



***THERMAL DIFFUSIVITY***

***THERMAL CONDUCTIVITY***

## Thermal Diffusivity, Thermal Conductivity

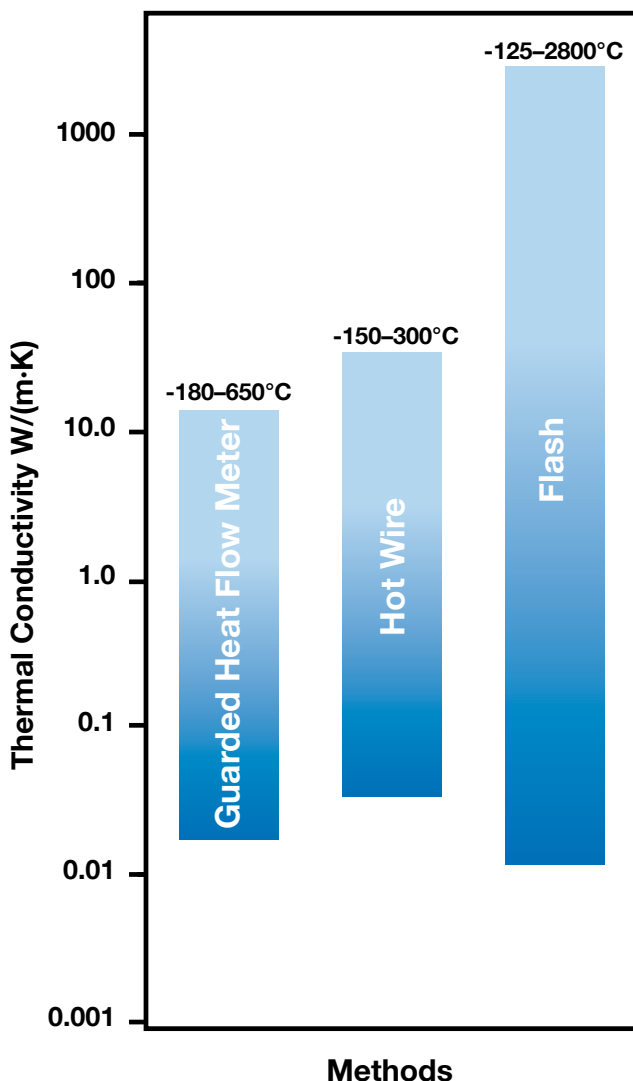
Information of the thermo physical properties of materials and heat transfer optimization of final products is becoming more and more vital for industrial applications. Over the past few decades, the flash method has developed into the most commonly used technique for the measurement of the thermal diffusivity and thermal conductivity of various kinds of solids, powders and liquids.

Application areas are electronic packaging, heat sinks, brackets, reactor cooling, heat exchangers, thermal insulators and many others. Trouble-free sample preparation, small required sample dimensions, fast measurement times and high accuracy are only a few of the advantages of this non-contact and non-destructive measurement technique.

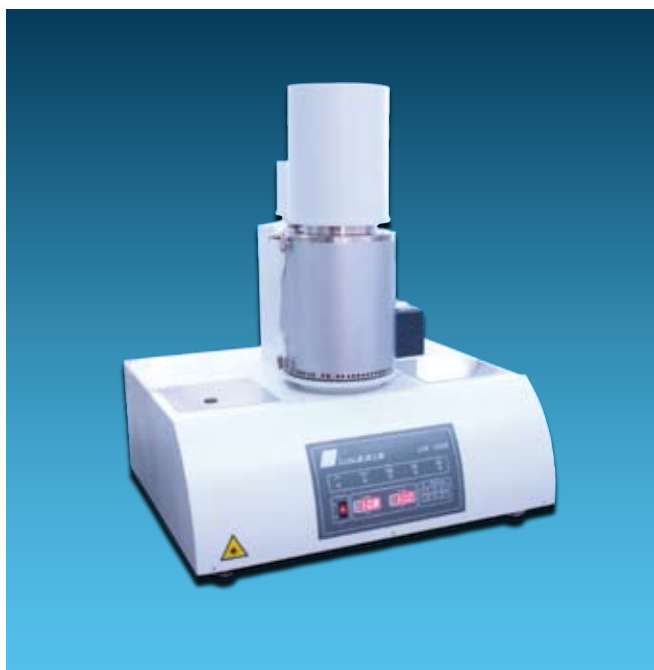
Linseis offers a variety of instruments to measure the Thermal Diffusivity. The XFA 500 provides a cost effective solution for the temperature range RT up to 500°C. The highly modular design allows upgrade to the LFA 1000 the high end system whenever the measurements require or the budget allows it.

