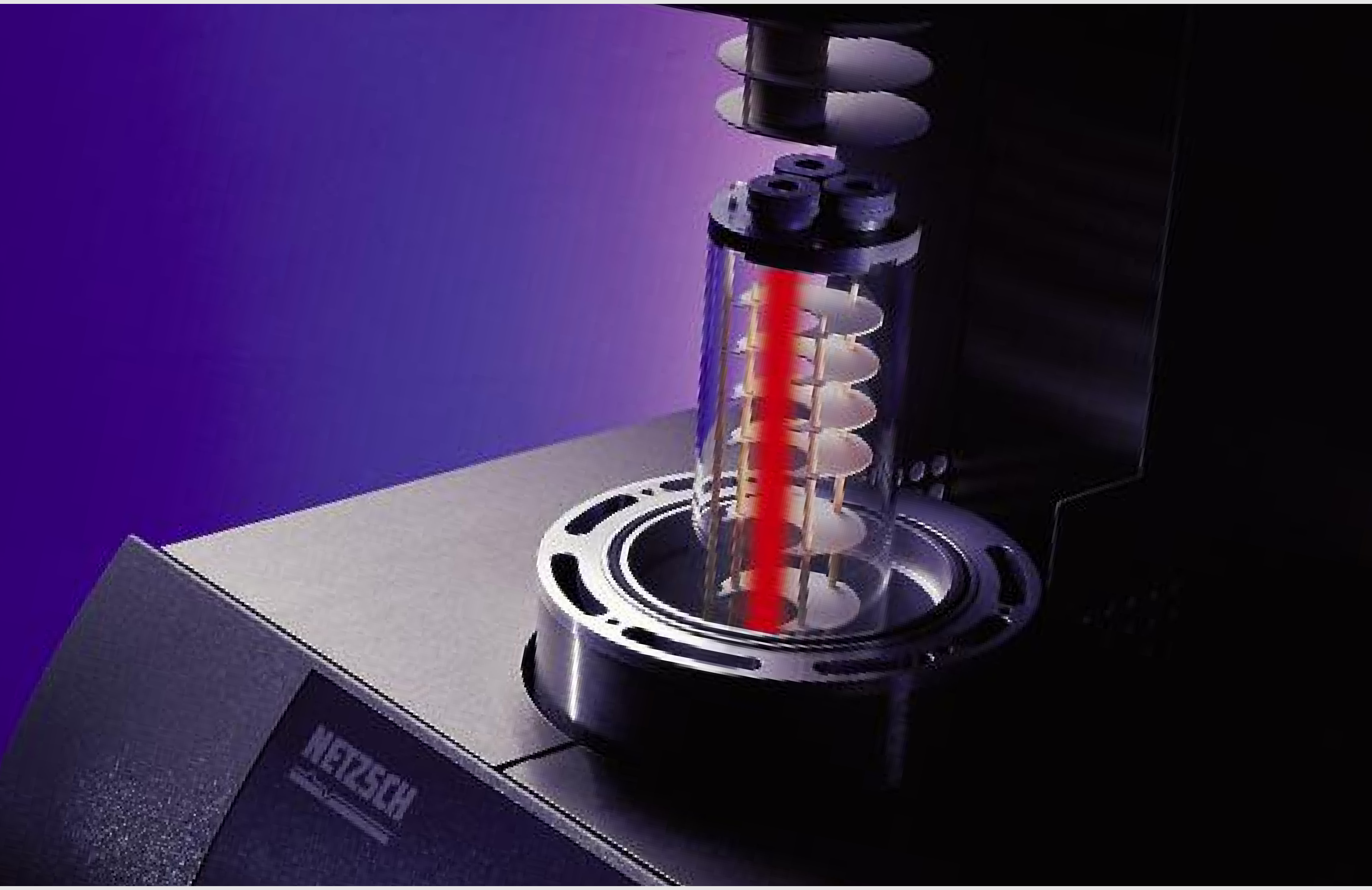
NETZSCH

Thermal Diffusivity - Thermal Conductivity



Leading Thermal Analysis.

