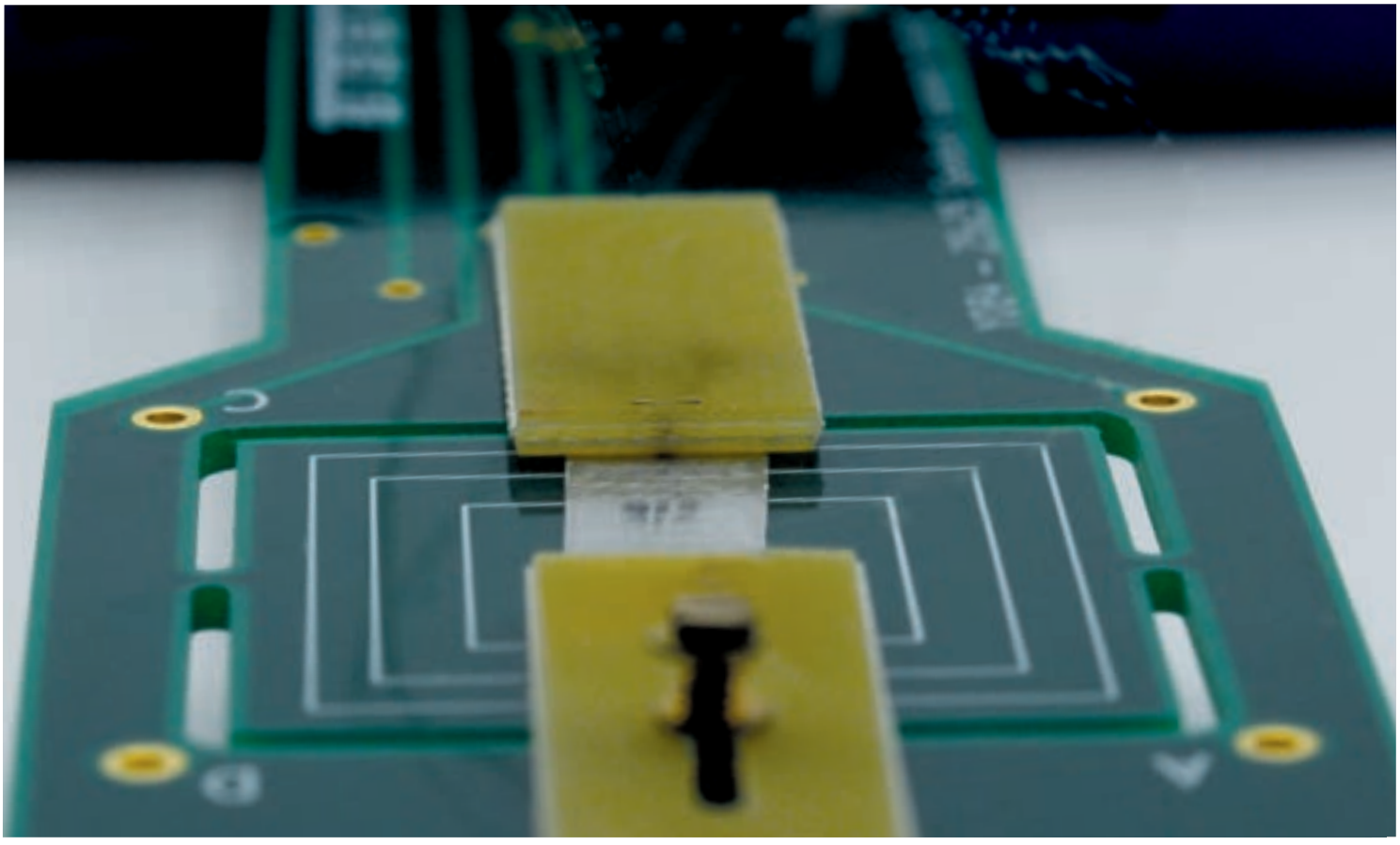
LINSEIS

THERMAL ANALYSIS

SEEBECK AND RESISTIVITY CHARACTERIZATION SYSTEM

LSR-1



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.

