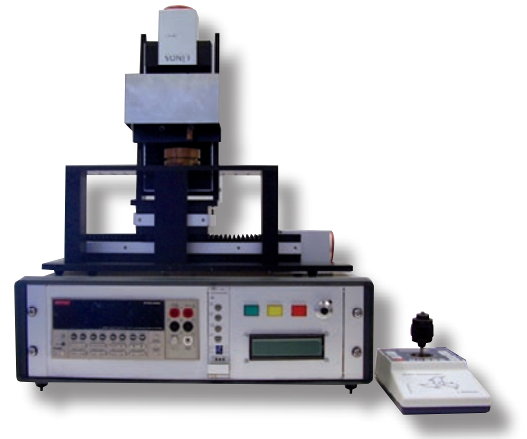
PSM – Potential-Seebeck Microprobe

A multidisciplinary measurement technique.

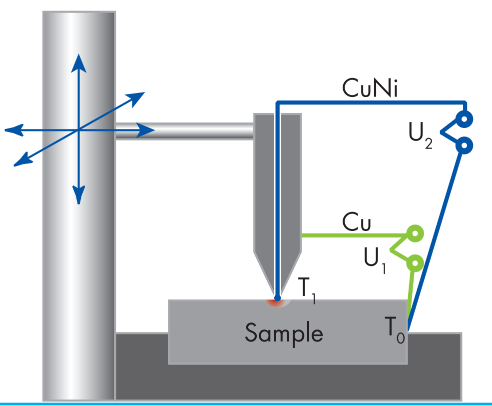
PSM



An instrument for spatial resolution of the Seebeck coefficient and the electrical conductivity.

The Seebeck-coefficient S is a measure of the electrically active constituents in a material. Different components in a sample are made visible by measuring the local resolution of S with a scanning thermoprobe and therefore a characterization is possible. This is particularly important for the investigation of functionally graded material.

A scanning Seebeck microprobe is a device for measuring the Seebeck coefficient on a samples surface which is spatially resolved to achieve information especially on the homogeneity or distribution of the components.



The electrical conductivity or resistivity

For many materials the homogeneity of the electrical conductivity plays an important role, especially in regards to the quality of semiconductors.

With the PSM both the electric resistivity and the ohmic contact resistance between different materials, e.g., in a stacked thermoelectric or other device, can be measured.

The measurement data for low resistance material are usually in the range of several µV and superpose with distortions. Therefore, and to avoid any thermoelectric effects, the current is a low frequent AC and the data are optimized with Fast Fourier (FFT) analysis.

PSM functionality

A heated probe tip is positioned onto the surface of a sample. The probe is connected with a thermocouple (in this case type T, Cu-CuNi) measuring the temperature T_1. The sample is in good electrical and thermal contact with a heat sink and also connected with a thermocouple measuring T_0. The probe tip heats the sample in the vicinity of the tip leading to a temperature gradient.
Combining the Cu-Cu and the CuNi-CuNi wires of the thermocouples the voltages U_0 and U_1 are measured yielding in the Seebeck coefficient S_S according to equations

$$U_0=(S_s-S_{Cu}) \cdot (T_1-T_2)$$

and

$$U_1=(S_S-S_{CuNi})\cdot(T_1-T_0)$$

yielding in

$$S_s=\frac{U_0}{U_1-U_0}(S_{Cu}-S_{CuNi})+S_{Cu}$$

which is the Seebeck coefficient of the sample at the position of the probe tip. Mounting the pointed probe to a three dimensional micro-positioning system allows the determination of the individual thermopower of each single sample position for a certain temperature, the easiest case room temperature.
The result is a two dimensional image of the Seebeck coefficient of the sample surface.

Using a special sample holder where an electrical current can be applied to the sample, the potential between one end and the probe tip can be measured, that is related to the electrical conductivity at the samples position. Thus in the same run a spatially resolved imaging of the Seebeck coefficient as well as the electrical conductivity can be performed.
The specific resistivity can be calculated for each single measurement point according to Ohm´s law.

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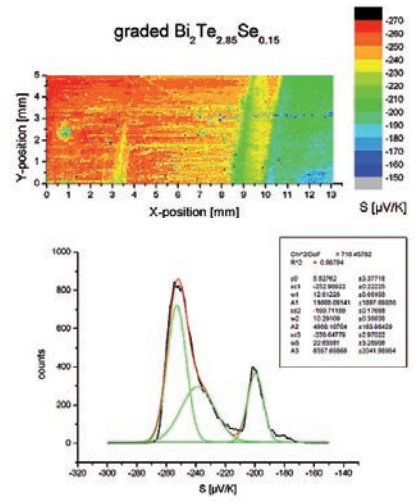
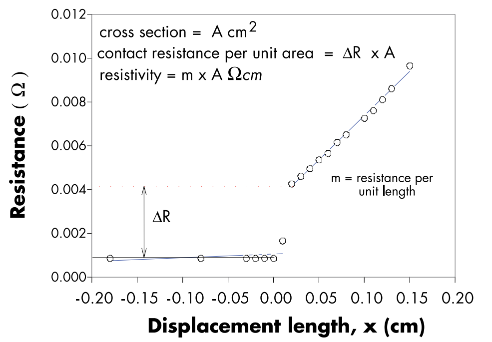
Applications



Seebeck coefficient in graded material



Contact resistance

The contact resistance of any ohmic contact can be measured with the potential probe. The gap in the measured resistance ΔR is proportional to the contact resistance.

Technical Setup

The measuring equipment consists of the following components:

- three-axis micro positioning stage with controller unit
- heatable measuring thermoprobe
- contact detection system
- analog multiplexer
- digital voltmeter
- current supply
- PC with GPIB interface and controlling program
- sample holder

Specifications

Positioning accuracy:	1 µm
Reproducibility (bidirectional)	3 µm.
Travel:	x-direction 150 mm, y-direction 50 mm
Local resolution of S	up to10 µm, depending on the sample´s thermal conductivity
Measuring time	<4 s per local data point
Reproducibility	better than 3% of the Seebeck coefficient and electrical conductivity
Seebeck accuracy	better than 5%
Accuracy electrical conductivity	better than 5% for highly doped semiconductors; better than 8% for metals
Local resolution:	1 µm

Application fields

- Measurement of the homogeneity in material for thermoelectrics, superconductivity, fuel cells, electro-ceramics and semiconductors.
- Prove of gradients in functionally graded material
- Prove of degradation effects
- Drift of resistance in NTC/PTC
- Conductivity losses in solid electrolytes
- Electrical conductivity losses in cathodic materials
- Decrease of peak temperature in GMR; changes in resistivity
- Quality control

The PSM measurement technique was developed by Panco in cooperation with the German Aerospace Centre DLR.

The Panco, Physics Technology – Development and Consulting company is specialized in the development and marketing of facilities in physics technology. This comprises the development of complex measurement devices for physical properties as well as control units and facilities which use physical effects for research and industry.

Panco's main goal is the application of thermoelectric effects.

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