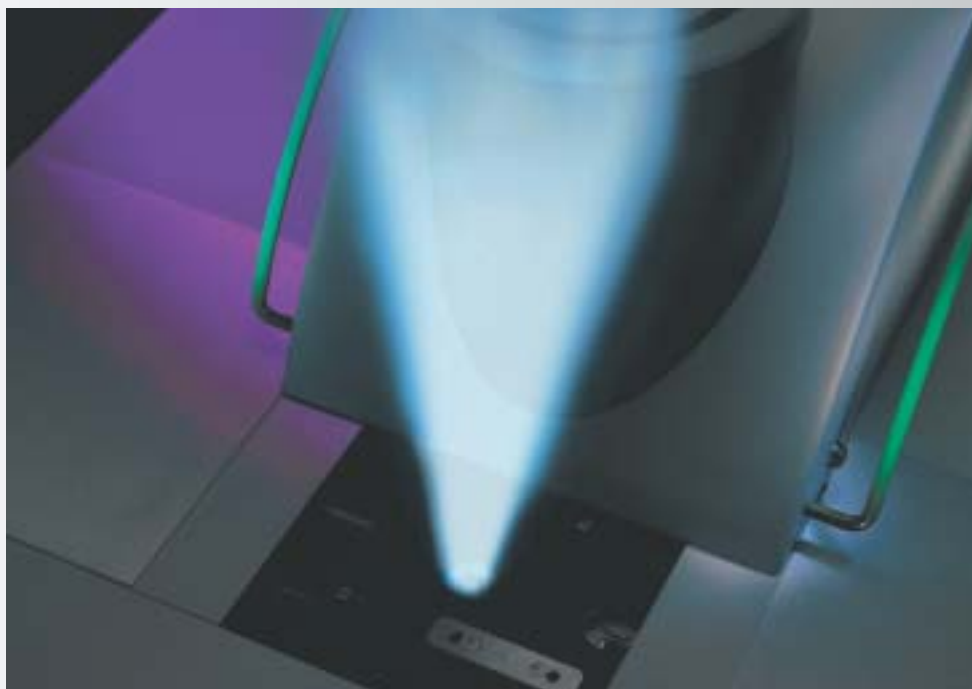


NETZSCH

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LFA-447

*NanoFlare*TM

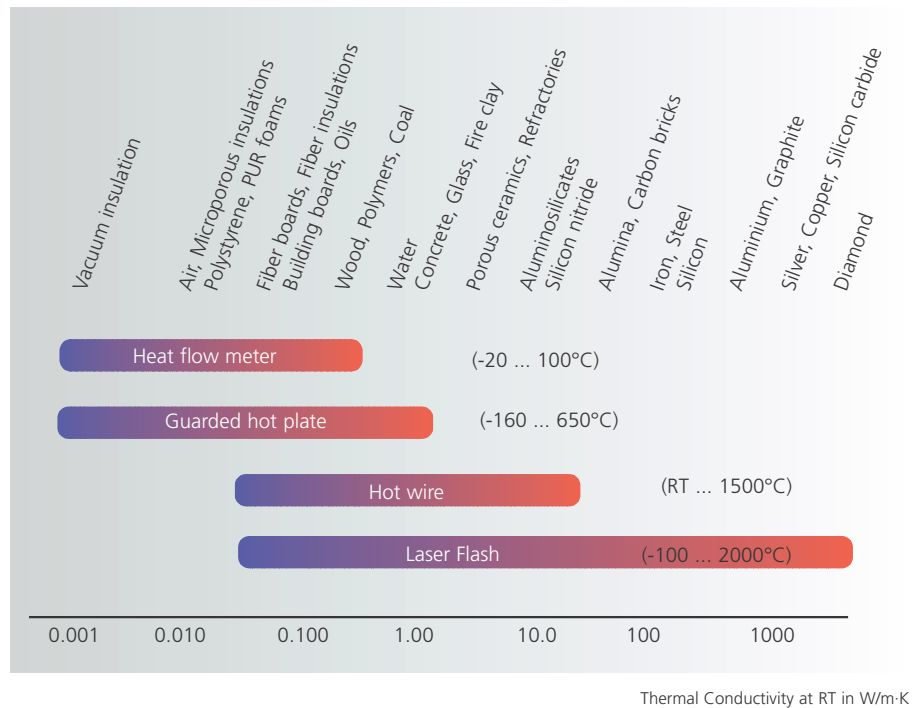
LFA 447 Nano Flash™

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 diffusi-

vity 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 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 *Nano Flash*™ system is designed as a cost-effective, easy-to-operate, highly accurate instrument for testing between room temperature and 300°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 C) 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.



