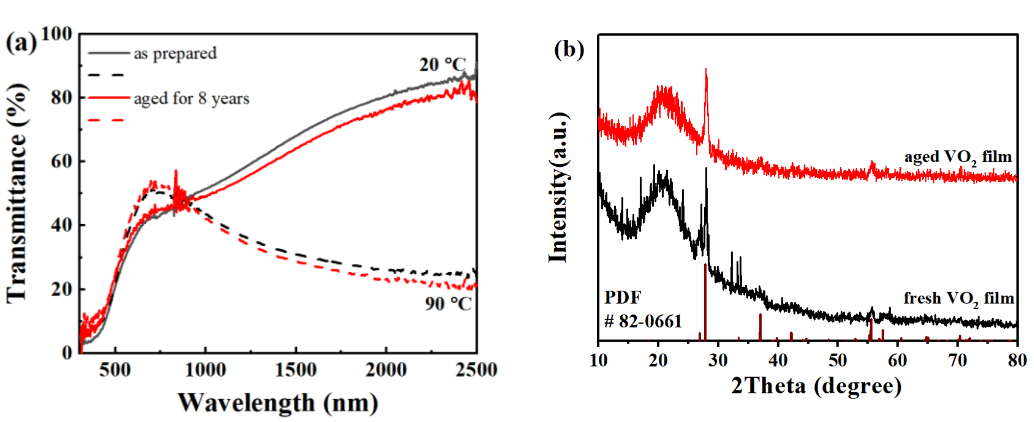

Fig.1 (a) UV-Vis-NIR transmittance spectra of VO_2 thin films as prepared and aged for 8 years. (b) GIXRD pattern of VO_2 thin films as prepared and aged for 8 years

Abstract

References:

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Abstract

H027: $W_{18}O_{49}$/PAM-PNIPAM Hydrogel Based Smart Windows with Enhanced Dual Photo- and Thermochromic Performance

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Smart window plays an important role in the field of building energy conservation, in which poly (N-isopropylacrylamide) (PNIPAM) has been widely investigated due to its excellent thermochromic properties. However, traditional PNIPAM-based smart window shows weak infrared (IR) shielding properties, which can limit its application in energy-efficient glazing. Herein, polyacrylamide-poly(N-isopropylacrylamide)/$W_{18}O_{49}$ hydrogel (PAM-PNIPAM/$W_{18}O_{49}$) with high luminous transmittance and high infrared shielding ability was prepared by adding an infrared shielding material ($W_{18}O_{49}$). This hydrogel exhibits excellent thermochromic and photochromic properties with a high luminous transmittance (T_{lum}). At the same time, after photochromic and thermochromic, T_{lum} and near-infrared (NIR) transmittance (T_{NIR}) will significantly decrease, which can fully meet the requirements for smart window, which not only has high light transmittance but also saves energy.

Key words: Smart window; Thermochromic; Photochromic;

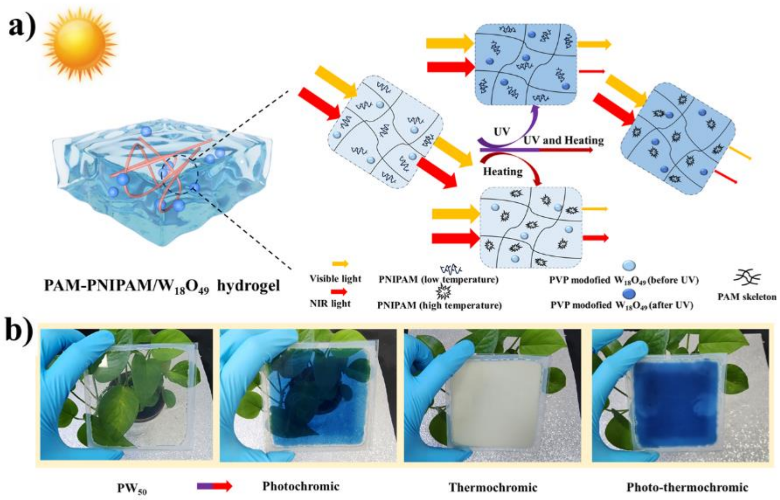

Fig.1 (a) Composite diagram of the PAM-PNIPAM/$W_{18}O_{49}$ composite hydrogel smart window. (b) The effect of thermochromic and photochromic on smart window

Abstract

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Abstract

H028: Thermochromic VO_2@Al_2O_3 with Excellent High Temperature Resistance and Durability by Atomic Layer Deposition

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Due to the reversible metal-insulator transition (MIT) behavior at around 68℃, vanadium dioxide (VO_2) has been potentially applied into various optoelectronic functional devices. Among them, thermochromic smart windows based on VO_2 have been an ideal solution to reduce the huge energy consumption of architectures in modern society. However, the thermodynamically unstable VO_2 spontaneously transforms into high valence vanadium oxides in moist environment, which unexpectedly deteriate the solar modulation ability (ΔT_{sol}) of VO_2. To address it, atomic layer deposition was employed to encapsulate the VO_2 particles with an outer Al_2O_3 coating, which acted as a protective shield for the VO_2. After a process of 500℃ insulation in the air atmosphere for half an hour, the composite VO_2@Al_2O_3 powders fully retained the monoclinic phase structrure of VO_2, illustrating excellent high temperature resistance. The VO_2@Al_2O_3 particles were mixed with PVP and ethanol to fabricate coating slurry, from which VO_2 nanocomposite film was obtained through spin-coating. The resulting film presented satisfactory thermochromic performance, with ΔT_{sol} of 14.9% and luminous transmittance (T_{lum}) of 52.5%. Furthertmore, the T_{lum} was boosted to 61.5% after 170 days due to the antireflective role of Al_2O_3. Additionally, ΔT_{sol} was improved to 19.8% because of the enlarged transmittance gap throughout the MIT behavior of VO_2, revealing outstanding durability of the VO_2@Al_2O_3 film. Thus, this work offers a new strategy for long-term VO_2 film fabrication and is beneficial for the commercialization of VO_2 thermochromic smart windows.

Key words: Vanadium Dioxide; Thermochromic Properties; High Temperature Resistance; Durability; Smart Windows;

Abstract

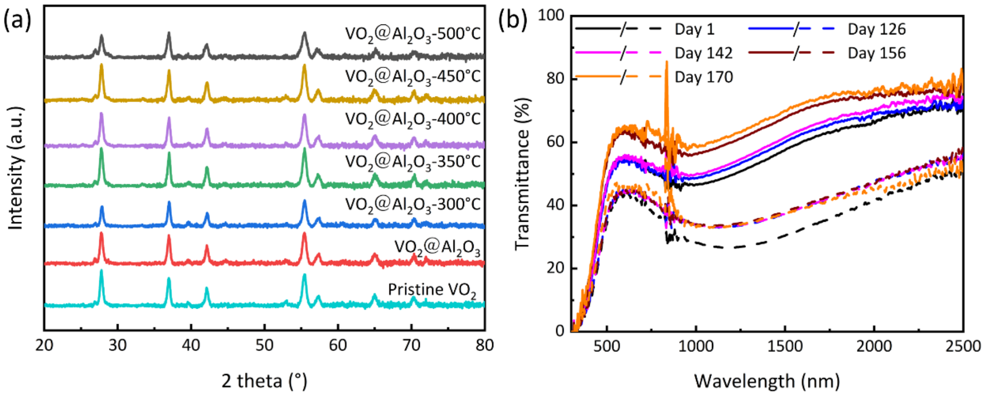

Fig.1 (a) XRD patterns of pristine VO_2 and $VO_2@Al_2O_3$ particles at different insulation temperatures. (b) Long-term transmittance spectra of $VO_2@Al_2O_3$ film.

References:

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[3] Li B, Tian S, Qian J, et al. Ceram Int, 2023, 49: 2310-2318.

Abstract

H029: Fully Discrete VO_2 Particulate Film with Ultra-High Luminous Transmittance and Excellent Thermochromic Performance

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VO_2 has attracted widespread attention due to its extraordinary thermochromic properties. Visually transparent VO_2 films hold great promise for applying in smart windows,[1] smart radiative coolers,[2] and microwave absorbing windows.[3] However, it remains a huge challenge to simultaneously achieve the ultra-high luminous transmittance (T_{lum}) and excellent thermochromic performance due to their contradictory relationship. Here, we develop a fully discrete VO_2 particulate (FDVP) film (Fig. 1) *via* a facile solution method. It shows an ultra-high T_{lum} of 92.7% due to the reflectance is significantly reduced. Below the phase transition temperature (T_c, 69.1 ºC), it is highly transparent to near infrared (NIR) light, while above T_c, it blocks NIR light through the strong localized surface plasmon resonance (LSPR) effect, resulting in an excellent solar energy modulation (ΔT_{sol}) of 10.5% for smart windows. In addition, a 3.5at.%W doped FDVP film exhibits a desired T_c of 25.8 ºC, an extremely narrow hysteresis width (ΔT) of 4.6 ºC, and good optical properties (T_{lum}=92.0%, ΔT_{sol}=8.2%). The performance represents a new milestone for thermochromic VO_2 films. This work will shed light on the structural design for high performance VO_2 films.

Key words: Vanadium dioxide; Transparent film; Thermochromic performance; Phase transition temperature;

Abstract

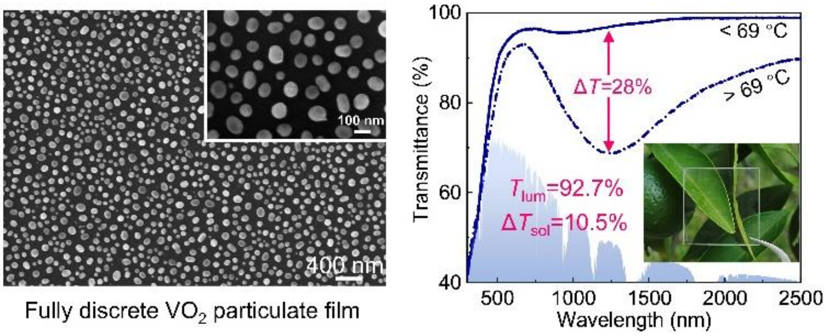

Fig.1 The SEM images and optical performance of the fully discrete VO_2 particulate film.

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.

Abstract

H030: Double-layer Broadband SiO_2 Antireflection Films with High Transmittance and Excellent Mechanical Performance for Solar Cells

Ziao Wang, Xuemin Zhang, Qiufen Liu, Gan Luo, Jianfeng Lu, Yi Xie, Xiujian Zhao, Shouqin Tian*

State Key Laboratory of Silicate Materials for Architectures, Wuhan University of Technology, Wuhan, China
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The solar cell as an essential solution to the energy shortage and environmental pollution is usually covered with a transparent glass to protect it from external stress and other environmental factors. However, there is at least 8% in the reflection of sunlight on the surface of the glass, resulting in a reduction of the solar transmittance and photoelectric conversion efficiency (PCE) of the solar panel. Accordingly, to reduce the reflection of sunlight, a layer of anti-reflection (AR) film was coated on the glass cover and thus AR film becomes a main approach in the photovoltaic industry to improve the PCE of solar panels. In this work, a PEG2000 modified acid-catalyzed SiO_2 film with lower refractive index was prepared by adding PEG2000 as pore-forming agent to acid-catalyzed SiO_2 sol via a facile sol-gel method, and then the film was coated on acid-catalyzed SiO_2 film to obtain a double-layer SiO_2 film with graded refractive index. As the refractive index and thickness of the two layers were matched, the film can obtain a higher transmittance increase than a single-layer SiO_2 film. When the mass ratio of PEG2000/TEOS was 40%, the film exhibited the highest transmittance increase of 3.03% in the range from 380 to 1100 nm and maintained a hardness of 3H. Moreover, the PCE of the perovskite solar cell was increased by 1.01% after application of the obtained AR film. And the film's WCA reached 6°, showing superhydrophilicity and ensuring the film's self-cleaning performance. Therefore, this work can provide a facile method to prepare AR films with high transmittance increase in the broad band and good weather resistance.