The LFA 1000/1000 HT provides unbeaten sampling rates, up to 6 samples at the same time, highest modularity, three different user exchangeable furnaces (-125 up to 2800°C) and two detectors as well as a high vacuum design ( $10E^{-5}$  mbar).

For the determination of Specific Heat ( $C_p$ ) and density ( $\rho$ ) Linseis offers a full range of Differential Scanning Calorimeters and Dilatometers.



Diamond  
 Aluminum, Graphite  
 Silicon  
 Iron, Steel  
 Alumina, Carbon Bricks  
 Silicon nitride  
 Alumina Silicates  
 Porous Ceramics, Refractories  
 Concrete, Glass, Fire clay  
 Water  
 Wood, Polymers, Coal  
 Building boards, Oils  
 Fiber boards, Fiber Insulations  
 Air, Polystyrene, PUR Foams  
 Vacuum Isolation



XFA 500/LFA 1000

## Principle

The sample is positioned on a sample robot, 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 high speed IR detector and thermal diffusivity values are computed from the temperature rise versus time data. The resulting measuring signal computes the thermal diffusivity, and in most cases the specific heat ( $C_p$ ) data. If the density ( $\rho$ ) is identified, the thermal conductivity can be calculated:

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

## Thermal Diffusivity & Conductivity measuring range

The Laser Flash technique covers the widest measuring range of all techniques, 0.1 up to 2000W(m\*K) for Thermal Conductivity and 0.01 up to 1000 mm<sup>2</sup>/s for Thermal Diffusivity.

## Accuracy & Repeatability

Highest Accuracy and repeatability, +/-3% for thermal diffusivity and +/-5% for thermal conductivity  
(Values may vary for special applications)

## Multilayer evaluation

The powerful software package enables the evaluation of two or three layer systems.

## Correspondence with International Standards

The LINSEIS LFA and XFA operate in agreement with national and international standards such as ASTM E-1461, DIN 30905 and DIN EN 821.

