Aalborg Universitet



Simple Data Pre-processing of the Laser Flash Analysis Results from the LFA 447 Apparatus

Johra, Hicham

Publication date: 2019

Document Version Publisher's PDF, also known as Version of record

Link to publication from Aalborg University

Citation for published version (APA):

Johra, H. (2019). Simple Data Pre-processing of the Laser Flash Analysis Results from the LFA 447 Apparatus. Department of Civil Engineering, Aalborg University. DCE Lecture notes No. 72

General rights

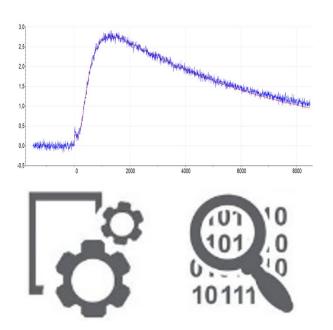
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- 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.

Simple Data Pre-processing of the Laser Flash Analysis Results from the LFA 447 Apparatus

Hicham Johra





ISSN 1901-7286 DCE Lecture Notes No. 72

Aalborg University Department of Civil Engineering Architectural Engineering

DCE Lecture Notes No. 72

Simple Data Pre-processing of the Laser Flash Analysis Results from the LFA 447 Apparatus

by

Hicham Johra

October 2019

© Aalborg University

Scientific Publications at the Department of Civil Engineering

Technical Reports are published for timely dissemination of research results and scientific work carried out at the Department of Civil Engineering (DCE) at Aalborg University. This medium allows publication of more detailed explanations and results than typically allowed in scientific journals.

Technical Memoranda are produced to enable the preliminary dissemination of scientific work by the personnel of the DCE where such release is deemed to be appropriate. Documents of this kind may be incomplete or temporary versions of papers—or part of continuing work. This should be kept in mind when references are given to publications of this kind.

Contract Reports are produced to report scientific work carried out under contract. Publications of this kind contain confidential matter and are reserved for the sponsors and the DCE. Therefore, Contract Reports are generally not available for public circulation.

Lecture Notes contain material produced by the lecturers at the DCE for educational purposes. This may be scientific notes, lecture books, example problems or manuals for laboratory work, or computer programs developed at the DCE.

Theses are monograms or collections of papers published to report the scientific work carried out at the DCE to obtain a degree as either PhD or Doctor of Technology. The thesis is publicly available after the defence of the degree.

Latest News is published to enable rapid communication of information about scientific work carried out at the DCE. This includes the status of research projects, developments in the laboratories, information about collaborative work and recent research results.

Published 2019 by Aalborg University Department of Civil Engineering Thomas Manns Vej 23 DK-9220 Aalborg Ø, Denmark

Printed in Aalborg at Aalborg University

ISSN 1901-7286 DCE Lecture Notes No. 72

Contents

1.	Fore	eword	7
2.	Intro	oduction	8
3.	VBA	Excel Macro for pre-processing (cleaning) LFA 447 measurement report 1	.1
4.	MA	TLAB script for pre-processing (cleaning) LFA 447 measurement report1	.4
5. data		TLAB script for averaging, decimating regularly, and calculating standard deviation of scattered nts	.5
6.	Арр	endices 1	.7
6	.1.	VBA Excel Macro code for pre-processing (cleaning) LFA measurement report 1	7
6	.2.	MATLAB code for pre-processing (cleaning) LFA measurement report 2	0
6	.3.	MATLAB code for averaging, decimating regularly, and calculating standard deviation of scattere	d
d	ata p	oints 2	2
Refe	erenc	es	5

1. Foreword

The aim of this technical report is to explain how to use simple scripts (VBA Excel Macro and MATLAB) to preprocess Laser Flash Analysis raw data results from the LFA 447 Apparatus (Netzsch Gerätebau GmbH [1]) at the Building Material Characterization Laboratory of Aalborg University - Department of Civil Engineering [2]. These scripts perform cleaning and ordering of the measurement points and mean average/standard deviation calculation for arbitrary decimation range of a given parameter.

2. Introduction

The raw data measurements of the Laser Flash Analysis Apparatus LFA 447 are processed and analyzed with the Netzsch Proteus[®] LFA Analysis software [1]. The processed measurement result points of a given test sample can be exported as a text file report. It is recommended to export the processed measurement result points of a given test sample as a text file with "tabulation" column separator and "point" decimal symbol (see *Figure 1* and *Figure 2*).

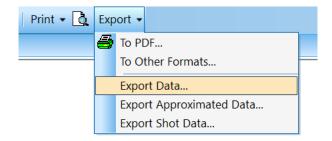


Figure 1: Export all measurement points from the Netzsch Proteus® LFA Analysis software.

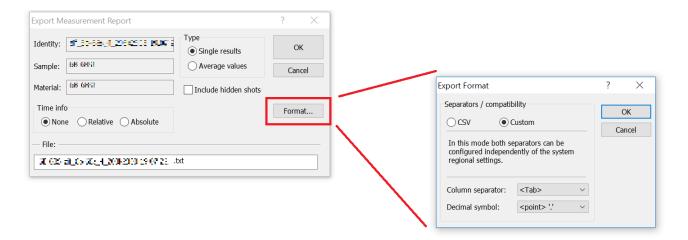


Figure 2: Export the measurement data as a text file report with "tabulation" as column separator and *"point" as decimal symbol.*

The exported measurement report text file is composed of a header describing the sample characteristics, and then followed by the measurement points organized by temperature range (see *Figure 3*). However, this data arrangement is not convenient to extract rapidly the temperature, thermal diffusivity and specific heat capacity of all measurements and have then placed consecutively in columns.