Key words: Double-layer SiO_2 film; PEG-modified; Acid-catalyzed; Transmittance

Abstract

increase; Hardness;

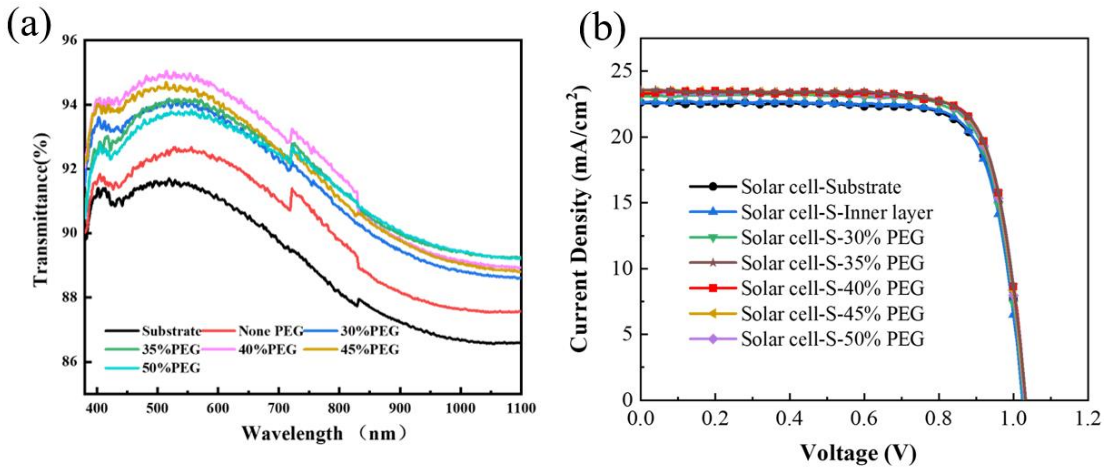

Fig. 1 (a) Transmittance spectra of double-layer SiO_2 films with different PEG2000 content (b) Voltage-current curves of perovskite solar cells coated with different AR films.

Abstract

H031: Processable Nanoarchitectonics of Two-dimensional Metallo-supramolecular Polymer for Electrochromic Energy Storage Devices with High Coloration Efficiency and Stability

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Two-dimensional porous metallo-supramolecular polymers (MSPs) have shown promising prospects for electrochemical-controlled functional devices as their highly reversible metal-centered redox chemistry. However, parallel efforts to solution-processable large-area uniform film based on high-quality MSPs have encountered with limited success. In this work, we develop a scalable method for synthesizing MSP-Fe with "gram" scale by coordinating 1,3,5-tris(4-(2,2′:6′,2′′-terpyridyl)phenyl)benzene with Fe(II) ions. A homogeneous solution of MSP-Fe in the mixture of EtOH/DMF (v/v = 1:1) is obtained. Furthermore, the uniform MSP-Fe film is assembled on a transparent conductive substrate by electrostatic spray technology. The obtained MSP-Fe films exhibit excellent electrochromic performance and energy storage property simultaneously, such as ultrahigh coloration efficiency of 1103.9 cm^2 C^{-1}, fast switching speed (< 1.5 s), large optical contrast (> 71.7%), and high specific capacity (12.01 mAh g^{-1}). More importantly, the degradation of optical contrast is only 3% after 10,000 cycles, proving the remarkable cycle stability of the MSP-Fe film. We further demonstrate a smart energy-storage indicator assembled by the MSP-Fe films, in which the energy-storage level is visually perceptible and recognizable in real-time. Furthermore, a large-area semi-solid-state electrochromic device (225 cm^2) is successfully constructed based on MSP-Fe films, which achieves a uniform, fast, and reversible color variation across the device.

Key words: Electrochromism; Metallo-supramolecular polymers; Electrostatic spray deposition; Semi-solid-state device; Energy storage device;

Abstract

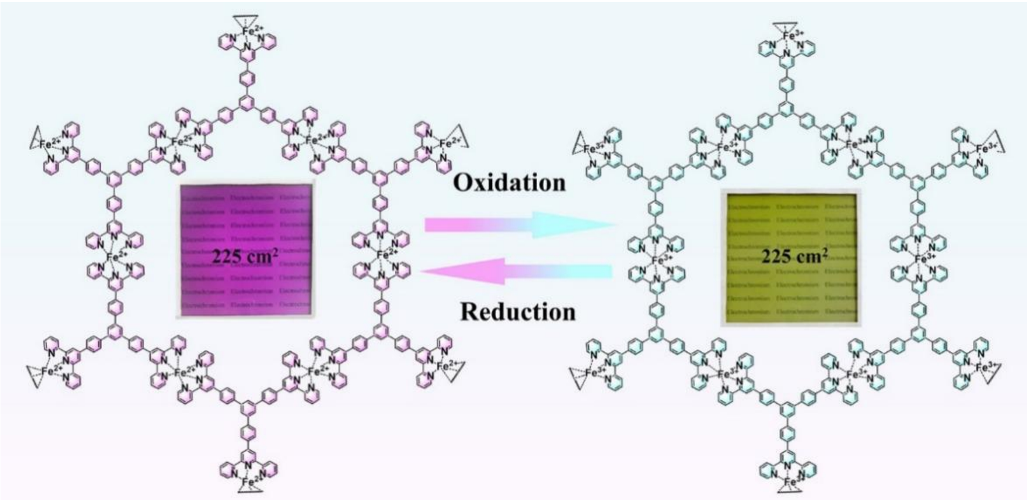

Fig.1 Molecular structure of MSP-Fe and the color of electrochromic device based on MSP-Fe film before and after the electrochemical reaction.

Abstract

H032: Green Synthesis of Ultra-bright Luminescent Carbon Dots for High-performance Tandem Luminescent Solar Concentrators

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Luminescent solar concentrators (LSCs) are widely recognised as prospective large-scale photovoltaic solar collectors owing to their affordable cost and suitability for building-integrated photovoltaics (BIPV). Among them, the core key is the choice of luminophores, lower photoluminescence quantum yield (PLQY) and smaller Stoke shifts would restrict the solar conversion performance of LSCs. In this work, the two high quantum-efficient and eco-friendly carbon dots (CDs, PLQY = 91.1%) and Cu_4I_6(pr-ted)$_2$ nanoparticles (Cu_4I_6(pr-ted)$_2$ NPs, PLQY = 92.2%, Stokes shift: 1.04 eV) were employed in tandem for the construction of semi-transparent LSCs (dimension: 5×5×0.2 cm^3, where Cu_4I_6(pr-ted)$_2$ NPs were used to fabricate the top layer of the LSC, and the CDs were used for the preparation of the bottom layer of LSC). The as-prepared semi-transparent tandem LSCs achieved a optical conversion efficiency (η_{opt}) of 6.40% under standard sunlight and exhibited good stability. The results indicate that this design provides an example for the fabrication of high-performance LSCs for environmentally friendly BIPV systems in the future.

Key words: Luminescent Solar Concentrators, Building-integrated Photovoltaics (BIPV), Stoke Shifts, Optical Conversion Efficiency;

Abstract

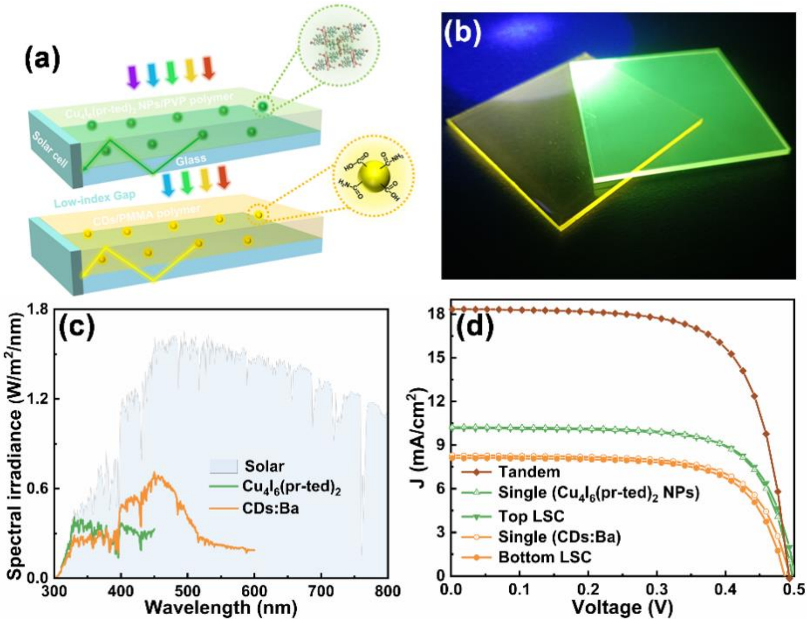

Fig.1 (a) Schematic diagram of the tandem LSC composed of Cu_4I_6(pr-ted)$_2$ NPs/PVP based LSC as a top layer and CDs/PMMA based LSC as a bottom layer. (b) Photographs of the tandem LSCs. (c) Calculated solar absorption of the LSCs and solar spectrum. (d)
Relationship of the photocurrent density and photovoltage (J–V) and η_{opt} of single-layer Cu_4I_6(pr-ted)$_2$ NPs/PVP based LSC, single-layer CDs/PMMA based LSC, and the tandem LSCs.

ABSTRACT

Session I

Advanced Glass Processing Technology

Session I：

Advanced Glass Processing Technology

Abstract

Proposal of ICG2023 Annual Meeting

Session I：Advanced Glass Processing Technology

In recent years, the glass industry has increasingly paid attention to the optimization and upgrading of existing processed glass products and the innovative development of new functional glass, making it better applied to high-tech fields. Advanced glass processing technology can optimize process management, optimize product structure and performance.

Advanced Glass Processing Technology focuses on the design, manufacturing, and related process research of various materials, equipment, and instruments in various glass processing. Topics include but are not limited to: design and cutting-edge technology of glass processing equipment; New preparation processes for glass processing; Glass processing solutions and mechanisms; Research and design of glass processing materials; Glass processing technology and application; Testing instruments of glass processing, etc.

Focused topics:

- design and cutting-edge technology of glass processing equipment
- New preparation processes for glass processing
- Glass processing solutions and mechanisms
- Research and design of glass processing materials
- Glass processing technology and application
- Testing instruments of glass processing

Session Chairs:

Hong Jiang, Hainan Holdings Special Glass Technology Co.,Ltd.

J Klouzek

A Goel

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Keynote Speakers:

Abstract

(1) Yong Gyu Choi, Korea Aerospace University,South Korea

(2) Hong Wang,State Key Laboratory of Green Building Materials, China Building Materials Academy, China

Invited Speakers:

1 Prof. Lijing Zhong, Institute of Light+X Science and Technology, Faculty of Electrical Engineering and Computer Science, Ningbo University,China

Title: A general approach to control the cross-section of laser-written optical waveguides in glass.

