Deutsches Zentrum
DLR für Luft- und Raumfahrt

Handout

CTEM – Combined ThermoElectric Measurement

Measured values
- Seebeck coefficient (differential thermo-voltage, thermopower)
- Electrical conductivity
- Thermal conductivity
- Thermoelectric figure of merit (direct measurement by the HARMAN method)

Description of facility
The CTEM (Combined ThermoElectric Measurement) combines temperature-dependent measurement of the four essential material parameters of a thermoelectric material:

- Seebeck coefficient (differential thermo-voltage, thermopower)
- Electrical conductivity
- Thermal conductivity
- Thermoelectric figure of merit (direct measurement by the HARMAN method)

Measurement of the first three quantities simultaneously to the figure of merit, which on the other hand can be calculated from those after a simple formula, provides methodical redundancy allowing for the detection and elimination of systematic errors. This redundancy turns the technique into a most reliable method.

The construction of the CTEM – placing a heatable evacuated measuring cell in a bath cryostat for liquid nitrogen – facilitates measurement within a temperature range from 80 K to 750 K. A definite measurement of thermal quantities (thermal conductivity and thermoelectric figure of merit) above 100 °C requires careful radiation shielding.

The measuring principle of CTEM involves cylindrical or prismatic sample shape. Specimens are soldered between two copper blocks in which thermocouples are inserted for temperature measurement and electric heaters for control of a temperature difference over the specimen.

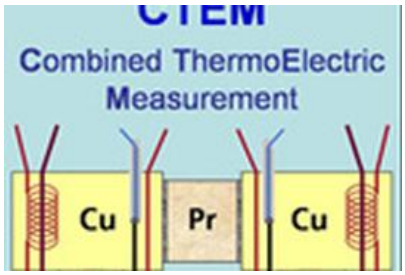
After adjustment of a temperature difference between the blocks, the Seebeck coefficient is determined from the thermo-voltages of the two pairs of thermocouple wires.

The electrical conductivity is determined by an AC method with subsequent numerical Fourier analysis for the elimination of interfering signal frequencies. The measurement of thermal conductivity is based on a dynamic absolute method. The relaxation of a temperature difference over the specimen can easily be followed via the thermo-voltage over the specimen decaying with time. Knowing the heat capacity of the blocks, the thermal conductivity of the sample can be deduced from the time constant obtained by a fitting procedure of the decay. The HARMAN method determines the thermoelectric figure of merit from the ratio of the thermo-voltage over the specimen (forming under DC current flow and adiabatic conditions) to the ohmic potential drop.

The simultaneous method of the CTEM reduces the effort of the measurement (sample preparation, mounting, and time consumption) and ensures that thermoelectric quantities, which are evaluated for consistent interpretation of transport phenomena, are measured on the very same specimen, thus limiting the risk of misinterpretations.

The equipment includes a set of specimen holders of different size and

CTEM ? Combined ThermoElectric Measurement



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shape, allowing adjustment to a wide range of specimen dimensions (cylindrical, prismatic).

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This handout, and cross-references to related measurement techiques and facilities are available at: http://messtec.dlr.de/link-285-en.

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