##Thermal_diffusivity

<pre>#Database 1fa_results.lfa.mdb HInstrument #LFA_d47 #Identity XXXXXXXXXXX #Date 20XX-XX #Waterial XXXXXXX #Type 25ingle_layer #Thickness_RT/mm 1.5110 #Diameter/mm 5.550 #Sensor In5b #Operator XXXXXXX #Cp_table XXXXXXXX #Cp_table XXXXXXXX #Remark_mment XXX #Cp_table XXXXXXXX #Remark_mment XXX #Cp_table XXXXXXXXX #Remark_mment XXX #Co_table dL_const #TaclcCode R+p/1/0-0-0 ##Results #Shot_number #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_t; 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.404 3 4 47.1 Rad. + pc. 0.404 3 4 47.1 Rad. + pc. 0.404 3 4 47.1 Rad. + pc. 0.404 3 5 46.8 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 10 47.0 Rad. + pc. 0.404 3 11 48.2 Rad. + pc. 0.408 3 10 47.0 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 10 47.8 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 19 48.4 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 19 48.3 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.404 3 21 49.0 Rad. + pc. 0.404 3 22 49.1 Rad. + pc. 0.404 3 23 48.9 R</pre>		al_infor				
<pre>#Identity XXXXXXX XX XX XX # #Date 20XX-XX XX #Waterial XXXXXX #Ref_temperature /°C 22.0 #Ref_density /(g/cm^3) 2.430 #Sample XXXXXX #Ref_temperature /°C 22.0 #Ref_density /(g/cm^3) 2.430 #Sample XXXXXX #Type #Single_layer #Thickness_RT/mm 1.5110 #Diameter/mm 5.550 #Sensor InSb #Operator XXXXXX #Remark_mment XXX #Cp_table XXXXXXX#01 #Expansion_table dl_const #CalcCode R+p/1/0-0-0 ###Results ##Shotnumber #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_tr 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.404 3 3 47.0 Rad. + pc. 0.404 3 4 47.1 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.406 3 10 47.0 Rad. + pc. 0.402 3 11 48.2 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.404 3 19 48.2 Rad. + pc. 0.407 3 19 48.2 Rad. + pc. 0.408 3 10 47.9 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.407 3 19 48.2 Rad. + pc. 0.408 3 20 47.8 Rad. + pc. 0.408 3 21 49.5 Rad. + pc. 0.408 3 22 49.5 Rad. + pc. 0.408 3 23 48.9 Rad. + pc. 0.408 3 24 49.5 Rad. + pc. 0.408 3 25 49.1 Rad. + pc. 0.408 3 25 49.1 Rad. + pc. 0.408 3 26 49.1 Rad. + pc. 0.408 3 27 48.9 Rad. + pc. 0.408 3 28 48.9 Rad. + pc. 0.408 3 29 49.0 Rad. + pc. 0.408 3 29 49.0 Rad. + pc. 0.408 3 29 49.0 Rad. + pc. 0.408 3 20 49.1 Rad. + pc. 0.408 3 21 49.5 Rad. + pc. 0.408 3 22 49.5 Rad. + pc. 0.408 3 24 49.5 Rad. + pc. 0.408 3 25 49.1 Rad. + pc. 0.408 3 26 49.1 Rad. + pc. 0.408 3 27 48.9 Rad. + pc. 0.408 3 28 48.9 Rad. + pc. 0.408 3 29 49.0 Rad. + pc. 0.408 3 29 49.0 Rad. + pc. 0.408 3 20 49.1 Rad. + pc. 0.408 3 20 49.2 Rad. + pc. 0.408 3 21 49.5 Rad. + pc. 0.40</pre>				a.mdb		
<pre>#Date 20XX-XX-XX #Waterial XXXXXX #Waterial XXXXXX #Waterial XXXXXXX #Waterial XXXXXXX #Ref_density /(g/cm^3) 2.430 #Sample XXXXXXXX #Type #Single_layer #Thickness_RT/mm 1.5110 #Diameter/mm 5.550 #Sensor InSb #Operator XXXXX #Remark_mment XXX #Cp_table XXXXXXX #1 #Remark_mment XXX #Cp_table XXXXXXX #1 #Expansion_table dl_const #CalcOde R+p1/0-0-0 ###Results #Shot_number #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_t: 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.402 3 3 47.0 Rad. + pc. 0.404 3 4 47.1 Rad. + pc. 0.400 3 5 46.8 Rad. + pc. 0.400 3 5 46.8 Rad. + pc. 0.400 3 5 46.9 Rad. + pc. 0.400 3 6 46.9 Rad. + pc. 0.400 3 6 46.9 Rad. + pc. 0.400 3 10 47.0 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 10 47.8 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.403 3 20 47.8 Rad. + pc. 0.406 3 21 49.0 Rad. + pc. 0.408 3 22 49.5 Rad. + pc. 0.408 3 23 47.8 Rad. + pc. 0.408 3 24 48.8 Rad. + pc. 0.408 3 25 49.1 Rad. + pc. 0.408 3 26 49.1 Rad. + pc. 0.408 3 27 48.9 Rad. + pc. 0.404 3 28 48.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 20 49.1 Rad. + pc. 0.404 3 20 49.2 Rad. + pc. 0.404 3 21 49.0 Rad. + pc. 0.408 3 22 49.5 Rad. + pc. 0.408 3 23 48.9 Rad. + pc. 0.408 3 24 48.8 Rad. + pc. 0.408 3 25 49.1 Rad. + pc. 0.408 3 26 49.1 Rad. + pc. 0.404 3 27 48.9 Rad. + pc. 0.404 3 29</pre>						
<pre>#Material XXXXXX #Ref_density /(g/cm³) 2.430 #Sample XXXXXXXX #Type #Single_layer #Thickness_RT/mm 1.5110 #Diameter/mm 5.550 #Sensor InSb #Operator XXXXXXX #Remark_mment XXX #Cp_table XXXXXXX #01 #Expansion_table dL_const #CalcCode R+p/1/0-0-0 ##Results #Shot_number #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_tr 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.392 3 3 47.0 Rad. + pc. 0.404 3 4 47.1 Rad. + pc. 0.404 3 4 47.1 Rad. + pc. 0.404 3 6 46.8 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.406 3 10 47.0 Rad. + pc. 0.406 3 11 48.2 Rad. + pc. 0.408 3 12 48.0 Rad. + pc. 0.408 3 13 47.9 Rad. + pc. 0.408 3 13 47.9 Rad. + pc. 0.408 3 14 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 19 48.3 Rad. + pc. 0.402 3 19 48.4 Rad. + pc. 0.402 3 19 48.4 Rad. + pc. 0.403 3 20 47.8 Rad. + pc. 0.408 3 22 49.5 Rad. + pc. 0.408 3 23 48.8 Rad. + pc. 0.408 3 24 48.8 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 26 49.1 Rad. + pc. 0.404 3 27 48.9 Rad. + pc. 0.404 3 28 48.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.402 3 20 47.8 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.404 3 21 49.0 Rad. + pc. 0.404 3 22 49.1 Rad. + pc. 0.404 3 23 48.9 Rad. + pc. 0.404 3 24 48.8 Rad. + pc. 0.404 3</pre>				(.XX.XX		
<pre>#Ref_temperature /°C 22.0 #Ref_density /(g/cm^3) 2.430 #Sample XXXXXXX #Type #Single_layer #Thickness_RT/mm 1.5110 #Diameter/mm 5.550 #Sensor InSb #Operator XXXXXX #01 #Kemark_mment XXX #(P_table XXXXXXX #101 #Expansion_table dL_const #alcCode R+p/1/0-0-0 ##Results #Shot_number #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_t: 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.402 3 3 47.0 Rad. + pc. 0.402 3 3 47.0 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 7 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.408 3 10 47.0 Rad. + pc. 0.408 3 11 47.0 Rad. + pc. 0.408 3 12 48.0 Rad. + pc. 0.408 3 13 47.0 Rad. + pc. 0.408 3 14 48.0 Rad. + pc. 0.409 3 13 47.9 Rad. + pc. 0.409 3 14 48.0 Rad. + pc. 0.409 3 15 48.2 Rad. + pc. 0.409 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.404 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 10 47.8 Rad. + pc. 0.402 3 10 47.8 Rad. + pc. 0.402 3 12 49.0 Rad. + pc. 0.403 3 12 49.0 Rad. + pc. 0.397 3 13 47.9 Rad. + pc. 0.398 3 20 47.8 Rad. + pc. 0.406 3 22 49.5 Rad. + pc. 0.406 3 23 48.9 Rad. + pc. 0.400 3 24 48.8 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 26 49.2 Rad. + pc. 0.404 3 27 48.9 Rad. + pc. 0.404 3 28 48.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.404 3 21 48.9 Rad. + pc. 0.404 3 22 49.5 Rad. + pc. 0.404 3 23 48.9 Rad. + pc. 0.404 3 24 48.8 Rad. + pc. 0.404 3 25 49.1 Rad.</pre>						