2 Prof. Haizheng Tao, Wuhan University of Technology, China

Title: Ultrafast laser micromachining solutions and mechanisms for ultra-low expansion glass-ceramic.

3 Prof.Chuang Dong, Dalian Jiaotong University, China

Title: Composition formulas of silicate glasses.

4 Dr.Hyung-Soo Moon, Corning Technology Center Korea, South Korea.

Title: Development of enabling technologies that add value to Corning glass and ceramics to create new innovative applications.

5 Prof. Shujiang Liu,Qilu University of Technology, China.

Title: Transparent glaze containing high-alumina glass frit: batch-to-melt conversion.

6 Hao Liu,SCHOTT Glass Technologies (Suzhou) Co.Ltd., China.

Title: Advanced Processing Technologies of Specialty Glass for Home Appliance and Consumer Electronics.

7 Wenge Xiao,Ningbo University, China

Title: 3D printing and pressureless sintering of highly efficient phosphor-in-glass.

Keynote Speakers

Yong Gyu Choi, Korea Aerospace University, Republic of Korea

Tentative Title: A New Molten-Salt-Bath-Free Ion Exchange Technique for Alkali-Containing Silicate Glasses

Abstract

Brief CV: Yong Gyu Choi received a B.S. degree from KAIST in 1991. Then, he moved to POSTECH where he earned his M.S. and Ph.D. degrees in 1994 and in 1998, respectively. During the period of 1994 to 1998, his works were focused on processing and characterizing amorphous materials doped with rare-earth elements. He became a senior research staff of ETRI in early 1998, where he was mainly involved in development of fiber amplifiers and fiber lasers for use in optical telecommunications. During the ETRI period, he visited University of Southampton and University of Sydney as a visiting research fellow. After 6 years of experience at ETRI, he joined Korea Aerospace University as a faculty member. He enjoyed his first sabbatical leave at IMI-NFG, Lehigh University in 2010-2011. For his second sabbatical leave in 2017-2018, he stayed at Zhejiang University. His current research interests range from optical functionalities of doped or undoped glasses to structural analysis of optical materials.

Hong Wang, Shanghai Jiao Tong University, China

Tentative Title: An All Solid Inorganic Electrochromic Glass

Brief CV: Hong Wang is a "Zhiyuan" Chair Professor of Materials Science and Engineering and the Director of Materials Genome Initiative Center at Shanghai Jiao Tong University. He earned a Ph.D. in Materials Science and Engineering from the University of Illinois at Urbana-Champaign. He worked in the thin film technology field in US as an industrial research scientist for 16 years in semiconductors, flat panel displays and large area coatings for global companies such as SONY, Panasonic and Guardian Industries Corp. In 2010, he became the Chief Scientist for the National Research Ce nter for Glass Processing and Associate Director of State Key Laboratory of Green Building Materials, China Building Materials Academy, Beijing. He joined the faculty of Shanghai Jiao Tong University in 2016. His current research interest is on materials genome engineering, high-throughput experiment, materials informatics, as well as energy efficient coated glass and electrochromic glass for smart windows.

Invited speakers

Lijing Zhong, Ningbo University, China.
Tentative Title: A general approach to control the cross-section of laser-written optical waveguides in glass

Haizheng Tao, Wuhan University of Technology, China.

Tentative Title: Ultrafast laser micromachining solutions and mechanisms for ultra-low expansion glass-ceramic

Chuang Dong, Dalian Jiaotong University, China.
Tentative Title: Composition formulas of silicate glasses

Abstract

Hyung-Soo Moon, Corning Technology Center Korea, Republic of Korea.
Tentative Title: Development of enabling technologie s that add value to Corning glass and ceramics to c reate new innovative applications

Shujiang Liu,Qilu University of Technology, China
Tentative Title: Transparent glaze containing high-a lumina glass frit: batch-to-melt conversion

Hao Liu, SCHOTT Glass Technologies (Suzhou) Co.Ltd., China
Tentative Title: Advanced Processing Technologies of Specialty Glass for Home Appliance and Consumer Electronics

Wenge Xiao, Ningbo University, China.
Tentative Title: 3D printing and pressureless sinteri ng of highly efficient phosphor-in-glass

Abstract

I0001:An All Solid Inorganic Electrochromic Glass

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2. National Research Center for Glass Processing, Beijing 100024, China
3. School of Materials Science and Engineering, Shanghai Jiao Tong University, Shanghai 200240, China
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Electrochromic smart glass controls the amount of light entering the window by adjusting the transmittance of the glass via electrical voltage. It selectively adjusts external thermal radiation and internal heat transfer, to achieve the goal of regulating indoor temperature and reducing the building energy consumption. An all solid inorganic electrochromic coating on glass was developed, with transition metal oxides tungsten oxide and nickel tungsten oxide as the electrochromic layer and ion storage layer. Large-area electrochromic glass up to 1m x 0.8m was deposited for construction, aircraft and high-speed train using a vertical magnetron sputtering coater. An insulating glass unit (IGU) was fabricated using the all solid-state inorganic electrochromic glass and a Low-E glass, with the electrochromic glass placed on the second side. The shielding coefficient of the IGU can be adjusted between 0.09 and 0.56. The transmission spectral curve of the electrochromic glass is very similar to natural sun light. As a result, a high color rendering index is obtained indoor. The switching time is 10 min for a 0.3m x 0.4m size glass at 40 C but will be cut to 5 min if the glass is heated to 70 C. Based on thermal performance simulating, the overall energy consumption is the lowest when the window to wall ratio is 0.5.

Key words: Electrochromic glass, Shading Coefficient, Insulating glass unit

Abstract

I0002:A New Molten-Salt-Bath-Free Ion Exchange Technique for Alkali-Containing Silicate Glasses

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It has been recognized that ion exchange (IX) achieved without use of molten-salt bath tends to suffer from various kinds of imperfections, e.g., pits and residues remaining on the glass surface in a relatively microscopic scale, and irregular distortions of the glass shape in a macroscopic scale. Given that these disadvantages are resolved to a tolerable level allowed for practical applications, the molten-salt-bath-free IX technique is supposed to open new opportunities; position selectability in IX is definitely one of the most useful benefits [1]. Presented in this talk is a molten-salt-bath-free IX technique which employs novel alkali-containing slurry sprayable or pasteable onto selected positions of the glass surface. A series of experiments have been performed in an effort to assess practicality of this non-immersion 'dry' IX process, and some representative results are addressed in the presentation.

Keywords: Ion exchange, Molten-salt-bath-free, Non-dipping, Non-immersion, Chemical strengthening

Abstract

Invited
I0003:Composition formulas of silicate glasses

Chuang Dong（董闯）[1], **Yanping Ma**（马艳平）[2], **Hong Jiangb** （姜宏）[2]

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2 State Key Laboratory of Marine Resources Utilization in South China Sea & Special Glass Key Lab of Hainan Province (Hainan University), Haikou 570228, China
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The cluster-plus-glue-atom model, developed by the present author (C.D.) for metallic glasses and solid solutions, is introduced to identify the composition units of silicate glasses in the form of a molecule-like supercluster unit $\{M_2O_3\}_n\{Si_2O_4\}_{16-n}$, where $\{M_2O_3\}$ and $\{Si_2O_4\}$ are respectively the basic units derived from trivalent (such as B_2O_3 and Al_2O_3) and quadrivalent (such as SiO_2) oxides, in correspondence to the coordination numbers of 3 to 4 according to the classical random network model. Soda-lime-silicate, aluminosilicate, and borosilicate glasses of historical importance are addressed. Classical soda-lime-silica glasses and modern aluminosilicate glasses generally satisfy 16-unit trivalent-cation formulas $\{M_2O_3\}_{16}$, as exemplified by ancient glasses such as those discovered in Egypt, Palestine, and Sudan, and by modern ones such as Container Glass, 1:1:6 Glass, Jena Standard Glass, and Gorilla® Glasses. Borosilicate glasses are characterized by extra quadrivalent $\{Si_2O_4\}$, as exemplified by Corning E-glass and Schott thermometer glass formulated by $\{M_2O_3\}_{12}\{Si_2O_4\}_4$, Schott utensil glass by $\{M_2O_3\}_{16}\{Si_2O_4\}_6$, and Corning Pyrex and Schott Welsbach chimney glasses by $\{M_2O_3\}_7\{Si_2O_4\}_9$ containing the highest silica proportion.

Key words: Silicate glasses; composition formula; structure model; cluster-plus-glue-atom model; structure unit

Abstract

I0004:Development of enabling technologies that add value to Corning® glass and ceramics to create new innovative applications

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Glass is a popular material of choice in various application spaces, especially in display and cover solutions for mobile devices, not to mention, traditional applications. Coating and micro-structuring technologies on glass with various compositions and form factors of glass substrates enable us to explore innovative opportunities further in semiconductor advanced packaging, telecommunication, automotive, and so forth [1-5]. Key enabling technologies we have developed include durable anti-reflection coating, engineered anti-glare surfaces, high-speed precision printing, metallization, micro-structuring, through glass vias, optic/electrical designs, and ion-exchange waveguide [6-8]. Glass compositions and their form factors in conjunction with the enabling technologies also play a critical role in defining the next-generation products [9]. This work will discuss the key enabling technologies that add values to Corning glass and ceramics and/or demonstrate their best capabilities.

Abstract

I0005:Ultrafast laser micromachining solutions and mechanisms for ultra-low expansion glass-ceramic

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Using the mean surface roughness, taper angle and circularity degree as indicators, we optimize the processing parameters about ultrafast laser micromachining a commercial ultra-low expansion glass-ceramics (ULGC). Furthermore, we identify the sequential appearance of photo-darkening, crystalizing, melting, foaming and vaporizing regions during the interactions of ultrafast laser with ULGC. Especially, the foaming region is identified to effectively mediate the thermal stress at the interfaces between different regions. By using a Bessel beam, higher surface quality could be obtained due to the possibility of the occurrence of only a foaming ceramic region in irradiated regions. This discovery gives us an important clue to optimize processing parameters to obtain high-quality ultrafast laser micromachining surface.

Key words: Ultralow expansion glass ceramics; Ultrafast laser; Micromachining

Abstract

I0006:A general approach to control the cross-section of laser-written optical waveguides in glass

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Among numerous schemes of fabricating photonics circuit in transparent materials, femtosecond laser direct writing (FLDW) technique has irreplaceable prospects for 3D fabrication capability in various transparent substrates including glasses and crystals[1]. Here, we report a novel invisible photonic element, highly see-through (HST) waveguide, which is written by femtosecond laser in glass. We establish a general synergistic control of the thermodynamic and dynamic behavior over the matter fluid in the laser irradiated confined region to tune the cross-section of waveguides and suppress the generation of scattering centers in the waveguides. An effective reduction of light leakage (covering red, green, and blue coupled light) by an order of magnitude compared to conventional waveguides is achieved, making it highly see-through at bright illumination of > 100 lux. A general dynamical model based on a frozen-in shock wave diffusion process is proposed, which is applicable to various glasses regardless of their compositions. We demonstrate ultra-wide tuning of HST waveguide mode diameters from 4.9 to 26.5 μm, making it versatile for functionalizing various transparent screens by mode-matching with fiber sources and integrated planar waveguides of different working wavelengths.
In our recent work published in [2], we have provided a more thorough insight into many beam shaping techniques designed to flatten the intensity distribution including the slit-shaping technique from the perspective of the intensity gradient damping effect. By exploiting this effect and under the same slit-shaping processing condition, we

Abstract

first reported a finding that the morphological evolution of the waveguide cross-section follows a similar response to laser irradiation regardless of the difference in the glass composition of 4 typical commercial silicate glasses (Eagle-XG, Gorilla, K9 and 7980 fused silica glasses), despite the large differences in the glass composition. As shown in Figure 1, each set of cross-sections is arranged according to the increase in net fluence (NF) and is representative of the corresponding cross-sectional morphology. As a result, in the direction perpendicular to the laser propagation direction, we observe highly analogous morphological evolution steps that:

i. At relative low NF, laser irradiation leaves a region with a circular cross-section and thoroughly positive refractive index change near the focus. And, its diameter varies from a few microns to tens of microns with the increase of pulse energy.

ii. The increase in NF results in a larger cross-section diameter, but leaves a darker center correspond to a negative refractive index change at the focal point. Increasing NF could expand central dark area. While further increasing the NF, as shown in Figure 2(a), the peak and valley appear alternately at the center.

