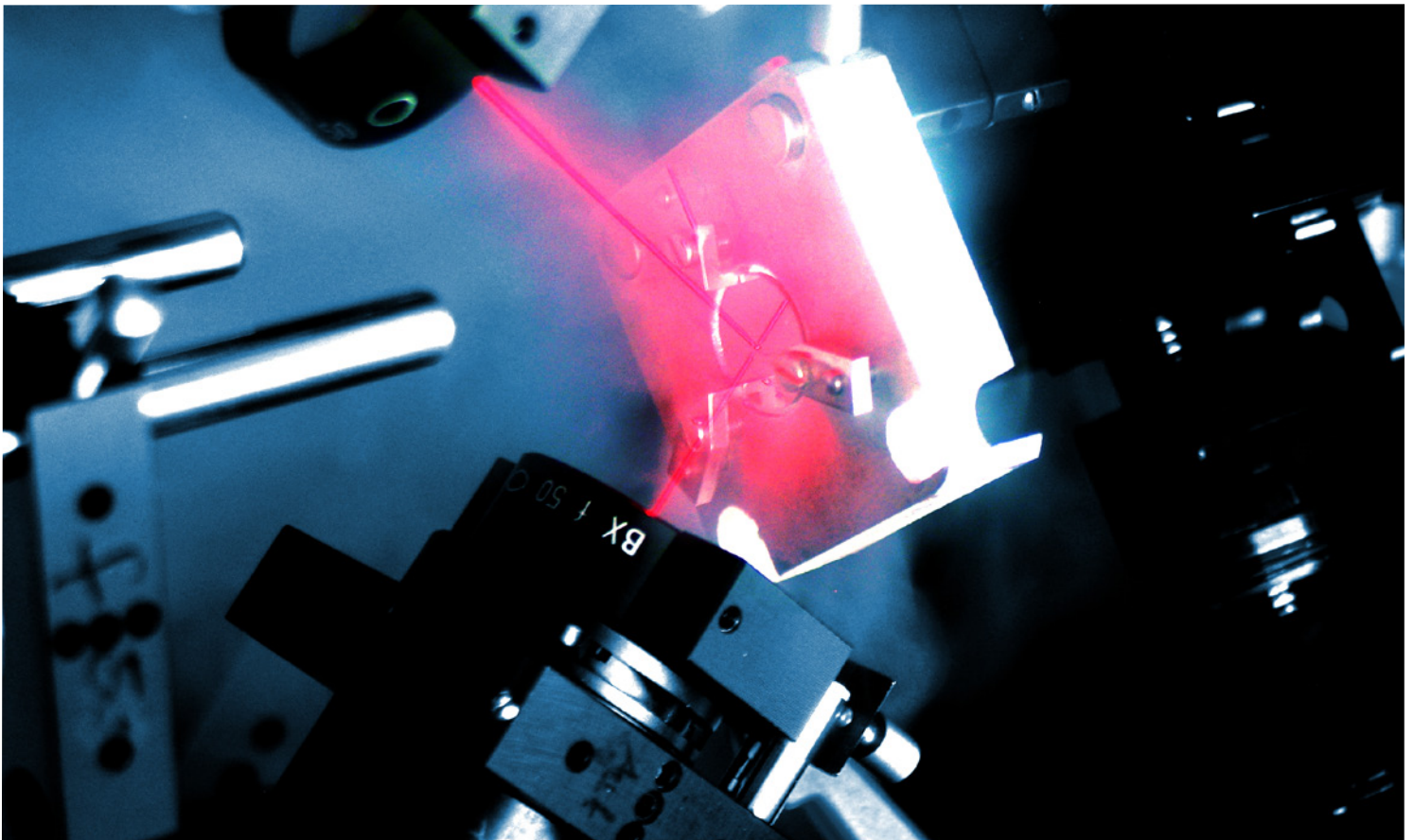


LINSEIS

T H E R M A L A N A L Y S I S

THIN FILM LASERFLASH

TF-LFA



Since 1957 LINSEIS Corporation has been delivering outstanding service, know how and leading innovative products in the field of thermal analysis and thermo physical properties.

We are driven by innovation and customer satisfaction.

Customer satisfaction, innovation, flexibility and high quality are what LINSEIS represents. Thanks to these fundamentals our company enjoys an exceptional reputation among the leading scientific and industrial organizations. LINSEIS has been offering highly innovative benchmark products for many years.

The LINSEIS business unit of thermal analysis is involved in the complete range of thermo analytical equipment for R&D as well as quality control. We support applications in sectors such as polymers, chemical industry, inorganic building materials and environmental analytics. In addition, thermo physical properties of solids, liquids and melts can be analyzed.

LINSEIS provides technological leadership. We develop and manufacture thermo analytic and thermo physical testing equipment to the highest standards and precision. Due to our innovative drive and precision, we are a leading manufacturer of thermal Analysis equipment.

The development of thermo analytical testing machines requires significant research and a high degree of precision. LINSEIS Corp. invests in this research to the benefit of our customers.

