

## Technical Setup

- three axis micro positioning stage with controller unit
- joy stick control
- heatable measuring thermoprobe
- force contact detection system
- analogue multiplexer
- digital voltmeter
- lock-in amplifiers for accurate electrical measurement
- camera
- PC with controlling program
- sample holder

## Specifications

|                                    |  |
|------------------------------------|--|
| <b>Positioning accuracy</b>        | Unidirectional: 0,05 $\mu\text{m}$ ;<br>bidirectional: 1 $\mu\text{m}$ |
| <b>Max. scanning area</b>          | 100 mm $\times$ 100 mm (typ)<br>155 mm $\times$ 155 mm<br>(OnReq)      |
| <b>Local resolution</b>            | up to 5 $\mu\text{m}$ depending on<br>thermal conductivity             |
| <b>Signal resolution</b>           | 100 nV (DVM)   |
| <b>Reproducibility</b>             | within 3%  |
| <b>Uncertainty</b>                 |  |
| <b>Seebeck</b>                     | < 3% (semiconductors)<br>< 5% (metals)                                 |
| <b>Electrical conductivity</b>     | < 4%   |
| <b>Measurement range:</b>          | 100 S/cm... 10000S/cm  |
| <b>...with higher uncertainty:</b> | <10 S/cm... >100000S/cm  |
| <b>Measurement time</b>            | < 4-20s per scan point   |
| <b>Size total</b>                  | ca. 55cm x 58cm x 62cm   |

## Application fields

- Measurement of the homogeneity in material for thermoelectrics, superconductivity, fuel cells, electroceramics and semiconductors.
- Proving gradients in functionally graded material
- Proving degradation effects
- Drift of resistance in NTC/PTC
- Losses of conductivity in solid electrolytes
- Losses in electrical conductivity of cathodic materials
- Decreasing of peak temperature in GMR; changes in resistivity
- Quality control

## General

The PSM measurement technique was developed by PANCO in cooperation with the German Aerospace Centre DLR. This second generation of PSM is based on the successful PSM I, improved and with a bigger resolution of the linear stages and a broader measurement range, especially for the potential measurement.

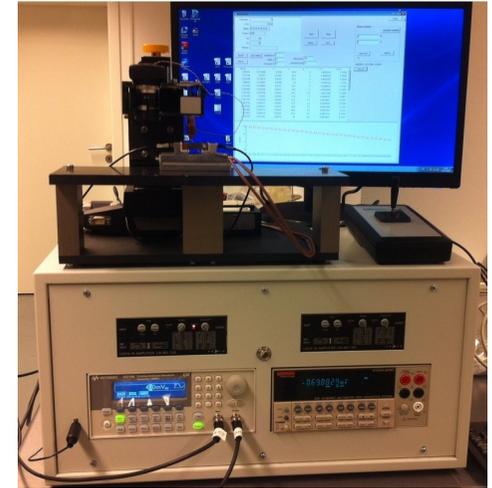
PANCO, Physics Technology – Development and Consulting, is a company specialised in development and marketing of facilities in physics technology. That is the development of complex measurement devices for physical properties but also control units and equipment for research and industry using physical effects. Particularly the application of thermoelectric effects is the goal of PANCO. PANCO is a reliable partner in international research projects and EU – projects.



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## PSM II 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 become visible by measuring the local resolution of  $S$  with a scanning thermoprobe and therefore a characterization is possible. Especially this is important for investigating functionally graded material.

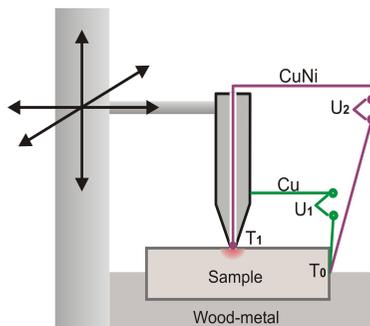
A scanning Seebeck microprobe is a device for measuring the Seebeck coefficient on a samples surface spatially resolved to achieve information especially on the homogeneity or distribution of the components.

### The electrical conductivity or resistivity

For many materials the homogeneity of the electrical conductivity plays an important role, especially for good quality of semiconductors.

With help of this tool not only the electric resistivity can be measured, but also the ohmic contact resistance between different materials, e.g., in a stacked thermoelectric or other device.

The measurement data for low resistance material are usually in the range of several  $\mu\text{V}$  and superpose with distortions. Therefore, and to avoid any thermoelectric effects the current is a low frequent AC and the data are optimised with a lock-in amplifier.



## Functionality

A heated probe tip is positioned onto the surface of a sample. The probe is connected with a thermocouple (type T) 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

$$U_0 = (S_s - S_{Cu}) \cdot (T_1 - T_0)$$

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 for the determination of the individual thermopower of each single sample position.

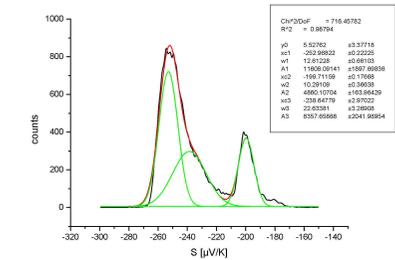
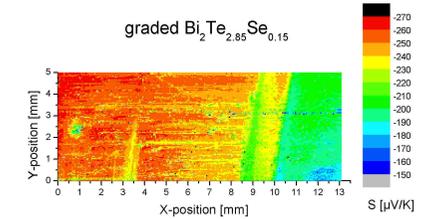
The result is a two dimensional image of the Seebeck coefficient of the sample surface that can directly be compared with a picture from the inbuilt camera that can also be used for an easy setting of the measurement area.

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 and of the electrical conductivity can be performed.

The specific resistivity can be calculated for each single measurement point according to Ohm's law.

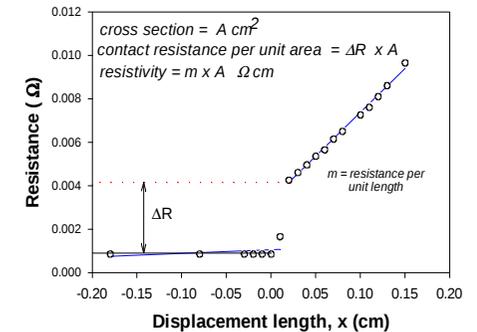
## Applications

### 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  $\Delta R$  is proportional to the contact resistance.