Flash Apparatus LFA 447 Nano Flash™

The NETZSCH LFA 447 Nano Flash™ is based on the well-known flash method. In this method, the front side of a plane-parallel sample is heated by a short light pulse. The resulting temperature rise on the rear surface is measured using an infrared detector. By analysis of the resulting temperature-versus-time curve, the thermal diffusivity can be determined.

The LFA 447 NanoFlash™ is a powerful research tool for

making accurate, rapid thermal diffusivity tests on small specimens. It can complete tests on dozens of samples at room temperature in a single morning or, with the optional furnace, make measurements at temperatures up to 300°C automatically.

Fast test times

The speed and repeatability of thermal diffusivity measurements have made this technique the method of

choice among researchers worldwide, replacing traditional steady-state methods that are difficult, costly, and much slower. By measuring thermal diffusivity (a) of a material, its thermal conductivity (λ) can be determined if specific heat (c_p) and density (ρ) are known:

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

Advanced data analysis

The evaluation of the measured data can be done using the well known half-time method:

$$a = 0.1388 \cdot \frac{d^2}{t_{1/2}}$$

The Nano Flash™ additionally allows the consideration of radial and facial heat losses and finite pulse effects using advanced mathematical regression routines.

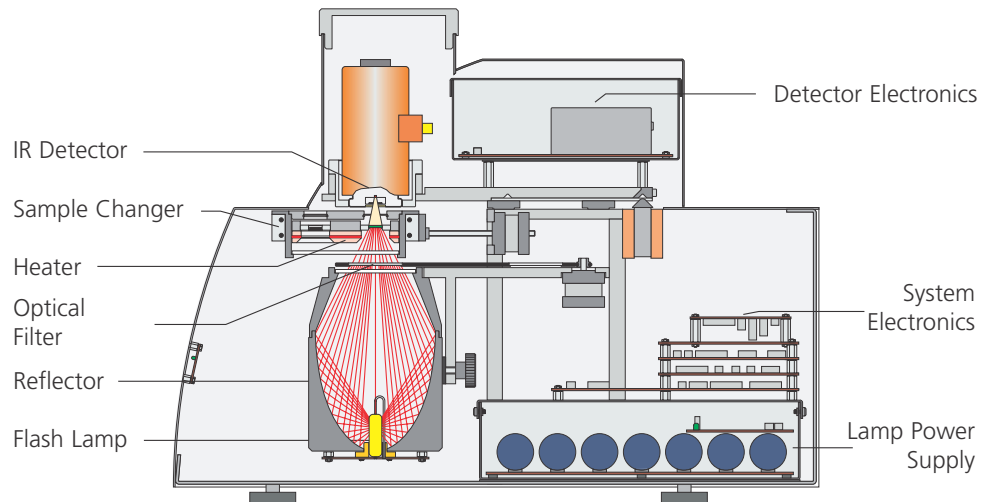
Using the multiproperty measurement capabilities of the Nano Flash™, both thermal diffusivity and specific heat can be determined simultaneously – on the same specimen – thus yielding thermal conductivity if the density is known.

Standardized test method

The Nano Flash™ works according to national and international standards such as ASTM E-1461, DIN EN 821 or DIN 30905.



LFA 447 Nano Flash™ – Setup System



In the LFA Nano Flash™, a state-of-the-art technology is integrated in a compact measuring system. The flash lamps, sample, and detector are horizontally arranged. Therefore the use of mirrors is not necessary. Short signal pathways and a good signal-to-noise ratio are thereby warranted.

The Flash Lamp:

A high-performance Xenon flash lamp is applied to produce the heat pulse on the front of the sample. The lamp is placed in a parabolic mirror, whereby a large part of the radiation given off is focused on the sample. The assembly of the mirror and the position of the lamp are conceived such that a homogenous illumination of the entire sample surface is warranted. The energy released from the flash lamp can be adjusted using the software. The length of the

heat pulse can also be varied in three stages from 0.1 through 0.5 ms by the software.

Sample Placement:

The samples are placed in an automatic sample changer which can test up to four samples in one test. The samples are thereby brought into a special sample carrier which can be adjusted according to the user's wishes. There are standard carriers for testing of round samples with 10, 12.7 or 25.4 mm diameter. Sample receptacles for the testing of square samples (8mm x 8mm) also exist. The measurement of the sample temperature is done with a thermocouple which is integrated into the system's sample holder plate. Special sample holders are available for the measurement of liquids and pastes with unmatched accuracy and test speed.

The Furnace:

The system can optionally be equipped with a furnace for temperature-dependent measurements up to 300°C. The furnace is directly integrated into the sample changer of the system, whereby a small thermal mass and thereby fast heating and cooling times are secured.