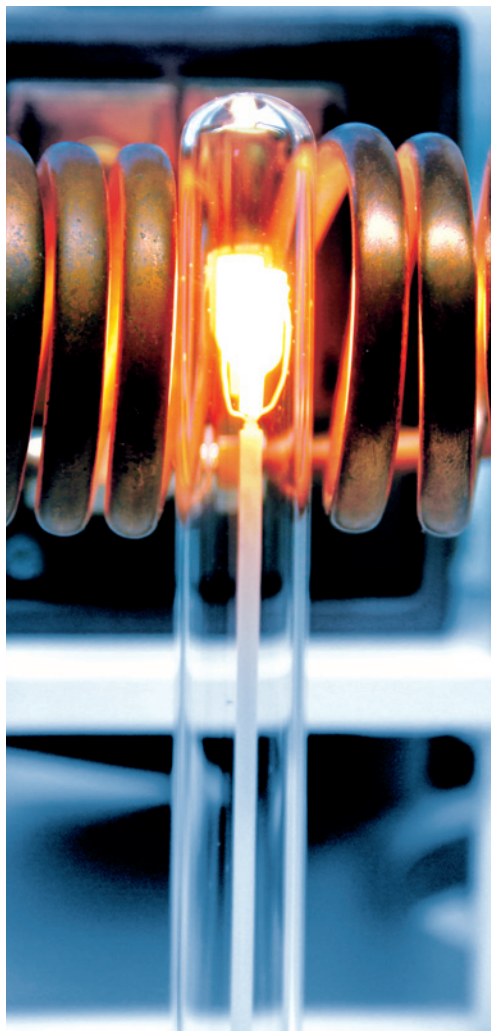


Claus Linseis
Managing Director



German engineering

The strive for the best due diligence and accountability is part of our DNA. Our history is affected by German engineering and strict quality control.



Innovation

We want to deliver the latest and best technology for our customers. LINSEIS continues to innovate and enhance our existing thermal analyzers. Our goal is constantly develop new technologies to enable continued discovery in Science.

GENERAL



TF-LFA

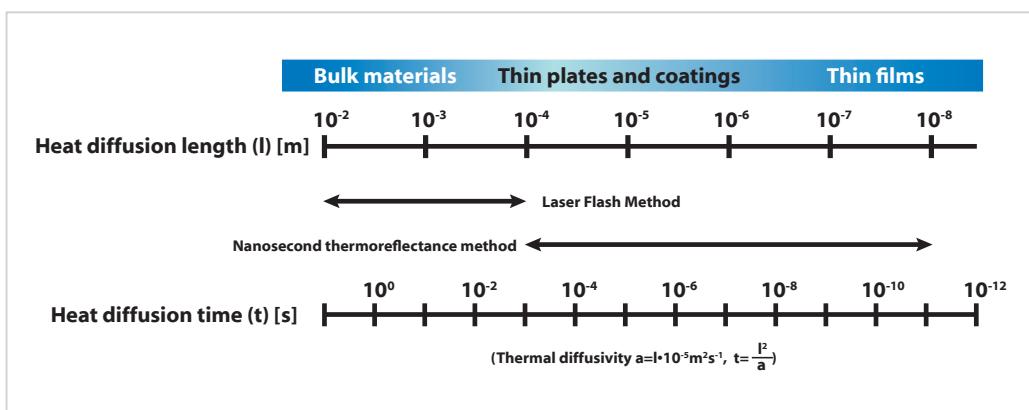
Information of the thermo physical properties of materials and heat transfer optimization of final products is becoming more and more vital for industrial applications.

Over the past few decades, the flash method has developed into the most commonly used technique for the measurement of the thermal diffusivity and thermal conductivity of various kinds of solids, powders and liquids.

Thermophysical properties from thin-films are becoming more and more important in industries such as, phase-change optical disk media, thermo-electric materials, light emitting diodes

(LEDs), phase change memories, flat panel displays, and the semiconductor industry. All these industries deposit a film on a substrate in order to give a device a particular function. Since the physical properties of these films differ from bulk material, these data are required for accurate thermal management predictions.

Based on the well established Laser Flash technique, the LINSEIS "Thin-Film-Laserflash" now offers a whole range of new possibilities to analyze thermophysical properties of thin films from 80nm up to 20μm thickness.

