Handout

Deutsches Zentrum
für Luft- und Raumfahrt

Seebeck micro-thermoprobe

Measured values

- Seebeck coefficient

Description of facility

The Seebeck coefficient S as the most relevant thermoelectric (TE) material parameter is deter¬mined by the TE material itself, by variation of the chemical composition (for example for solid solutions) as well as by microstructure, in particular the concentration of grain boundaries or electrically conductive inclusions etc. The Seebeck coefficient is systematically related to the mechanism of charge and heat transport to the carrier density and thus to the electrical and thermal conductivity and thermoelectric figure of merit.

Furthermore, S strongly varies with temperature in most TE materials. At constant temperature, local scans of the Seebeck coefficient over extended surface areas provide a unique characterisation tool of the homogeneity or inhomogeneity of materials with respect to their electrical properties. As the Seebeck coefficient is systematically correlated to the electrical conductivity, this technique is also suitable for the evaluation of standard materials of semiconductor technology with regard to homogeneity of doping distribution.

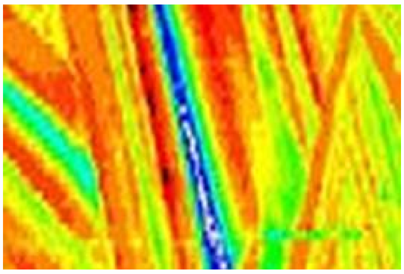
Along with methods for determination of temperature-dependent TE properties on homogenous monolithic specimens, local imaging of the Seebeck coefficient reaching sub-millimetre resolution is of particular importance for the development of functionally graded TE materials.

The easy functional principle was first implemented in an automated set-up for the homogeneity characterisation of bismuth telluride TE materials at the Martin-Luther-University of Halle Wittenberg (Germany). DLR took over the unique technique of the Seebeck micro thermoprobe, which was then qualified at DLR for application to a variety of materials and diagnostically utilised for a multitude of transports-physical and technological tasks, e.g.

- homogeneity analysis and semiconductor physical evaluation of TE materials based on bismuth telluride
- analysis of functionally graded and segmented TE structures
- phase homogeneity of zinc antimonide grown by normal freezing
- electrical homogeneity of large Clathrate crystals made by Czochralski growth
- homogeneity studies on lead / silver antimony tellurides
- functional homogeneity of large-volume hot pressed TE pellets (up to 80 mm in diameter)
- SMP as a quick method for determination of the Seebeck coefficient on arbitrary shaped pecimens at room temperature.

The method is of particular importance for preparative material development because it already allows a Seebeck measurement even if just needle-like crystals of about 100 µm in thickness can be prepared. The feasibility of Seebeck measurements on individual micro-crystals allows direct comparison with functional properties that have been integrally measured on monolithic (for example pressed polycrystalline) specimens.
An advanced set-ip of the Seebeck

Seebeck micro-thermoprobe - Principle



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microprobe has been tested that allows for control of the sample temperature below and above ambient temperature.

Technical specifications

- Spatially resolved 1D und 2D scans
- Signal resolution *ΔS/S*:<2%
- Maximal offset: 2 μV/K
- Spatial resolution: 20...50 μm (depending on the thermal conductivity of the sample)
- Positioning accuracy: < 1 μm
- Operation at room temperature (extension for temperature range 90–400 K)
- Temperature stability: 0.1 K
- Acquisition rate: 1-5 sec per data point
- Non-destructive testing method
- Data output formats: Line scans, 2D area scans (waterfall graph or coloured map), statistics of data values

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Application
Local scans of the Seebeck coefficient

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This handout, and cross-references to related measurement techiques and facilities are available at: http://messtec.dlr.de/link-290-en.

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