THERMAL ANALYSIS

# TRANSIENT HOT BRIDGE

THB Basic
THB Advance
THB Ultimate

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.

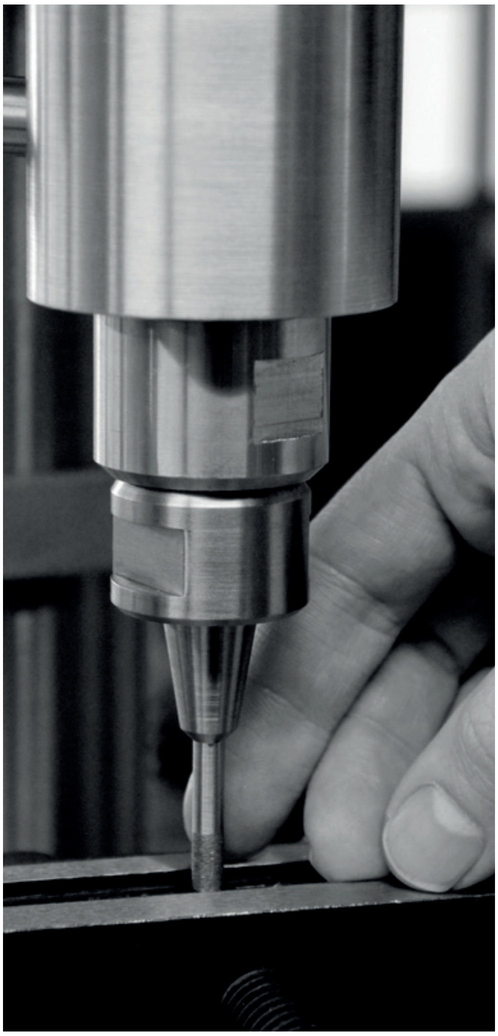
Customer satisfaction, innovation, flexibility and high quality are what LINSEIS represents. Thanks to these fundamentals, our company enjoys an exceptional reputation among the leading scientific and industrial organizations. LINSEIS has been offering highly innovative benchmark products for many years.

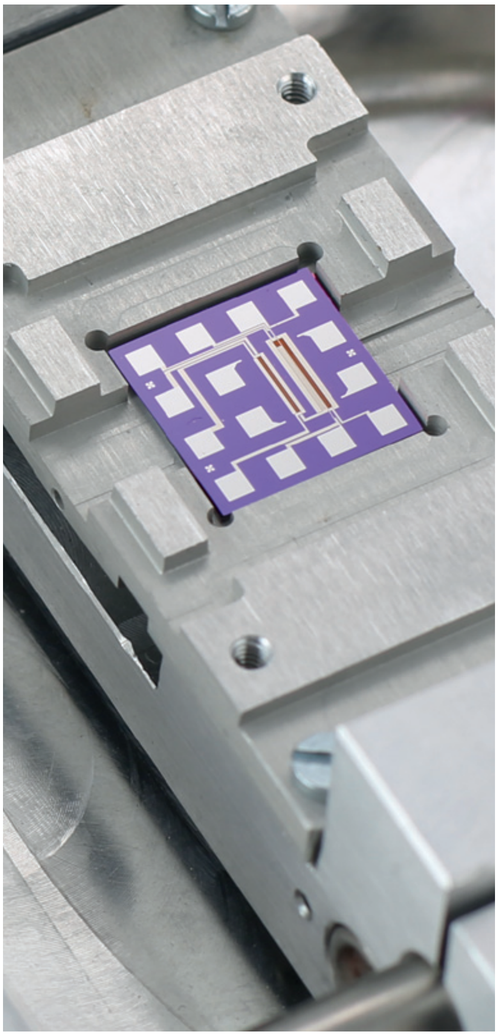
The LINSEIS business unit of thermal analysis is involved in the complete range of thermo analytical equipment for R&D as well as quality control. We support applications in sectors such as polymers, chemical industry, inorganic building materials and environmental analytics. In addition, thermo physical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

# THB– TRANSIENT HOT BRIDGE

Knowledge of heat transport properties of materials is becoming more and more crucial. Many application fields like automotive, aviation, aerospace but also power generation / energy industries or ceramics industries, building materials and glass industry and many more need very precise information about the thermal behavior of the used materials.
Heat management is becoming very important in the building industries due to exploding energy costs (isolation) or in the semiconducting industries if we think of power electronics and highly integrated circuits. The ongoing developements require a substantial research & developement process in these two but also many other fields.