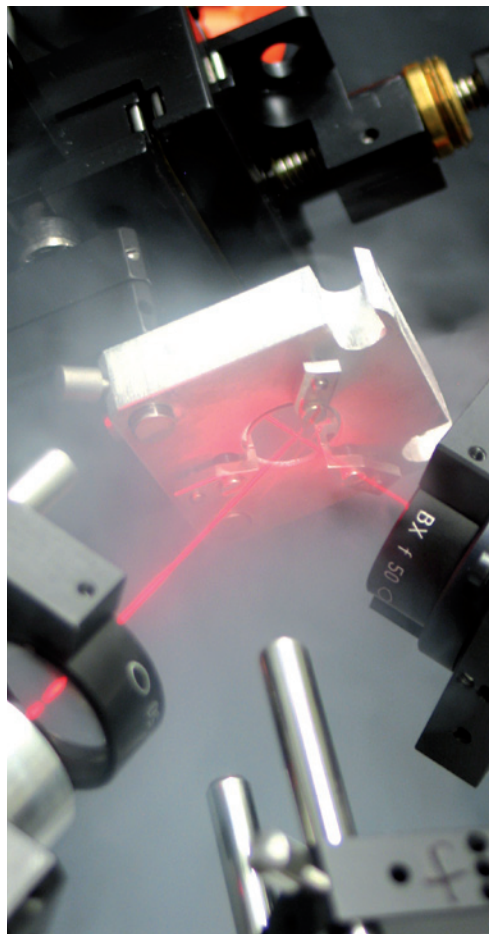


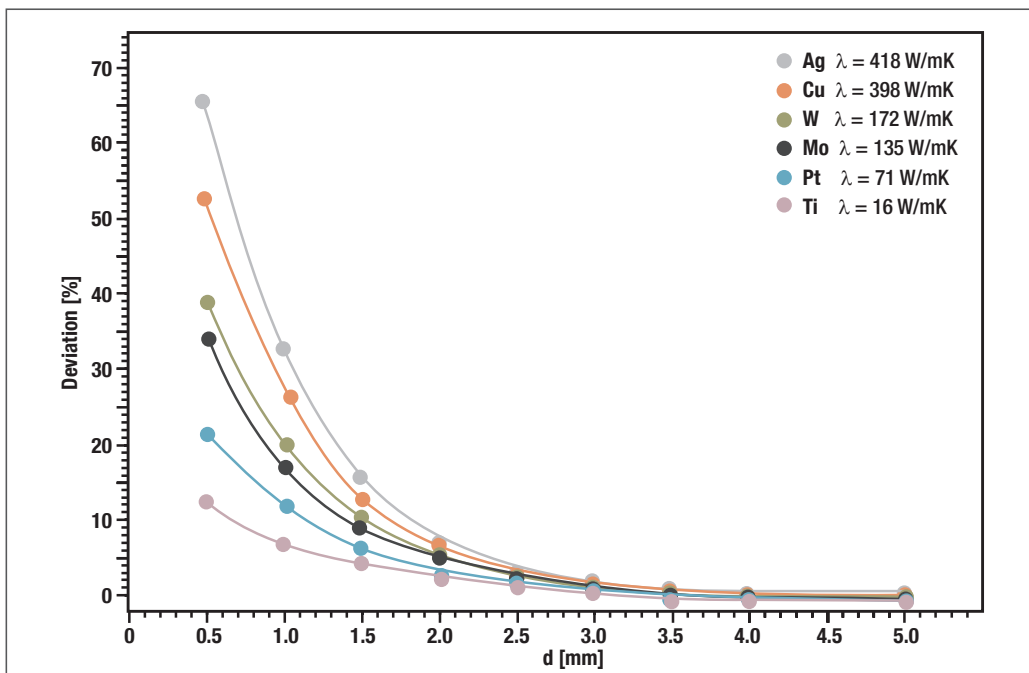
LASERFLASH TECHNIQUE

Description of the standard Laserflash technique

A sample is positioned on a sample holder, located in a furnace. The furnace is then held at a predetermined temperature. At this temperature the sample surface is then irradiated with a programmed energy pulse (laser or xenon flash). This energy pulse results in a homogeneous temperature rise at the sample surface. The resulting temperature rise of the rear surface of the sample is measured by a IR detector and thermal diffusivity values are computed from the temperature rise versus time data. The resulting measuring signal computes the thermal diffusivity.

For thin layers in the μm or nm range, this arrangement of the standard laser flash technique is no more sufficient, as the time scale of the experiment is too fast for the used components. The heating pulse duration is too long and the data acquisition too slow. This problem exacerbates for materials with higher thermal diffusivity (see Fig. below).





The graph from Schoderböck et. al., *Int. J. Thermophys.* (2009) illustrates the limitation of the classic Laserflash technique. Samples with a

thickness of less than 2mm (depending on the thermal diffusivity of the material) already show a significant deviation from literature values.

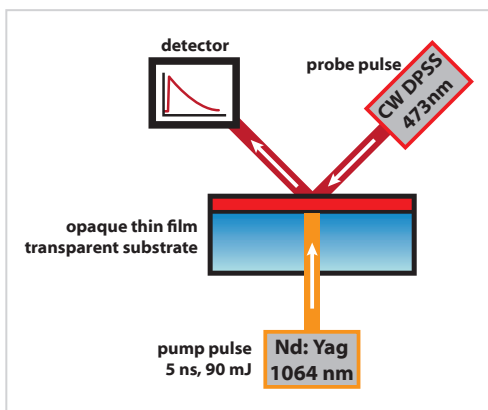
DESCRIPTION OF THE LASERFLASH TECHNIQUE

As thermal properties of thin layers and films differ considerably from the properties of the corresponding bulk material a technique overcoming the limitations of the classical Laserflash method is required: the "High Speed Laserflash Method".