Key words: Femtosecond laser micromachining; optics waveguide; glass; see-through photonic circuit

Abstract

I0007:Transparent glaze containing high-alumina glass frit: batch-to-melt conversion

Shujiang LIU

The application of high-alumina (HA) glass frits in the field of transparent glazes is of potentially technological interest due to their excellent mechanical properties, while the strong crystallization tendency limits their practical application. Here, we investigated the crystallization and melting behaviors of the HA frit when it was introduced into a model low-melting glaze batch. It is found that, with increasing temperature, glass phase first forms within the low-melting glaze batch, while CaAl2Si2O8 and MgAl2O4 crystallize at the surface of HA frits. The molten glass surrounding HA frits can decrease the number of active sites for nucleation, thus weakening surface crystallization. Moreover, the alkali cations in the molten glass tend to diffuse towards the crystallized HA frits, this accelerates crystal dissolution by lowering the viscosity of the diffusion layer around dissolving crystals. Thus, the transparent glaze containing 30 wt% HA frit was obtained by firing at 1453 K for 30 min, and the hardness value was increased from 5.92 GPa to 6.46 GPa. The results provide insights into the mechanism of batch-to-melt conversion for high-alumina bearing transparent glazes.

Abstract

I0008:Advanced Processing Technologies of Specialty Glass for Home Appliance and Consumer Electronics

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Abstract: As a high-tech material, specialty glass has been widely used in various applications such as consumer electronics, automotive, medical industry, and astronautics. As a global material technology group, SCHOTT are constantly exploring unique and innovative ways to make a difference for businesses and people, and are a highly skilled partner for many high-tech industries: Healthcare, Home Appliances & Living, Consumer Electronics, Semiconductors & Datacom, Optics, Industry & Energy, Automotive, Astronomy & Aerospace.

In this talk, several advanced processing technologies will be introduced, including cold processing, chemical strengthening, coating, chemical etching, and laser-structuring. Advanced mechanical polishing has several advantages: (1) to improve strength performance by minimizing size and distribution of surface and edge flaw of glass product; (2) to achieve extremely low surface roughness for optical application such as AR glass. Multiple steps of chemical strengthening can significantly improve strength performance by adding residual stress on glass surface. Transparent anti-scratch hard coating would be introduced for wide applications such as home appliance (e.g., cooktop) and consumer electronics. Chemical etching can also improve strength performance by softening flaw tips. In addition, it can be used to achieve special appearance on glass surface such as glow anti-glare effect and CD texture. Structured glass can be realized by using laser-structuring technology for various applications such as GCB (Glass Circuit Board), semiconductors, bio-application and so on.

In general, several advanced processing technologies should be involved to produce a glass product with high performance for extreme conditions and strict requirements. For example, by combining unique LABS glass composition with special processing technologies, SCHOTT Xensation® α has established a new benchmark of cover glass for consumer electronics with the aid of its outstanding performance of sharp impact resistance and scratch resistance.

Abstract

Key words: Processing; Specialty Glass

Abstract

I0009:3D printing and pressureless sintering of highly efficient phosphor-in-glass

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Abstract: Although phosphor-in-glass (PiG) composites are priomising all-inorganic color converters for high-power white light-emitting diodes, strong interfacial reaction between phosphors and glass matrix at high temperatures results in remarkable quantum efficiency loss of the embedded phosphors, and traditional solutions rely on high-pressure consolidation techniques. Here we report the intrinsic inhibition of interfacial reaction by using silica glass rather than multicomponent glasses as the matrix. Full densification of PiG based on silica glass is achieved via a pressureless sintering method, rendering these color-tunable PiG composites not only accessible to three-dimensional printing technique, but also highly efficient (internal quantum efficiency > 90%), thermally stable and hydrothermally stable. Using $Lu_3Al_5O_{12}:Ce^{3+}$ phosphor as an example, we further demonstrate that the optical performance of phosphor-converted LEDs/LDs based on the as-developed PiG can approach that of ceramic counterparts. Our work not only provide a way to balance the brightness and the price for high-power solid-state light sources but also unleash the potential of silica glass as an inorganic matrix for emerging optical applications.

Key words: Phosphors; silica glass; 3D printing; solid-state lighting

Abstract

I00010:Large area patterning of ultra-high thermal-stable structural colors in transparent solids

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Abstract: Printing stable color with a lithography-free and environment-friendly technique is in high demand for applications[1]. We reported a facile strategy of ultrafast laser direct writing (ULDW) to produce large-scale embedded structural colors inside transparent solids. The diffraction effect of gratings enables effective generation of vivid structural colors. The structural colors inside the various glass exhibit excellent thermal stability under high temperature, which promises that the written information can be stable for long time even with unlimited lifetime at room temperature[2]. The structural colors in the applications of coloring, anti-counterfeiting, and information storage are also demonstrated. Our studies indicate that the presented ULDW allows for fabricating large-scale and high thermal-stable structural colors with prospects of three-dimensional patterning, which will find various applications, especially under harsh conditions.

Key words: Glass; Ultrafast laser direct writing; Structrual color

Abstract

I00011:Development and characterization of a novel RE3+ doped Core-shell CeO2 abrasive system and its Glass CMP investigations

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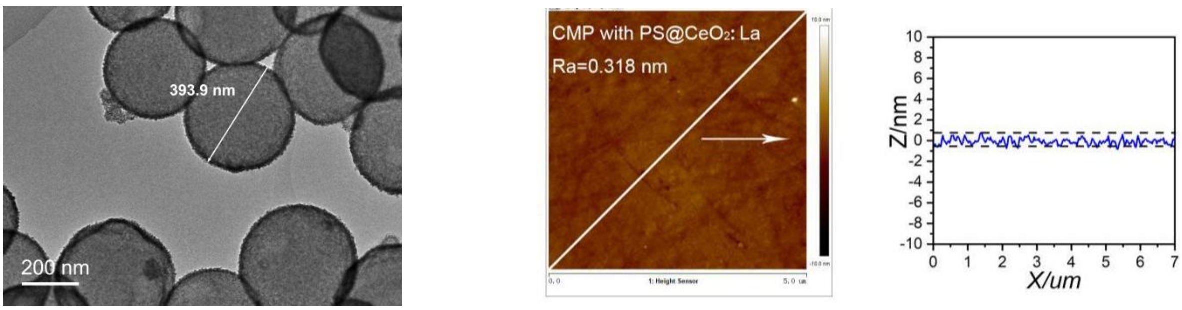
Abstract: In recent years, Ultra-Thin Glass (UTG) has attracted substantial market attention due to its multi-scenario applications. One of the technical cores in UTG manufacturing is the abrasive design of the chemical mechanical polishing (CMP) process. The present work proposed rare-earth-doped core-shell structured PS@CeO_2, PS@CeO_2:La, and PS@CeO_2:Yb abrasives synthesized by a low-temperature two-step method. The core-shell abrasives are large uniform nanospheres with a size of about 375 nm ~ 450 nm. According to the matching effect of RE^{3+} radii and defect sizes, La^{3+} with larger radii exhibits a more substantial modulation effect than Yb^{3+} upon the lattice distortion and Ce^{3+}/Ce^{4+} chemical shift. The CMP results revealed the superior polishing efficiency and better flattening ability of core-shell abrasives. The optimized PS@CeO_2:La shows the best glass polishing ability (*MRR*=480.22 nm/min, Ra=0.32nm), which is attributed to the increased Ce^{3+} composition from 9.79% to 28.14% (compared with the pristine PS@CeO_2) and large particle size, indicative of potential applications of novel abrasive systems in the field of glass polishing.

Keywords: PS@CeO_2, Chemical Mechanical Polish (CMP), Glass Polish



(a) (b)

Figure 1. (a) TEM image of PS@CeO_2:La, (b) 2D-AFM image and profile curve of the glass substrate after CMP with of PS@CeO_2:La

Abstract

I00012:Joining of metallic glasses in liquid via ultrasonic vibrations

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Abstract: Joining processes especially for metallic materials play critical roles in manufacturing industries and structural applications, therefore they are essential to human life. As a more complex technique, under-liquid joining has far-reaching implications for national defense, offshore mining. Furthermore, up-to-now, the effective joining of metals in extreme environments, such as the flammable organo-solvent or the arctic liquid nitrogen, still uninvestigated. Therefore, an efficient under-liquid joining approach is urgently called for. Here we report a method to join different types of metallic glasses under water, seawater, alcohol and liquid-nitrogen. The dynamic heterogeneity and liquid-like region expansion induced fluid-like behavior under ultrasonic vibration promote oxide layer dispersion and metal bonding, allowing metallic glasses are successfully joined in heat-free conditions, while still exhibits excellent tensile strength (1522 MPa), bending strength (2930 MPa) and improved corrosion properties. Our results provide a promising strategy for manufacturing under offshore, polar, oil-gas and space environments.

Key words: Under-liquid joining; Ultrasonic vibration; Metallic glasses; Extreme environmental; Fluid-like behavior

I00013:Plasticity and Rejuvenation of Aged Metallic Glasses by Ultrasonic Vibrations

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Abstract

Metallic glasses (MGs) possess exceptional properties, but their properties consistently deteriorate over time, thereby resulting in increased complexity in processing. It thus poses a formidable challenge to the forming of long-term aged MGs. Here, we report ultrasonic vibration (UV) loading can lead to large plasticity and strong rejuvenation in significantly aged MGs within 1 second. A large UV-induced plasticity (UVIP) of 80% height reduction can be achieved in LaNiAl MG samples aged at 85% of its glass transition temperature (0.85 T_g) for a duration of up to 1 month. The energy threshold required for UVIP monotonously increases with aging time. After the UV loading process, the aged samples show strong rejuvenation, with the relaxation enthalpy even surpassing that of as-cast samples. These findings suggest that UV loading is an effective technique for forming and rejuvenating aged MGs simultaneously, providing an alternative avenue to explore the interplay between the property and microstructures as well as expanding the application prospects of MGs.