LINSEIS has a lot of experience in thermal properties measurement and covers a very broad range of different techniques to measure thermal conductivity, thermal diffusivity and specific heat. They include the laser flash method, the hot plate method (heat flux meter) and the hot wire technique.

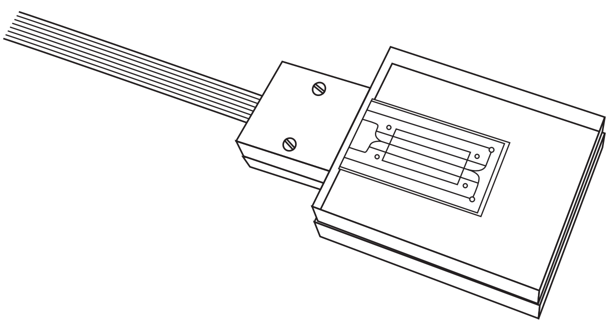
**Method:**

The THB measurement method, initially developed by the National Metrology Institute of Germany, is an optimized transient or quasi steady state hot wire to measure all relevant thermal transport properties (thermal conductivity, thermal diffusivity and volumetric specific heat) with the highest possible accuracy.

**Temperature range from -150 to 700 °C**

**Easy set-up and sample preparation**

**Broad thermal conductivity range from 0.01 to 500 W/m•K**



Sensor sandwich between two PMMA samples

# Improved technology – THB Basic, Advanced and Ultimate Models

## Hardware

- Smallest footprint
- Light in weight
- Optimized electronics for highest efficiency
- Fastest data acquisition
- Highest measurement accuracy
- Lowest signal to noise ratio

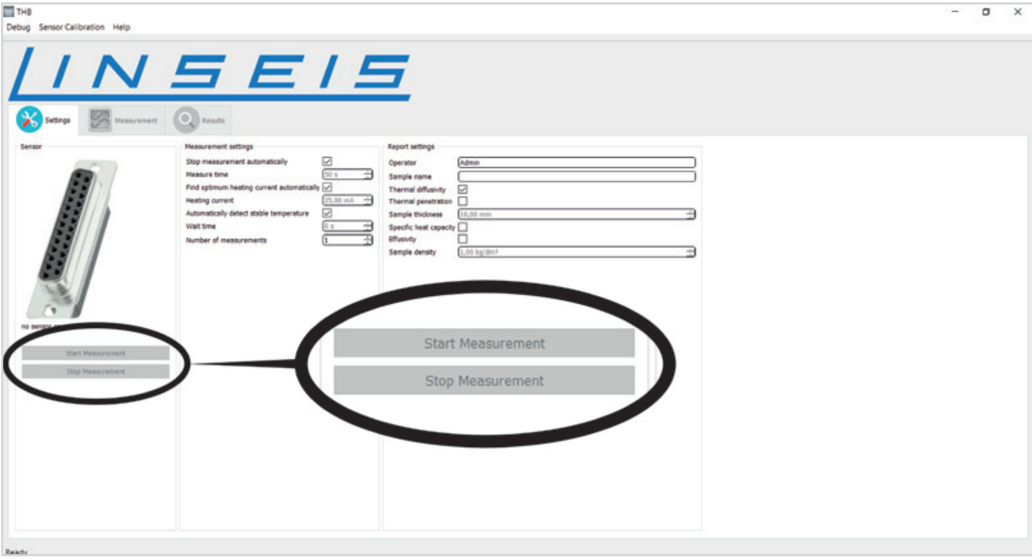
## Software

- User friendly software. Easy to use and powerfull in operation
- using EEPROMs
- Linseis Intelligence Software for fully automatic operation
  - no user settings required
  - highest accuracy
  - limiting operational errors
- Faster measurements