High Speed Laserflash Method

Rear heating Front detection (RF)

The measurement geometry is the same as for the standard Laserflash technique: detector and laser are on opposite sides of the samples. Because IR-detectors are too slow for measurement of thin layers, detection is done by the so called thermoreflectance method. The idea behind this technique is that once a material is heated up, the change in the reflectance of the surface can be utilized to derive the thermal properties. The reflectivity is measured with respect to time, and the data received can be matched to a model which contains coefficients that correspond to thermal properties.

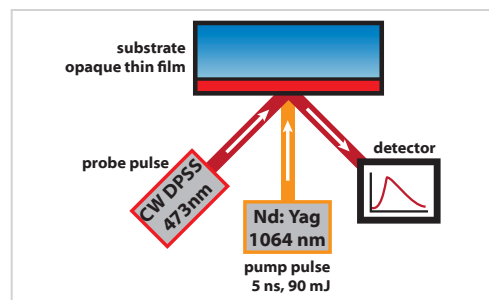


Time Domain Thermoreflectance Method

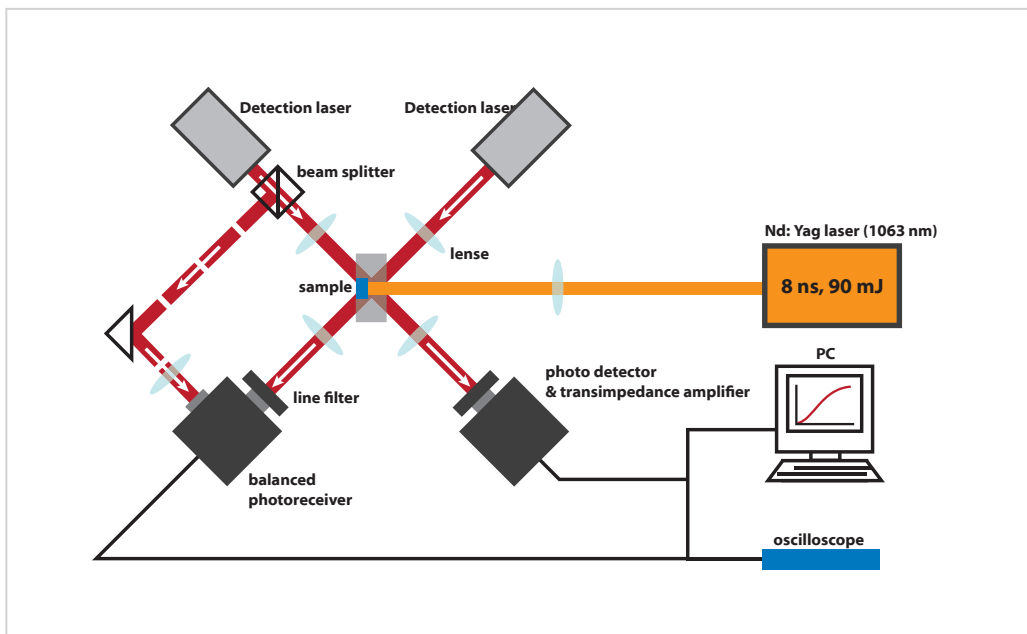
Front heating Front detection (FF)

