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Fine ceramics (advanced ceramics, advanced technical ceramics) — Measurement of Seebeck coefficient and electrical conductivity of bulk-type thermoelectric materials at room and high temperatures

Céramiques techniques — Mesurage du coefficient de Seebeck et de la conductivité électrique de matériaux thermoélectriques en vrac à température ambiante et à haute température

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Contents

Page

Foreword

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This document was prepared by Technical Committee ISO/TC 206, *Fine ceramics*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Fine ceramics (advanced ceramics, advanced technical ceramics) — Measurement of Seebeck coefficient and electrical conductivity of bulk-type thermoelectric materials at room and high temperatures

1 Scope

This document specifies the measurement methods for the electronic transport properties of bulk-type thermoelectric materials at room and elevated temperatures. The measurement methods cover the simultaneous determination of Seebeck coefficient and electrical conductivity of bulk-type thermoelectric materials in a temperature range from 300 K to 1 200 K. The measurement methods are applicable to bulk-type thermoelectric materials used for power generation, energy harvesting, cooling and heating, among other things.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO 23331, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for total electrical conductivity of conductive fine ceramics*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
thermoelectric figure of merit
zT
dimensionless factor representing the thermoelectric conversion efficiency of a given material

3.2
thermoelectric power factor
$S^2\sigma$
characteristic value of a thermoelectric material given by the product of the square of Seebeck coefficient (S) and electrical conductivity (σ)

Note 1 to entry: The units of the thermoelectric power factor are watts per metre per square kelvin (W/mK^2).

3.3
Seebeck coefficient
S
intrinsic property which describes the induced voltage (thermal electromotive force, *E*) from a given temperature difference (ΔT) in a material

Note 1 to entry: The units of the Seebeck coefficient are microvolts per kelvin (μV/K).

3.4
electrical conductivity
σ
ability of a material to allow the transport of electric charges

Note 1 to entry: The units of electrical conductivity are Siemens per centimetre (S/cm).

4 Principle

This document is for simultaneously measuring the Seebeck coefficient and the electrical conductivity of bulk-type thermoelectric materials using one measurement system. The off-axis four-terminal method can be used to simultaneously measure the Seebeck coefficient and the electrical conductivity of bulk-type thermoelectric material using one measurement system. As shown in Figure 1, the specimen is set between two metal blocks in the heating zone and two thermocouple probes separately contact the surface of the specimen. The measurement of the Seebeck coefficient of a bulk-type thermoelectric material is necessary to measure the temperature difference between two positions (point H and point C) on a specimen and the voltage across the two same positions (Figure 1). Seebeck coefficient can be calculated by following Formula (1):

$$S = E / \Delta T \tag{1}$$

where

E is the induced thermoelectric voltage (thermal electromotive force) between the point H and point C of the specimen;

ΔT is the temperature difference between the point H and point C (= T_H - T_C).

For Seebeck coefficient measurement, measured temperature is the average temperature of the hot- and cold-side thermocouple probes.

By using the measuring system illustrated in Figure 2, electrical conductivity is also measured based on the four-terminal method. This method is conducted by placing four probes. Constant current is applied through the two outmost probes, causing a measurable voltage drop, *V*, between the two inner probes. The electrical resistance, *R*, is calculated using Ohm's law following Formula (2):

$$R = V / I \tag{2}$$

where

V is the voltage;

I is the current.

The resistivity, *ρ*, is be calculated following Formula (3):

$$\rho = RA / l \tag{3}$$