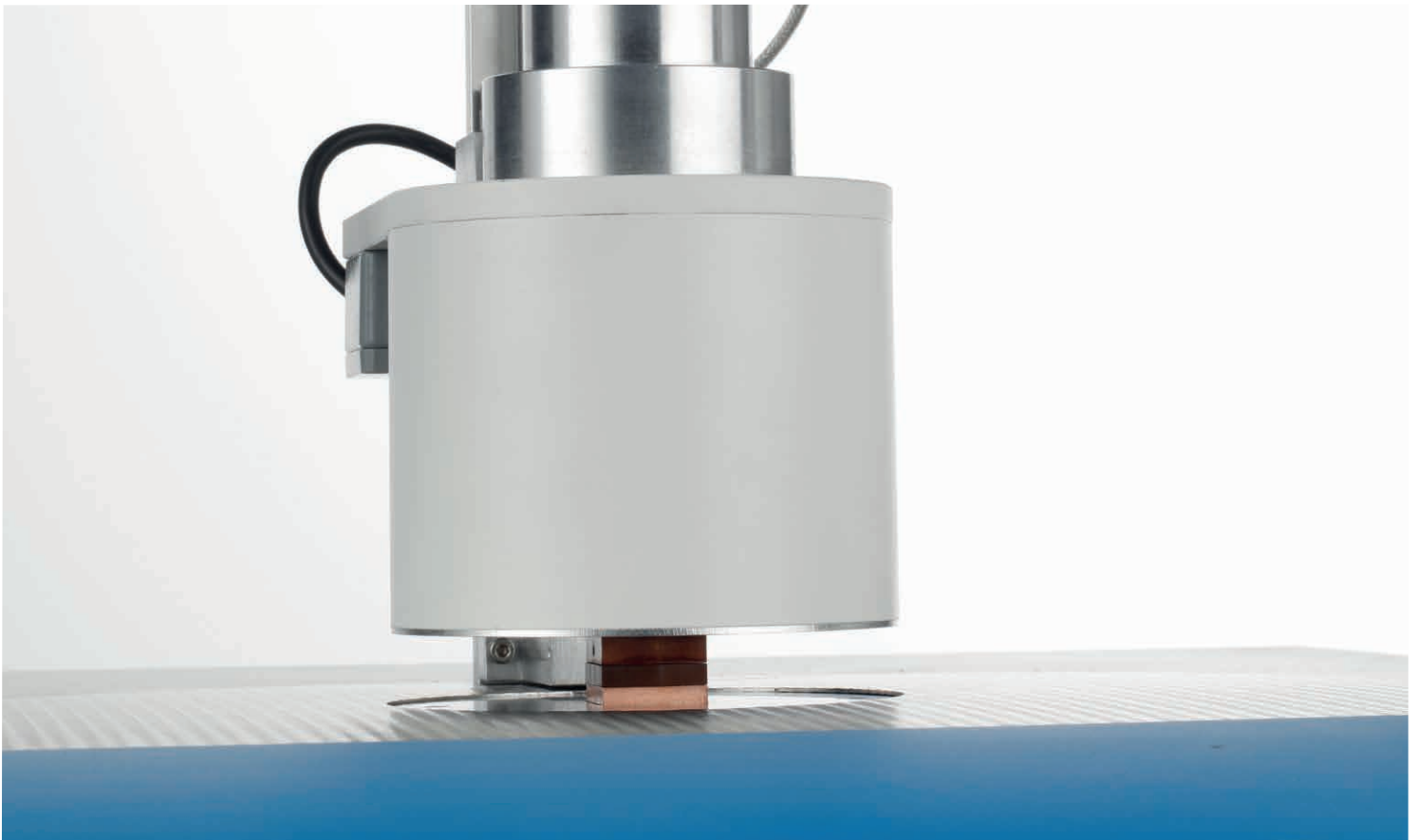


LINSEIS

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

TIM-Tester (TIM L58)

Characterization of Thermal
Interface Materials and Phase
Change Materials under varia-
ble load and temperatures



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.