Description of the Time-Domain Thermoreflectance technique

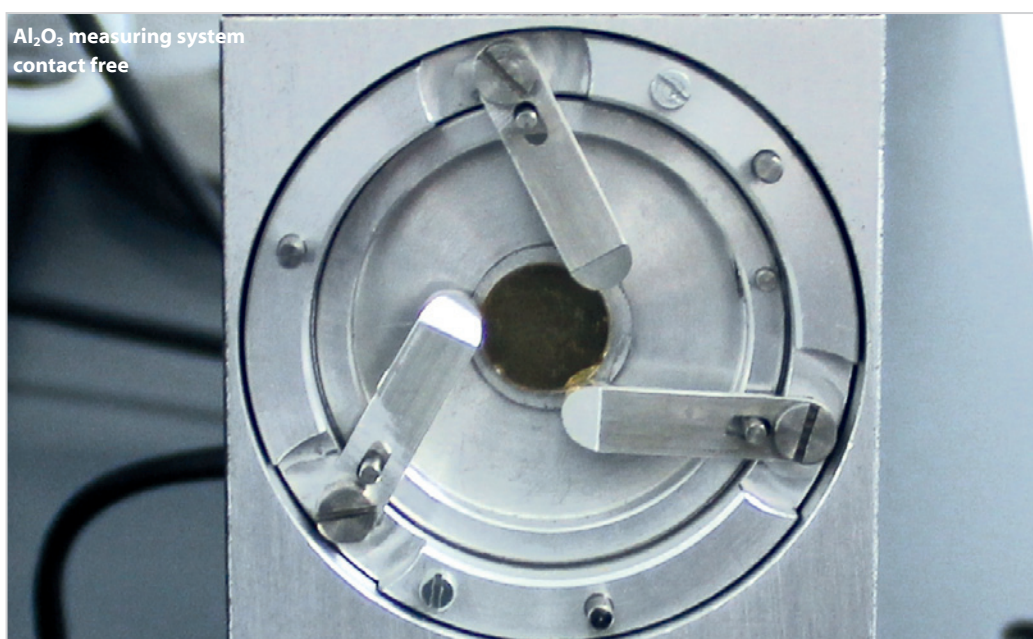
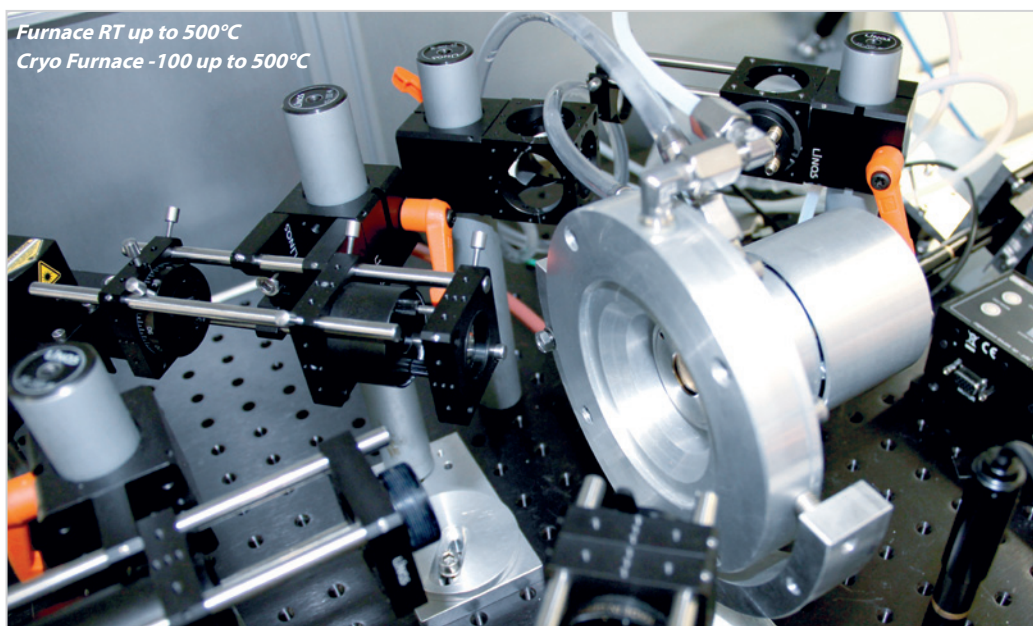
The measurement geometry is called "front heating front detection (FF)" because detector and laser are on the same side of the sample. This method can be applied to thin layers on non-transparent substrates for which the RF technique is not suitable. For the measurement, a heating pulse applied to the front side of the sample and the temperature rise at this spot is measured with a detection laser coming from the side. The thermal diffusivity of the sample layer can be calculated by using falling edge of the normalized temperature rise in combination with a multilayer model developed by Linseis in cooperation with Prof. David G. Cahill of the University of Illinois.



Combined High Speed Laserflash RF and Time Domain Thermoreflectance Method FF



COMPONENTS



SOFTWARE

All thermo analytical devices of LINSEIS are PC controlled, the individual software modules exclusively run under Microsoft® Windows® operating systems. The complete software consists of 3 modules: temperature control, data acquisition and data evaluation. The Linseis 32 – bit software encounters all essential features for measurement preparation, execution and evaluation, just like with other thermo analytical experiments. Due to our specialists and application experts LINSEIS was able to develop this easy understandable and highly practical software.

General Software

- Fully compatible MS® Windows™ 32 – bit software
- Data security in case of power failure
- Thermocouple break protection
- Evaluation of current measurement

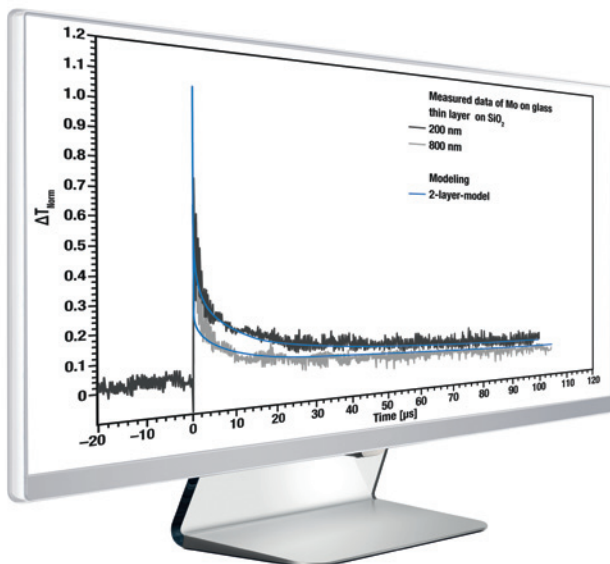
- Curve comparison
- Storage and export of evaluations
- Export and import of data ASCII
- Data export to MS Excel