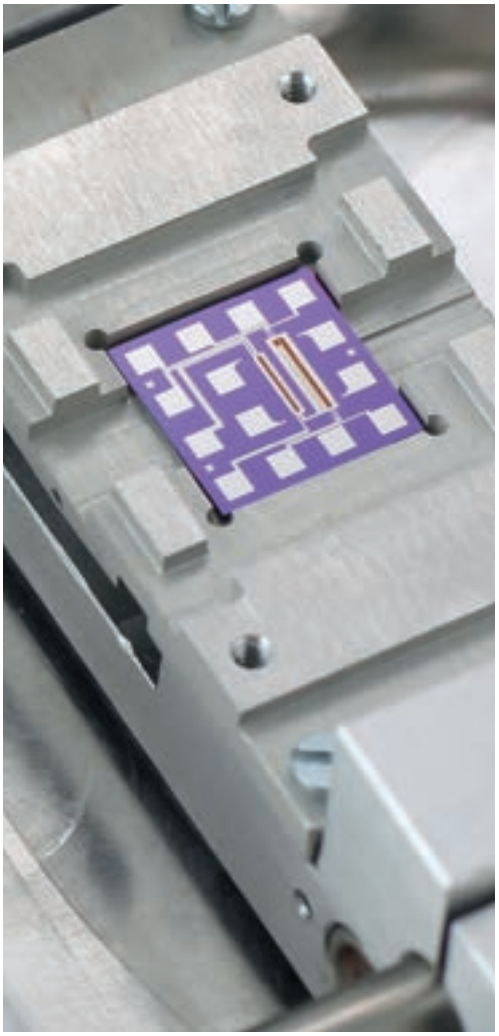
Customer satisfaction, innovation, flexibility and high quality are what LINSEIS represents. Thanks to these fundamentals, our company enjoys an exceptional reputation among the leading scientific and industrial organizations. LINSEIS has been offering highly innovative benchmark products for many years.