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.

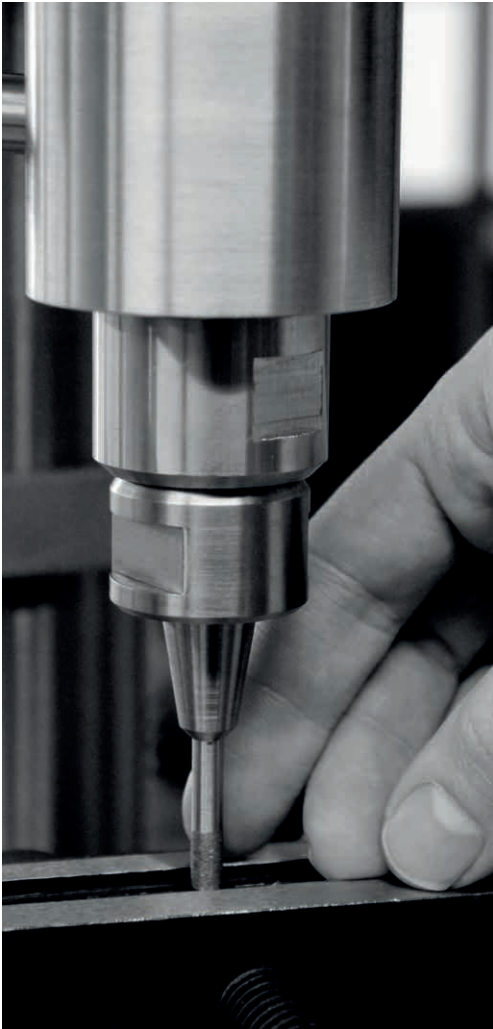
The LINSEIS business unit of thermal analysis is involved in the complete range of thermo analytical equipment for R&D as well as quality control. We support applications in sectors such as polymers, chemical industry, inorganic building materials and environmental analytics. In addition, thermo physical 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 invests in this research to the benefit of our customers.

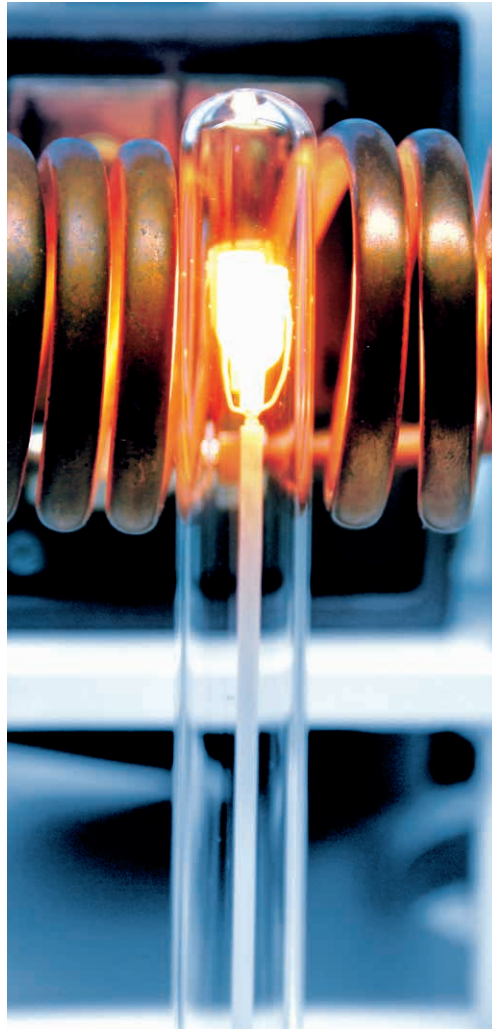


Claus Linseis
Managing Director



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



Automatic pressure adjustment using electric actuator (up to 8 MPa)

Automatic thickness determination using high resolution LVDT

Instruments working according to ASTM D5470

Full integrated, software controlled device

Safety Box Option (protective enclosure with safety interlocks)

Vacuum tight design (including protective chamber)

Waste heat management, thermal runaway protection in batteries and electronic packaging is becoming more and more important as power densities of these devices increase. Thermal management of these complex systems is not trivial and requires a fundamental understanding of how components and interface materials work together to shed heat.