<pre>#Ref_density /(g/cm^3) 2.430 #Sample XXXXXXX #Single_layer #Thickness_RT/mm 1.5110 #Diameter/mm 5.550 #Sensor IN5 #Operator XXXXX #Remark_mment XXX #Remark_mment XXX #Remark_mment XXX #Remark_mment XXX #Remark_mment XXX #Shot_number #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_t; 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.402 3 3 47.0 Rad. + pc. 0.409 3 5 46.8 Rad. + pc. 0.409 3 5 46.8 Rad. + pc. 0.409 3 5 46.9 Rad. + pc. 0.409 3 6 46.9 Rad. + pc. 0.409 3 6 46.9 Rad. + pc. 0.409 3 6 46.9 Rad. + pc. 0.409 3 7 47.1 Rad. + pc. 0.409 3 8 47.1 Rad. + pc. 0.409 3 8 47.1 Rad. + pc. 0.409 3 10 47.0 Rad. + pc. 0.409 3 11 48.2 Rad. + pc. 0.409 3 12 48.0 Rad. + pc. 0.409 3 13 47.9 Rad. + pc. 0.409 3 14 48.0 Rad. + pc. 0.409 3 15 48.2 Rad. + pc. 0.409 3 15 48.2 Rad. + pc. 0.409 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.409 3 20 47.8 Rad. + pc. 0.407 3 414 48.0 Rad. + pc. 0.409 3 21 49.0 Rad. + pc. 0.409 3 22 49.5 Rad. + pc. 0.409 3 23 48.9 Rad. + pc. 0.409 3 24 48.8 Rad. + pc. 0.409 3 25 49.1 Rad. + pc. 0.409 3 25 49.1 Rad. + pc. 0.409 3 26 49.1 Rad. + pc. 0.409 3 27 48. Rad. + pc. 0.409 3 28 48.9 Rad. + pc. 0.409 3 29 49.0 Rad. + pc. 0.402 3 20 47.8 Rad. + pc. 0.409 3 21 49.0 Rad. + pc. 0.409 3 23 48.9 Rad. + pc. 0.409 3 24 48.8 Rad. + pc. 0.409 3 25 49.1 Rad. + pc. 0.409 3 25 49.1 Rad. + pc. 0.409 3 26 49.1 Rad. + pc. 0.409 3 27 48.9 Rad. + pc. 0.409 3 28 48.9 Rad. + pc. 0.409 3 29 49.0 Rad. + pc. 0.409 3 29 49.0 Rad. + pc. 0.402 3 20 47.8 Rad. + pc. 0.409 3 21 49.0 Rad. + pc. 0.409 3 23 48.9 Rad. + pc. 0.409 3 24 48.8 Rad. + pc. 0.409 3 25 49.1 Rad. + pc. 0.409 3 25 49.1 Rad. + pc. 0.409 3 26 49.1 Rad. + pc. 0.409 3 27 48.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.409 3 29 49.0 Rad. + pc. 0.409 3 20 49.1 Rad. + pc. 0.409 3 20 49.2 Rad. + pc. 0.409 3 21 49.0 Rad. + pc. 0.409 3 23 49.0 Rad. + pc. 0.409 3 24 48.9 Rad</pre>						
<pre>#Sample XXXXXXX #Type #Single_layer #Thickness_RT/mm 1.5110 #Diameter/mm 5.550 #Sensor InSb #Operator XXXXXX #Remark_mment XXX #Cp_table XXXXXXX #01 #Expansion_table dL_const #CalcCode R+p/1/0-0-0 ##Results #Shot_number #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_tr 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.392 3 3 47.0 Rad. + pc. 0.404 3 4 47.1 Rad. + pc. 0.404 3 6 46.8 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.409 3 6 46.8 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.406 3 10 47.0 Rad. + pc. 0.408 3 10 47.0 Rad. + pc. 0.408 3 11 48.0 Rad. + pc. 0.408 3 12 48.0 Rad. + pc. 0.408 3 13 47.9 Rad. + pc. 0.408 3 14 48.0 Rad. + pc. 0.408 3 15 48.2 Rad. + pc. 0.408 3 16 47.9 Rad. + pc. 0.408 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 19 48.8 Rad. + pc. 0.403 3 20 47.8 Rad. + pc. 0.403 3 22 49.5 Rad. + pc. 0.408 3 22 49.5 Rad. + pc. 0.408 3 23 48.9 Rad. + pc. 0.400 3 24 48.8 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 26 49.1 Rad. + pc. 0.400 3 26 49.1 Rad. + pc. 0.400 3 27 48.9 Rad. + pc. 0.404 3 28 48.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.</pre>						
<pre>#Type #Single_layer #Thickness_RT/mm</pre>						
<pre>#Thickness_RT/mm 1.5110 #Diameter/mm 5.550 #Sensor IN5b #Operator XXXXXX #01 #Expansion_table dL_const #Tc_lcCde R+p/1/0-0-0 ##Results ##Results ##Results #Shot_number #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_tr 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.402 3 3 47.0 Rad. + pc. 0.404 3 4 47.1 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 10 47.0 Rad. + pc. 0.404 3 11 48.2 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.404 3 19 48.2 Rad. + pc. 0.404 3 19 48.2 Rad. + pc. 0.404 3 10 47.9 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.404 3 15 48.2 Rad. + pc. 0.404 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.404 3 18 48.0 Rad. + pc. 0.404 3 19 48.2 Rad. + pc. 0.404 3 12 49.0 Rad. + pc. 0.404 3 12 49.0 Rad. + pc. 0.404 3 12 49.0 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 48.0 Rad. + pc. 0.404 3 14 48.0 Rad. + pc. 0.404 3 15 48.2 Rad. + pc. 0.404 3 16 47.9 Rad. + pc. 0.404 3 17 47.9 Rad. + pc. 0.404 3 18 48.0 Rad. + pc. 0.404 3 12 49.0 Rad. + pc. 0.404 3 13 48.9 Rad. + pc. 0.404 3 14 48.9 Rad. + pc. 0.404 3 15 48.9 Rad. + pc. 0.404 3 15 48.9 Rad. + pc. 0.404 3 16 49.9 Rad. + pc. 0.404 3 17 47.9 Rad. + pc. 0.404 3 18 48.9 Rad. + pc. 0.404 3 18 48.9 Rad. + pc. 0.404 3 19 48.9 Rad. + pc. 0.404 3 12 49.0 Rad. + pc. 0.404 3 12 49.0 Rad. + pc. 0.404 3 13 48.9 Rad. + pc. 0.404 3 14 48.9 Rad. + pc. 0.404 3 15 49.1 Rad. + pc. 0.404 3 15 49.2 Rad. + pc. 0.404 3 15 49.0 Rad. + pc. 0.404 3 15 49.0 Rad. + pc. 0.4</pre>	#Sample	XXXXXXX	X			
<pre>#Diameter/mm 5.550 #Sensor InSb #Operator XXXXXX #Remark_mment XXX #Cp_table XXXXXXX #I #Expansion_table dL_const #Expansion_table dL_const #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_tr 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.392 3 3 47.0 Rad. + pc. 0.4041 3 4 47.1 Rad. + pc. 0.4041 3 4 47.1 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.400 3 10 47.0 Rad. + pc. 0.400 3 #Mean 47.0 0.400 #Std Dev 0.1 0.400 HStd Dev 0.1 0.400 HStd Dev 0.1 0.400 11 48.2 Rad. + pc. 0.401 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 12 49.0 Rad. + pc. 0.402 3 12 49.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 12 49.0 Rad. + pc. 0.403 3 22 49.5 Rad. + pc. 0.404 3 23 47.8 Rad. + pc. 0.404 3 24 48.8 Rad. + pc. 0.404 3 25 49.1 Rad. + pc. 0.404 3 26 49.1 Rad. + pc. 0.404 3 27 48.9 Rad. + pc. 0.404 3 28 49.9 Rad. + pc. 0.404 3 29 49.2 Rad. + pc. 0.404 3 29 49.2 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.404 3 21 49.0 Rad. + pc. 0.404 3 23 48.9 Rad. + pc. 0.404 3 24 48.8 Rad. + pc. 0.404 3 25 49.1 Rad. + pc. 0.404 3 25 49.1 Rad. + pc. 0.404 3 26 49.1 Rad. + pc. 0.404 3 27 48.9 Rad. + pc. 0.404 3 28 48.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.404 3</pre>						
<pre>#Sensor InSb #Operator XXXX #Remark_mment XXX #Remark_mment XXX #Cp_table XXXXXXX#01 #Expansion_table dL_const #faltCode R+p/1/0-0-0 ##Results #Shot_number #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_tr 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.402 3 3 47.0 Rad. + pc. 0.402 3 3 47.0 Rad. + pc. 0.401 3 4 47.1 Rad. + pc. 0.400 3 6 46.9 Rad. + pc. 0.400 3 6 46.9 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.408 3 10 47.0 Rad. + pc. 0.408 3 11 47.0 Rad. + pc. 0.408 3 12 48.0 Rad. + pc. 0.408 3 13 47.0 Rad. + pc. 0.408 3 14 48.0 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.407 3 #Mean 48.0 0.401 #Std Dev 0.1 0.403 21 49.0 Rad. + pc. 0.338 3 20 47.8 Rad. + pc. 0.408 3 22 49.5 Rad. + pc. 0.408 3 23 48.8 Rad. + pc. 0.408 3 24 48.8 Rad. + pc. 0.408 3 25 49.1 Rad. + pc. 0.408 3 25 49.1 Rad. + pc. 0.408 3 25 49.1 Rad. + pc. 0.408 3 26 49.1 Rad. + pc. 0.408 3 27 48.9 Rad. + pc. 0.408 3 28 48.9 Rad. + pc. 0.408 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.408 3 20 47.8 Rad. + pc. 0.408 3 21 48.8 Rad. + pc. 0.408 3 22 49.5 Rad. + pc. 0.408 3 23 48.9 Rad. + pc. 0.408 3 24 48.8 Rad. + pc. 0.408 3 25 49.1 Rad. + pc. 0.408 3 26 49.2 Rad. + pc. 0.408 3 27 48.9 Rad. + pc. 0.408 3 28 49.9 Rad. + pc. 0.408 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.402 3 20 49.0 Rad. + pc. 0.408 3 29 49.0 Rad. + pc. 0.408 3 29 49.0 Rad. + pc. 0.408 3 20 49.1 Rad. + pc. 0.408 3 20 49.2 Rad. + pc. 0.408 3 20 49.2 Rad. + pc. 0.408 3 20 49.2 Rad. + pc. 0.408 3 20 49.4 Rad. + pc. 0</pre>	#Thickn	ess_RT/n	nm 1.5110			
#Operator XXXXXXX #Remark_mment XXX #Kp_table XXXXXXXXX #01 #Expansion_table dL_const #dl.Code R+p/1/0-0-0 ##Results #femperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_t 1 47.3 Rad. + pc. 0.402 3 3 46.9 Rad. + pc. 0.392 3 2 46.9 Rad. + pc. 0.401 3 3 47.0 Rad. + pc. 0.399 3 5 46.8 Rad. + pc. 0.404 3 3 47.1 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 3 47.1 Rad. + pc. 0.404 3 7 1.7 Rad. + pc. 0.404 3 3 3 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.400 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	#Diamet	er/mm	5.550			