## Absolute technique

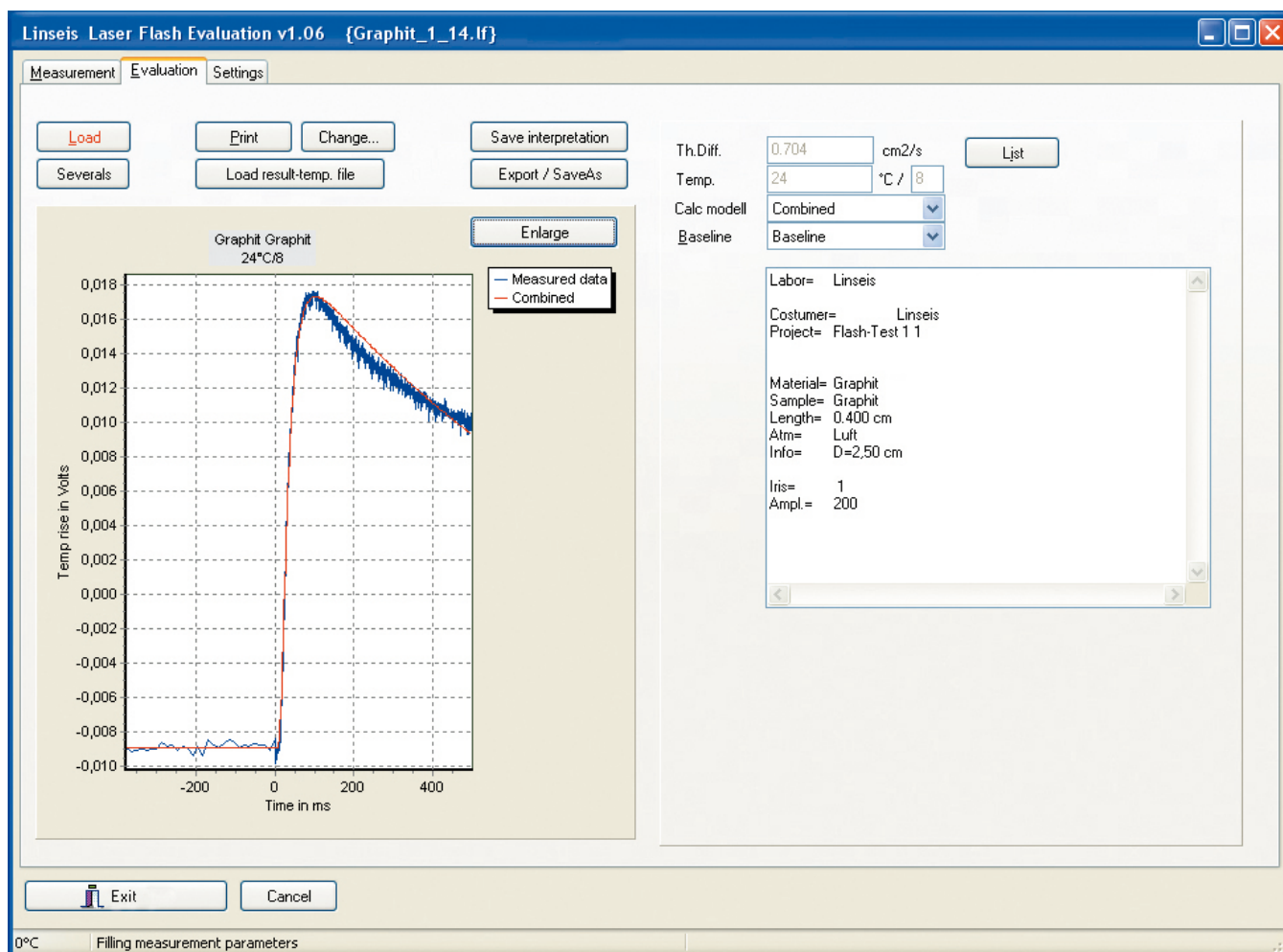
The method used is an absolute measurement technique (for thermal diffusivity) hence there is no need to calibrate the system.

## Speed and Flexibility

The combination of sample robot and test method allows unbeaten measurement turnaround time. A typical measurement for up to 6 samples takes only a few hours.

## System Design

Linseis is offering an unparalleled modular system design for this Thermophysical properties Analyzer. It is possible to upgrade the temperature range (exchangeable furnaces/measuring system) and the detector (InSb/MCT). This enables the user to start with a cost effective solution and upgrade the system whenever the budget allows or the measurement task requires it.



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

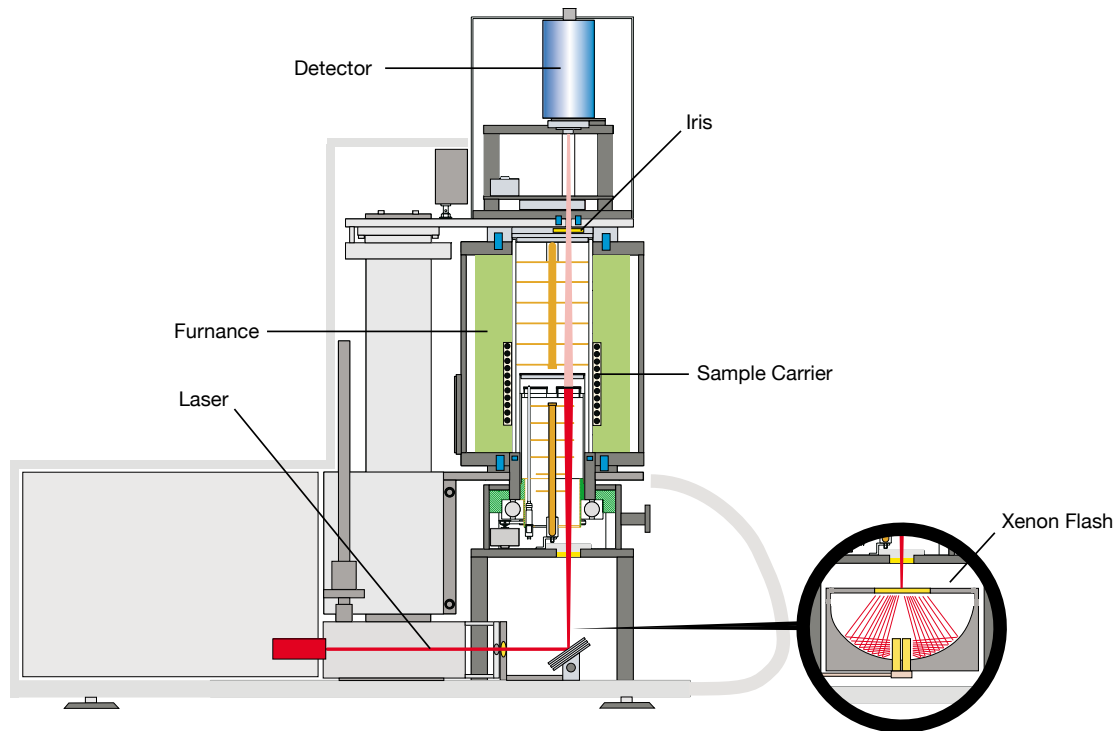
- Fully compatible MS® Windows™ 32 – bit software
- Data security in case of power failure
- Thermocouple break protection
- Evaluation of current measurement
- Curve comparison
- Storage and export of evaluations
- Export and import of data ASCII
- Data export to MS Excel
- Multi - method analysis (DSC TG, TMA, DIL, etc.)
- Programmable gas control