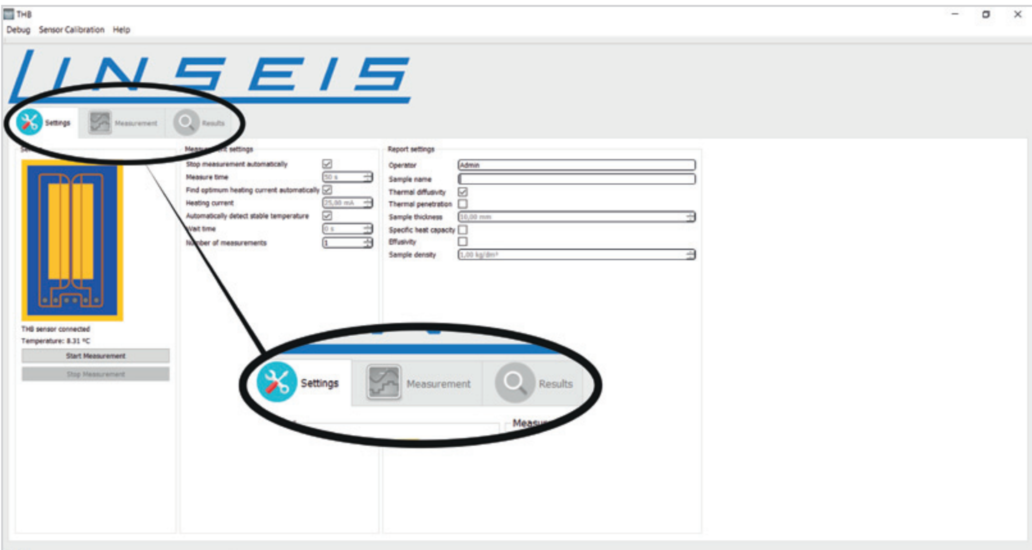
# New automatic Software

## 3 steps to results

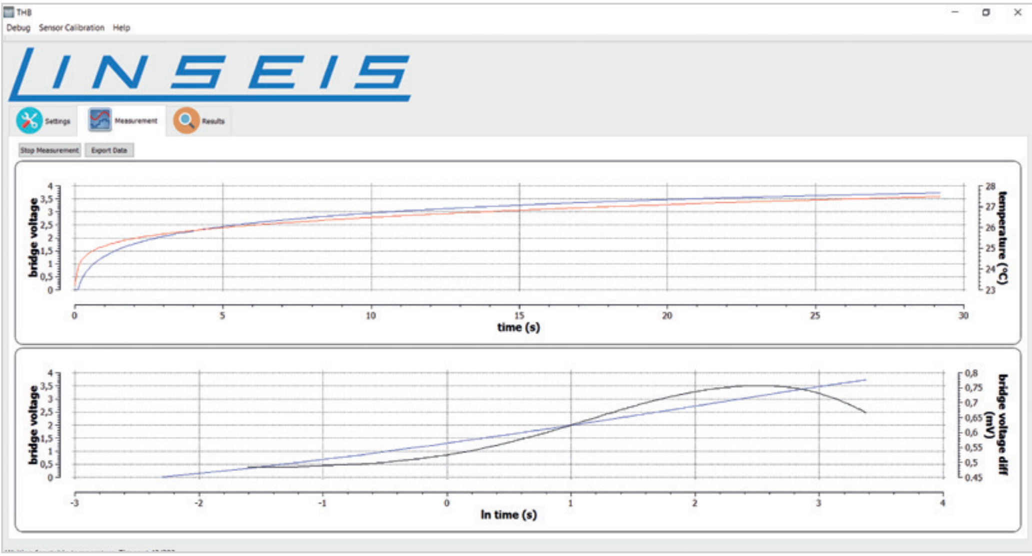
### 1 The first new feature of the software is that it automatically detects when no sensor is connected




### 2 Easy user interface: Settings, measurements and results



# 3 The logarithmic representation of the curves and the graphs depending linearly on the time




After finding the parameters, the software automatically switches to the measurement tab where one can observe the measurement.