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



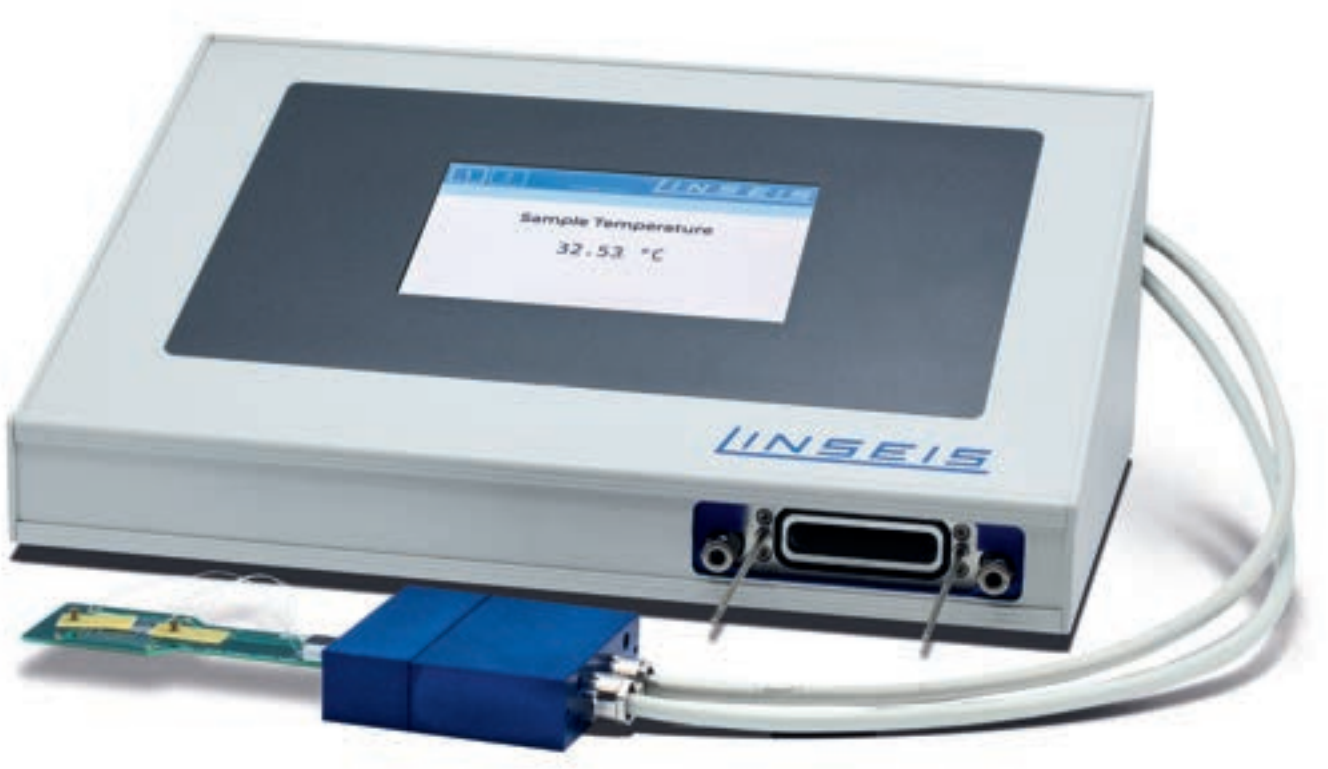
German engineering

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.

GENERAL



The LSR-1 System permits the characterization of metallic and semiconducting samples according to the well-known Van-der-Pauw (Resistivity) as well as static DC and slope Seebeck Coefficient measurement technique. It measures: Electrical Resistivity and Seebeck Coefficient.

The compact desktop setup offers fully integrated sample holders for various temperature requirements. Optional low temperature (LN2) attachments and a heated version up to 200°C as well as a vacuum tight measurement chamber in combination with a selection of gas dosing systems ensures that all fields of application can be covered.

The comprehensive Windows based software provides an easy to use user interface, including wizards for setting up a measurement profile and an integrated measurement data evaluation.

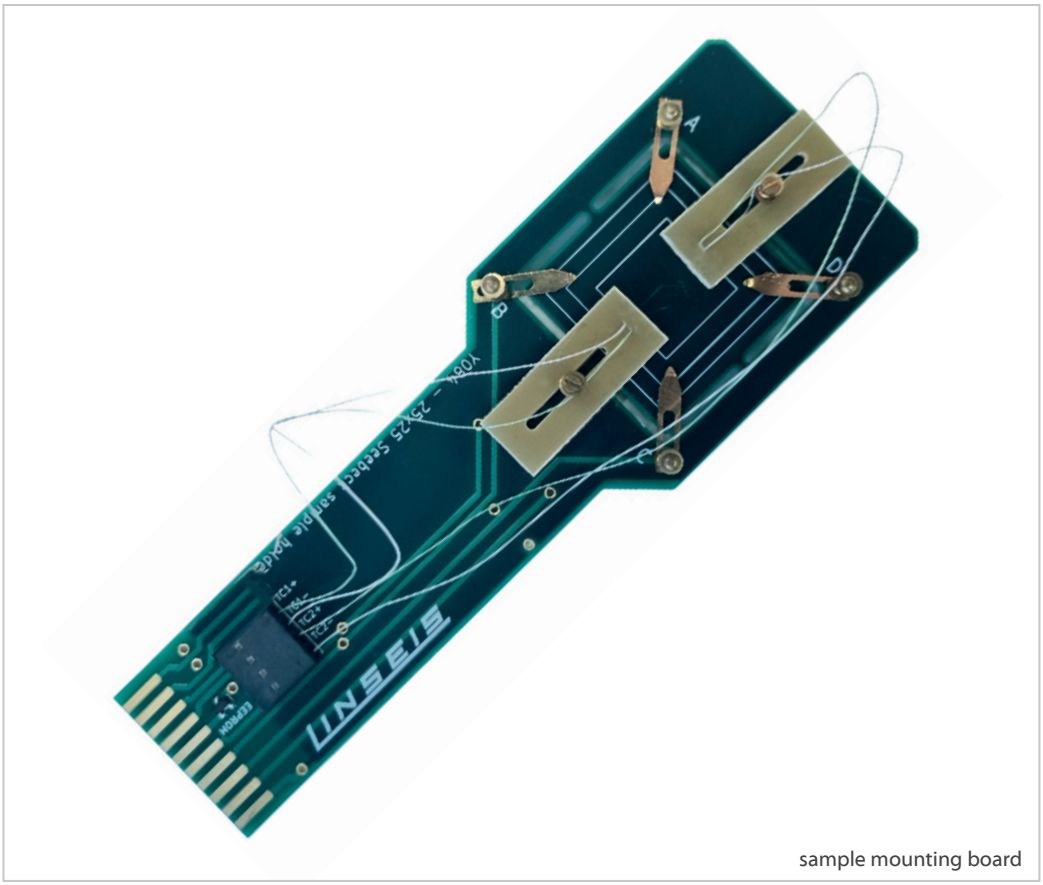
Measured parameters

- Resistivity / Conductivity (Ohm*cm or S/cm)
- Seebeck Coefficient (µV/K)

Key Features

- Modular system design. Can be upgraded with gas dosing system, illumination and Cryo-option.