Keywords：Metallic glass; Ultrasonic vibration induced plasticity; Aging; Rejuvenation

Abstract

I00014:High-order mode laser direct writing waveguide for conformal 3D photonics circuits

韩旭虎

Femtosecond laser direct writing technique can efficiently manufacture optical waveguides with arbitrary 3D spatial distribution in transparent materials, which is widely used in optical communication[1], 3D photonic circuits [2] and 3D photonics topological insulators[3], and has attracted great attentions in the field of integrated optics. Usually, on the one hand, waveguides with circularly symmetrical cross-sections can better match optical fibers and reduce coupling losses; on the other hand, in 3D photonic circuits, directional couplers (DC) need to be coupled in different directions, and circularly symmetric cross-sectional waveguides can make the coupling coefficients consistent in all directions. Laser beam shaping methods such as astigmatic beams generated by slits[4], cylindrical lenses[5], and multifocal beams generated by spatial light modulators (SLM) [6]are used to modulate the circularity of waveguide cross-sections. However, there is an essential disadvantage in mathematical theory, that is, the lack of rotation invariance. Therefore, the waveguide cross-section will be distorted with the ‘attack angle’ when processing large-area curved waveguides, especially spatial 3D curved waveguides (Fig. 1b). In order to solve the problem of cross-section distortion of curved waveguides, we firstly elaborate on the mechanism of how the optical field distribution affects the cross-section of waveguides by comparing the cross-section evolution of optical waveguides processed in different glasses by different higher-order mode beam, including TEM01, TEM02 and first and second order vortex beams. As a result, the vortex beam due to its rotational invariance was found to be the best mode distribution keeping the waveguide cross-section constant in the curved section. Waveguides with transmission loss less than 0.25 dB/cm were prepared using a second-order vortex beam in the application, and a bridge device applied to a fiber-silicon photonics chip was demonstrated. This study is expected to be applied to the large-scale fabrication of 3D optical chips.

Abstract

I00015:On the erasure of femtosecond laser imprinted nanogratings in optical glasses

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Abstract: Self-assembled porous nanogratings (NGs) were imprinted by infrared femtosecond laser inside 8 commercial oxide glasses, and their thermal stability investigated through isochronal annealing experiments. As the annealing temperature is increased, NGs erase, which is ascertained by retardance measurements and corresponds to the collapse of nanopores composing the NGs. Additionally, this aspect is well predicted from the Rayleigh-Plesset equation, and the glass viscosity plays a preponderous role in it.[1] Combining both annealing or laser writing experiments, we can predict the erasure of nanopores during the laser irradiation process, since the later can also be viewed as a thermal process, i.e., a nearly instantaneous heating of the glass matrix induced by laser pulse absorption, followed by a cooling step. This approach enables one to find what maximum temperature nanopores can survive during the laser cooling timescale, ultimately defining an upper temperature limit to the existence of NGs. Consequently, for characteristic cooling timescales of 30 ns and 1 μs, the upper temperature limits of nanopores survival are reached when the glass viscosity values respectively equal log (η, Pa·s) ~ -0.75 and log (η, Pa·s) ~ 1. A higher temperature limit is correlated to a wider laser processing window to fabricate NGs (Fig. 1a). However, this temperature limit is lowered for much longer thermal processes with minutes / hours timescales corresponding to a glass viscosity typically of log (η, Pa·s) ~ 10.1. As an example, erasure time versus temperature is provided in Fig. 1b for the 8 glasses under consideration, and more details on establishing such relationship will be provided at the conference.

Overall, the time-temperature characteristics of any thermal process (irradiation, annealing, etc.), along with the temperature dependent glass viscosity, will inevitably impact the "survival" of the NGs.

Keyword: self-assembled porous nanogratings, commercial oxide glasses, femtosecond laser direct writing

Abstract

I00016:In-Situ Observation of Ultra-Thin Glass Deformation Induced by Ion Exchange

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Abstract: Chemical strengthening of alkali-containing silicate glasses is almost always achieved using a molten-salt bath, which is desired to cause no macroscopic deformation of a given glass. However, in many practical situations, the immersed glass is deformed during ion exchange due to, for example, uneven stress distributions. Among such unwanted deformations, warpage is probably most frequently observed. Degree of this warpage, expressed in terms of radius of curvature, is also sensitive to ion exchange conditions such as temperature and duration time [1]. Here, we notice that there is only limited information available on time dependence of the warpage. In an effort to better understand the warpage (or bending) of plate glass caused by ion exchange, we have performed experiments in which ultra-thin glass subjected to a molten-salt-bath-free ion exchange is *in-situ* monitored with a special attention to its time-dependent evolution of radius of curvature. The obtained results are delineated in a quantitative manner, and the related implications are suggested.

Keywords: Ultra-thin glass; Chemical strengthening; Ion exchange; Warpage

Abstract

I00017:Control of Macroscopic Deformation of Silicate Glass Sheets via Position-Selective Ion Exchange

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Abstract: Deformation, e.g., bending, of silicate glasses is normally induced by their unique viscoelastic characteristics in response to applied thermomechanical conditions. This 'shaping' process of a given silicate glass sheet generally procedes chemical or physical strengthening process. It is obvious that unbalanced compressive stresses present on the surface of chemically strengthened glass tends to cause a macroscopic deformation like warpage, which in most instances needs to be avoided in the case of the molten-salt-bath ion exchange technique. However, we come up with that a 'position-selective' ion exchange technique is able to intentionally deform alkali-containing silicate glass sheets into a desired shape. In this study, we experimentally demonstrate that a molten-salt-bath-free 'dry' ion exchange process can be employed to control macroscopic deformation of the glass sheets. Our 'position-selective' ion exchange technique adopts alkali-containing slurry either sprayable or pasteable onto selected positions of the glass surface [1]. We present some examples of the macroscopic shape changes in silicate glasses including the ultra-thin glass.

Key words: Ion exchange, Molten-salt-bath-free, Non-dipping, Non-immersion, Glass deformation, Glass bending, Chemical strengthening

Abstract

I00018:Broadening the Long-Wavelength Infrared Abbe Diagram Using Te-Based Chalcogenide Glasses

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Abstract: Thermal camera is able to visualize thermal distributions of a given subject, and normally best operates across the long-wavelength infrared (LWIR; 8-12 m) range. To be more competitive in the civilian sectors, it needs to be cheaper, lighter and smaller, while keeping its performance being enhanced. Single-crystalline Ge is still adopted mainly due to its high refractive index with low dispersion over the LWIR range. Here, chalcogenide glasses are undoubtedly more competitive than their crystalline counterparts in terms of compositional flexibility and molding-process compatibility. However, both refractive index and Abbe number of the commercially available chalcogenide glasses occupy only a relatively restricted area in the LWIR Abbe diagram, which then strongly implies that not only refractive index but also Abbe number should be preferentially more diversified in order to ensure more degrees of freedom in designing LWIR-imaging lens assembly for any given requirements. Tellurium has been verified to markedly enhance refractive index and Abbe number of chalcogenide glasses owing to the highest atomic polarizability among the chalcogen elements; however, the effects of Te addition have been remained largely unresolved. Now, in this study, we propose that, in the case of Te-containing chalcogenide glasses, compositional engineering with regard to the LWIR Abbe number requires a new criterion conspicuously different from what has been applied to sulfide and selenide glasses: The distinct behaviors of telluride glasses are delineated, and then a new strategy for compositional search is detailed with a particular attention paid to adjustment of their refractive index dispersion.

Key words: Chalcogenide glasses; Engineering of refractive index and its dispersion

Abstract

I00019:Compositional study on Germanate Glass System for Lead-Free Perovskite Nanocrystal-Embedded Glass for LED Applications

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Abstract: Halide Perovskite nanocrystals have exhibited remarkable promise within the optoelectronics field, finding applications in solar cells, lasers, and Light Emitting Diodes (LEDs) [1]. Particularly, $CsPbX_3$ (X=Cl, Br, I) nanocrystals attract as next-generation optical materials due to their remarkably narrow emission spectrum of around 20 nm and exceptional quantum efficiency. However, the widespread adoption of these nanocrystals faces challenges due to their Pb content, a heavy metal known for its environmental concerns. Moreover, their susceptibility to degradation from air and light further restricts their viability for commercial use [2]. Thus, recently, many studies have carried out to find a Lead-Free Metal Halide Perovskite (LFMHP) nanocrystal. Elements within the same group as Pb^{2+}, such as Sn^{2+} and Ge^{2+}, have been mostly studied alongside elements from the same period, including Sb^{3+} and Bi^{3+}. Recent investigations have extended to substitutions involving lanthanide and actinide groups and transition metal groups. However, these researches were based on wet chemical process such as colloidal synthesis and thermal injection, posing limitations in terms of thermal and chemical stability. In order to guarantee chemical and thermal stability, there have been also various exploration of Pb-free perovskite nanocrystal incorporation within a glass matrix.

In this study, in order to achieve LFMHP nanocrystals replacing Pb from CsPbBr3 within the previously reported germanate glass composition, PbO was substituted with alternative materials such as SnO, Eu_2O_3, ZnO, MnO, and so on. Among various compositions, a luminescence under UV excitation was detected from a glass containing Cs_2ZnBr_4 nanocrystals of which the composition change and heat treatment condition were varied to improve emission intensity. The presence of Cs_2ZnBr_4 perovskite nanocrystals within the glass matrix was verified using X-ray Diffraction (XRD) and Transmission Electron Microscopy (TEM). Photoluminescence (PL) and Photoluminescence Quantum Yield (PLQY) were measured and demonstrated the potential of the material for LED applications.

Abstract

Key words: Lead free perovskite, Nano crystal, glass, LED, Photoluminescence

Abstract

I00020:Eu2+: CsCaX3 (X=Cl, Br, I) perovskite nanocrystals in glasses for blue light-emitting applications

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Abstract

Metal halide perovskite nanocrystals (PNCs) are considered as luminescent materials for next generation display for their wide color gamut. Compared with green and red ones, performance of blue light-emitting PNCs still lags much behind. Herein, divalent europium doped cesium calcium halide (Eu^{2+}: $CsCaX_3$, X=Cl, Br, and I) PNCs are precipitated in glasses for the first time. These Eu^{2+}: $CsCaX_3$ PNCs in glasses show blue emission from 435 nm to 458 nm with a maximal photoluminescence quantum yield of 81.9% and full width at half maximum of 22-30 nm. These Eu^{2+}: $CsCaX_3$ PNCs embedded in glasses exhibit good chemical-, thermal-, and photo-stabilities. Utilizing these Eu^{2+}: $CsCaCl_3$ perovskite nanocrystals doped glasses as down-conversion layers and commercial 395 nm UV LED chip as excitation, deep blue LEDs with external quantum efficiency of 24.6% (I=100 mA), maximal luminous efficacy of 5.2 lm/W (I=50 mA), and long-term operation stability are realized. These results demonstrate that Eu^{2+}: $CsCaX_3$ PNCs doped glasses have promising application in the field of blue LEDs.

Abstract

POSTER

I00021:Glass photonic wires for bonding PLCs and fibers

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Photonic wire bonding is the most promising solution for efficient interconnection between different planar light-wave circuits (PLCs), and between PLCs and optical fibers. However, theoretically, the optical fiber has a circular symmetric cross-section, and its modes typically have a Laguerre–Gaussian distribution[1]. Meanwhile, the typical PLCs have rectangular or trapezoidal cross-sections that support Hermite–Gaussian modes. Therefore, the mode fields of optical fiber and PLC are mismatched, resulting in a baseline loss due to this mismatching when interconnecting optical fiber with PLCs, making it impossible to achieve perfect coupling. Compared with the photonic wire materials based on the multiphoton polymerization [2], glass has higher mechanical strength, larger transparent window, and higher damage threshold.