Our LINSEIS Thermal Interface Material Tester (TIM-Tester/TIM L58) is the perfect solution for thermal management optimization of these complex systems.

The TIM Tester measures thermal impedance and identifies an apparent thermal conductivity for a wide range of materials from liquid compounds to hard solid materials. The approach is consistent with the ASTM D5470 - standard.

Thermal interface materials such as thermal fluids, thermal pastes (greases), phase change materials (PCM), solders or resilient thermal conductors are tested automatically by applying pressure up to 8 MPa (for \varnothing 20mm sample) and heat up to 300°C.

The software platform allows the instrument to be operated over a wide temperature and pressure range while recording all test parameters in real time. This allows the user the freedom to fully explore an experimental design space for materials optimization. The sample holder is designed with sample size and shape flexibility in mind to accommodate actual size parts.



Solid samples and TIM pads



Different samples of thermal interface materials



Exchangeable meter bars

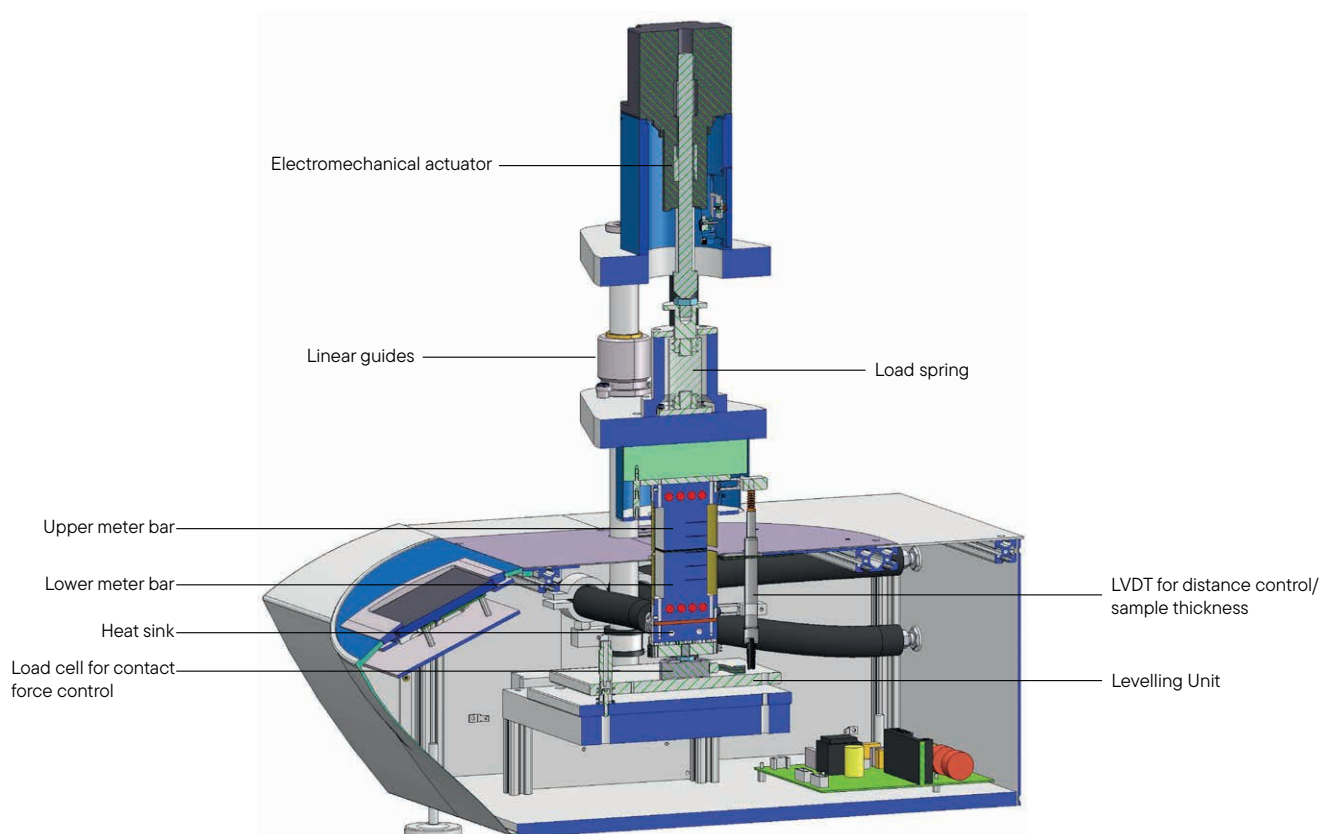


Cutting tool for sample preparation

PRINCIPLE

A sample is positioned between a hot and a cold meter bar, where the hot meter bar is connected to a regulated heating stage and the cold meter bar is connected to a thermostatically controlled, liquid cooled heat sink. The contact pressure on the sample can be automatically adjusted with an integrated electric actuator (in terms of pressure stability over temperature). The sample dimension (thickness) can either be entered manually or can be measured (and controlled) using an integrated sensor.