The top graph shows the temperature in red and the bridge voltage in blue in linear depence of the time.

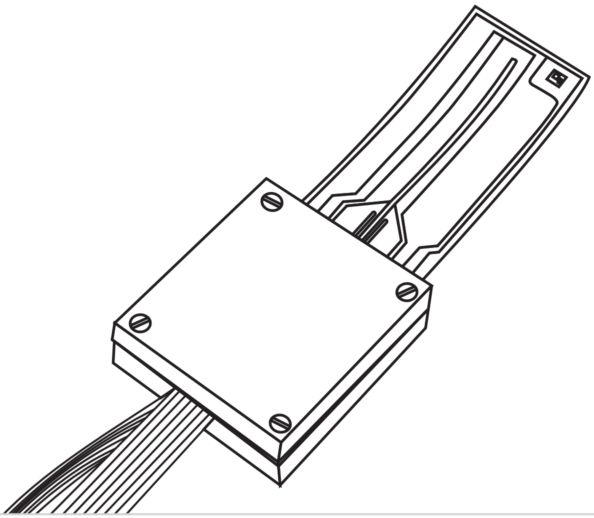
in the lower diagram one can see the logarithmic plot of the bridge voltage, again in blue, and the derivative of the bridge voltage in black.

After the measurement is finished, the tab automatically switches to results.

Here, a new feature is that one can see not only the logarithmic representation of the curves, but also the graph depending linearly on the time. The reason for that is, that with the logarithmic time axis it might seem that the curve is not continued which might confuse some of the users.

# Different sensors for various applications and temperatures

## Hot Point Sensor



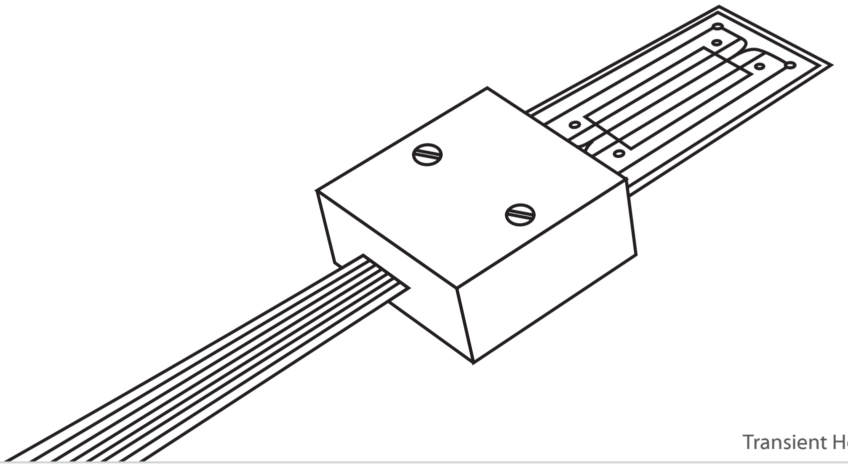
Hot Point Sensor

The thermal conductivity of the specimen using the hot point sensor is determined by the heating power of the sensor, the effective radius of the sensor which is constant and the y-axis intersection of a linear approximation of the temperature rise, see right figure, where the the temperature rise is plotted against $1 / \sqrt{t}$. Here only the linear part of the curve is used for the calculation.

- Suited for measuring small or anisotropic samples
- Uncertainty about 5 % –10 %
- Sensor is heated by a heating current
- Temperature rise as function of time is measured

| | Min. sample size | Temperature range | Measuring range | Suitable for |
|---|---|---|---|---|
| **Hotpoint** | 1.5 x 1.5 x 2 mm | -150 up to 200°C | 0.01 up to 30 W/mK | S, P, L, G |
| **Hotpoint HT** | 10 x 10 x 10 mm | RT up to 1000°C | 0.01 up to 5 W/mK | S, P, L, G |

