Comparative Seebeck Coefficient Measurements on Ceramic and Compacted Powder Column Samples; Case of ZnO

Nataliya Sharova[1], Christian Kjølseth[2], Skjalg Erdal[2], Truls Norby[2]

[1] *NorECs Norwegian Electro Ceramics AS, Oslo Research Park, Gaustadalleen 21, NO-0349 Oslo, Norway*

[2] *University of Oslo, Department of Chemistry, SMN, FERMiO, Gaustadalleen 21, NO-0349 Oslo, Norway*

Introduction

The *Seebeck coefficient* (thermoelectric power) is a basic quantity in the characterization of the electronic structure and thermoelectric properties of materials and is defined as

$$Q = \Delta E/\Delta T$$

where ΔT – is the temperature difference across specimen and

ΔE – the generated potential difference.

The Seebeck coefficient yields information of the sign and entropy and, in turn, concentration of the charge carriers. Via the conductivity it furthermore yields the charge mobility. Materials with large Seebeck coefficients, high electrical conductivity, and limited thermal conductivity are of interest for use in thermoelectric generators.

Objective

Some materials obtained as powders from synthesis cannot be cast or sintered into solid bodies as a consequence of, for example, low decomposition temperature.

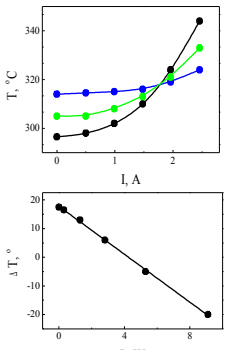
NorECs AS has developed a sample holder in which a column of powder is lightly compacted and held during Seebeck coefficient measurements.

In the present work we compare results from this setup with those on a more commonly applied ceramic bar sample, using ZnO as a case study.

Experiment

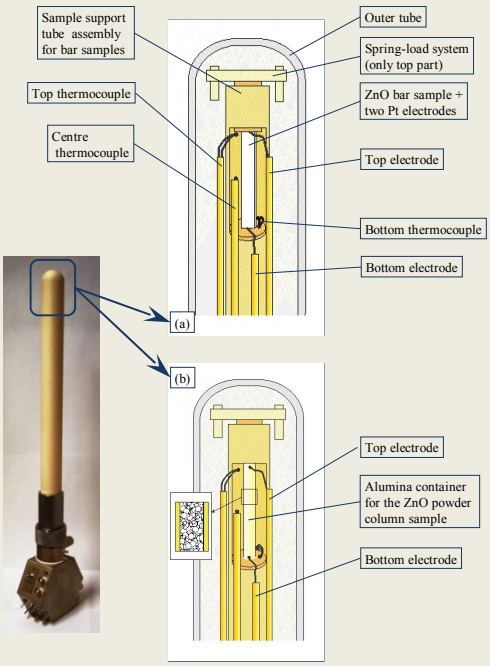
- The ceramic ZnO sample was sintered at 1000 °C, the ZnO powder sample was pre-calcined at 450 °C.
- A special alumina container was made for the powder column sample. The distance between electrodes was approximately 4 cm for both setups.
- Both samples were mounted in NorECs ProboStat sample holders supplied with wet H_2 from the same gas mixer.
- Different temperature gradients were obtained by moving the cell away from the centre of the hot zone in the furnace. Alternatively the temperature gradient can be created using a ProboStat internal heater (Fig.1).
- T = 300 – 450 °C

Fig.1. Temperature difference across the ZnO bar sample in the ProboStat measurement cell created using the internal heater.



a) Temperatures at the top (●), center (●) and bottom (●) thermocouples as a function of current sent through the internal heater.

b) Temperature gradient across the bar sample as a function of supplied power. Calculated from the Fig. 1a.



Schematic of the samples setup in the ProboStat measurement cell for the bar (a) and column powder (b) samples (not to scale).

Results and Discussion

- The Seebeck coefficient measurements were carried out by measuring the voltage and temperature difference over the ZnO ceramic and powder column samples in the following cell:

$$(T_1)Pt \mid H_2O(P_{H_2O}), H_2(P_{H_2}) \mid ZnO \mid H_2(P_{H_2}), H_2O(P_{H_2O}) \mid Pt(T_2)$$

- Typical experimental dependences for the EMF of the cell as a function of the temperature difference are shown in the Fig.2.
- The Seebeck coefficients were calculated as the slopes of the linear fits of the curves and were 0.41 and 0.33 mV/K for the ceramic and powder samples, respectively.
- The deviations may probably be attributed to
  - thermocouple inaccuracies
  - varying degree of equilibrium with the gas phase

and are within the uncertainty of the method under the conditions applied.

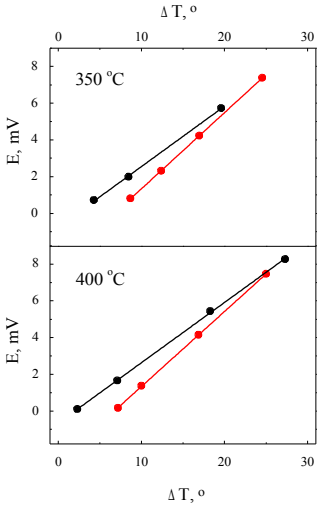


Fig.2. Voltage measurements on ZnO bar (red) and ZnO powder column (black) samples as a function of the temperature difference over the sample in wet H_2 at 350 and 400 °C.

Conclusion:

The Seebeck coefficients may be measured with reasonable confidence on compacted powder columns in the specially developed sample holder in cases where solid bodies are not available.