The heat flux through the sample is measured using several temperature sensors which are located in a known distance inside of each of the meter bars. The thermal impedance can be obtained from the temperature drop caused by the sample material using its geometry for the calculation. For obtaining the apparent thermal conductivity, the thermal impedance for a single and a multiple layered specimen can be plotted against the thickness of the respective specimen.



SOFTWARE

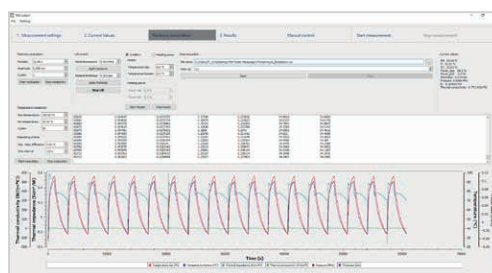
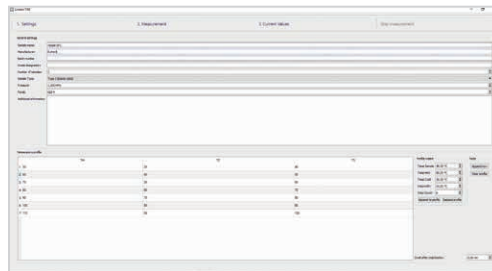
Smart Software Solutions from LINSEIS

The all new Rhodium Software greatly enhances your workflow as the intuitive data handling only requires minimum parameter input.

AutoEval offers a valuable guidance for the user when evaluating standard processes such as thermal impedance or thermal conductivity determination.



- Software packages are compatible with latest Windows operating system
- Set up menu entries
- Software controlled heating, cooling or dwell time segments
- Software controlled thickness determination down to 1 μm , force/pressure adjustment
- Easy data export (measurement report)
- All specific measuring parameters (User, Lab, Sample, Company, etc.)
- Optional password and user levels
- Multiple language versions such as English, German
- QC- and Cycling-Option
- Quality management software plug-in: Allows to easily identify thermal impedance deviations for a faster evaluation during the manufacturing process
- Cycling Software plug-in: Allows to measure the thermal impedance of a sample under thickness or temperature cycling (e.g. aging studies of grease)