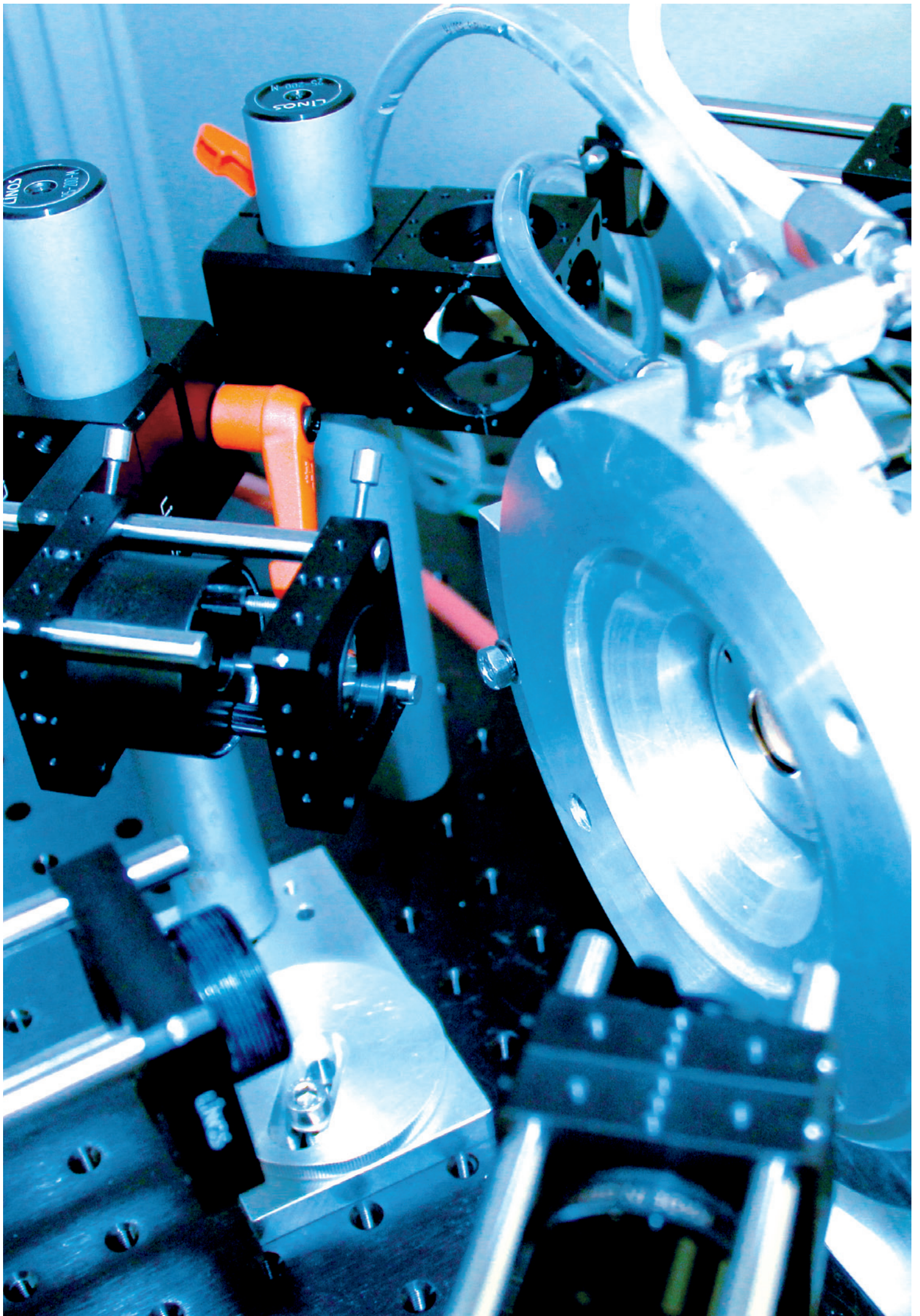
Evaluation Software

- Automatic or manual input of related measurement data: (density), C_p (Specific Heat)
- Model wizard for selection of the appropriate model
- Determination of contact resistance

Measurement Software

- Easy and user-friendly data input for temperature segments, gases etc.
- Software automatically displays corrected measurements after the energy pulse
- Fully automated measurement