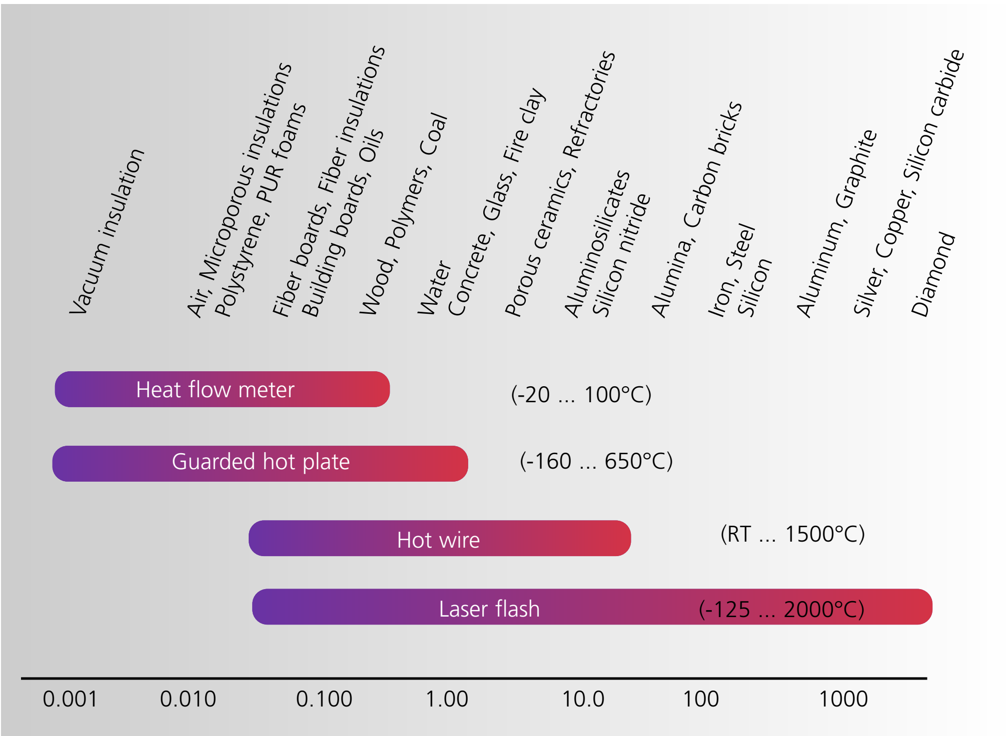
LFA 457

Micro Flash®

LFA 457 *MicroFlash*®

What is the heating/cooling load of a building as a function of the weather conditions and how can I improve it? How can I improve the heat transfer out of an electronic component? What are the optimum materials and how do I design a heat exchanger system to achieve a required efficiency? In order to answer questions like these, material properties such as thermal diffusivity and thermal conductivity must be known. Engineers must select from a variety of test methods to characterize the diverse array of materials and configurations they employ in their designs. For ceramics, metals, composites, and multi-layer systems, the flash technique is an ideal choice. Easy sample preparation, fast testing times, and high accuracy are only some of the advantages of this non-contact test method. NETZSCH offers a variety of flash systems to cover a broad range of applications and temperatures up to 2000 °C. The NETZSCH LFA 457 *MicroFlash*® system is designed as a cost-effective, easy-to-operate, highly accurate instrument for testing between -125 °C and 1100 °C.

For the measurement of low conductivity materials such as insulations, NETZSCH offers a broad selection of heat flow meters and guarded hot plate instruments. For the analysis of refractory materials, a hot wire system (TCT 426) is available. Differential scanning calorimeters (DSC 404 *Pegasus*®) for the measurement of specific heat, and dilatometers (DIL 402 C series) for the analysis of density and length changes up to high temperatures, are also available.



Thermal Conductivity at RT in W/(m·K)

LFA 457 *MicroFlash*® - Measurement Principle

The NETZSCH LFA 457 *MicroFlash*® is based on the well-established flash method.
The measurement principle is as follows. The front side of a plane parallel solid sample is heated by a short laser pulse. The absorbed heat induced propagates through the sample and causes a temperature increase on the rear surface. This temperature rise is measured versus time using an infrared detector. The thermal diffusivity (a) and in most cases the specific heat (c_p) can be ascertained using the measured signal. If the density (ρ) is known, the thermal conductivity (λ) can be determined:

$$\lambda(T)=a(T)\cdot c_p(T)\cdot \rho(T)$$

The key features of the NETZSCH LFA 457 *MicroFlash*® are as follows:

Temperature dependent tests
The instrument allows tests between -125 °C and 1100 °C.