SPECIFICATIONS

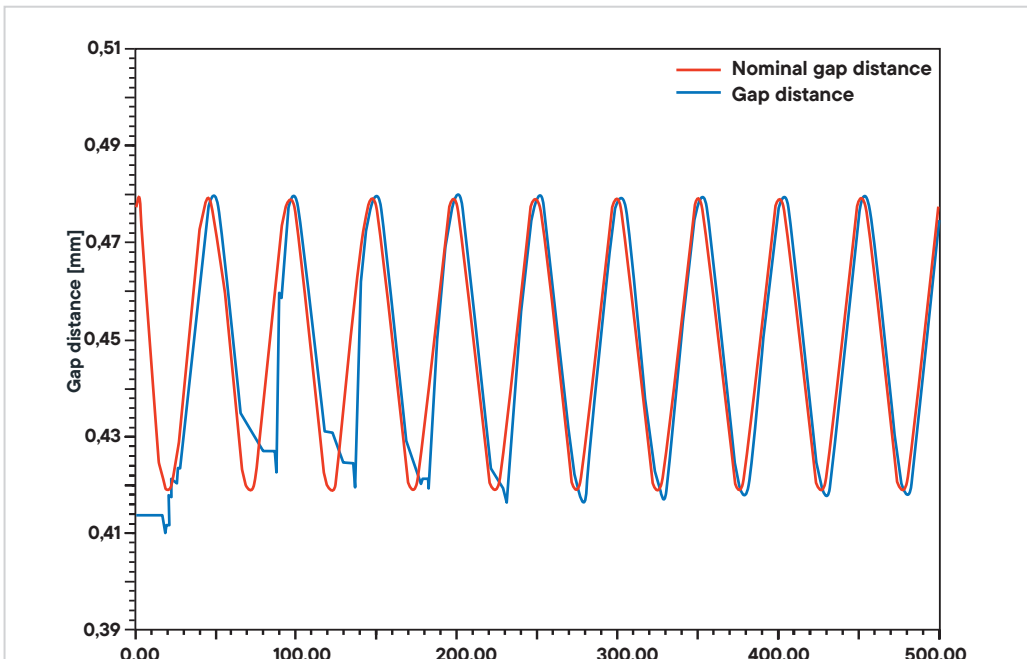
	TIM-Tester (TIM L58)
Sample temperature range (max)	-30°C to 450°C*
Standard sample size	Round: ∅ 20 mm, 25 mm, 40 mm Rectangular: 20 mm x 20 mm, 25 mm x 25 mm, 40 mm x 40 mm Other sizes on request
Sample thickness	0.001 to 8 mm (up to 20 mm)
Thickness control	±1 µm
Sample measurement range	0.1 - 50 W/mK
Sample resistance range	0.005 - 500 [cm ² K/W]*
Contact pressure range	0 up to 16 MPa (0 up to 2300 psi/depending on sample size and shape) From round ∅ 20mm (up to 16 MPa) to ∅ 40 mm (up to 4 MPa) and rectangular 20mm x 20mm (up to 12 MPa) to 40mm x 40mm (up to 3.1 MPa)
Reproducibility	± 2 %*
Accuracy	± 3- 5 %*
Force options	500 N, 1000 N, 2000 N, 5000 N (also possible: 0.5 kN, 1 kN, 2 kN, 5 kN)
Meter bar material	Aluminium, Copper, Brass (others & special coatings on request)
Software Plugins	Thickness modulation Temperature cycling Quality management tool
Cooling options	Standard water cooling unit, intracooler 600 (-20°C cold side)**, intracooler 1000 (-30°C cold side)**
Power supply	110/115/220/230 VAC 50/60 Hz