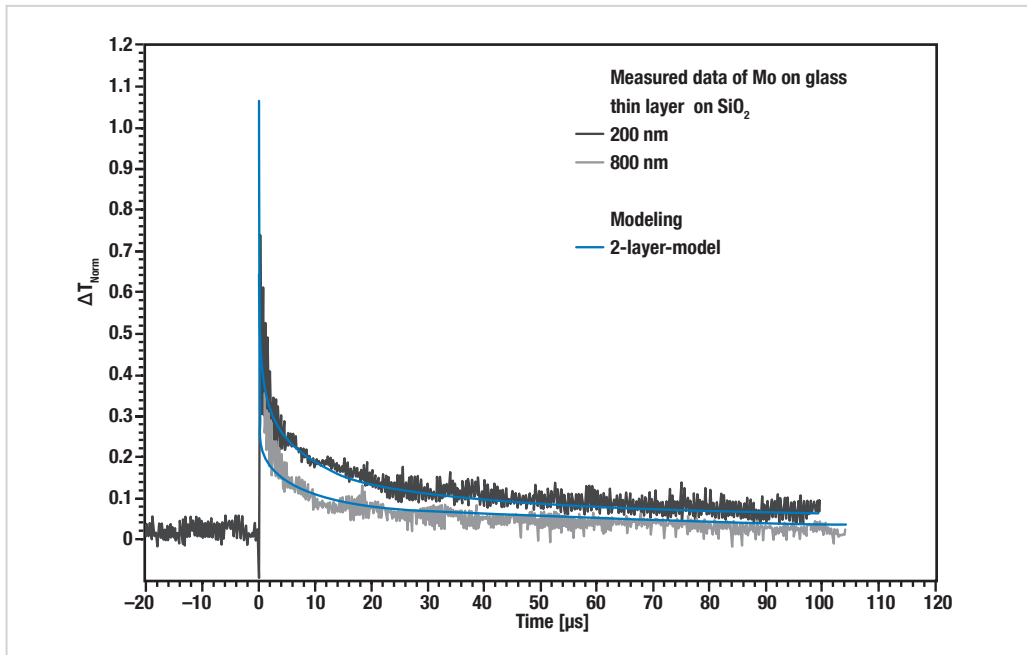


TECHNICAL SPECIFICATIONS

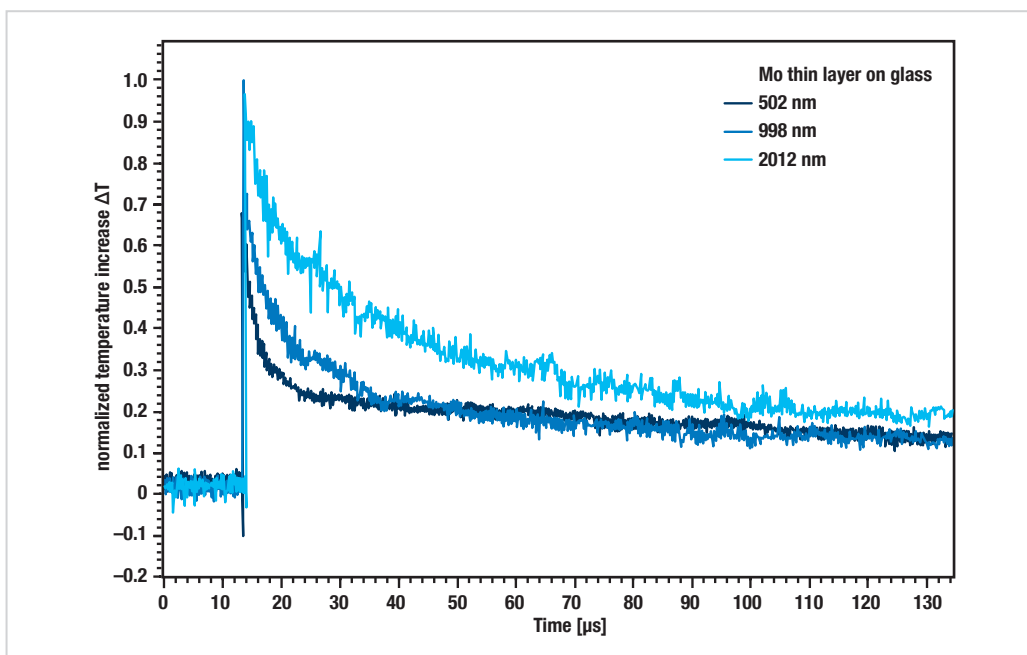
	Thin-Film-LFA
Sample dimensions	Round with a diameter of 10mm to 20mm
Thin film samples	80nm up to 20µm (depends on sample)
Temperature range	RT, RT up to 500°C or -100 to 500°C
Heating and cooling rates	0.01 up to 10°C/min
Vacuum	up to 10 ⁻⁴ mbar
Atmosphere	inert, oxidizing or reducing
Diffusivity Measuring range	0,01mm ² /s up to 1000mm ² /s
Pumplaser	Nd:YAG Laser (1064 nm), maximum pulse current: 90mJ/pulse (software controlled), Pulse width: 5 ns spot size 2-4 mm (depends on arrangement)
Probe-Laser	DPSS CW Laser (473 nm, 50 mW)
Frontside-Thermoreflectance	Si-PIN-Photodiode, active diameter: 0.8mm, bandwidth DC ... 400MHz, risetime: 1ns
Rearside-Thermoreflectance	Photoreceiver, active diameter: 0.4mm, bandwidth DC ... 650MHz, risetime: 800ps