### Evaluation Software

- Automatic or manual input of related measurement data: (density), Cp (Specific Heat)
- Model wizard for selection of the appropriate model
- Finite pulse correction
- Heat loss correction
- Multilayer model
- Determination of contact resistance
- Cp (Specific Heat) determination by comparative method

### Measurement Software

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



## Laser

The used Nd: YAG Laser has a power output of 25J/pulse. Both the power and the pulse length can be easily adjusted by the Software. The system design includes all safety features to guarantee a secure operation, "Laser Class 1".

## Xenon Flash Lamp

The second pulse source, the Xenon flash lamp offers a cost effective solution to perform Thermophysical property measurements. The integrated lamp delivers a maximum energy pulse of 10J/pulse.

## Sample robot

The fully motorized sample robot can carry up to 6 samples (10 or 12.7 mm round or 10 mm square) or up to 3 samples (25.4 mm round). This design allows unbeaten sample throughput and sample size at the same time. Liquid samples can be measured in special containers. Other sample geometries or sizes are certainly possible on request.

## Environmental options

The system can be operated under vacuum  $10^{-5}$  mbar, oxidizing or reducing atmospheres. Furthermore a manual or automatic Software controlled gas control box (2, 3 or 4 gases) can be attached to generate specific atmospheres.

## Furnace

The LFA/XFA unit can be equipped with 4 different furnaces. All furnaces are easily exchangeable.

Analyzer	Furnace Model	Temperature
LFA 1000	Cryo-Furnace	-125 up to 500°C
LFA 1000/XFA 500	Furnace 1:	RT up to 600°C
LFA 1000	Furnace 2:	RT up to 1250°C
LFA 1000	Furnace 3:	RT up to 1600°C
LFA 1000 HT	Furnace 4:	RT up to 2000°C
LFA 1000 HT	Furnace 5:	RT up to 2800°C