Fast testing times
Tests at one temperature generally take only a few seconds. Measurements over the entire temperature range can be done within a few hours (usually three tests per day; morning, afternoon and over night).

Non-destructive, non-contact test technique
Samples can be analyzed with other analytical methods after the tests.

Broadest measurement range
The technique can be used for materials with thermal diffusivities between 0.01 mm²/s and 1000 mm²/s (thermal conductivities between 0.1 W/(m*K) and 2000 W/(m*K)).

Absolute measurement technique
The flash method is an absolute test technique for thermal diffusivity. No calibration is required for the determination of this thermophysical property.

High accuracy and repeatability
Measurements on standard materials prove that the thermal diffusivity can be determined within ±2%. The thermal conductivity can be directly determined within ±3% for most materials.

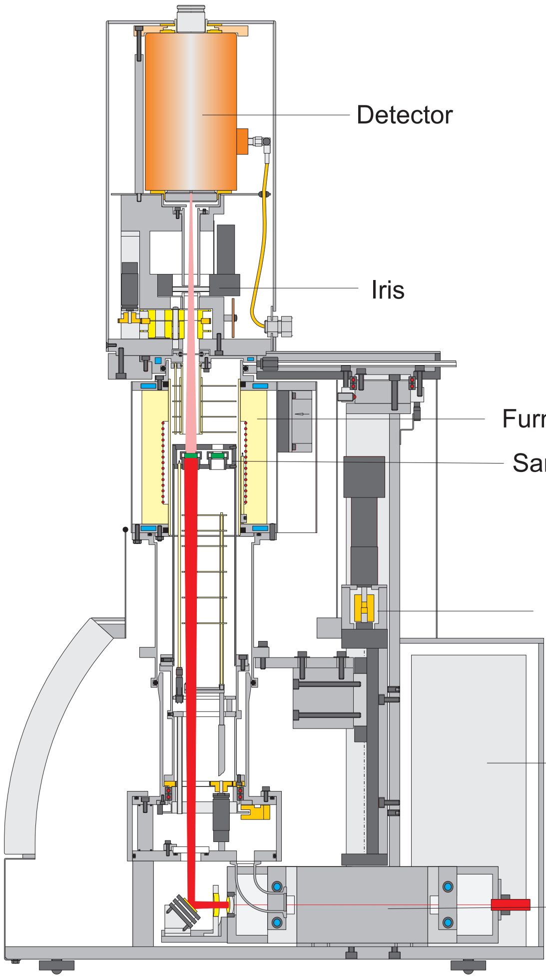
Multi-layer systems
Using advanced analysis routines, two- and three-layer systems can be analyzed, e.g. for the characterization of coatings under real application conditions.

Various sample holders
Special sample holders for various sample geometries and even for tests on liquids, powder and pastes can be used in the LFA 457.

Integrated robot system
The LFA 457 *MicroFlash*® comes with an integrated robot system for tests on up to three samples at the same time.

Standarized technique
The *MicroFlash*® operates in accordance with national and international standards such as ASTM E-1461 or DIN EN 821.

LFA 457 *MicroFlash*® – Design



LFA 457 *MicroFlash*® - 1100 °C version

The NETZSCH LFA 457 *MicroFlash*® integrates state-of-the-art technology in a robust, easy-to-operate table-top measurement instrument. The laser pulse is guided by a mirror to the sample carrier within the furnace. The down-view IR-detector is directed to the rear surface of a sample. Short distances between light source, sample(s) and detector yield an excellent signal-to-noise ratio and permit easy operation and sample change. The wide range of different sample holders, detector types, and furnaces, along with the vacuum-tight design, allow easy adjustment of the system to nearly all possible applications.

Laser

The Nd-YAG, with a maximum pulse energy of 18.5 J and a pulse length of 0.5 ms, is based in the bottom part of the instrument. The power output is controlled by the software and can be easily adjusted to the required application. The laser is connected to a sophisticated interlock system allowing the laser to fire only when the entire system is fully closed (Laser Class 1).

Furnaces

Two user-interchangeable furnaces are available for the LFA 457 *MicroFlash*®. The low-temperature furnace comes with a controlled liquid nitrogen supply and allows measurements between -125 °C and 500 °C. The forced-air cooled high-temperature furnace allows measurements between room temperature and 1100 °C. The furnace is moved with a motorized hoist.