<pre>#Remark_mment XXX #Cp_table XXXXXXX #01 #Expansion_table dL_const #CalcCode R+p/1/0-0-0 ##Results #Shot_number #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_tr 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.392 3 3 47.0 Rad. + pc. 0.404 3 4 47.1 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.405 3 10 47.0 Rad. + pc. 0.405 3 10 47.0 Rad. + pc. 0.408 3 11 48.2 Rad. + pc. 0.408 3 13 47.9 Rad. + pc. 0.409 3 13 47.9 Rad. + pc. 0.408 3 14 48.0 Rad. + pc. 0.408 3 15 48.2 Rad. + pc. 0.408 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.404 3 19 48.2 Rad. + pc. 0.407 3 #Mean 48.0 0.401 #Std_Dev 0.1 0.603 21 49.0 Rad. + pc. 0.408 3 22 49.5 Rad. + pc. 0.408 3 23 48.8 Rad. + pc. 0.408 3 24 48.8 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 26 49.1 Rad. + pc. 0.402 3 28 48.9 Rad. + pc. 0.402 3 29 49.0 Rad. + pc. 0.402 3 29 49.0 Rad. + pc. 0.402 3 20 47.8 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 26 49.1 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.402 3 20 47.8 Rad. + pc. 0.402 3 20 47.8 Rad. + pc. 0.400 3 21 48.9 Rad. + pc. 0.400 3 22 49.5 Rad. + pc. 0.400 3 23 48.9 Rad. + pc. 0.404 3 24 48.8 Rad. + pc. 0.404 3 25 49.1 Rad. + pc. 0.404 3 26 49.1 Rad. + pc. 0.404 3 27 48.9 Rad. + pc. 0.404 3 28 49.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 20 47.8 Rad</pre>	#Sensor	InSb				
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	#Operat	or	XXXXXX			
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	#Remark	_mment	XXX			
<pre>#CalcCode R+p/1/0-0-0 ##Results ##Results #Shot_number #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_t; 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.392 3 3 47.0 Rad. + pc. 0.399 3 5 46.8 Rad. + pc. 0.404 3 4 47.1 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 1 47.0 Rad. + pc. 0.405 3 10 47.0 Rad. + pc. 0.400 3 #Mean 47.0 0.400 #Std Dev 0.1 0.004 11 48.2 Rad. + pc. 0.409 3 13 47.9 Rad. + pc. 0.409 3 14 48.0 Rad. + pc. 0.409 3 15 48.2 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.401 3 16 47.9 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.401 3 16 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.405 3 19 48.2 Rad. + pc. 0.402 3 12 49.0 Rad. + pc. 0.405 3 12 49.0 Rad. + pc. 0.402 3 13 48.0 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 12 49.0 Rad. + pc. 0.402 3 12 49.8 Rad. + pc. 0.402 3 13 48.8 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.404 3 16 47.9 Rad. + pc. 0.405 3 17 47.9 Rad. + pc. 0.406 3 24 9.5 Rad. + pc. 0.406 3 22 49.5 Rad. + pc. 0.400 3 23 48.9 Rad. + pc. 0.400 3 24 48.8 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 26 49.1 Rad. + pc. 0.404 3 28 49.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.402 3 20 47.8 Rad. + pc. 0.404 3 21 49.0 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 26 49.1 Rad. + pc. 0.404 3 27 48.9 Rad. + pc. 0.404 3 28 48.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.400 3 21 49.0 Rad. + pc. 0.404 3 23 49.9 Rad. + pc. 0.404 3 24 48.8 Rad. + pc. 0.404 3 25 49.1 Rad. + pc. 0.404 3 26 49.1 Rad. + pc. 0.404 3 27 48.9 Rad. + p</pre>	#Cp_tab	le	XXXXXXXX #01			
<pre>##Results ##Results ##Results #Shot_number #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_t; 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.402 3 3 47.0 Rad. + pc. 0.401 3 4 47.1 Rad. + pc. 0.400 3 6 46.9 Rad. + pc. 0.400 3 6 46.9 Rad. + pc. 0.400 3 8 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.405 3 10 47.0 Rad. + pc. 0.406 3 11 48.2 Rad. + pc. 0.400 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.0 Rad. + pc. 0.402 3 19 48.0 Rad. + pc. 0.402 3 10 47.9 Rad. + pc. 0.402 3 11 48.0 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.405 3 19 48.2 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.407 3 #Mean 48.0 0.401 #Std_Dev 0.1 0.603 21 49.5 Rad. + pc. 0.408 3 22 49.5 Rad. + pc. 0.408 3 22 49.5 Rad. + pc. 0.408 3 23 48.9 Rad. + pc. 0.400 3 24 48.8 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 26 49.1 Rad. + pc. 0.402 3 28 48.9 Rad. + pc. 0.402 3</pre>	#Expans	ion_tabl	le dL_cons	st		
#Shot_number #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_tr 1 47.3 Rad. + $pc.$ 0.402 3 2 46.9 Rad. + $pc.$ 0.392 3 3 47.0 Rad. + $pc.$ 0.401 3 4 47.1 Rad. + $pc.$ 0.401 3 5 46.8 Rad. + $pc.$ 0.404 3 6 46.9 Rad. + $pc.$ 0.404 3 7 47.1 Rad. + $pc.$ 0.404 3 8 47.1 Rad. + $pc.$ 0.404 3 8 47.1 Rad. + $pc.$ 0.404 3 9 46.9 Rad. + $pc.$ 0.404 3 10 47.0 Rad. + $pc.$ 0.404 3 #Mean 47.0 0.404 3 3 11 48.2 Rad. + $pc.$ 0.409 3 12 48.0 Rad. + $pc.$ 0.401 3 15 48.2 Rad. + $pc.$ 0.402 3 14 48.0 <td>#CalcCo</td> <td>de</td> <td>R+p/1/0-0-0</td> <td></td> <td></td> <td></td>	#CalcCo	de	R+p/1/0-0-0			
#Shot_number #Temperature/°C #Model #Diffusivity/(mm^2/s) #Pulse_tr 1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.392 3 3 47.0 Rad. + pc. 0.399 3 4 47.1 Rad. + pc. 0.401 3 5 46.8 Rad. + pc. 0.404 3 6 46.9 Rad. + pc. 0.404 3 7 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 9 46.9 Rad. + pc. 0.405 3 10 47.0 Rad. + pc. 0.406 3 #Mean 47.0 0.401 0.402 3 11 48.2 Rad. + pc. 0.409 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc.						
1 47.3 Rad. + pc. 0.402 3 2 46.9 Rad. + pc. 0.392 3 3 47.0 Rad. + pc. 0.392 3 4 47.1 Rad. + pc. 0.399 3 5 46.8 Rad. + pc. 0.401 3 6 46.9 Rad. + pc. 0.400 3 6 46.9 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 9 46.9 Rad. + pc. 0.404 3 9 46.9 Rad. + pc. 0.400 3 #Wean 47.0 Rad. + pc. 0.400 3 11 48.2 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.399 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.397 3 16 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402	##Resul	ts				
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$					<pre>#Diffusivity/(mm^2/s)</pre>	#Pulse_type
3 47.0 Rad. + pc. 0.401 3 4 47.1 Rad. + pc. 0.399 3 5 46.8 Rad. + pc. 0.400 3 6 46.9 Rad. + pc. 0.400 3 7 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 9 46.9 Rad. + pc. 0.405 3 10 47.0 Rad. + pc. 0.406 3 #Mean 47.0 0.402 3 3 11 48.2 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.403 3 16 48.0 Rad. + pc. 0.403 3				0.402		
4 47.1 Rad. + pc. 0.399 3 5 46.8 Rad. + pc. 0.490 3 6 46.9 Rad. + pc. 0.399 3 7 47.1 Rad. + pc. 0.399 3 7 47.1 Rad. + pc. 0.399 3 9 46.9 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.404 3 9 46.9 Rad. + pc. 0.400 3 #Wean 47.0 Rad. + pc. 0.400 3 11 48.2 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.402 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.403 3 20 47.8 Rad. + pc. <td></td> <td>46.9</td> <td>Rad. + pc.</td> <td>0.392</td> <td></td> <td></td>		46.9	Rad. + pc.	0.392		
5 46.8 Rad. + pc. 0.400 3 6 46.9 Rad. + pc. 0.399 3 7 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.494 3 9 46.9 Rad. + pc. 0.404 3 10 47.0 Rad. + pc. 0.400 3 #Mean 47.0 0.400 3 #Std_Dev 0.1 0.004 1 11 48.2 Rad. + pc. 0.399 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.493 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.493 3 20 47.8 Rad. + pc. 0.398 3 21 49.0 Rad. + pc. 0.397 3		47.0	Rad. + pc.	0.401	3	
6 46.9 Rad. + pc. 0.399 3 7 47.1 Rad. + pc. 0.399 3 8 47.1 Rad. + pc. 0.399 3 9 46.9 Rad. + pc. 0.495 3 10 47.0 Rad. + pc. 0.405 3 #Mean 47.0 0.400 0 0 #Std_Dev 0.1 0.004 1 1 11 48.2 Rad. + pc. 0.399 3 12 48.0 Rad. + pc. 0.399 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.492 3 15 48.2 Rad. + pc. 0.492 3 16 47.9 Rad. + pc. 0.493 3 17 47.9 Rad. + pc. 0.493 3 18 48.0 Rad. + pc. 0.493 3 20 47.8 Rad. + pc. 0.397 3 21 49.0 Rad. + pc.		47.1	Rad. + pc.	0.399	3	