## Transient Hot Bridge (THB) Sensor



Transient Hot Bridge Sensor

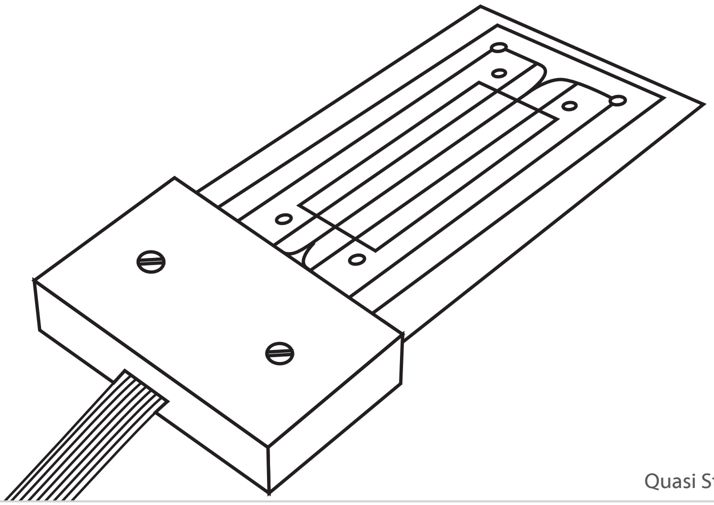
The THB method was developed from the Hot wire and hot strip method.

During the measurement the sensor emits a constant heating currents and also heats itself. The temperature rise is recorded using the bridge voltage and is a measure for the thermal properties of the sample.

- patented sensor
- suitable for fast and high accuracy measurements
- Thermal Conductivity, Thermal Diffusivity and Specific Heat Capacity
- uncertainty < 3%
- most accurate sensor for low conductive materials

| | Min. sample size | Temperature range | Measuring range | Suitable for |
|---|---|---|---|---|
| **THB/A** | 20 x 40 x 5 mm | -150 up to 300°C | 0.01 up to 5 W/mK | S |
| **THB/A/Metal** | 20 x 40 x 5 mm | -150 up to 300°C | 0.01 up to 5 W/mK | S, P, L |
| **THB/B** | 10 x 20 x 3 mm | -150 up to 300°C | 0.01 up to 5 W/mK | S |
| **THB/B/Metal** | 10 x 20 x 3 mm | -150 up to 300°C | 0.01 up to 5 W/mK | S, P, L |
| **THB/A/HT** | 20 x 40 x 5 mm | RT up to 700°C | 0.01 up to 5 W/mK | S |
| **THB/B/HT** | 10 x 20 x 5 mm | RT up to 700°C | 0.01 up to 5 W/mK | S |

## Quasi Steady State (QSS) Sensor



Quasi Steady State Sensor

The methos uses a transient technique to generate a steady-state signal. By that, the sensor combines the advantages of steady state and transient measurment techniques. The method is based on the measurement of two temperatures of a line/strip heat source embedded in the test material. The heater creates a time and distant dependent temperature field along the sensor and the sample and the temperature is measured by temperature sensors.