- Vacuum tight measurement chamber for measurements under defined atmospheres.
- Easy to use and exchangeable sample holders, with integrated primary and secondary heater.
- Integrated state of the art measurement electronics provides most accurate results for challenging samples.
- The unit can be used for simultaneous measurement of both Seebeck Coefficient and Electric Resistance (Resistivity).
- The sample holder uses a special contact mechanism, permitting measurement of high reproducibility.
- V-I plot measurement can be made to qualify that the sensor is in good contact with the sample.
- Measurement is controlled by a computer, fully automatic measurements with selected temperature difference at a specified furnace temperature.
- Measured raw data is stored on disc.
- System comes with Constantan Reference incl. tables and certificate



sample mounting board

SPECIFICATIONS

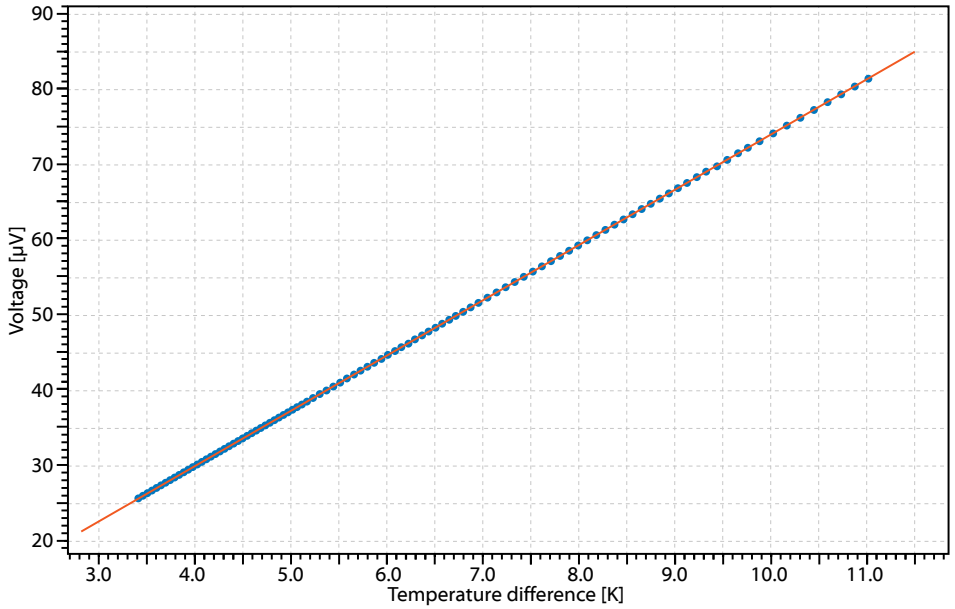
Thermoelectric power generation is a method of direct electric power generation from heat, based on the thermoelectric effect which was discovered by J. T. Seebeck, a German physicist in 1821. In the face of recent global warming, caused by carbon dioxide and depletion of fossil fuels, thermoelectric conversion devices are attracting attention because of its effective utilization of waste heat energies. LINSEIS has developed the LSR-1 system for a reliable, easy and fast characterization of thermoelectric materials at room temperature or in the temperature range from -160°C up to +200°C.