7 47.1 Rad. + pc. 0.404 3 8 47.1 Rad. + pc. 0.399 3 9 46.9 Rad. + pc. 0.406 3 10 47.0 Rad. + pc. 0.400 3 #Wean 47.0 0.400 3 #Std_Dev 0.1 0.0401 3 11 48.2 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.399 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.8 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.401 3 21 49.0 Rad. + pc. 0.401 3 22 49.5 Rad. + pc. 0.400 3 <td></td> <td>46.8</td> <td>Rad. + pc.</td> <td>0.400</td> <td>3</td> <td></td>		46.8	Rad. + pc.	0.400	3	
8 47.1 Rad. + pc. 0.399 3 9 46.9 Rad. + pc. 0.406 3 10 47.0 Rad. + pc. 0.400 #Mean 47.0 0.400 #Std Dev 0.1 0.400 #Std Dev 0.1 0.400 #Std Dev 0.1 0.400 11 48.2 Rad. + pc. 0.399 12 48.0 Rad. + pc. 0.399 13 47.9 Rad. + pc. 0.402 14 48.0 Rad. + pc. 0.402 15 48.2 Rad. + pc. 0.402 16 47.9 Rad. + pc. 0.402 17 47.9 Rad. + pc. 0.402 18 48.0 Rad. + pc. 0.405 19 48.2 Rad. + pc. 0.398 20 47.8 Rad. + pc. 0.380 21 49.0 Rad. + pc. 0.397 22 49.5 Rad. + pc. 0.406 24 48.8 Rad. + pc.		46.9	Rad. + pc.	0.399	3	
9 46.9 Rad. + pc. 0.405 3 10 47.0 Rad. + pc. 0.406 3 #%ean 47.0 0.400 3 #\$td_Dev 0.1 0.040 3 11 48.2 Rad. + pc. 0.399 3 12 48.0 Rad. + pc. 0.399 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.404 3 20 47.8 Rad. + pc. 0.407 3 #Mean 48.0 0.401 3 3 21 49.0 Rad. + pc. 0.307 3 22 49.5 Rad. + pc. 0.408 3 23 48.9 Rad. + pc. 0.408 3 22	7	47.1	Rad. + pc.	0.404	3	
10 47.0 Rad. + pc. 0.400 3 #Mean 47.0 0.400 3 \$\$td_Dev 0.1 0.004 1 11 48.2 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.399 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.401 3 21 49.0 Rad. + pc. 0.401 3 22 49.5 Rad. + pc. 0.401 3 23 48.8 Rad. + pc. 0.403 3 24 48.8 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 2	8	47.1	Rad. + pc.	0.399	3	
#Mean 47.0 0.400 #Std_Dev 0.1 0.004 11 48.2 Rad. + pc. 0.402 3 12 48.0 Rad. + pc. 0.399 3 13 47.9 Rad. + pc. 0.402 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.401 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.405 3 19 48.2 Rad. + pc. 0.405 3 20 47.8 Rad. + pc. 0.398 3 20 47.8 Rad. + pc. 0.397 3 21 49.0 Rad. + pc. 0.397 3 22 49.5 Rad. + pc. 0.396 3 22 49.5 Rad. + pc. 0.400 3 24 48.8 <	9	46.9	Rad. + pc.	0.405	3	
	10	47.0	Rad. + pc.	0.400	3	
11 48.2 Rad. + pc. 0.492 3 12 48.0 Rad. + pc. 0.399 3 13 47.9 Rad. + pc. 0.399 3 14 48.0 Rad. + pc. 0.492 3 15 48.2 Rad. + pc. 0.492 3 15 48.2 Rad. + pc. 0.492 3 16 47.9 Rad. + pc. 0.492 3 17 47.9 Rad. + pc. 0.492 3 18 48.0 Rad. + pc. 0.492 3 19 48.2 Rad. + pc. 0.497 3 #Mean 48.0 0 0.401 3 \$20 47.8 Rad. + pc. 0.380 3 20 47.8 Rad. + pc. 0.380 3 21 49.0 Rad. + pc. 0.490 3 22 49.5 Rad. + pc. 0.490 3 23 48.9 Rad. + pc. 0.490 3 24 48.8 Rad. + pc.	#Mean	47.0	0.400			
12 48.0 Rad. + pc. 0.399 3 13 47.9 Rad. + pc. 0.399 3 14 48.0 Rad. + pc. 0.492 3 15 48.2 Rad. + pc. 0.492 3 16 47.9 Rad. + pc. 0.491 3 16 47.9 Rad. + pc. 0.492 3 17 47.9 Rad. + pc. 0.492 3 18 48.0 Rad. + pc. 0.495 3 20 47.8 Rad. + pc. 0.493 3 21 49.0 Rad. + pc. 0.398 3 22 49.5 Rad. + pc. 0.397 3 21 49.0 Rad. + pc. 0.397 3 22 49.5 Rad. + pc. 0.490 3 23 48.9 Rad. + pc. 0.490 3 24 48. Rad. + pc. 0.490 3 25 49.1 Rad. + pc. 0.490 3 26 49.1 Rad. + pc	#Std_De	v	0.1	0.004		
13 47.9 Rad. + pc. 0.399 3 14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.401 3 16 47.9 Rad. + pc. 0.401 3 16 47.9 Rad. + pc. 0.402 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 20 47.8 Rad. + pc. 0.407 3 #Mean 48.0 0.401 * * \$21 49.0 Rad. + pc. 0.380 3 22 49.5 Rad. + pc. 0.397 3 23 48.9 Rad. + pc. 0.400 3 24 48.8 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 26 49.1 Rad. + pc. 0.400 3 27 48.9 Rad. + pc. 0.400 3 28 48.9 Rad. + pc. <td>11</td> <td>48.2</td> <td>Rad. + pc.</td> <td>0.402</td> <td>3</td> <td></td>	11	48.2	Rad. + pc.	0.402	3	
14 48.0 Rad. + pc. 0.402 3 15 48.2 Rad. + pc. 0.401 3 16 47.9 Rad. + pc. 0.397 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.402 3 19 48.2 Rad. + pc. 0.402 3 20 47.8 Rad. + pc. 0.407 3 #Mean 48.0 0.401 4 4 \$Std_Dev 0.1 0.003 4 4 21 49.0 Rad. + pc. 0.380 3 22 49.5 Rad. + pc. 0.401 3 23 48.9 Rad. + pc. 0.400 3 24 48.8 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 26 49.1 Rad. + pc. 0.400 3 27 48.9 Rad. + pc. 0.400 3 28 48.9 Rad. + pc.	12	48.0	Rad. + pc.	0.399	3	
15 48.2 Rad. + pc. 0.401 3 16 47.9 Rad. + pc. 0.397 3 17 47.9 Rad. + pc. 0.402 3 18 48.0 Rad. + pc. 0.405 3 19 48.2 Rad. + pc. 0.405 3 20 47.8 Rad. + pc. 0.407 3 #Mean 48.0 0.401 401 401 #Std_Dev 0.1 0.403 3 21 49.0 Rad. + pc. 0.397 3 22 49.5 Rad. + pc. 0.400 3 23 48.9 Rad. + pc. 0.400 3 24 48. Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 26 49.1 Rad. + pc. 0.400 3 27 48.9 Rad. + pc. 0.400 3 27 48.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 <td>13</td> <td>47.9</td> <td>Rad. + pc.</td> <td>0.399</td> <td>3</td> <td></td>	13	47.9	Rad. + pc.	0.399	3	
	14	48.0	Rad. + pc.	0.402	3	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	15	48.2	Rad. + pc.	0.401	3	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	16	47.9	Rad. + pc.	0.397	3	
19 48.2 Rad. + pc. 0.398 3 20 47.8 Rad. + pc. 0.497 3 #Mean 48.0 0.401 4 \$85td_Dev 0.1 0.003 21 49.0 Rad. + pc. 0.397 32 48.9 Rad. + pc. 0.397 23 48.9 Rad. + pc. 0.400 24 48.8 Rad. + pc. 0.400 25 49.1 Rad. + pc. 0.400 26 49.1 Rad. + pc. 0.404 27 48.9 Rad. + pc. 0.404 27 48.9 Rad. + pc. 0.404 29 49.0 Rad. + pc. 0.404 30 49.2 Rad. + pc. 0.404	17	47.9		0.402	3	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	18	48.0	Rad. + pc.	0.405	3	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	19				3	
#Wean 48.0 0.401 #Std_Dev 0.1 0.003 21 49.0 Rad. + pc. 0.380 3 22 49.5 Rad. + pc. 0.397 3 23 48.9 Rad. + pc. 0.400 3 24 48.8 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.400 3 26 49.1 Rad. + pc. 0.400 3 27 48.9 Rad. + pc. 0.400 3 28 48.9 Rad. + pc. 0.400 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.404 3 30 49.2 Rad. + pc. 0.404 3					3	
#Std_Dev 0.1 0.003 21 49.0 Rad. + pc. 0.380 3 22 49.5 Rad. + pc. 0.397 3 23 48.9 Rad. + pc. 0.440 3 24 48.8 Rad. + pc. 0.440 3 25 49.1 Rad. + pc. 0.440 3 26 49.1 Rad. + pc. 0.4395 3 26 49.1 Rad. + pc. 0.440 3 27 48.9 Rad. + pc. 0.440 3 29 49.0 Rad. + pc. 0.4395 3 36 49.2 Rad. + pc. 0.4397 3						
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				0.003		
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$					3	
23 48.9 Rad. + pc. 0.400 3 24 48.8 Rad. + pc. 0.400 3 25 49.1 Rad. + pc. 0.396 3 26 49.1 Rad. + pc. 0.400 3 27 48.9 Rad. + pc. 0.400 3 28 48.9 Rad. + pc. 0.395 3 29 49.0 Rad. + pc. 0.397 3 30 49.2 Rad. + pc. 0.402 3						
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$						
25 49.1 Rad. + pc. 0.396 3 26 49.1 Rad. + pc. 0.400 3 27 48.9 Rad. + pc. 0.395 3 28 48.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.397 3 30 49.2 Rad. + pc. 0.402 3						
26 49.1 Rad. + pc. 0.400 3 27 48.9 Rad. + pc. 0.395 3 28 48.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.397 3 30 49.2 Rad. + pc. 0.402 3						
27 48.9 Rad. + pc. 0.395 3 28 48.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.397 3 30 49.2 Rad. + pc. 0.402 3						
28 48.9 Rad. + pc. 0.404 3 29 49.0 Rad. + pc. 0.397 3 30 49.2 Rad. + pc. 0.402 3						
29 49.0 Rad. + pc. 0.397 3 30 49.2 Rad. + pc. 0.402 3						
30 49.2 Rad. + pc. 0.402 3						
#mean 49.0 0.39/				0.402	5	
#Std Dev 0.2 0.007				o oo-		