* Under optimum conditions

** Lowest cold side meter bar temperature under optimum conditions

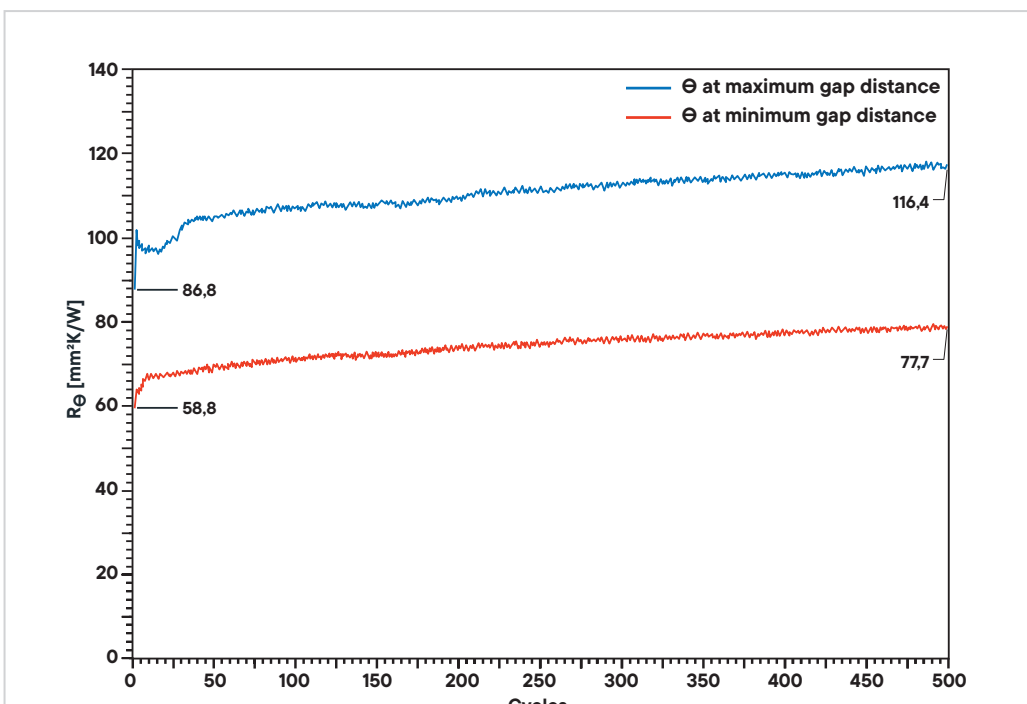
APPLICATIONS

Cycle Testing



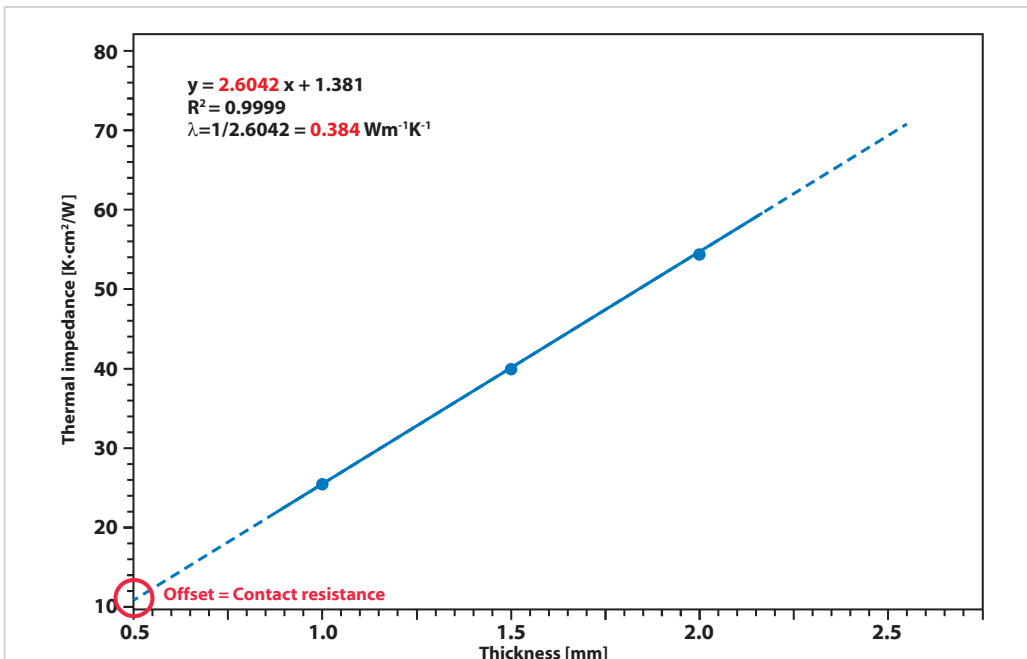
Aging studies and behavior under continuous load are important tests to understand the long-term performance of TIM materials. For this characterization the TIM-Tester (TIM L58) offers the software plug-in to cycle either the temperature or the gap distance or compression, respectively. During the cycling process all properties like temperature, gap distance/sample thickness, pressure and thermal impedance will be monitored continuously to directly detect changes of behavior. The following analysis shows the cycling test of a Gap Filler with an initial thickness of 400 μm . An expansion and compression of $\pm 30 \mu\text{m}$ with a frequency of 0.02 Hz at constant sample temperature were defined in the performance test. The first image shows this cycling with the nominal and live tracked gap distance. On the second picture one can observe that with the number of cycles the thermal impedance slightly rises leading to slightly lower performance with long term use. This information helps to model devices and estimate the life time of the individual parts.