Suited for samples with a high thermal conductivity

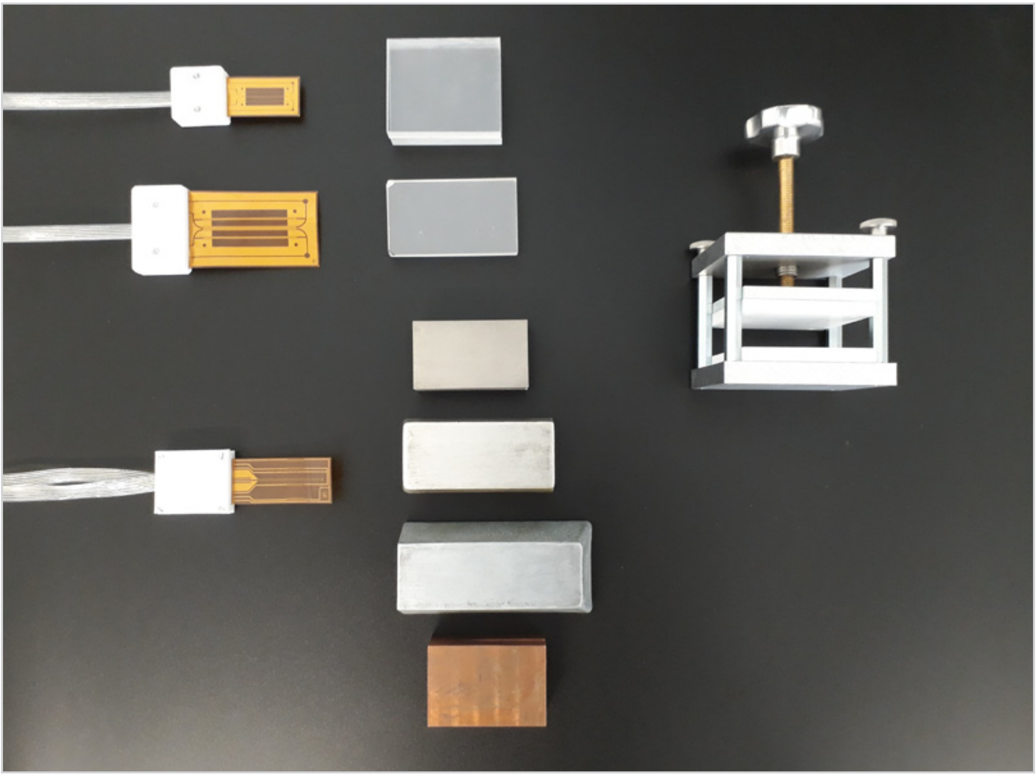
- Combines the advantages of steady state and transient measurement techniques
- Uncertainty < 5 %
- Heater creates a time and distant dependent temperature field along the sensor and the material under test
- Bridge voltage of resistors is measurement

QSS sensor can measure also thermal diffusivity, specific heat capacity, penetration depth and thermal effusivity

→ very broad measurement range of thermal conductivity and diffusivity

| | Min. sample size | Temperature range | Measuring range | Suitable for |
|---|---|---|---|---|
| **QSS** | 25 x 55 x 3 mm | -150 up to 200°C | 0.005 up to 1800 W/mK | S, P |
| **QSS HC** | 25 x 55 x 3 mm | RT up to 700°C | 0.2 up to 100 W/mK | S, P, L |

# Accessories



# Specifications

| | THB Basic | THB Advance | THB Ultimate |
|---|---|---|---|
| **Thermal Conductivity range** | 0.01 to 5 W/mK | 0.005 to 500 W/mK | 0.005 to 1800 W/mK |
| **Thermal Diffusivity range** | 0.05 up to 50 $mm^2/s$ | 0.05 up to 300 $mm^2/s$ | 0.05 up to 1200 $mm^2/s$ |
| **Specific Heat Range** | 100 to 5000 $kJ/(m^3K)$ | 100 to 5000 $kJ/(m^3K)$ | 100 to 5000 $kJ/(m^3K)$ |
| **THB-Sensors** | ✓ | ✓ | ✓ |
| **QSS-Sensors** | ✗ | ✓ | ✓ |
| **Hotpoint-Sensors** | ✗ | ✓ | ✓ |