	LSR-1
Temperature Range	Basic unit: Room temperature to 200°C (hot side temperature) Cryo option: -160°C to 200°C (cold side and hot side temp.)
Heating rate	0.01 up to 100 K/min
Temperature precision	High accuracy class 1 type K thermocouple
Sample size	**Seebeck** L: 8 mm to 25 mm; W: 2 mm to 25 mm; T: thin film to 2 mm Resistivity L: 18 mm to 25 mm; W: 18 mm to 25 mm; T: thin film to 2 mm
Measuring Range / Method	
Sample holder	Integrated PCB Board with Primary and Secondary Heater
Seebeck coefficient **Static dc method**	Seebeck Coeffecient measurement range: 0 to 2.5 mV/K Temperature gradient up to 10K Seebeck Voltage measurement: range +-8 mV
Electric Resistivity **Four-terminal method**	10^{-4} up to 10^{7}(Ωcm)
Resolution	
Thermovoltage	0.5 nV/K (nV = 10^{-9} V)
Electric Resistivity	10 nOhm (nOhm = 10^{-9} Ohm)
Thermocouples	0.01°C
Accuracy	
Seebeck coefficient	+/-6% (Semiconductor*) +/-4% (Metal*)
Electric Resistivity	+/-9% (Semiconductor*) +/-4% (Metal*)
Repeatability	
Seebeck coefficient	+/-3,5%*
Electric Resistivity	+/-2%*
Atmosphere	Inert, reducing, oxidising, vacuum Low pressure helium gas or N2, recommended
Power requirement	230V / 110V 50Hz / 60 Hz
Vacuum Pump	optional

*depends on sample

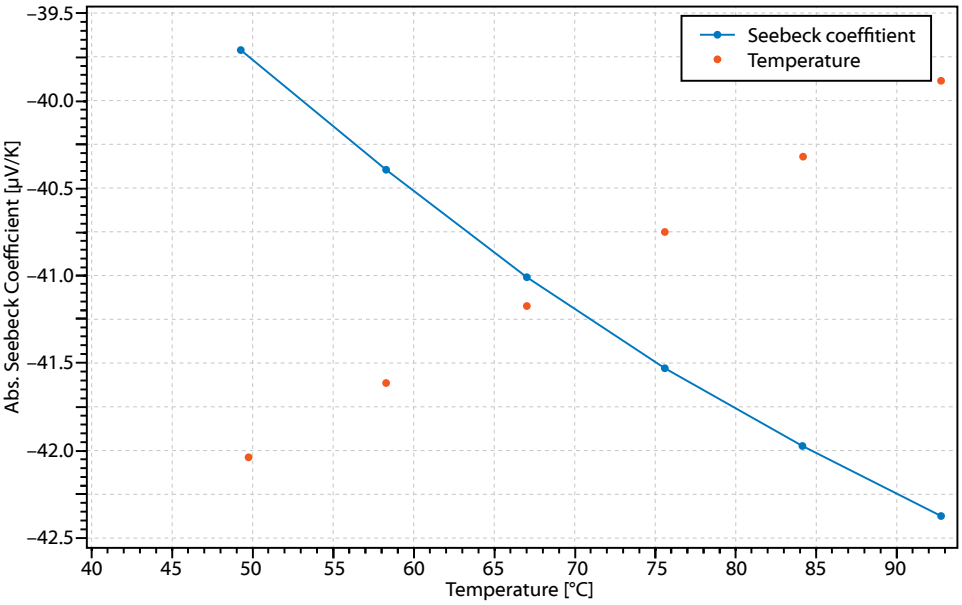
APPLICATIONS

Evaluating acquired data through linear regression



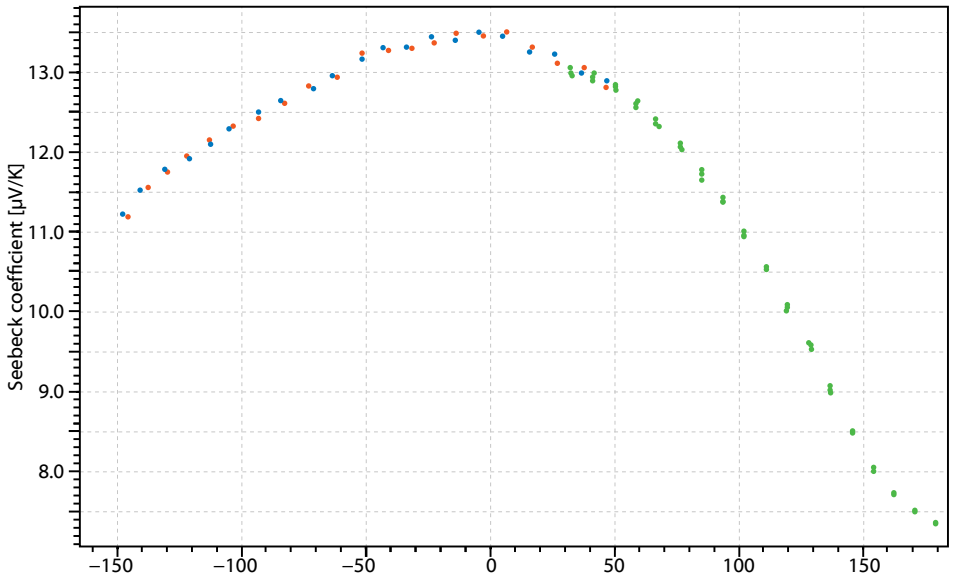
Seebeck voltage/temperature gradient (blue) measured while sweeping gradient heater power together with the linear regression (orange).
Seebeck coefficient is determined by the slope of the linear regression

