



Aalborg Universitet

AALBORG UNIVERSITY
DENMARK

Combined Effects of Compression and Sub-Tg Annealing on Structure and Properties of Aluminosilicate Glass

Svenson, Mouritz Nolsøe; Youngman, Randall E.; Thirion, Lynn M.; Mauro, John C.; Rzoska, Sylwester J.; Bockowski, Michal; Smedskjær, Morten Mattrup

Publication date:
2016

[Link to publication from Aalborg University](#)

Citation for published version (APA):

Svenson, M. N., Youngman, R. E., Thirion, L. M., Mauro, J. C., Rzoska, S. J., Bockowski, M., & Smedskjær, M. M. (2016). *Combined Effects of Compression and Sub-Tg Annealing on Structure and Properties of Aluminosilicate Glass*. Abstract from 24th International Congress on Glass, Shanghai, China.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal -

Take down policy

If you believe that this document breaches copyright please contact us at vbn@aub.aau.dk providing details, and we will remove access to the work immediately and investigate your claim.

Combined Effects of Compression and Sub- T_g Annealing on Structure and Properties of Aluminosilicate Glass

M.N. Svenson¹, R.E. Youngman², L.M. Thirion², J.C. Mauro², S.J. Rzoska³, M. Bockowski³,
M.M. Smedskjaer¹

¹ Department of Chemistry and Bioscience, Aalborg University, Aalborg, Denmark

² Science and Technology Division, Corning Incorporated, Corning, US

³ Institute of High-Pressure Physics, Polish Academy of Sciences, Warsaw, Poland

mns@bio.aau.dk

The structure and properties of glasses can be modified through changes in their volume (density). Densification has previously been found to increase the glass hardness^{1,2}, refractive index¹, heat capacity overshoot during glass transition^{1,3}, and elastic moduli² across a variety of oxide compositions. However, the densification mechanism and the structural origin of the changes in properties are not well understood. Here, we present results on the combined effects of isostatic compression at elevated temperature (hot compression), sub- T_g annealing, and K^+ -for- Na^+ ion exchange on the mechanical properties of a commercial sodium-magnesium aluminosilicate glass. Considered separately, each of these three post-treatments are known to increase the glass hardness, but the combined effects are not well understood. Here we use ²³Na 3Q (triple quantum) MAS (magic angle spinning) NMR spectroscopy to study the relation between changes in local atomic environments, density, and mechanical properties. The effect of ion exchange on hardness is found to be sensitive to the isostatic compression temperature, which in turn governs the local structure around Na⁴.

When pre-compressed glasses are sub- T_g annealed at ambient pressure, the pressure-induced densified structure relaxes, i.e., density decreases. On the other hand, when pre-annealed samples are hot compressed at T_g , the structural modifications induced by sub- T_g annealing will also relax. To combine the effects of sub- T_g annealing and hot compression, we therefore perform hot compression followed by *in situ* sub- T_g annealing under 1 GPa pressure. We find that this combined treatment increases the hardness to a greater extent than hot compression alone. We also study the hardness and density relaxation during subsequent ambient pressure sub- T_g annealing, along with changes in the heat capacity overshoot during glass transition.

1) M.M. Smedskjaer, R.E. Youngman, S. Striepe, M. Potuzak, U. Bauer, J. Deubener, H. Behrens, J.C. Mauro, Irreversibility of pressure induced boron speciation change in glass, *Scientific Reports*, **4** (2013) 3770.

2) S. Striepe, M.M. Smedskjaer, J. Deubener, U. Bauer, H. Behrens, M. Potuzak, R.E. Youngman, J.C. Mauro, Y. Yue, Elastic and micromechanical properties of isostatically compressed soda-lime-borate glasses, *Journal of Non-Crystalline Solids*, **364** (2013) 44-52.

3) Y. Yue, L. Wondraczek, H. Behrens, J. Deubener, Glass transition in an isostatically compressed calcium metaphosphate glass, *Journal of Chemical Physics*, **126** (2007) 144902.

4) M.N. Svenson, L. M. Thirion, R.E. Youngman, J.C. Mauro, S.J. Rzoska, M. Bockowski, M.M. Smedskjaer, Pressure induced changes in interdiffusivity and compressive stress in chemically strengthened glass, *ACS Applied Materials and Interfaces*, **6** (2014) 10436-10444.