Figure 3: LFA 447 measurement data report text file.

The content of the report text file can directly be copy/pasted into Excel, but one can see in *Figure 4* that there are intermediate lines and columns which are unnecessary and should be deleted. However, deleting many lines manually on Excel is very tedious and time-consuming. That is why a VBA Macro or MATLAB Script performing this task automatically is a great time-saver.

3	##General_information				
4	#Database	Ifa results.lfa.mdb			
5	#Instrument	#LFA 447			
6	#Identity	XXXXXXXXXXXXX XX.XX.XX			
7	#Date	20XX-XX-XX			
8	#Material	XXXXXXX			
9	#Ref_temperature /°C	22			
10	#Ref_density /(g/cm^3)	2.430			
11	#Sample	XXXXXXXXX			
12	#Type	#Single_layer			
13	#Thickness_RT/mm	15.110			
14	#Diameter/mm	5.550			
15	#Sensor	InSb			
16	#Operator	XXXXXX			
17	#Remark_mment	XXX			
18	#Cp_table	XXXXXXXX #01			
19	#Expansion_table	dL_const			
20	#CalcCode	R+p/l/0-0-0			
21					
22	##Results			2	
23	#Shot_number	#Temperature/°C	#Model	#Diffusivity/(mm^2/s)	#Pulse_type
24	1		Rad. + pc.	0.402	3
25	2		Rad. + pc.	0.392	3
26	3		Rad. + pc.	0.401	3
27	4		Rad. + pc.	0.399	3
28	5		Rad. + pc.	0.4	3
29	6		Rad. + pc.	0.399	3
30	7		Rad. + pc.	0.404	
31	8		Rad. + pc.	0.399	3
32	9		Rad. + pc.	0.405	3
33	10		Rad. + pc.	0.4	3
-	#Mean	47	-	0.4	
	#Std_Dev	0.1	D. J. J.	0.004	
36	11		Rad. + pc.	0.402	3
37	12		Rad. + pc.	0.399	3
38 39	13		Rad. + pc. Rad. + pc.	0.399	3
40	14		Rad. + pc. Rad. + pc.	0.402	3
40	15		Rad. + pc. Rad. + pc.	0.401	
41	10		Rad. + pc.	0.397	3
42	18		Rad. + pc.	0.402	3
44	19		Rad. + pc.	0.398	3
45	20		Rad. + pc.	0.398	
_	#Mean	48		0.401	
47	#Std Dev	0.1		0.003	

Figure 4: Example of a measurement report text file copy/pasted into Excel with unnecessary intermediate lines and columns which should be deleted (framed in red).

In addition, the measurement points are not necessarily set in order according to temperature and the number of points per temperature range can have arbitrary value. It is therefore tedious to group scattered measurement points by temperature and calculate mean average and standard deviation for specific range of temperatures.

The different scripts presented in this report clean, order, decimate and calculate the mean average and standard deviation of the LFA 447 measurement data from the report text files.

3. VBA Excel Macro for pre-processing (cleaning) LFA 447 measurement report

The Microsoft Excel Macro-Enable Worksheet named "LFA_447_data_result_pre-processing" contains an Excel VBA Macro which removes automatically the unnecessary columns containing the strings "#Model" and "#Pulse_type", and removes the unnecessary lines containing the strings "#Mean" and "#Std_Dev". All other data is left as it is.

To "clean" the LFA 447 result report from the aforementioned columns and lines, open the result report text file with the "Notepad" software (see *Figure 5*). Select all the text of the report text file (Ctrl + A) and copy it (Ctrl + C).

File Edit Format	ment report - test - Note View Help				×
##Thermal_diff					
_					
##General_info					
#Database	lfa_results.lf	a.mdb			
#Instrument	#LFA_447	v vv vv			
#Identity	XXXXXXXXXXXXXX X				
#Date 20XX-X					
#Material	XXXXXX				
#Ref_temperatu					
<pre>#Ref_density / #Somple YYYYY</pre>					
#Sample XXXXXX					
	e_layer				
<pre>#Thickness_RT/ #Diamates</pre>					
#Diameter/mm #Sensor InSb	5.550				
#Operator	XXXXXX				
#Operator #Remark mment	XXX				
#Cp table	XXXXXXXXX #01				
		c+			
#Expansion_tab #CalcCode	le dL_con R+p/1/0-0-0	50			
fcalccode	N+p/1/0-0-0				
##Results					
#Shot_number	<pre>#Temperature/°</pre>	C #Model	<pre>#Diffusivity/(mm^2/s)</pre>	<pre>#Pulse_type</pre>	
L 47.3	Rad. + pc.	0.402	3		
2 46.9	Rad. + pc.	0.392	3		
3 47.0	Rad. + pc.	0.401	3		
47.1	Rad. + pc.	0.399	3		
5 46.8	Rad. + pc.	0.400	3		
5 46.9	Rad. + pc.	0.399	3		
7 47.1	Rad. + pc.	0.404	3		
3 47.1	Rad. + pc.	0.399	3		
46.9	Rad. + pc.	0.405	3		
10 47.0	Rad. + pc.	0.400	3		
#Mean 47.0	0.400		-		
#Std Dev	0.1	0.004			
48.2	Rad. + pc.	0.402	3		
48.0	Rad. + pc.	0.399	3		
13 47.9	Rad. + pc.	0.399	3		
48.0	Rad. + pc.	0.402	3		
48.2	Rad. + pc.	0.401	3		
16 47.9	Rad. + pc.	0.397	3		
17 47.9	Rad. + pc.	0.402	3		
18 48.0	Rad. + pc.	0.405	3		
48.2	Rad. + pc.	0.398	3		
47.8	Rad. + pc.	0.407	3		
#Mean 48.0	0.401		-		
#Std_Dev	0.1	0.003			
49.0	Rad. + pc.	0.380	3		
49.5	Rad. + pc.	0.397	3		
	Rad. + pc.	0.400	3		
23 48.9					
48.9					
48.9				Ln 1, Col 1	>

Figure 5: LFA 447 measurement results report text file.

Open the Excel file "LFA_447_data_result_pre-processing" and paste (Ctrl + V) the entire content of the report text file into the yellow cell "A1" of the only sheet (named "data") of the Excel file (see *Figure 6*).

1	A	В	С	D	E	F	G	
1	##Therma	diffusivity	1					
2								
3	##General	informatio	on					
4	#Database	Ifa results	.lfa.mdb					
5	#Instrume							
6	#Identity		xxx xx.xx	.xx				
7	#Date	20XX-XX-X						
8	#Material		7					
9	#Ref_temp	22						
10	#Ref_dens							
11	#Sample	XXXXXXXX		-	-			
12	#Type	#Single_la	ver	-				
13	#Thickness							
14	#Diameter							
15	#Sensor	InSb						
16								
17	#Remark_							
18	#Cp table		#01					
19	#Expansio							-
20	#CalcCode		0					
21	in concectore	11.01100						
22	##Results							
23	#Shot_nun	#Tempera	#Model	#Diffusivit	#Pulse type			-
24	1		Rad. + pc.	0.402	3			
25	2		Rad. + pc.	0.392	3			
26	3		Rad. + pc.	0.392	3		-	
27	4		Rad. + pc.	0.399	3			-
28	5		Rad. + pc.	0.399	3			
29	6		Rad. + pc.	0.399	3			
30	7		Rad. + pc. Rad. + pc.	0.399	3			
31	8		Rad. + pc.	0.399	3			-
32	9		Rad. + pc.	0.399	3			-
33	10		Rad. + pc. Rad. + pc.	0.405	3			1
33 34	#Mean	47	nau. + pc.	0.4	5			-
35	#Std Dev	0.1		0.4				
36	#Std_Dev		Rad. + pc.	0.004	3			
37	1.00				3			-
38	12		Rad. + pc.	0.399	3			
	13		Rad. + pc.	0.399				
39	14		Rad. + pc.	0.402	3			1
40 41	15		Rad. + pc.	0.401	3			
-	16		Rad. + pc.	0.397	3			-
42	17		Rad. + pc.	0.402	3			-
43	18		Rad. + pc.	0.405	3			-
44	19		Rad. + pc.	0.398	3		-	-
45	20		Rad. + pc.	0.407	3			
46	#Mean	48		0.401				
47	#Std_Dev	0.1		0.003				

Figure 6: Paste all report text content into the yellow cell "A1" of the only sheet (named "data") of the Excel file "LFA_447_data_result_pre-processing".