Detectors

A highly sensitive MCT (Mercury Cadmium Telluride) IR-detector is generally used in the system. This detector covers the temperature range from -125 °C to 1100 °C. For improved sensitivity at high temperatures, a InSb (Indium Antimonide) detector is additionally available. Both detectors can be changed by the operator within minutes.

Automatic sample changer

The integrated motorized robot system allows measurement of up to three samples at the same time. The sample carriers are arranged on a robust sample carrier tube which rotates during sample change. For large sample sizes, the system can be equipped with a carrier plate for single sample operation.

Sample carriers

A wide range of different sample carriers for circular or square solid samples between 10 mm and 25.4 mm are available. Sample holders for special geometries are available upon request. Of course, sample carriers for tests on laminates, fibers, pastes and liquids are available, as well.

LFA 457 *MicroFlash*® – Software

The LFA 457 *MicroFlash*® comes with a 32-bit Windows® software package, specially tailored to the needs of our users. It combines easy handling and complex evaluation routines, thus offering a solution to almost every problem the user might face.

More than 20 different evaluation models are available to the user. These have been developed with leading experts from science and industry and correspond to present-day requirements and state-of-the-art technology.

Software Features

- 32-bit Windows® software: fully compatible with other Windows® programs
- multi-tasking: simultaneous measurement and evaluation
- full network compatibility
- easy printout and export of measuring curves and data (ASCII)
- selectable screen design by means of docking windows
- multi-moduling: operation of several different instruments with one computer
- integrated database

Measuring Task

- full control of the sample changer
- easy and user-friendly input of test parameters
- free selection of temperature programs
- optimization of the system parameters (measuring time, amplification, etc.)
- automatic evaluation of the measurement after each shot with one or several evaluation models

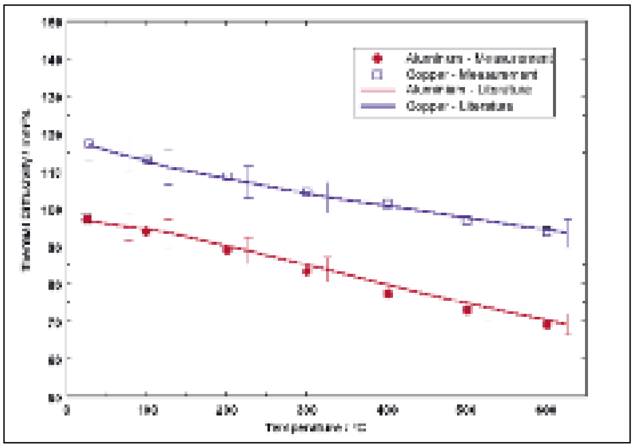
Evaluation Task

- presentation of an individual response curve and the entire result, as well as test parameters and measured values, in one portrayal
- free input or import of density and specific heat values for determination of thermal conductivity
- simultaneous presentation of thermal diffusivity and conductivity data in one plot
- storage and restoration at any point during the analysis
- presentation and new evaluation of data from previous measurements