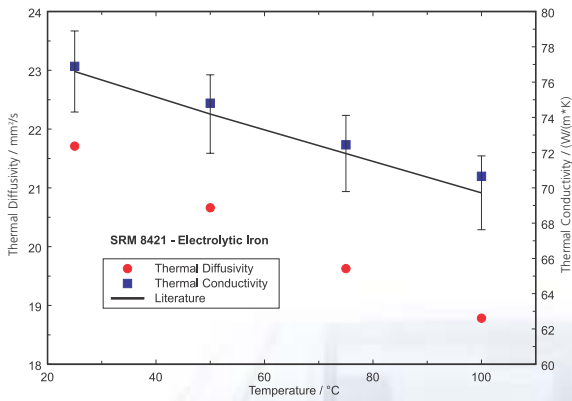
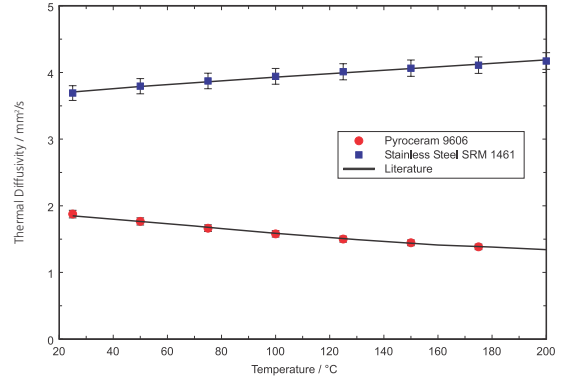
The Detector:

The measurements of the temperature increases on the rear of the sample is carried out with a liquid-nitrogen-cooled InSb (Indium-Antimonide) infrared detector. The non-contact measurement of the temperature increase guarantees an easy sample change and a short response time for the signal acquisition system. Both the detector and amplifier components are designed for measurements with data acquisition rates of up to 500 kHz.

LFA 447 Nano Flash™ – Performance

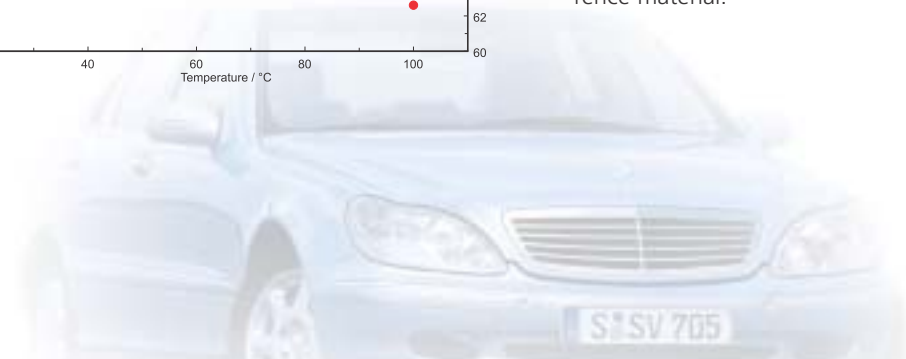
Performance – Stainless Steel and Pyroceram 9606

The thermal diffusivities of two well-known standard materials (NIST SRM 1461 Stainless Steel and Pyroceram 9606) were measured versus temperature with the LFA 447 Nano Flash™. The figure shows the measurement results as compared to literature values (Touloukian et al., 1970, Henderson et al., 1998) up to 200°C. It can clearly be seen that the deviations between the literature values and the measurement results are less than 3% (error bars). This demonstrates the high accuracy of this flash unit in the field of metals and ceramics.



Accuracy - NIST SRM 8421 Electrolytic Iron

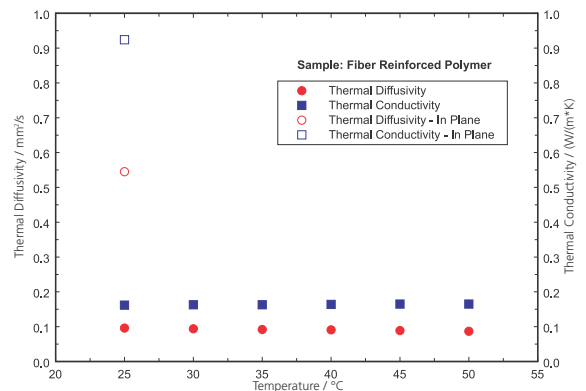
A certified NIST thermal conductivity reference material (SRM 8421) was measured between room temperature and 100°C. Additionally shown are the NIST values for the thermal conductivity for this material together with the stated accuracy (3%). As expected, both the thermal diffusivity and thermal conductivity decrease with temperature. It can be seen that the determined thermal conductivity values are close to the NIST values. The measured deviations are within the stated uncertainty range for this certified standard reference material.