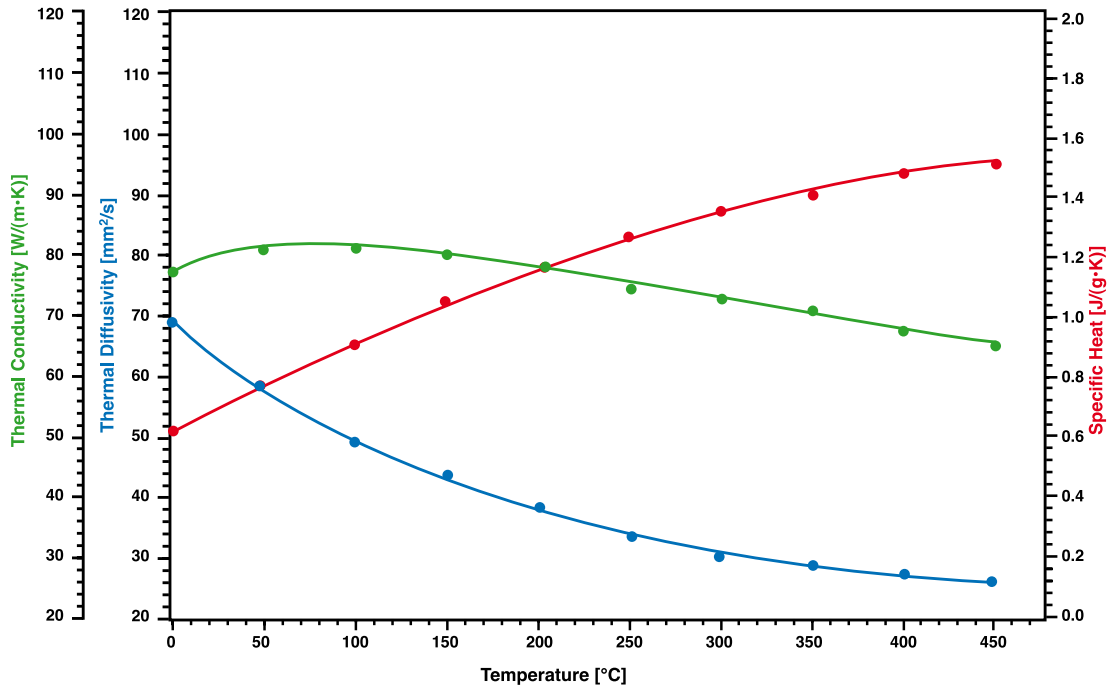
## Detectors

The system can be either equipped with an InSb detector or with a MCT detector. Both are easily user exchangeable. Both detectors can be ordered with an 8 hour or 24 hour Dewar. For even longer measurements an automatic cooling accessory with Dewar can be ordered.

### Application Example: Graphite (polycrystalline)

Graphite is an excellent material for checking the performance of a Laser/Xenon Flash Thermal Analyzer. The analyzed material shows a maximum thermal diffusivity around room temperature. The specific heat of the material

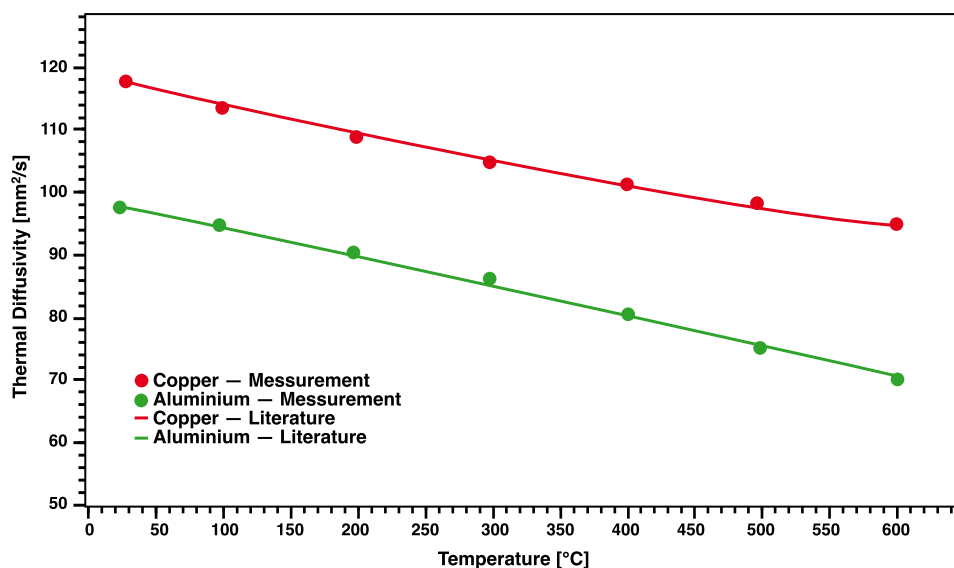
which can be analyzed by comparative method or by using a DSC / High Temperature DSC shows a significant increase at higher temperatures.