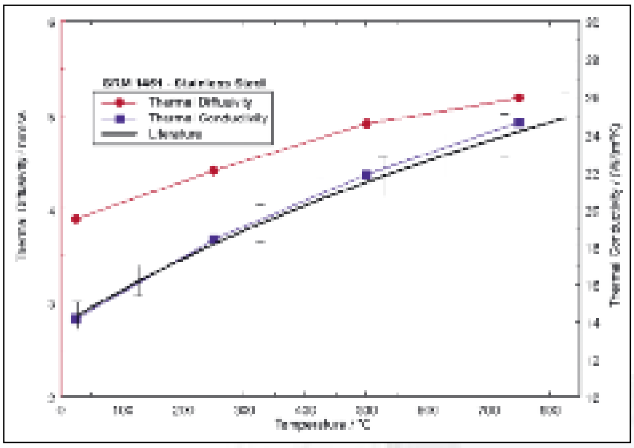
Evaluation Models

- accurate finite pulse correction
- standard heat loss corrections according to literature by Cowan and Clark and Taylor, are integrated
- Cowan-Fit: non-linear regression based on the original publication by Cowan (with optional finite pulse correction)
- improved Cape-Lehmann model: non-linear regression with consideration of radial and facial heat losses (with optional finite pulse correction)
- correction of radiation effects: a new model that takes radiation effects into account is integrated for accurate analysis of tests on oxide ceramics or glasses (simultaneously with heat loss and finite pulse corrections)
- 2- or 3-layer systems: analysis of multi-layer systems applying non-linear regression, with consideration to the heat loss (with optional finite pulse correction)
- contact resistance: determination of the contact resistance in a layer system
- model wizard: evaluation of a response curve with several models simultaneously; determination of the optimum model using statistic criteria
- determination of specific heat by means of a comparative method

LFA 457 *MicroFlash*® – Performance



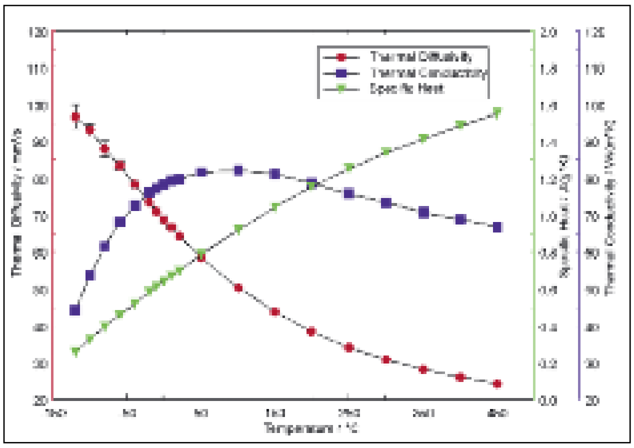
Copper and Aluminum
Pure metal samples are excellent for checking the performance of a laser flash device. Presented in the figure are the thermal diffusivity results measured on pure copper (99.999%) and pure aluminum (99.9%) between room temperature and 600 °C. The results are compared with literature values taken from the TPRC database (lines). The literature values have a stated uncertainty of ±4 % (error bars). However, the measurement results achieved with the *MicroFlash*® generally are in agreement within ±2 % with the values given in literature.

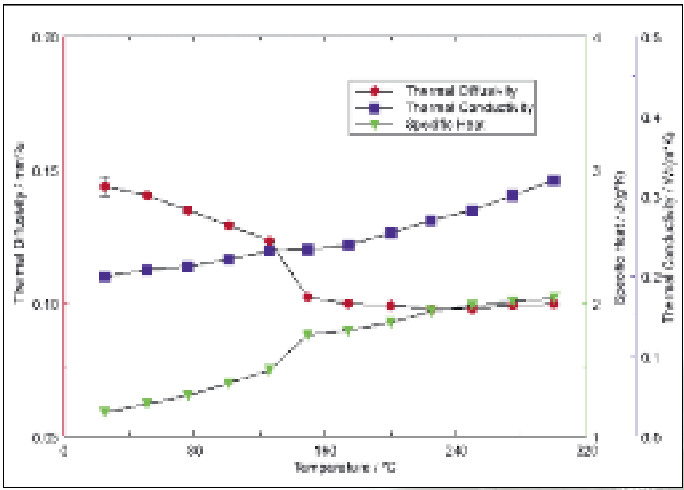


Stainless Steel
Stainless steel (SRM 1461) is a reliable standard material for checking the performance of thermophysical properties testing equipment up to high temperatures. Presented here are the measured thermal diffusivity and thermal conductivity of a NIST thermal conductivity standard reference material (SRM 1461). Additionally shown are the thermal conductivity values of the corresponding NIST certificate together with the stated uncertainty. The results achieved with the LFA 457 are clearly well within the given uncertainty range.

LFA 457 *MicroFlash*® – Applications

Polycrystalline Graphite
Graphite materials are known to show a maximum thermal conductivity around room temperature, which can easily be analyzed using the low temperature version of the LFA 457. The physical explanation for this maximum is the high Debye temperature of this material (>1000 K). The decrease in thermal diffusivity with increasing temperature dominates the temperature dependence of the thermal conductivity in the high temperature region. The specific heat decreases strongly at temperatures below room temperature and dominates the temperature dependence of the thermal conductivity there.