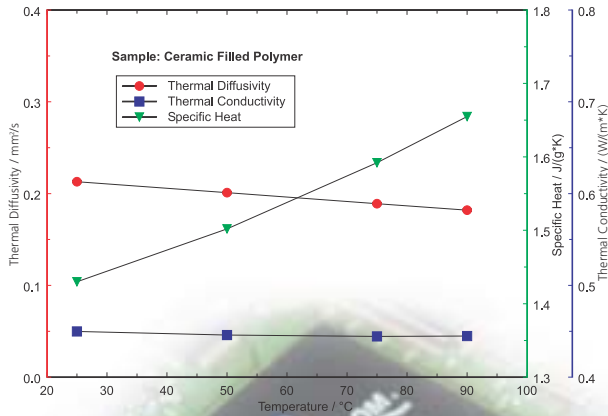


LFA 447 Nano Flash™ – Applications

In-Plane Tests – Fiber-Reinforced Epoxy

More and more polymers, metals or ceramics are being reinforced with fibers to improve their bending strength and to adjust them to special applications. In many cases, the fiber reinforcement results in a high degree of anisotropy to the mechanical and thermal transport properties. By employing special sample holders, the flash technique allows analysis of this anisotropy in the thermal diffusivity and thermal conductivity. The measurement example clearly demonstrates that the values for both the thermal diffusivity and thermal conductivity, perpendicular to the fiber direction are significantly lower than the results of the in-plane test (in the fiber direction).





Thermal Conductivity Determination – Polymer Tape

The LFA 447 *Nano Flash*TM allows easy and fast temperature-dependent measurement of the thermal diffusivity. Additionally, the specific heat can be determined by employing a comparative method. A direct determination of the thermal conductivity is possible, if the bulk density of the material is known. This method was used for the thermophysical properties characterization of a polymer tape between room temperature and 90°C. The calibration standard for the specific heat determination was Pyroceram 9606. It can clearly be seen that both the thermal diffusivity and specific heat changed significantly versus temperature. The resulting thermal conductivity depicts nearly no temperature dependence.

Technical Specifications

Standard Sample Size	up to 25.4 mm (1") diameter, or 8 mm square, up to 3 mm (0.12") thick
Temperature Range	
LFA 447/0 <i>Nano Flash</i> TM	Ambient, or as controlled by external fluid source
LFA 447/2 <i>Nano Flash</i> TM	Ambient to 300°C
Thermal Diffusivity Range	0.01 to 1000 mm²/s
Repeatability	Thermal Diffusivity: +/-3 % Specific Heat: +/-5 %
Accuracy	Thermal Diffusivity: +/-5 % Specific Heat: +/-5 %
Flash Source	Xenon Flash Lamp Wavelength: 150...2000 nm Pulse Energy: up to ~10 joules (selectable)
Sensor Type	InSb IR Detector with integral dewar
Utilities	230V - 50/60 Hz, 15A - Controller Distilled Water (approx. 1L / week) Liquid Nitrogen (approx. 1L / 8 hrs.)
Dimensions (LxWxH)	(61 x 56 x 43) cm³ (24 x 22 x 17) in³

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 offers an unmatched

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

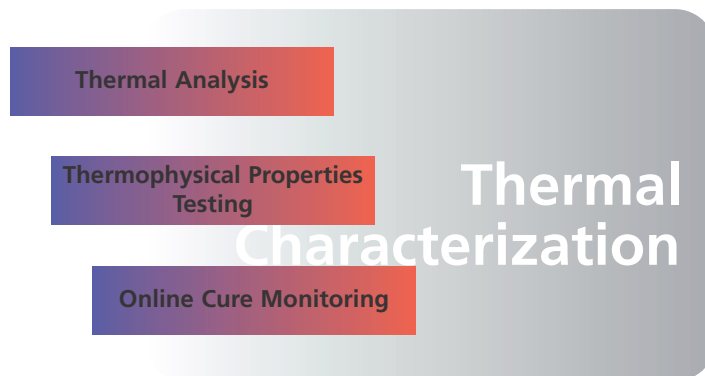
engineers. You receive sound advice, accurate data, and real solutions for your thermal design problems from an unbiased, independent source. Contact us for further details.

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 and 2800°C . The DSC 404 C, 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.



NETZSCH-Gerätebau GmbH
D-95100 Selb/Bavaria • Wittelsbacherstraße 42
Phone: +49/9287/881-0 • Fax +49/9287/881-144
e-mail: at@ngb.netzsch.com

www.ngb.netzsch.com