Press "Ctrl + m" to execute the Excel macro and clean the data (see *Figure 7*). One can see that all data points are now continuous and contiguous. The process will also work if other results are in the report text file such as thermal conductivity, specific heat capacity or contact resistance.

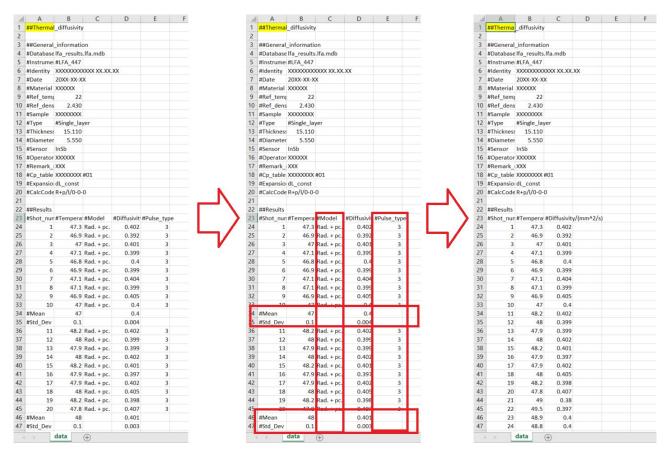


Figure 7: Report text file content before data cleaning (left); columns and lines which will be deleted from the sheet (center); report text file content after data cleaning (right).

4. MATLAB script for pre-processing (cleaning) LFA 447 measurement report

The MATLAB script named "LFA_447_data_result_pre_processing.m" takes a LFA 447 measurement report text file as input and creates and new text file with the report's data without the unnecessary columns containing the strings "#Model" and "#Pulse_type", and without the unnecessary lines containing the strings "#Mean" and "#Std_Dev". The report information before the data header is not kept. All other data is left as it is. The output text file is placed in the same folder as the input measurement report text file. The name of the output text file is the same as the one of the input file and preceded by "clean_data_".

To generate the "clean" LFA 447 result report, open and run the MATLAB script "LFA_447_data_result_pre_processing.m". Select the input measurement report text file (see *Figure 8*).

• →	~ ↑ 📕		~ U				۶
					-		•
	Name	^	Date modified	Туре	S	ize	
	E LFA 447 measurer	ment report - test	02-10-2019 11:26	Text Document		71	KB
	test_data		02-10-2019 17:12	Text Document		10	<В
	File name: LF	A 447 measurement repor	rt - test	(*.txt)			~

Figure 8: Select the input measurement report text file when running the MATLAB script.

If no error message has been displayed in the MATLAB command window, the operation has been completed successfully and a new text file has been generated in the same folder as the input measurement report text file without the unnecessary lines and columns (see *Figure 9*).

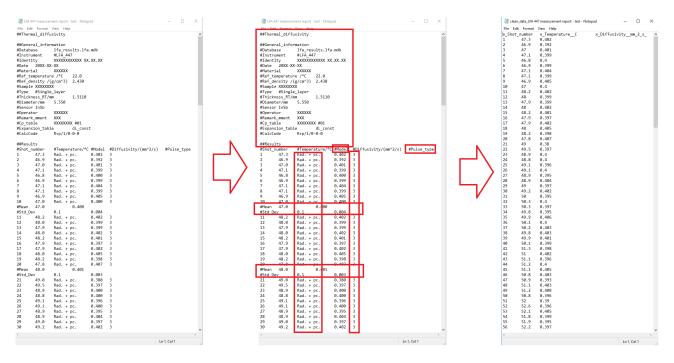


Figure 9: Input report text file content before data cleaning (left); columns and lines which are not kept from the input file (center); output text file after data pre-processing by the MATLAB script (right).

5. MATLAB script for averaging, decimating regularly, and calculating standard deviation of scattered data points

The MATLAB script named "average_decimate_std_dev_scattered_data.m" takes a tabulation delimited, point decimal delimiter data text file with 2 columns of scattered data points as input. From this file, it sets in order, averages and decimates (resampling) the second data column as a function of the first data column of the text file with a specific decimation/resampling step size. The standard deviation of the first data column is calculated for each decimation/resampling step. The decimation/resampling result is saved in a new output text file with the same name as the input file and preceded by "avrg_decimated_std_dev_". The output text file is placed in the same folder as the input text file. A detailed example of the script processing is presented hereafter.

To decimate / resample a data file with 2 data columns, open and run the MATLAB script "average_decimate_std_dev_scattered_data.m". Select the input text file (see *Figure 10*).

📣 Select Fil	e to Open				×
$\leftarrow \rightarrow$ v	< ↑ 🖡		✓ Ŭ		P
Organize 🔻	New folder				?
	Name	Date modified	Туре	Size	
	📄 clean_data_LFA 447 measurement report	04-10-2019 11:30	Text Document	3 KB	
	LFA 447 measurement report - test	02-10-2019 11:26	Text Document	7 KB	
	📄 test_data	02-10-2019 17:12	Text Document	10 KB	
	File name: test_data		~ (*.txt)		\sim
			Open	Cance	

Figure 10: Select the input text file when running the MATLAB script.

Choose decimation / resampling step size (see Figure 11).

承 Delta	_		×					
Enter a value of decimation step size								
	(Ж	Cancel					

Figure 11: Indicate the decimation / resampling step size.

If no error message has been displayed in the MATLAB command window, the operation has been completed successfully and a new text file has been generated in the same folder as the input file. One can see in *Figure 12 (on the left)* that the input file has scattered data in the first column (the data points are not ordered in ascending or descending order). The input file has values in the first column ranging from 9.6 to 60.5. In the current example, the decimation / resampling step size is 10, meaning that the data in the second column will be averaged (and standard deviation calculated) for corresponding first column's values of 0 ±5, 10 ±5, 20 ±5, 30 ±5, 40 ±5, 50 ±5, 60 ±5 and 70 ±5. Consequently, one can see in the output file (*Figure 12 on the right*) that the data points of column 2 have been averaged (and standard deviation calculated) for column 1 average values of 0, 10, 20, 30, 40, 50, 60 and 70. In the case of column 1 average values of 0 and 70, there is no column 2 data corresponding to column 1 data points 0 ±5 or 70 ±5. The corresponding average data for column 2 is thus set to "NaN" and the standard deviation is left as an empty cell.

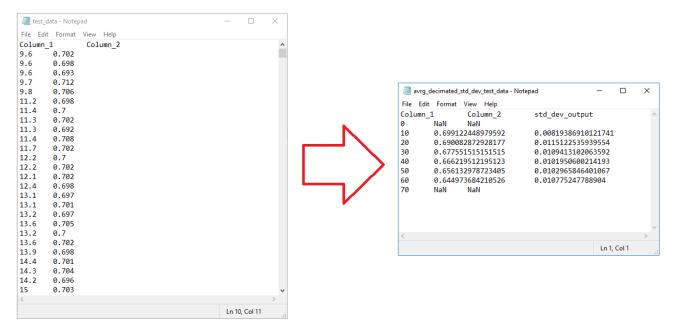


Figure 12: Input file with scattered data in 2 columns (left); output file with first column set in ascending order and decimated according to decimation / resampling step size, second column with average of the data according to the first data column, and third column with the standard deviation of the second column for each step (right).