Thermal Resistance



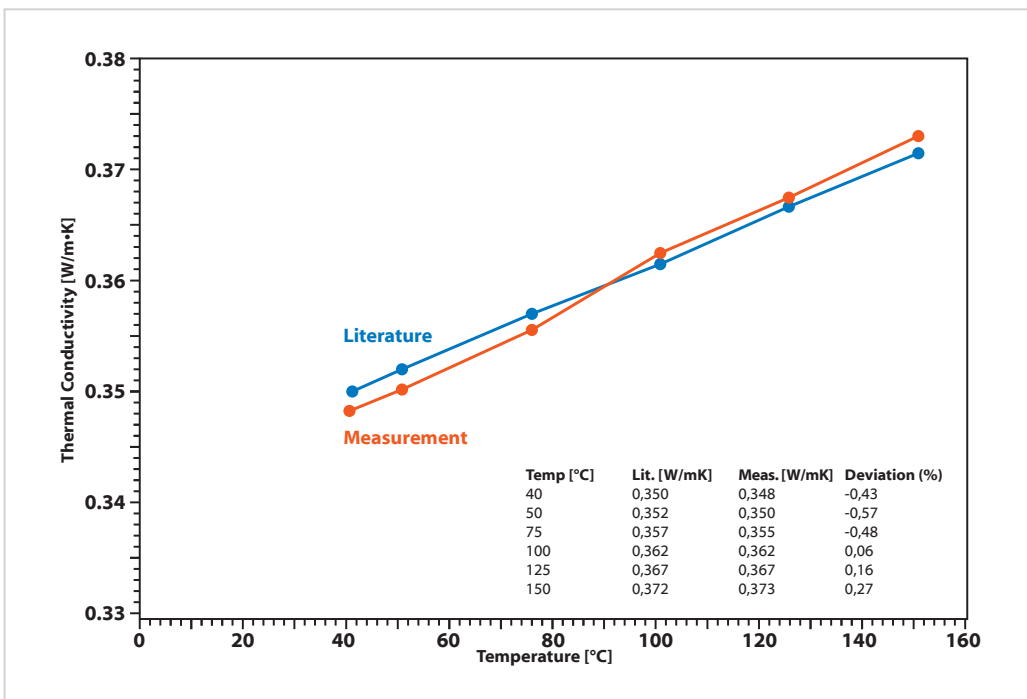
APPLICATIONS

Measurement of Vespel™ (at 50°C, 1MPa)



