Deutsches Zentrum
DLR für Luft- und Raumfahrt

Handout

High temperature measurement of Seebeck coefficient and electrical conductivity (300 K–1000 K)

Measured values
- Seebeck coefficient
- Electrical Conductivity
- Room temperature

Description of facility
The Seebeck coefficient is the central material parameter for the development of thermoelectric materials and applications. It is the essential parameter for the formation of an output voltage by thermoelectric generators and for the sensitivity of thermoelectric sensors. In most materials it is closely related to the concentration of charge carriers, which has to be adjusted to reach best thermoelectric materials and system properties. A substantial portion of material-relevant information about thermoelectrics can be already drawn from the relation between Seebeck coefficient and electric conductivity such as from the variation of these quantities with temperature.

Extensive thermoelectric materials characterisation for the development of high temperature materials requires measurement of both properties in an as wide as possible temperature range from room temperature or below up to the highest achievable temperatures. Commercial measuring devices fulfilling these requirements are not yet available. Main challenges in the implementation of according laboratory facilities consist in reliable contacting of signal leads and attachment of thermometers (thermocouples) to the specimen, for precise temperature measurement directly at the location of thermo-voltage measurement as well as reliable control of temperatures and temperature gradients in the sample holder by means of controlled heaters and radiation shielding.

Because there are no absolute standards to date for the measurement of the Seebeck coefficient, high precision of measurements can only be achieved by comparing the results of equipment of different construction and methodology and subsequent elimination of systematic errors related to constructive and methodical causes. The DLR operates several Seebeck measuring systems for prismatic and disc geometry of specimens, providing both complement and redundancy in geometry, principle, and temperature range (partly overlapping). Pellet shaped sample type (12.7 mm in diameter) is favoured at DLR for measurement up to high temperatures.

Sample holder of high temperature measuring system in van der Pauw geometry (partially assembled)

The high temperature sample holder for simultaneous measurement of the Seebeck coefficient and electrical conductivity consists of two symmetric molybdenum blocks assembled on a ceramic base (centre of figure). Gradient heaters have been incorporated in cavities along the blocks. To each of the blocks one half of the symmetric ceramic sample supports is attached. A ceramic bridge which forms the abutment of a graphite spring is joined to both blocks by screw rods. The spring is pressing the pellet-shaped specimen against the sample holder. Two sensing probes for temperature and electric potential are pressed from below against the specimen via thin channels through each half of the sample support. Isothermal conditions for the measurement of electrical conductivity are achieved as good as possible per radiation shields (left). Ceramics-isolated high temperature signal leads lead from the sample holder to a coolable ceramic feed

Sample holder of high temperature measuring system in van der Pauw geometry (partially assembled)

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line. The sample holder allows a quick and easy exchange of the specimen. At present the equipment covers a temperature range from room temperature up to 700 °C (enlargement up to 1000 °C is underway). An alternative construction accomplishes a comparably high temperature measurement by four-point in-line geometry.

Application
Measurement of Seebeck coefficient and electrical conductivity

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This handout, and cross-references to related measurement techiques and facilities are available at: http://messtec.dlr.de/link-287-en.

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