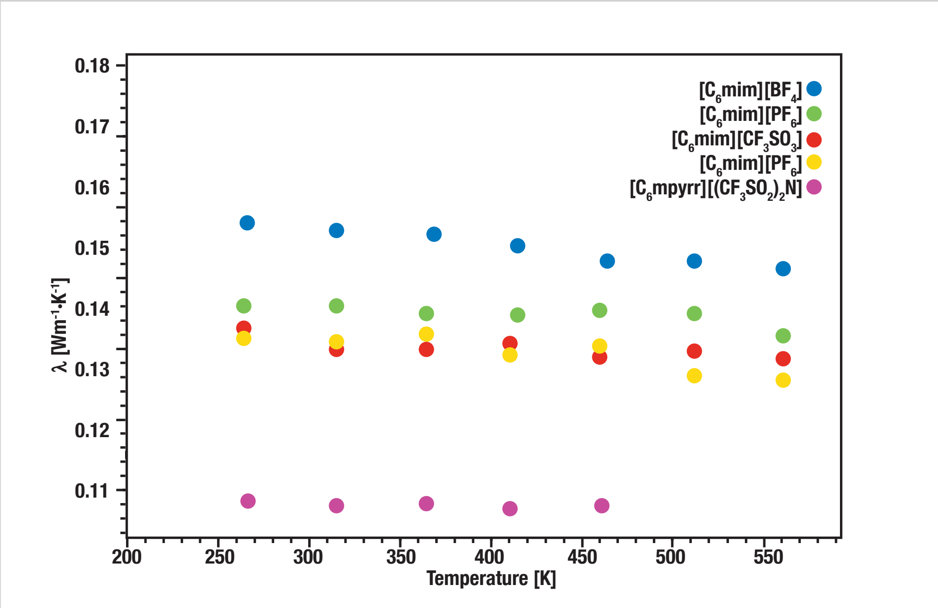
| | |
|---|---|
| **Measured parameters** | Thermal Conductivity, Thermal Diffusivity, Specific Heat, Effusivity |
| **Measuring method** | Transient Hot Bridge and Quasi Steady State Method |
| **Temperature range** | From -150°C up to 700°C |
| **Sample size** | Smallest sample size: 1.5 x 1.5 mm Largest sample size: unlimited |
| **Sensor Types** | Kapton, Ceramic |
| **Precision** | Better than 1% |
| **Accuracy** | Better than 4% |
| **Instrument dimensions** | 200mm x 200mm x 65mm |
| **Power requirements** | 36 Watt, 65 to 264V (AC), 47 to 63 Hz (US/EU socket included) |
| **Software** | Advanced THB Windows® based software interface. Allows fastest measurement times on the market. No room for user errors thanks to optimized, software-controlled measurement algorithms. This allows for most accurate and time saving measurements available. One button solution. Easy data export to Microsoft Excel® |