In this work, we propose a novel waveguide of photonic lattice like waveguide (PLLW) for creating 3D photonic-wire in glass (Corning Eagle XG). We fabricate a waveguide photonic wire with its cross-section varies continuously along the waveguide direction, and its mode field transforms from LG_{00} mode to HG_{00} or HG_{20} mode. Specifically, a PLLW with circular input and rectangular output for conversing LG_{00} mode with a designed radii of 8.8 μm to HG_{00} mode with a size of 3×6 μm. Secondly, the circular input is changed to HG_{10} and HG_{20}-mode-shaped cross-section. The glass photonic wires have high conversion efficiency, and insertion loss less than 1.5 dB at 1550 nm, butting with the SMF-28 fiber. Furthermore, we demonstrate a 19-core glass photonic wire with the aim to convert LG_{00} to HG_{00}. This method enables detachable optical bridge and connector architecture suitable for interconnecting multi core fiber or multi-channel fiber array with PLCs.

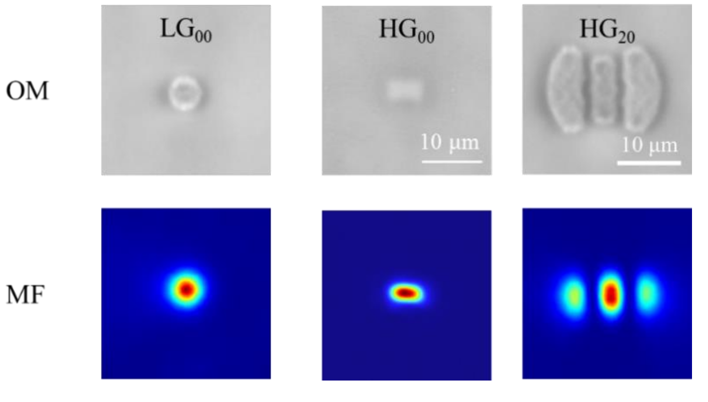

Fig. 1 Optical microscopic (OM) images and mode field (MF) distributions of the photonic wire.

Key words: glass, photonic wire, femtosecond laser direct writing, optical waveguide

Abstract

I00022:Femtosecond laser single-pulse plane-by-plane inscription of low loss FBG

胡嘉澄

Since the invention of fiber Bragg grating (FBG) in 1978, it has been widely used in many fields such as fiber communication systems, fiber sensors and fiber lasers1. Femtosecond laser direct writing (FLDW) method, as a powerful tool for inducing refractive index modification in transparent medium though the laser-material interaction via nonlinear multiphoton absorption, provides a new avenue for the inscription of FBG2. Technically, FLDW method usually creates micro-voids with strong refractive index change in the modified region in order to increase the coupling coefficient of FBG, which induces a significant insertion loss3. On the other hand, the low loss Type-I FBGs with a low refractive index contrast and small refractive-index modification (RIM) region exhibits low coupling coefficient. Therefore, the key to enhancing the performance of FBG lies in achieving a balance between resonance attenuation and insertion loss by extending the Type-I RIM region in the core, in order to achieve a high coupling coefficient while maintaining low loss. In this work, we propose a novel femtosecond plane-by-plane (Pl-b-Pl) inscription to fabricate high quality FBGs with high efficiency and low scattering loss. A designed fixture in Fig. 1(a) and a pair of cylindrical lenses are utilized to enlarge the modification region. Comparing to the commonly Point-by-Point (P-b-P) method, the FBGs fabricated by Pl-b-Pl method show a significantly reduced scattering loss and cladding mode loss. By adjusting the laser power, an optimal equilibrium between insertion loss and resonance attenuation is attained. As a result, a FBG with all-positive RIM regions is fabricated with an ultra-low loss of 0.008 dB and a resonance attenuation of 10.81 dB. Which exhibits an optimized κ/α of 2083.18 and high net reflectivity of 99.77 %. The proposed technique and analytical methods hold significant implications for enhancing the quality of FBGs, and can be widely implemented in FBG multiplexing arrays and all-fiber lasers.

ABSTRACT

Session J

Low Carbon Glass and Related Technology

ICG Annual Meeting 2023
November 12-15, 2023, Hangzhou·China

Session J：

Low Carbon Glass and Related Technology

Abstract

Proposal of ICG Annual Meeting 2023 Sessions

Session J：Low Carbon Glass and Related Technology

Brief Introduction:

Developing low-carbon technology is a potential approach towards achieving significant progress through technological innovation and advancement. It's also a means to encourage collaboration between nations and promote collective progress. Considering factors like energy resources, development, industrial structure, technological advancements, and the necessary reduction of emissions, it's crucial to prioritize the development of low-carbon technology and circular economy for the long-term sustainable survival of the global economy.

Focused topics:

- Carbon-Reducing Technology,
- Carbon-Free Alternatives such as renewable and clean energy,
- Decarbonization Technology

Session Chairs: Prof. Dr. Jie Chen

Point of Contact: Prof. Dr. Jie Chen

Keynote speakers:

Prof., Dr. Yibing Cheng, Foshan Xianhu Laboratory and Wuhan University Of Technology

Prof. Dr. Alicia Durán, the Institute of Ceramics and Glass of the Spanish Research Council (CSIC), Spain

Dr. René Reichel, Avancis GmbH, Germany

Dr. Xin Cao，CNBM Research Institute for Advanced Glass Materials Group Co., Ltd, China

Keynote Speakers

Abstract

Prof. Dr. Yibing Cheng, Foshan Xianhu Laboratory and Wuhan University Of Technology

Tentative Title: Carbon-Free Ammonia Combustion for High Temperature Industrial Applications

Prof. Dr. Alicia Durán, Institute of Ceramics and Glass of the Spanish Research Council (CSIC), Spain

Tentative Title: A ROADMAP tO TRAVEL THE AGE OF GLASS

Dr. René Reichel, AVANCIS GmbH, Germany

Tentative Title: Advantages of thin-film photovoltaics
glass/glass modules for superior BIPV applications

Dr. Xin Cao, CNBM Research Institute for Advanced Glass
Materials Group Co., Ltd, China

Tentative Title: Low carbon development status and trend of advanced glass materials

… …

Invited Speakers

Abstract

	**Prof. Dr. Hong Ye,** University of Sci. & Tech. of China, China **Tentative Title:** Analysis on energy performance of building windows and advanced energy efficient materials
	**Dr. Peter Borowski,** AVANCIS GmbH, Germany **Tentative Title:** Using world-record thin-film photovoltaics on rigid glass for semi-transparent applications
	**Dr. Haruki Niida ,** Nippon Sheet Glass Co., Ltd. Itami, Hyogo 664-8520, Japan **Tentative Title:** Float Glass – Carbon Neutral by 2050
	**Dr. Bastian Siepchen,** CTF SOLAR GmbH, Germany **Tentative Title:** High efficient CdSeTe solar cells ã€‹20% and application in CNBMâ€™s module technology

Abstract

Mr. Xiaobo Peng, CNBM Research Institute for Advanced Glass Materials Group Co., Ltd, China

Tentative Title: Ultra-light and high-strength hollow glassmicrospheres and its application

J001: Carbon-Free Ammonia Combustion for High Temperature Industrial Applications

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Manufacturing of building materials, such as glass, ceramics, cements etc., involves high temperature processing at 1200-1600°C. This is achieved usually through combustion of fossil fuels, mainly coal, heavy oil and nature gas, which is a major contributor to CO2 emission. These industries are now under great pressures to reduce the carbon emission and move towards sustainable manufacturing processes. Currently, there are only two carbon-free fuels suitable for combustion in industrial scales, hydrogen and ammonia. Both of them can be produced in large scales using entirely renewable energy and resources. Hydrogen has technical challenges in large scale transportation and storage, thus is difficult to meet the very large quantity demands by high temperature manufacturing industries as a fuel. On the other hand, the transportation and storage of ammonia are more matured technologies. But, ammonia is difficult for ignition and combustion, and contains nitrogen in the molecule, which can produce NOx during combustion. Our work as well as reports in literature have demonstrated that with proper design of burners, stable combustion of ammonia can be achieved and by developing a multi-level de-NOx approach, both NOx and residual ammonia emissions can be well controlled to meet the regulatory standards. Thus ammonia combustion appears a very promising technique for high temperature manufacturing industry to meet the targets of "carbon peaking" and "carbon neutrality".

Key words： Carbon neutrality; Low carbon; Digital technologies; Innovate technologies;

Abstract

J002: A Roadmap to Travel the Age of Glass

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In May 2021, the news that glass communities everywhere had been waiting for winged its way round the world; the United Nations had endorsed 2022 as the International Year of Glass. The application had taken the previous 18 months to prepare and included a 30-minute video, an electronic brochure and printed documents explaining the vital role glassy materials play in helping the world achieve the humanitarian goals encompassed in the UN 2030 declarations.

The submission of the application rested largely on the International Commission on Glass, along with the Community of Glass Associations and the International Committee for Museums and Collections of Glass (ICOM-Glass). Nineteen countries co-sponsored the Resolution A/75/L.84, approving the International Year of Glass. More than 2500 institutions, companies, artists and individuals from 95 countries all over the world have written to support this common dream and messages continue coming.

The book Welcome to the Glass Age, focusing on the various UN 2030 goals was published and a great and successful Opening Ceremony was held in the Room of Human Rights in the Palace of nations in Geneva, on 10-11 February 2022. More than 7500 online attendants on 10th and 11th February joined the 140 in person participants, constituting the biggest event in the history of glass field but also the most wider in the history of United Nations.

In July, the ICG Congress in Berlin celebrating the DGG's centenary gathered more than 850 participants and Tokyo celebrated a brilliant closing ceremony on 8-9th December. Several Trade Fairs displayed parallel events promoting IYOG2022 and the role of Glass in Society, in particular VITRUM 2021, GLASSMAN, in Monterrey, 11-12th May; Mir-Stekla in Moscow, 6-9th June; and Glasstech in Düsseldorf, 20-23th September, 2022. Glasspex/Glasspro in Mumbai and the China International Glass Industrial Technical Exhibition were moved to 2023. The Defriefing event in

Abstract

United Nations New York, on 14th December closed formally the IYOG opening the roadmap to the Age of Glass.

Other worldwide activities included: a) a US Glass Day, Washington DC, April, b) an 'Iberoamerican International Congress Women in Glass. Artists and Scientists', Madrid, Spain in May, d) an International Festival of Art, Stourbridge, UK, August, e) a place within the Venice Biennale in September and f) dedicated issues of several glass Journals.

Events were organised locally with up to 10 000 activities, including ideas and materials such as posters, display boards, articles, comics and U tube clips. People from every corner of the planet contributed to the arts, the imaginative use of glass in architecture, its recyclability, and its role in ensuring our well-being.

A key issue in the approval of IYOG2022 was the power of glass as a tool to build a more sustainable and a fairer planet. In this talk, the most important activities will be summarized, including a video showing the power of IYOG across the planet.

The main question is to answer how to design and travel the roadmap to follow constructing the Age of Glass

Abstract

J003: Advantages of thin-film photovoltaics glass/glass modules for superior BIPV applications

René Reichel, Thomas Dalibor, Peter Borowski, Sven Ring, Manuel Dias, René Kalio, Stefan Grünsteidel

Thin-film photovoltaic (PV) based on copper, indium, gallium, sulfur and selenium (CIGSSe) provides excellent color homogeneity and therefore a superior esthetics particularly in applications on or attached to buildings (BIPV) compared to wafer-based technologies. Compared to other thin-film technologies, CIGSSe achieves the best photon conversion efficiency among the cost-efficient PVmodules technologies with a record efficiency of 20.3% on a 30x30cm2 module. An established, alldry manufacturing process including sputtering and thermal processing steps leads to a cadmiumand lead-free glass-glass product (AVANCIS SKALA)

Due to the substrate configuration during the fully automated manufacturing of AVANCIS' CIGSSe process, colored PV modules can be realized without much effort or disruption on the overall production process. Typically, colored BIPV modules are manufactured by applying either a colored cover glass or a colored lamination foil. To achieve the impression of color, different approaches are possible: bulk coloration, thick-film printing or thin-film coating. However, depending on the mechanism on how to achieve the color impression the corresponding efficiency loss can be quite high. All color techniques can be used with thin-film PV based on CIGSSe.