Seebeck coefficient vs. temperature



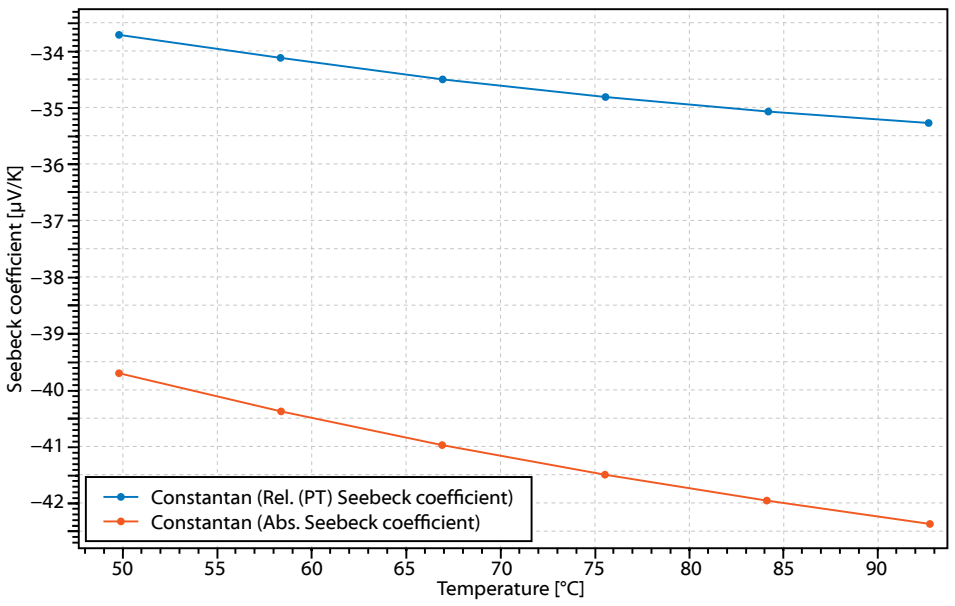
Seebeck coefficient measurement example of constantan

Absolute Seebeck coefficient



By this method the Seebeck coefficient is measured relative to Alumel. In order to calculate the absolute Seebeck coefficient Platinum is measured relative to the Alumel wire over temperature.

Constantan



The table for the absolute Seebeck coefficient deposited in the HCS software database and is used by the software for the automated calculation of absolute Seebeck coefficient and for the Seebeck coefficient relative to platinum (as it is often used as reference in the literature).

LINSEIS GmbH Germany
Vielitzerstr. 43
95100 Selb
Tel.: (+49) 9287 880 0
E-mail: info@linseis.de

LINSEIS Inc. USA
109 North Gold Drive
Robbinsville, NJ 08691
Tel.: (+1) 609 223 2070
E-mail: info@linseis.de

LINSEIS China
Kaige Scientific Park 2653 Hunan Road
201315 Shanghai
Tel.: (+86) 21 5055 0642
Tel.: (+86) 10 6223 7812
E-mail: info@linseis.de

LINSEIS France
2A Chemin des Eglantines
69580 Sathonay Village
Tel.: (+33) 6.24.72.33.31
E-mail: contact@ribori-instrumentation.com

LINSEIS Poland
ul. Dabrowskiego 1
05-800 Pruszków
Tel.: (+48) 692 773 795
E-mail: info@linseis.de

RMI, s.r.o.
Pernštýnská 116
533 41 Lázně Bohdaneč
Tel: 466 921 885, 404
e-mail: sale@rmi.cz
web: www.rmi.cz

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