Evaluation of Homogeneity by Micro-scale Measurement of Thermal and Electric Properties Using Thermal Probe

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To confirm performance in thermoelectric materials and thermoelectric module, evaluation of not only average performance but also homogeneity in sample is necessary. Ulvac-riko, Inc. has been developing Thermoelectronic Characteristics Evaluation Instrument (ZEM) designed for simultaneous measurement of Seebeck coefficient and electric resistivity, and Laser Flash Method Thermal Constant Measuring System (TC) designed for simultaneous measurement of thermal diffusivity and specific heat capacity. These instruments can determine thermal properties of homogeneous sample very accurately, but the shape and dimensions of the sample are somehow restricted in order to guarantee the accuracy. On the other hand, there is a strong demand for instruments that can evaluate lateral distribution of such properties with micrometer-scale. We have been developing a new product named Scanning Thermal Probe Micro-analyzer (STPM). Tip size of thermal probe is about 20 μm, and contact area between thermal probe and sample is very small. STPM is applicable to distribution measurement of thermal properties with fine scale. In this presentation, we explain the principle of the measurement in STPM and report the distribution evaluation of Seebeck coefficient in bulk sample.

The distribution of Seebeck coefficient and thermal conductivity in bulk sample is simultaneously estimated using STPM. Seebeck coefficient is estimated from the electrical potential and temperature of the contact point. The temperature at the contact point is calculated from temperatures in the heated probe. On the other hand, thermal conductivity is calculated from temperatures in the probe after making a contact. As a demonstration, the distribution of Seebeck coefficient of homogeneity thermoelectric material (press-sintered $(Bi,Sb)_2Te_3$) was evaluated by using STPM. The average of Seebeck coefficient was calculated at 220 $\mu V\ K^{-1}$. The standard deviation was estimated at 9 $\mu V\ K^{-1}$. The standard deviation corresponds to maximum unevenness of thermoelectric materials by the performance in STPM.

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