At Avancis, we developed a patented color technology (ACT) which is based on interference and therefore without too much transparency loss for the cover glass and subsequently retaining high efficiencies for the BIPV modules.

By variation of the cover glass surface either by imprinting or by etching and in addition to the different coloration options, an even higher variety of BIPV products can be realized without changing the underlying standard production of CIGSSe resulting in a broad product portfolio for architects to choose from.

With a large number of already realized BIPV applications using our product SKALA

we are able to provide real monitoring data of the electric yield from façade systems in various locations and for various orientations.

J004: Low carbon development status and trend of advanced glass materials

Cao Xin

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Carbon peak and carbon neutrality have become China's national development strategy, unswervingly promote low-carbon manufacturing is the only way for the high-quality development of the glass industry. This paper briefly analyzed the research status and development trend of carbon emission reduction technology in each key process of glass manufacturing. Specifically, they included digital technologies such as applied machine learning and numerical simulation; raw material technology such as introducing active raw materials and optimizing raw material morphology; melting technologies such as using alternative fuels, improving combustion efficiency, and optimizing furnace structure; innovate energy-saving technologies such as full furnace insulation and development of reflective coatings; develop new methods such as additive manufacturing and injection molding; breaking through new varieties such as energy-saving glass, intelligent glass, and power generation glass; adopting carbon capture technology to enhance terminal collection capacity; expand new application scenarios such as smart agriculture and photovoltaic building integration, with the aim of promoting the manufacturing of advanced glass materials and the application of low-carbon technology, and helping to achieve China's "dual carbon" goals.

Abstract

J005:建筑窗户节能性能分析及先进节能材料设计

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窗户是建筑的重要组成部分，具有增强采光、开阔视野、强化通风等功能。另一方面，这些与外界联通的特性使得窗户成为建筑节能的薄弱环节。窗户的节能性能成为影响建筑整体节能效果的关键。课题组依托工程热物理学科背景，基于辐射传输理论，详细分析了窗户在建筑与外界传热过程中的作用，指出了提升窗户节能性能的路径。研究发现，提升窗户对太阳辐射和长波热辐射的调控能力是降低建筑能耗的有效手段。具体来说，提升太阳辐射调控能力在夏季节能收益较高，而冬季则应优先考虑提升长波热辐射调控能力。基于上述发现，课题组基于辐射调控原理设计了多种新型节能材料。利用热致变色材料实现了对太阳辐射和长波热辐射的双重调控，该双重调控窗可显著降低夏季制冷能耗。通过光子晶体结构实现了高近红外反射率和低长波发射率的节能窗，具有可见光透过率高和结构简单等特点。课题组的相关研究有望促进建筑窗户的节能化进程。

关键词： 建筑窗户；建筑节能；辐射调控；

Abstract

J006: Using world-record thin-film photovoltaics on rigid glass for semi-transparent applications

Peter Borowski, Thomas Dalibor, Rene Reichel, Marko Stölzel, Patrick Eraerds, Christian Schubbert, Janina Moereke, Hisham Aboulfadl, Thomas Schutt, Julian Röder, Maik Schubert

Thin-film photovoltaics (PV) based on copper, indium, gallium, sulfur and selenium (CIGSSe) provides high photon conversion efficiency (PCE), proven longevity, a particularly low carbon footprint and compared to wafer-based technologies superior esthetics particularly in applications on or attached to buildings (BIPV). We report on a new PCE world record for mid-sized, cost-efficient thin-film PV rigid glass modules of 20.3% from AVANCIS' R&D pilot line in Munich, Germany. An established, alldry manufacturing process including sputtering and thermal processing steps leads to a cadmiumand lead-free glass-glass product (AVANCIS SKALA), whose application lies particularly in the buildingintegrated sector. AVANCIS currently works on the development of thin-film tandem PV technologies (like CIGSSe / CIGSSe and CIGSSe / Perovskites) for the roadmap towards even higher PCEs.

Compared to wafer-based standard crystalline silicon photovoltaics, thin-film PV has a unique advantage in semi-transparent solutions, i.e., where a certain fraction of the incoming light is not used for the conversion into electricity but rather transmitted through the PV module. In conventional wafer-based silicon PV modules, semi-transparency is achieved by increasing the distance between the cells, which leads to an inhomogeneous block-like pattern. In contrast, we report on the production of 'true' semi-transparent PV modules that even from a close distance appear as a grey filter rather than a dark / light pattern. These innovative glass-glass PV modules are characterized in terms of power generation, transparency and visual impression. We discuss potential applications like semi-transparent roofing, shading elements, windows and Agri-PV, particularly greenhouses. These applications open new spaces for the generation of electricity by replacing passive material and thereby contributing to decarbonization in the building sector.

Abstract

Abstract

J007: Float Glass – Carbon Neutral by 2050

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In 2015, the United Nations Sustainable Development Summit adopted the 17 Sustainable Development Goals (SDGs), broken down into 169 targets, to protect the environment and fight against climate change. After that year, the world has changed direction in seeking for sustainable society. The glass industry is no exception. Glass products are being used in society to combat climate change, for example as solar panel coverplates and energy efficient windows, and glass is infinitely recyclable. However, large energy consumption has been indispensable in glass manufacturing for a long time. From view point of glass industry, carbon neutrality is one of keys to contribute to a sustainable society. Last year, NSG Group's aims, reducing greenhouse gas emissions by 30% by 2030 compared to 2018 levels, was certified by the Science Based Targets initiative (SBTi). Responding to climate change is one of the most important missions for NSG Group. The Group has been promoting various activities to shift to renewable energy and to reduce total CO2 emissions. In glass manufacturing, possible measures are, for example, direct CO2 emission reduction, energy consumption efficiency improvement, productivity improvement, waste material reduction and so on. In fact, the NSG Group successfully manufactured architectural glass with hydrogen firing in a world-first trial in 2021. The Group also became the world's first flat glass manufacturer to fire 100% biofuel in the furnace in 2022. We will review the activities of the Group for float glass manufacturing, including those firing trials, and our commitment to deliver change in our journey to carbon neutrality.

Key words: Float Glass; Carbon Neutral;

Abstract

J008: High efficient CdSeTe solar cells >20% and application in CNBM's module technology

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CdTe thin film PV technology is the most successful thin film PV technology in the market so far. The record CdTe thin film dot cell efficiency is 22.3%[1]. Many reviews [2,3]have discussed the pathway to reach the efficiency of above 25%. One of the advantages of CdTe thin film technology is the direct coating of the functional layers on glass sheets, which enables fully integrated module production lines including the preparation of the photovoltaic cell, series interconnection of solar cells as well as glass-glass encapsulation.

CTF SOLAR GmbH develops the production processes and technology. Starting with an initial annual production capacity of 100 MWp capacity two factories (Chengdu, Handan) are in operation and two further factories (Ruichang, Jiamusi) will go into operation shortly. Second generation of factory with annual production capacity of 300 MWp was designed by CTF to further reduce the production cost and one factory is being erected in Zhuzhou and will go into operation in the next months. The third factory generation with annual capacity of 500 MWp is currently developed by CTF.

The research and development for the process and technology development are execute in CTF's headquarter in Dresden, Germany. The pilot line laboratory comprises all necessary process for fully processing of TCO coated glass sheets with the functional layers to dot cells, mini modules or pilot modules. The size ranges from 1 cm^2 dot cells till pilot modules of 30*40 cm^2. The main processes are close-spaced sublimation (CSS) for absorber coating, sputtering (PVD) for coating

Abstract

of back electron reflector and metal back contact, laser scribing for series interconnection and cell definition, furnace processes for absorber activation and dopant diffusion as well as further wet chemical treatments and encapsulation.
This paper describes the research and development efforts of CTF SOLAR GmbH to reach highest dot cell efficiency of 20.84% as well as our transfer to the production lines leading to current hero module efficiencies of 17.24% at a panel size of 1.92m2.

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Abstract

J009: Ultra-light and high-strength hollow glass microspheres and its application

Xiaobo Peng

Ultra-light and ultra-strong hollow glass microspheres is a type of artificially synthesized tiny spherical glass powders with single hollow cavity containing a small amount of gas， whose particle size distributes from several microns to hundreds of microns in diameter. Its density is from 0.1 to 0.7 g/cm3 ,and compression strength is from 1.5Mpa to 206 MPa(200~30000PSI),which has light weight, high strength, low thermal conductivity and good thermal stability. Ultra-light and ultra-strong hollow glass microspheres is widely used in aerospace ablative materials, deep-sea solid buoyant materials, high-frequency and high-speed and low-dielectric communication materials, emulsion explosive sensitization materials and lightweight composite materials and other high-end materials and other fields. It is called the“King of Composite Materials” and the“Space Materials of the 21st century.” Currently, the methods for large-scale production of ultra-light and ultra-strong hollow glass microspheres are glass powder method and spray granulation method(soft chemical method).The glass powder method is the only way that can prepare high-performance hollow glass microspheres. Its greatest advantage is able to design glass system to meet with the need of terminal application, and its product is of good quality. It's 3M Company (glass powder method) and PQ Corporation(spray granulation method)of United States that started the large-scale production of ultra-light and ultra-strong hollow glass microspheres first in the 1980's in the world. China started the study on hollow glass microspheres in the 1990s, having made great progress after more than 30 years of research and development, and has fully mastered the preparation technology of the large-scale production of ultra-light and ultra-strong hollow glass microspheres. The domestic representative companies are Research Institute for Advanced Glass Materials Group Co., LTD(glass powder method) and Sinosteel Ma'Anshan New Material Technology Co., LTD (spray granulation method). The hollow glass microspheres has broad application prospects in many fields ,especially in aerospace, deep-sea exploration, green building and other high-end applications, because of its excellent properties. With the increasing

Abstract

market demand and the expansion of application fields, the hollow glass microspheres industry will continue to maintain a high growth trend in the next five to ten years, and the New Sijie Industry Research Center predicts that the scale is expected to reach more than 4 billion US dollars in 2026.

Abstract

J0010: Low CO2 Emission Lining for Furnace Melter Crowns

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The necessity to reduce the CO2 emissions is forcing the glass industry to develop more efficient glass melting technologies. Possible solutions are offered by highly electrified melting furnaces, hydrogen fired furnaces and combined solutions like hybrid furnaces. The new melting technologies will change the furnace operations, which will lead to more corrosive conditions than in the past and a higher efficiency to reduce the cost impact of these two energy carriers. RHI Magnesita has developed a wide range of refractory materials to support its customers in this technologic transition in which the melting crown lining is playing an important role. A proper material selection has been done to preserve the furnace lifetime even in a more aggressive atmosphere. In combination with a smart crown design, the energy saving achieved can be significant. Highly corrosion resistant in a wide range of temperatures and furnace atmospheres, a Silica Based
solution has been selected for the optimum lining of the combustion chamber crown: based on fused silica and a lime free bonding, this products has proven its excellent behavior in many different applications, maintaining its stability in terms of microstructure, corrosion resistance, thermal expansion, general performances. Recent calculations and tests in humid conditions and low operating temperatures have confirmed these features. The application of fused Silica based material has been combined with RHIMs Honeycomb design, which allows to maximize the energy transfer from the melter crown to the glass bath. The lining concept is completed with the application of a Monolithic Insulation applied by gunning, which reduce the risk of rat hole formation significantly. The new lining concept is suitable for the expected operation conditions of hybrid furnaces and permits to achieve the highest insulation levels in a competitive asset, including a faster installation method that requires less manpower, providing its own contribute to the carbon footprint reduction. The paper describes the technical advantages in detail.

