APPLICATION**NOTE**

Measurement of the Thermal Conductivity of Thermoelectric Materials by Means of the Laserflash Technique

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Introduction

For thermoelectric applications, different materials such as bismuth telluride, plumb telluride and skutterudite are increasingly employed. For an economic use, for example, in automobiles or thermal power plants, high efficiency of the thermoelectric systems is required. This is indicated by the so-called figure of merit (ZT). Along with a high Seebeck coefficient and high electrical conductivity, a low thermal conductivity is also required. The objective of the investigations is to reduce the phononic contribution and to increase the electronic contribution of the thermal conductivity. This can, for example, be realized by means of doping or establishment of structural conditions (targeted phonon scattering).

Experimental

The thermal conductivity measurements were carried out with the LFA 457 *MicroFlash*® (figure 1) on disk-shaped samples with a thickness of 2 to 3 mm and a diameter of 12.6 mm. The front surfaces of the samples were plane-parallel.

1 LFA 457 *MicroFlash*® for measurements between -125°C and 1100°C

Results and Discussion

Shown in figure 2 are the specific heat capacity, thermal diffusivity and thermal conductivity of $Bi_{0,5}Sb_{1,5}Te_3$ (P-38). The specific heat shows only a slight increase with increasing temperature. The thermal diffusivity decreases in the low-temperature range with increasing temperature and strongly increases at higher temperatures. At low temperatures, this corresponds to the behavior of a mere phononic conductor with the well-known 1/T dependence [1]. At higher temperatures, the contribution by the free electrons/holes which are increasingly formed in a semiconducting material with increasing temperature dominates. The thermal conductivity follows this trend due to the low temperature dependence of the specific heat capacity.

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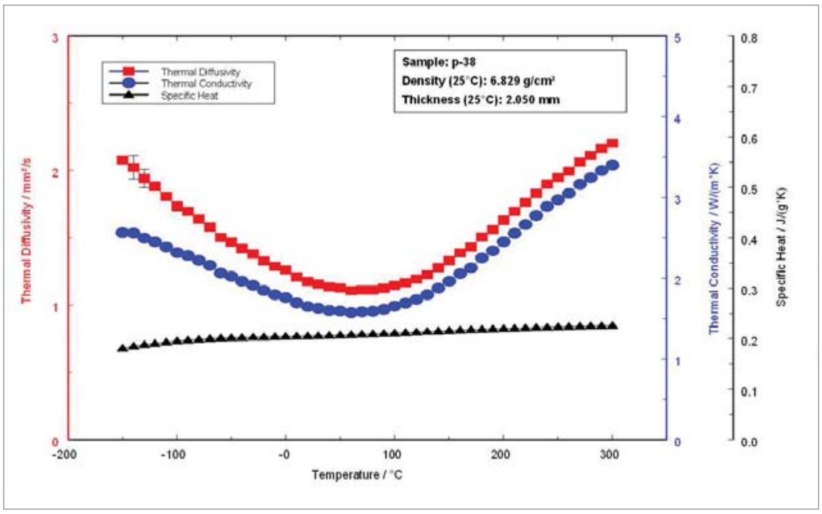
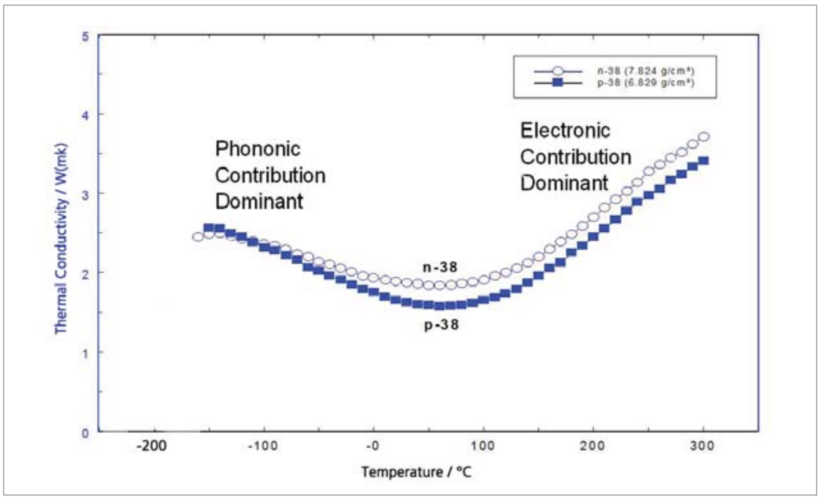
Figure 3 shows the comparison of the thermal conductivity of the p- and n-conducting layers P-38 ($Bi_{0,5}Sb_{1,5}Te_3$) and N38 ($Bi_2Se_{0,2}Te_{2,8}$). At -150°C, the thermal conductivity for both materials is approximately the same. Up to room temperature, the decrease in thermal conductivity of N-38 is lower compared to P-38. There is probably a stronger decrease in the phononic contribution of the thermal conductivity for P-38.

The increase in thermal conductivity at higher temperatures is approximately the same for both materials. It can therefore be concluded that the amount of the electron/hole contribution is the same for both materials. In both cases, a comparatively low thermal conductivity was determined. The strong increase at higher temperatures could refer to a high electrical conductivity, assuming a high figure of merit (ZT) for these materials.



2 Thermophysical properties of sample P-38



3 Thermal conductivity of P-38 and N-38

Summary

A laser flash system was used for the investigation of the thermophysical properties of different thermoelectric materials. It could be demonstrated that the laser flash method is well-suited for optimization of thermoelectric materials (low lattice conductivity and high ZT values) and direct determination of the thermal diffusivity, specific heat capacity and thermal conductivity. By means of the LFA 457 *MicroFlash*®, conclusions on the optimum structure and composition of thermoelectric materials can be drawn.

Literature

[1] C. Kittel, H. Krömer, Thermodynamik, 5. Auflage, Oldenburg Wissenschaftsverlag GmbH, München (2001)

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