Polycarbonate

Polycarbonate (PC) is a popular polymer material used, among other things, for electric tool casings. To optimize the production/molding process by finite element simulations, the thermophysical properties have to be known. The thermal diffusivity can be determined not only in the solid region but also at temperatures above the glass transition (>140 °C) if a molten material cell is employed in the LFA 457. Together with the specific heat (measured with a DSC) and density data, the thermal conductivity can be determined. The slight increase in the thermal conductivity versus temperature is typical for 100% amorphous materials. Furthermore, the glass transition is visible in the specific heat curve and in the thermal diffusivity result. In the thermal conductivity result, this second order transition cannot be seen.

Technical Specifications

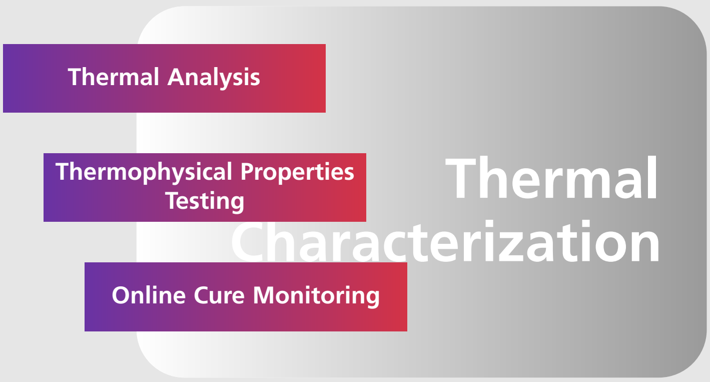
Standard Sample Size	Ø 10 mm, 0.1 mm to 6 mm thick Ø 12.7 mm, 0.1 mm to 6 mm thick Ø 25.4 mm, 0.1 mm to 6 mm thick ☐10 mm x 10 mm, 0.1 mm to 6 mm thick	
Furnaces	-125 °C to 500 °C (Helium atmosphere recommended) RT to 1100 °C	
Laser	Nd-YAG, Energy: 0 J to 18.5 J, Pulse Width: 0.5 ms	
Sensors	MCT (Mercury Cadmium Telluride), LN2-cooled InSb (Indium Antimonide), LN2-cooled	
Thermal Diffusivity Range	0.01 mm^2/s to 1000 mm^2/s	
Thermal Conductivity Range	0.1 W/(m·K) to 2000 W/(m·K)	
Repeatability	Thermal Diffusivity: Specific Heat:	±2% (for standard materials) ±3% (for standard materials)
Accuracy	Thermal Diffusivity: Specific Heat:	±3% (for most materials) ±5% (for most materials)
Measurement atmosphere	Inert, oxidizing or vacuum (<10^{-2} mbar)	
Utilities	110/230 V 50/60 Hz, 16 A (one 230 V line is required for the PU) Water 1 liter/week, LN2 2 liters/day	
Instrument Dimensions	width: 570 mm, depth: 550 mm, height: 880 mm	

Testing Services

Are you interested in the thermal characterization of your material but don't want to invest in an instrument? NETZSCH has the solution. NETZSCH contract testing services offer an unsurpassed range of instruments and methods for the analysis of your materials. We offer a wide range of thermal characterization services conducted by our experienced staff of scientists and engineers. You receive sound advice, accurate data, and real solutions for your thermal design problems from an unbiased, independent source. Contact us for further details.

State-of-the-Art Thermal Characterization with NETZSCH

Knowledge of the thermal characteristics of materials is critical to material development and design in every modern industry. Researchers who need reliable thermal analysis, thermophysical property data or cure monitoring turn to the state-of-the-art instruments and services offered by NETZSCH.



Our DSC, TG, STA, DIL, DMA, DEA and TMA instruments form the core of the NETZSCH Thermal Analysis instruments, allowing measurement of dielectric properties, dimensional or mass changes and transformation energetics between -260 °C and 2800 °C.
The DSC 404 *Pegasus*®, DIL 402 C and the different LFA models, as well as the thermal conductivity instrument family (TCT, HFM, and GHP), are well established components of the NETZSCH thermophysical properties world.

NGB · LFA 457 · E · 1500 · 1108 · LH

Leading Thermal Analysis.

NETZSCH

NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42 · 95100 Selb/Germany
Phone: +49 9287 881-0 · Fax: +49 9287 881-505
E-mail: at@netzsch.com

www.netzsch.com