Abstract

J0011: Capture, Purification and Application of Kiln Carbon Dioxide Flue Gas in Glass Industry

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With the rapid growth of national economy, China has become the largest country of carbon dioxide emissions in the world. In China's traditional high energy consuming industries, the building materials industry has accounted for 15% of the CO2 emissions of national energy activities. Under the guidance of 2030 Carbon peak and 2060 carbon neutralization, energy conservation and emission reduction of building materials industry is imperative. China Building Materials Group takes the lead in promoting carbon emission reduction in glass industry, exploring low-carbon green development for building materials industry and accumulating experience in technology, construction, operation and management. It fills in the blank of carbon capture, purification and application technology in the glass industry, and creates a precedent for recycling CO2 gas in the world glass industry. This paper introduces the capture, purification and application technology of carbon dioxide flue gas in glass kiln and A new device for capture and purification of carbon dioxide flue gas is designed, which overcomes the shortcomings of the original technology. The results show that the recovery rate of CO2 from glass kiln can reach 95% and the purity is more than 99.9% by using pressure swing adsorption and adsorption distillation. The social and economic benefits are obviously.

Key words: CCS; Glass Kiln; Energy Saving and Emission Reduction; Pressure Swing Adsorption; Adsorption Distillation; Purification;

Abstract

J0012: Hybrid oxy-gas furnace with high percentage of green electric energy and smart ESIII control, progressing on the path to decarbonization.

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How can we reduce our carbon emissions with new furnace concepts and ideas. New ideas only can be safely developed and tested by using validated Computational Fluid Dynamics (CFD) such as GS Glass Furnace Model (GS GFM). It is quite logical that no glass producer will build a new furnace concept melting 100+ tons per day without thorough analysis, calculations and extensive CFD modeling. Lately most glass producers are asking how to reduce carbon emissions with either increasing the amount of electric melting or hydrogen. We have seen in the past such intensive use of CFD modeling when the Oxy-fuel applications emerged. Now with the next generation of large Hybrid (with more than 50% electric boosting) or all Electric melters we can see an increase in demand once again.

We will present actual results and data from a furnace that is producing borosilicate glass.

Its hybrid furnace is melting around 160 tons per day and its design is improved during each rebuilt, every 5 years, focusing on glass quality and energy efficiency. Currently, the combustion space using oxygen and natural gas, combined with high electric boosting within the bath of glass. This configuration has been successful in increasing the electrical energy to a high degree even 60%, resulting in significantly reduced CO2 emissions. To maintain stable operation & temperature we are using Expert System III Model based predictive furnace control connected to AI Furnace camera with batch monitoring.

To address the rebuilt needed in 2022, to face the realities of global warming and to tackle once gain CO2 emissions, the customer, Glass Service a.s and F.I.C worked together during three years to determine what could be the next step for this

Abstract

furnace and its forehearths.

The presentation will be divided into following parts:

- First, we will present an overview of the initial data analysis and all the benefits obtained for the understanding of the furnace and its potential evolutions.
- Secondly, we will describe a synthesis of the modeling and design work, for the furnace and one of its forehearth, to obtain a final recommendation.
- For forehearth there was a redesign implementing new design features and to convert the entire design into a FIC-HVP-system that potentially can go all Electric with 80% Energy savings.
- To conclude, we will show final results after the rebuilt from summer 2022

The final furnace emits only 157 kg of CO2 per ton molten glass. (a comparable traditional furnace would emit 400 kg of CO2 per ton of molten glass.

Key words: Hybrid furnace; electric boosting; CO_2 reduction; furnace design; forehearth design; energy audit; modelling; alternative energies;

Abstract

J0013: Application of Energy Saveing and Carbon Reduction Technology for Glass Furnace

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In this paper, several mature energy saving and carbon reduction technologies for glass furnace are introduced, including sealing and separation equipment of suspended wall series, new gradient composite insulation, infrared high radiation energy saving coating, new bubbling technology, fire-electric composite melting technology. These technologies have improved the combustion efficiency and energy conversion efficiency of glass furnace, resulting in significant energy saving and carbon reduction effects.

Key words: Glass Furnace; Energy Saving; Carbon Reduction;

Abstract

J0014: Anhydrous Borate for Carbon Emission reduction

Songlin Shi

Environmental, social, and governance (ESG) issues are playing an increasing role in companies' decisions about choice of raw materials. Refined borates (such as, sodium borate or boric acid) which are commonly used in variety of glass applications do not contain carbon or carbonate, hence no direct CO_2 emission. However, choosing the right form (anhydrous instead of hydrous) reduces energy consumption of the melting process and hence carbon footprint. Our research, working closely with Celsian, aims to quantify the CO_2-emission reduction of anhydrous borate (both sodium or non-sodium) in pharmaceutical glass, glass wool (c-glass) and specialty glass (LCD-TFT glass) respectively. The research using the combination of Joule Meter measurement and Energy Balance Model (EBM), endeavors to represent industrial central cases by applying typical furnaces settings in abovementioned glass applications. Results have shown that anhydrous sodium borate ($Na_2B_4O_7$) and anhydrous boric acid (B_2O_3) reduce carbon footprint significantly over hydrous sodium borate ($Na_2B_4O_7 \cdot 5H_2O$) and boric acid (H_3BO_3). Apart from CO_2-emission during furnace melting, the report also briefly quantifies CO_2-emissionr reduction during supply chain for anhydrous products.

Abstract

J0015:平板玻璃工厂供配电系统稳定运行与应急响应实践

付台承

平板玻璃工厂为降低生产风险，提高工厂生产的稳定性，保障供配电系统安全运行，同时实现能源有效利用，一般会制定余热发电与油电系统孤岛运维及应急计划，并付诸实践。本文通过运维管理和应急响应措施的实施，确保了余热发电和油电系统的稳定运行。在上级电源突然失电时，可以利用余热发电和油电系统继续供电，无扰切换电源，能有效保证生产过程稳定进行。通过实施该实践计划，平板玻璃工厂的供配电系统安全性和稳定性得到了提高，生产过程中的波动和风险已得到有效控制。此外，余热发电和油电系统的稳定运行也实现了能源的有效利用，从而提高了工厂的经济效益。

Abstract

J0016: Application and Development of Building Integrated Photovoltaic

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As a multifunctional technology that integrates solar power generation products into buildings, building integrated photovoltaic (BIPV) has the advantages of energy conservation, environmental protection, land utilization efficiency and low power load. With the rapid development of photovoltaic technology in China, the conversion efficiency of photovoltaic cells has been continuously improved, and the cost of electricity has been continuously reduced. The market size of BIPV in China will further expand. Especially under the significant goals of carbon peak and carbon neutrality, the layout of BIPV has become an important part of the renew energy industry. Based on this, this article systematically introduces the development of silicon photovoltaic cell technology in BIPV and the latest research progress in BIPV applications, and predicts the future market prospects and development trends.

Key words: BIPV; thin-film solar cells; technology application; development trend;

Abstract

J0017：千吨级大跨度玻璃熔窑大碹的设计和施工

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通过提高单个玻璃熔窑的熔化量可以起到降低玻璃单位能耗的效果。例如日熔化量 600t 的玻璃熔窑，玻璃单位能耗 1330~1610 kcal/kg 玻璃;日熔化量 1000 t 的玻璃熔窑，玻璃单位能耗 1 250~1 400 kcal/kg 玻璃。因此，熔化量 1000t/d 以上的玻璃熔窑具有低能耗的优势。熔窑碹顶处于火焰上方，在生产过程中承受配合料粉尘的侵蚀和高温碱性气体的侵蚀。大碹设计和施工直接影响到窑炉的使用寿命、玻璃成品率和优良品率，特别是大吨位玻璃熔窑大碹跨度更大，在设计和施工过程中都有更高的要求。根据 CTIEC 实践经验，本文提出跨度 14 m 以上的玻璃窑炉硅砖大碹因其跨度大、重量大，因此要求：(1) 选择质量好的优质硅砖，荷重软化温度 1680℃以上，常温耐压强度 40 MPa 以上，残余石英的质量分数在 1.5%以下；(2) 大碹的厚度根据碹跨进行选择，建议 14 m 以上跨度的硅砖碹厚取 500mm 以上，15m 以上跨度的硅砖碹厚取 525 mm。碹砖的尺寸偏差和外观质量要求更严格，特别是碹砖的扭曲和裂纹长度；(3) 施工时，注意复核碹胎强度，泥缝控制在 1. 8 mm 左右。

关键词： 玻璃熔窑；大碹；耐火材料；

Abstract

J0018：超大型太阳能超白压延玻璃熔窑通路的研究与设计

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多年来 CTIEC 采用卡脖结构与多通路结构相结合形式设计超白压延玻璃熔窑，理论和实践证明此种设计进入通路中的玻璃液澄清均化充分，玻璃液质量高。近年来中国多个 1200 吨超白压延玻璃熔窑投产并且取得了低能耗高成品率，也说明 CTIEC 超白压延玻璃熔窑结构的优越性。本文总结了 1000t/d 以上超白压延玻璃熔窑成形通路的设计，提出 a.大吨位一窑四线，支线数量最少，总投资和运行费用最低，缺点是产品的规格型号少，对压延机和操作人员的技术要求较高。b.大吨位一窑五线支线数量适中，通过多种宽板线和窄板线的组合，熔窑的产量可在 1200~1550t/d 之间调整。产品的规格型号较多，总投资和运行费用适中，能满足绝大部分企业的需求。c.大吨位一窑六线数量较多，总投资和运行费用较高，优点在于产品的规格型号多，各条支线可同时生产 2.0 mm 以下的产品。d.大吨位一窑八线支线数量最多，通路的总长度最长，总投资和运行费用高，生产线的投资回报率低。优点在于产品的规格型号多,各条支线可同时生产 2.0 mm 以下的产品。

关键词： 太阳能超白压延玻璃熔窑；成型通路设计;

Abstract

J0019:大面积新型高效碲化镉薄膜太阳能电池关键技术研发及产业化

殷新建，陈瑛，吴一民，邵传斌，钱双，岳志远

碲化镉薄膜太阳能电池经过近 50 年的研究发展，是光电性能最优异，最具发展前景的薄膜光伏产品之一，也是当前产业化水平最高的薄膜太阳能电池。光伏器件的光电转换性能提升重点是优化其电流-电压特性。本研究通过在碲化镉薄膜光伏器件制备工艺中引入三元 CdSeTe 吸收层材料和 ZnTe 背电极过渡层材料，实现短路电流密度和开路电压的共同提升，同时经过良好的湿化学处理工艺，填充因子也得以改善，实现了 1.92m2 的大尺寸碲化镉薄膜太阳能电池光电转换效率超过 17.25%，成功地将实验室研发成果导入产业化生产，促进了我国双碳目标实现和绿色建材发展。

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