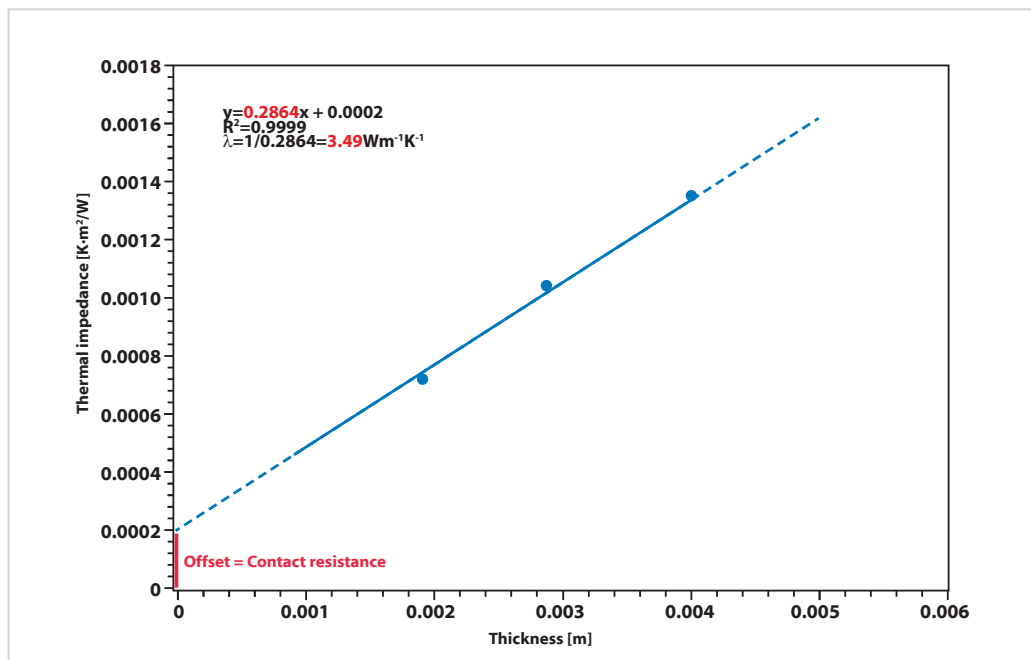
Measurement of the thermal impedance (thermal conductivity) of a 25mm x 25mm Vespel™ sample at 50°C ($T_H=70^\circ\text{C}$, $T_C=30^\circ\text{C}$) and a contact pressure of 1 MPa. Three different samples with a thickness between 1,0 mm and 2,00 mm have been measured in order to determine the apparent thermal conductivity and thermal contact resistance (using linear regression).

Temperature dependent measurement of Vespel™



Plot of the temperature dependent apparent thermal conductivity of a 25mm x 25mm Vespel™ sample between 40°C and 150°C and a constant contact pressure of 1 MPa.

Measurement of type 2 thermal pad (at 50°C)



Measurement of the thermal impedance (thermal conductivity) of a 25mm x 25mm thermal conductive pad (sample type 2) at 50°C ($T_H=70^\circ\text{C}$, $T_C=30^\circ\text{C}$). Three different samples with a thickness between 2.01 mm and 3.02 mm have been measured in order to determine the thermal contact resistance (using linear regression).

Possible sample types

Type I

Viscous liquids that exhibit unlimited deformation when a stress is applied. These include liquid compounds such as greases, pastes, and phase change materials. These materials exhibit no evidence of elastic behavior or the tendency to return to initial shape after deflection stresses are removed.

Type II

Viscoelastic solids where stresses of deformati-

on are ultimately balanced by internal material stresses thus limiting further deformation. Examples include gels, soft, and hard rubbers. These materials exhibit linear elastic properties with significant deflection relative to material thickness.

Type III

Elastic solids which exhibit negligible deflection. Examples include ceramics, metals, and some types of plastics.



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