Characterization of commercial Bi_2Te_3 thermoelectric materials

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In this work we present results of experimental investigations of commercially available n- and p-type Bi_2Te_3 alloys. The as delivered samples are slabs with a diameter of D~31mm and thicknesses of L = 1.5 – 2mm. They were analyzed by energy dispersive X-ray analysis (EDX) to estimate the elemental composition, by spectroscopic ellipsometry in the IR and UV-VIS to estimate the real and imaginary part of the refractive index and by IR-thermography to estimate the thermal diffusivity as well as a potential anisotropy. For SE analysis the samples were mechanically polished. By mass fractions the empirical formula of the compound is $Bi_2Te_{2.7}Se_{0.3}$. In the case p-type samples the empirical formula of the compound is $Bi_{0.4}6Sb_{1.54}$ Te_3. For IR thermography the samples were instantaneously heated on the front side by a pulsed diode laser with a peak wavelength of 808nm and an operating power between 12W and 33W. The pulse duration was in the range from 10msec to 100msec.

To estimate the absorbed energy of the incident laser pulse the temperature rise at the end of the heating phase on the front side was evaluated for several heating times. From theoretical point of view the temperature rise is proportional. Based on this the absorbed energy lies in the range of 3 to 10% of the incident energy. The temperature evolution was measured with an IR camera which is a cooled 1280 x 1024pixel FPA with a thermal resolution of typically 18mK and sensitive in the spectral range of 1.5-5µm. A frame rate of 333.33Hz was chosen and the spatial resolution was 4.33pixel / mm. From thermal imaging on the front side no anisotropy in the in-plane thermal diffusivity was detected.

To obtain the thermal diffusivity in z-direction temperature measurements were carried out at the rear side of the samples (z = L, transmission mode). The measured (red) and modelled (black) temperature rise above ambient for a pulse heating of 100msec of a n-type sample. The thermal diffusivity was evaluated with Parker's method, which was modified to consider the finite heat duration. With this, a thermal diffusivity of $1.01 x 10^{-6}$ m^2/s was obtained. This leads to a thermal conductivity of 1.2W/m.K for a density of 7700kg/m³ and a specific heat capacity of 154 J/kg.K. From SE measurement the imaginary part of the refractive index is $n'' \approx 4$ at = 808nm. From that the absorption coefficient was estimated at $6.2 x 10^{-5}$ cm^{-1} which leads to a penetration depth of the laser light of 16nm. Therefore, the absorption of the laser pulse takes place at the front side (z = 0) and can be modelled as a Dirac Delta function (z).

Speaker Biography

Karl Heinz Gresslehner have completed his PhD in the field of semiconductor physics in 1981 at the Johannes Kepler University in Linz. He was working more than 10 years in the industry and 24 years as a teacher at a school for higher technical education (HTL). Since 2016 he is a professor at the University of Applied Sciences in Upper Austria and is the head of the research group Thermoelectricity.

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