APPLICATIONS

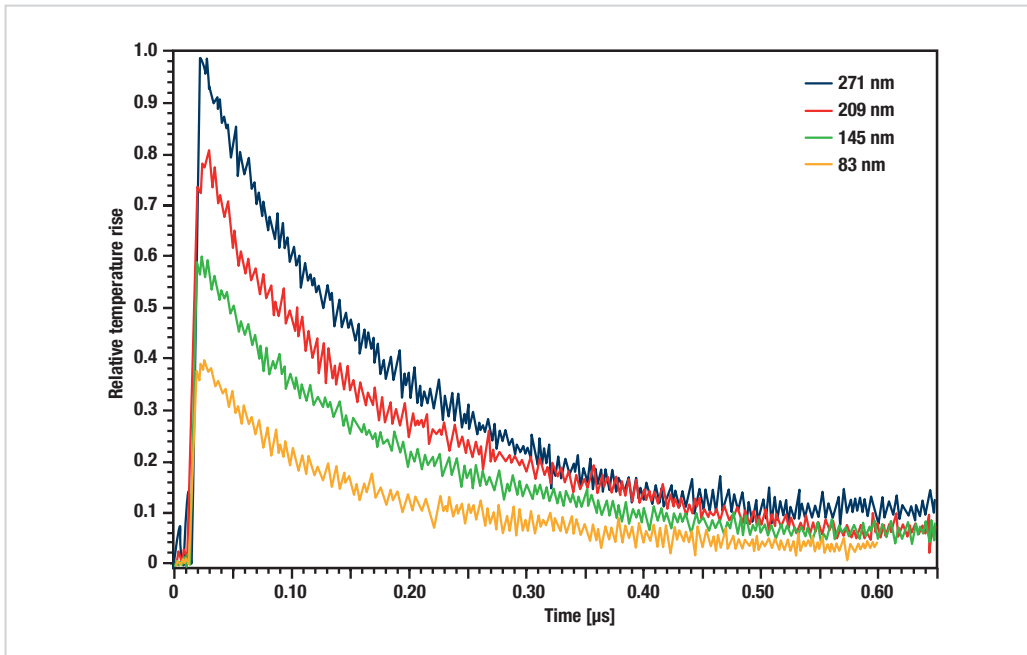
Comparison of measured and calculated curves (2-layer model)



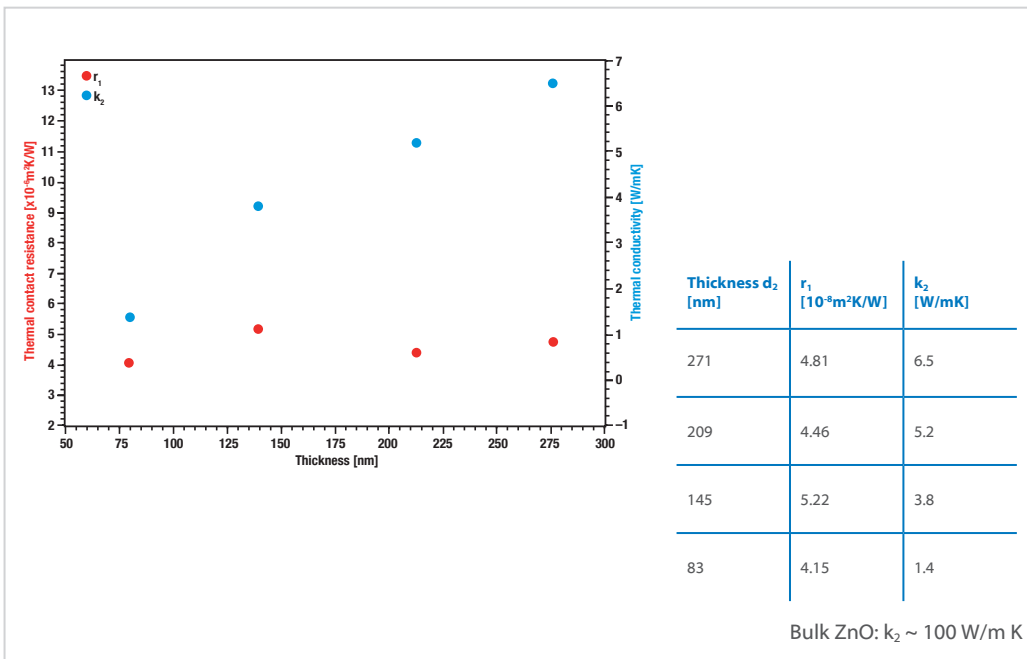
Mo thin layer on SiO_2 ; Temperature-time-curve of samples of different thickness



Temperature-time-curve of ZnO-samples of different thickness



Measured thermal conductivity and thermal contact resistance of ZnO thin films



**LINSEIS GmbH Germany**

Vielitzerstr. 43
95100 Selb
Tel.: (+49) 9287-880 - 0
Fax: (+49) 9287-70488
E-mail: info@linseis.de

**LINSEIS Inc. USA**

109 North Gold Drive
Robbinsville, NJ 08691
Tel.: (+1) 609 223 2070
Fax: (+1) 609 223 2074
E-mail: info@linseis.com

**LINSEIS China**

Kaige Scientific Park 2653 Hunan Road
201315 Shanghai
Tel.: (+21) 5055 0642
Fax: (+21) 6806 3576

**LINSEIS France**

Bureaux Paris
52 Boulevard Sébastopol
75003 Paris
Tel.: (+33) 1 73.02.82.72

**LINSEIS Poland**

Dabrowskiego 1
05-800Przyslaw
Tel.: (+48) 692-773-795

www.linseis.com

Products: DIL, TG, STA, DSC, HDSC, DTA, TMA, MS/FTIR, In-Situ EGA, Laser Flash, Seebeck Effect, Thin Film Analyzer, Hall-Effect

Services: Service Lab, Calibration Service

08/17

LINSEIS