**Complies to the following Norms:**

- ASTM D 5930-01
- ISO 22007-2
- ASTM D 5334

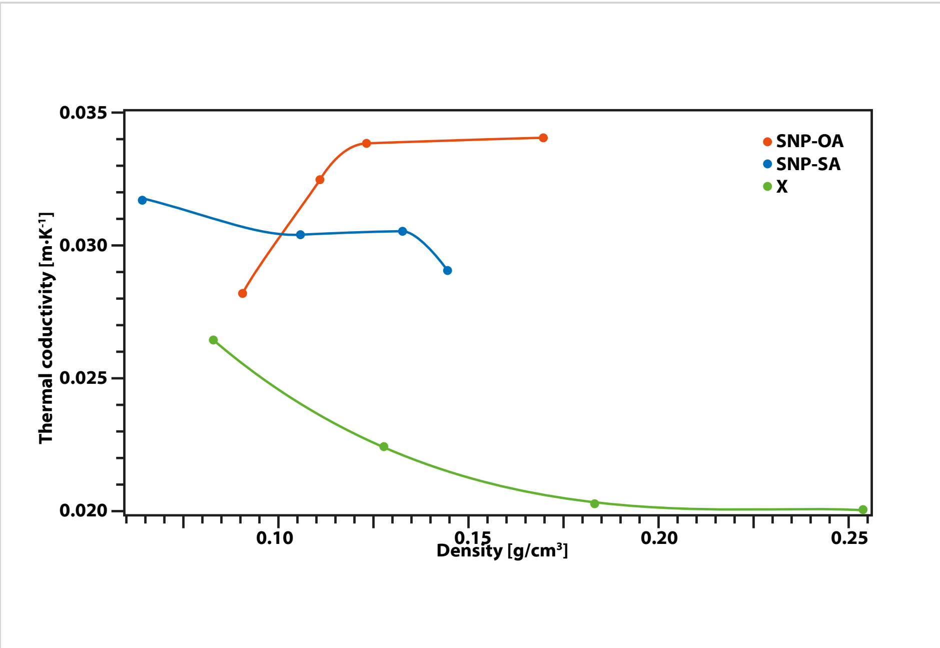
# Applications

## Thermal Conductivity of Ionic Liquids



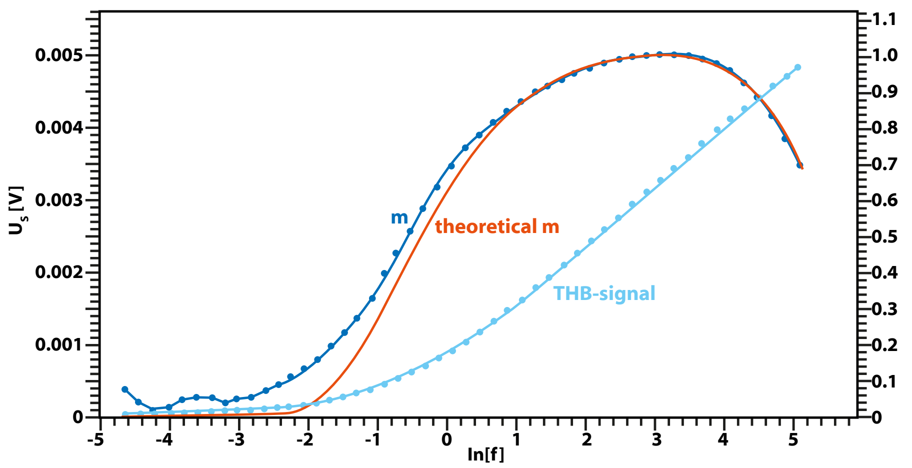

The LINSEIS Transient Hot Bridge Analyzer (THB) is the most accurate method on the market to measure the thermal conductivity of Ionic Liquids form -150 to 700 °C.
With this optimized Hot Wire technique, measurements can be performed in the liquid as well in the solid state at low temperatures. The measurement time is below one minute.
The figure shows the thermal conductivity of various Ionic Liquids as a function of the temperature.

## Aerogel powders



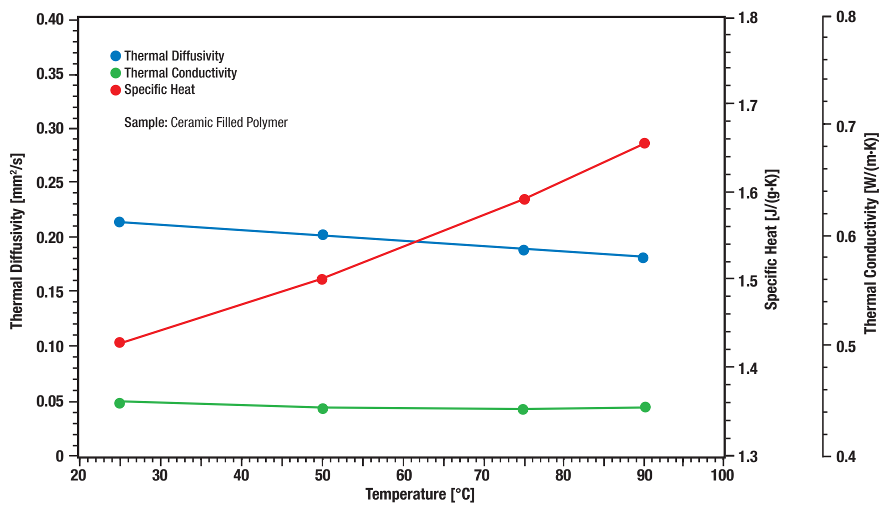

Thermal conductivity of Aerogel powders at different densities. The measurements have been performed with a powder sample holder with which the volume and therefore the density can be varied.

## Typical THB Signal




Typical THB measurement signal and its derivative signal. In the logarithmic time scale the sensor voltage increases linearly with increasing temperature due to the heating current. From the slope m, the thermal conductivity can be calculated; thermal diffusivity from the time to reach the maximum.

## Ceramic filled polymer




To optimize material properties a big variety of additives are known and used in material technologies and composite materials are of big interest, too. Even more important is the exact examination of the real properties of these materials, which can vary widely due to production conditions and mixture. Composite materials are widely used from electronic to building materials industries.

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