6. Appendices

6.1. VBA Excel Macro code for pre-processing (cleaning) LFA measurement report

```
Sub clean data LFA 1()
' clean data LFA 1 Macro
' Remove the entire columns containing "#Model" and "#Pulse type"
' Remove all the lines containing "#Mean" and "Std Dev"
Dim FindString As String
Dim Rng As Range
' Find the column containing "#Model" and delete it entirely
With Sheets ("data"). Used Range
    FindString = "#Model"
    Set Rng = .Find(What:=FindString,
   After:=.Cells(.Cells.Count),
   LookIn:=xlValues,
   LookAt:=xlWhole,
    SearchOrder:=xlByRows, _
    SearchDirection:=xlNext, _
   MatchCase:=False)
    ' If there is no "#Model" found, an error message is displayed and
the script is terminated
    If Rng Is Nothing Then
       MsgBox "Nothing found"
        Exit Sub
    End If
    Columns (Rng.Column).EntireColumn.Delete
End With
' Find the column containing "#Pulse type" and delete it entirely
With Sheets ("data"). Used Range
   FindString = "#Pulse type"
    Set Rng = .Find(What:=FindString, _
   After:=.Cells(.Cells.Count),
   LookIn:=xlValues, _
    LookAt:=xlWhole, _
    SearchOrder:=xlByRows,
    SearchDirection:=xlNext, _
   MatchCase:=False)
```

```
' If there is no "#Pulse type" found, an error message is displayed
and the script is terminated
    If Rng Is Nothing Then
       MsqBox "Error"
        Exit Sub
    End If
    Columns (Rng.Column).EntireColumn.Delete
End With
' Find all the lines containing "#Mean" and delete them
' Find the first occurrence of "#Mean"
FindString = "#Mean"
With Sheets ("data"). Used Range
    Set Rng = .Find(What:=FindString, _
   After:=.Cells(.Cells.Count),
   LookIn:=xlValues,
    LookAt:=xlWhole,
    SearchOrder:=xlByRows,
    SearchDirection:=xlNext, _
   MatchCase:=False)
End With
' Loop to delete the entire line containing "#Mean" until there is no
"#Mean" which can be found
Do While Not Rng Is Nothing
Rows (Rng.Row) .EntireRow.Delete
With Sheets ("data"). Used Range
    Set Rng = .Find(What:=FindString, _
   After:=.Cells(.Cells.Count),
   LookIn:=xlValues,
   LookAt:=xlWhole,
    SearchOrder:=xlByRows, _
    SearchDirection:=xlNext, _
   MatchCase:=False)
End With
Loop
' Find all the lines containing "#Std_Dev" and delete them
' Find the first occurrence of "#Std Dev"
FindString = "#Std Dev"
With Sheets ("data"). Used Range
    Set Rng = .Find(What:=FindString,
```

```
After:=.Cells(.Cells.Count), _
    LookIn:=xlValues, _
    LookAt:=xlWhole,
    SearchOrder:=xlByRows, _
    SearchDirection:=xlNext, _
    MatchCase:=False)
End With
' Loop to delete the entire line containing "#Std Dev" until there is no
"#Std Dev" which can be found
Do While Not Rng Is Nothing
Rows (Rng.Row) .EntireRow.Delete
With Sheets ("data"). Used Range
    Set Rng = .Find(What:=FindString, _
    After:=.Cells(.Cells.Count), _
    LookIn:=xlValues,
    LookAt:=xlWhole,
    SearchOrder:=xlByRows, _
    SearchDirection:=xlNext, _
    MatchCase:=False)
End With
Loop
Application.Goto Range("A1")
End Sub
```

6.2. MATLAB code for pre-processing (cleaning) LFA measurement report

```
%% Removes unnecessary columns and lines from a LFA 447 measurement
report text file and save it in a new text file
% Prompt user for location of input file
% Remove the unnecessary columns containing "#Model" and "#Pulse type"
% Remove the unnecessary lines containing "#Mean" and "#Std Dev"
% Remove all text before the tabulated data (before the data header)
% A new result file is generated and saved in the same folder as the
input file
22
% Prompt user for input file
[file,path,indx] = uigetfile('*.txt');
if isequal(file,0)
  disp('Error: the data pre-processing has been terminated.')
  return;
end
% get file name
filename = [path file];
[fileID,errmsg] = fopen(filename);
if isempty(errmsg)
  disp('Input file has been loaded correctly.')
else
  disp('Error: the data pre-processing has been terminated.')
  return;
end
% Import data
cdata = readtable(filename);
fclose(fileID);
% Get list of all variable from the table
list var names = cdata.Properties.VariableNames;
% Find index of variable "Shot number"
index shot = find(contains(list var names, 'Shot number'));
if isempty(index shot)
   disp('The report text file is not valid. This script will be
terminated immediately.');
   return
end
% Find index of variable "Model"
index model = find(contains(list var names, 'Model'));
if isempty(index model)
   disp('The report text file is not valid. This script will be
terminated immediately.');
   return
end
```

```
% Find index of variable "Pulse type"
index pulse type = find(contains(list var names, 'Pulse type'));
if isempty(index pulse_type)
    disp('The report text file is not valid. This script will be
terminated immediately.');
    return
else
    disp('The report text file is valid.');
end
% Delete columns "model" and "Pulse type"
cdata =
removevars(cdata, {char(string(cdata.Properties.VariableNames(index model)
)), char(string(cdata.Properties.VariableNames(index pulse type)))});
% Get back the new Shot number variable number where the #Mean and
#Std Dev string should be found
index shot = find(contains(list var names, 'Shot number'));
% Get the real name of the shot var
shot var name = char(cdata.Properties.VariableNames(index shot));
% Create new table without the #Mean and #Std Dev lines
clean data = cdata((cdata.(shot var name) ~= "#Mean" &
cdata.(shot var name) ~= "#Std Dev"),:); % cdata.(shot var name) with the
"()" because "shot_var_name" is not a variable but an expression which
give a char variable name
% Create a new text file with the clean data table in same folder as
input file
new filename = [path 'clean data ' file];
writetable(clean data, new filename, 'Delimiter', 'tab');
% Create final message and display it with name of the new created file
msg = strcat('A clean result data text file named "clean data ', file, '"
has been created in the same folder as the input file.');
disp(msg);
```

6.3. MATLAB code for averaging, decimating regularly, and calculating standard deviation of scattered data points

```
%% Average and decimate regularly scattered data with fixed defined step
% Prompt user for location of input file
% Prompt user for step size for decimation of the averaged data
% Group Y scattered data (only 1 Y column in a 2 column data set with X
as first and Y as second column) in chunck and average it and decimate it
according to the step size of decimation of X
% Minimum and maximum are defined according to extremas in the X data and
according to the decimation step size
% Standard deviation is calculated for each step adn stored in additional
column
% A new result file is generated and saved in the same folder as the
input file
22
% Prompt user for input file
[file,path,indx] = uigetfile('*.txt');
if isequal(file, 0)
  disp('Error: the data treatment has been terminated.')
   return;
end
% get file name
filename = [path file];
[fileID,errmsg] = fopen(filename);
if isempty(errmsg)
   disp('Input file has been loaded correctly.')
else
  disp('Error: the data treatment has been terminated.')
  return;
end
% Import data
cdata = readtable(filename);
fclose(fileID);
% Check that there is at least 2 columns (because only the 2 first
columns
% are used for data treatment
if length(cdata.Properties.VariableNames) < 2</pre>
   disp('Error: input file data is wrong. The data treatment has been
terminated.')
  return;
end
% Check that data is longer than 1 row
if length(cdata{:,1}) > 1 && length(cdata{:,2}) > 1
  disp('Input data is valid.')
else
```

```
disp('Error: wrong data. The data treatment has been terminated.')
   return;
end
% Prompt user for decimation step size
prompt = {'Enter a value of decimation step size'};
dlgtitle = 'Delta';
definput = \{ '1' \};
opts.Interpreter = 'tex';
answer = inputdlq(prompt,dlqtitle,[1 40],definput,opts);
delta = str2double(answer); % convert answer into numerical
% Get first point in X data and last point in X data
first = min(cdata{:,1});
last = max(cdata{:,1});
distance = last - first;
% Check that the step size is not zero and that it is not larger than the
% distance between the first and last point
if delta > 0 && delta < distance</pre>
   disp('Step size for decimation is valid.')
else
   disp('Error: wrong step size for decimation. The data treatment has
been terminated.')
   return
end
% round to the closest first data point or round lower according to
% decimation step size
starting point = delta*floor(first/delta);
% do the same for the last data point
ending point = delta*ceil(last/delta);
% Because of numerical truncation, there might be one step too many at
the
% beginning and / or at the end. But this step will be empty or NaN
X_output = (starting_point:delta:ending_point)';
Y output = NaN(length(X output),1);
std dev output = NaN(length(X_output),1);
for i = 1:length(X output)
% for each step in X output, get the average of the Y data values
% at distance delta/2 from the current X output.
   selection_array = (cdata{:,1} >= X_output(i)-delta/2).*(cdata{:,1} <=</pre>
X output(i)+delta/2); % have to fulfill 2 conditions with ".*"
   sub table=(cdata(logical(selection array),2));
   Y output(i) = mean(sub table{:,1});
   std dev output(i) = std(sub table{:,1});
end
table output = table(X output,Y output,std dev output); % Arrange all
```

```
data in a table
```

table_output.Properties.VariableNames([1 2]) =
cdata.Properties.VariableNames([1 2]); % Rename table header with header
of original input file

% Write table data into text file in same folder as input file new_filename = [path 'avrg_decimated_std_dev_' file]; writetable(table_output,new_filename,'Delimiter','tab');

disp('Result file has been created in the same file as the input file.');

References

- [1] Netzsch Gerätebau GmbH. Operating Instructions Nano-Flash-Apparatus LFA 447, 2001.
- [2] Building Material Characterization Laboratory of Aalborg University, Department of Civil Engineering, Aalborg, Denmark.

https://buildingmaterials.civil.aau.dk