### Application Example: Aluminum and Copper

The pure metals Copper and Aluminum are used in this example to demonstrate the performance of the Linseis Laser Flash device. The measurement results of the two materials

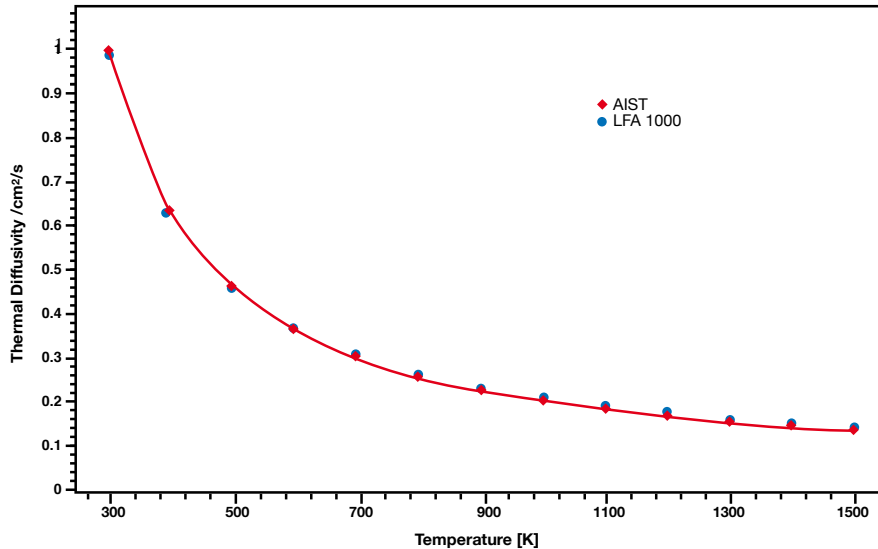
are compared with literature values. The measured results vary within 2% of the given literature values; this demonstrates the excellent performance of the instrument.



### Isotropic Graphite (AIST)

This graph shows the Thermal Diffusivity values measured on a Linseis LFA 1000 compared to the values measured at AIST\* Japan. The literature values of the used Isotropic Gra-

phite from AIST\* the measured results on the LFA 1000 vary by less than 2%. \*(National Institute of Advanced Industrial Science and Technology, Japan)




## Technical Specifications

	XFA 500	LFA 1000	LFA 1000 HT
Sample dimensions:	Ø 10 mm, 0.1 to 6 mm thick	Ø 10 mm, 0.1 to 6 mm thick	for one sample Ø 10 up to 25.4mm, 0.1 to 8 mm thick
	Ø 12.7 mm, 0.1 to 6 mm thick	Ø 12.7 mm, 0.1 to 6 mm thick	
	Ø 25.4 mm, 0.1 to 6 mm thick	Ø 25.4 mm, 0.1 to 6 mm thick	
	10x10 mm, 0.1 to 6mm thick	10x10 mm, 0.1 to 6mm thick	
Max. Sample number:	Up to 6 samples Ø 12,7mm round	Up to 6 samples Ø 12,7mm round	
	Up to 3 samples Ø 25,4mm round	Up to 3 samples Ø 25,4mm round	
Temperature range:	RT up to 600°C	-125 up to 500°C	RT up to 2000/2800°C
		RT up to 1250/1600°C	RT up to 1250/1600°C
Vacuum:	10E <sup>-5</sup> mbar	10E <sup>-5</sup> mbar	10E <sup>-5</sup> mbar
Atmosphere:	inert, oxidizing or reducing	inert, oxidizing or reducing	inert or reducing
Measuring range:			
Thermal Diffusivity	0.01 mm²/s up to 1000 mm²/s	0.01 mm²/s up to 1000 mm²/s	
Thermal Conductivity	0.1 W/(m·K) to 2000 W/(m·K)	0.1 W/(m·K) to 2000 W/(m·K)	
Repeatability Thermal Diffusivity:	±3% (for most materials)	±3% (for most materials)	±3% (for most materials)
Specific Heat:	±5% (for most materials)	±3% (for most materials)	±3% (for most materials)
Accuracy Thermal Diffusivity:	±3% (for most materials)	±3% (for most materials)	±3% (for most materials)
Specific Heat:	±5% (for most materials)	±3% (for most materials)	±3% (for most materials)
Pulse source:	Xenon Flash	Nd: YAG Laser	Nd: YAG Laser
Pulse energy:	10J/pulse	25J/pulse	25J/pulse
Pulse energy adjustment:	yes	yes	yes
Pulse length adjustment:	no	software adjustable	software adjustable
Sensor type:	InSb, LN <sub>2</sub> cooled	InSb or MCT, LN <sub>2</sub> cooled	InSb or MCT, LN <sub>2</sub> cooled



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Products: DIL, TG, STA, DSC, HDSC, DTA, TMA, MS/FTIR, Laser Flash  
Services: Service Lab, Calibration Service

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