Impact of different conditions of technological process on thermoelectric properties of nano-grained n-type PbTe

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Almost all world's electrical power is produced by heat engines. Up to two-thirds of this is lost as waste heat and not converted into electricity [1]. Thus, there is strong need for searching materials that can directly convert heat to electrical energy. Lead chalcogenides, which contain lead telluride compounds have this peculiar future.

PbTe compounds exhibit variety of interesting properties especially in the field of thermoelectrics. However, detailed understanding their structure is crucial for appropriate designing all stages of technological process.

The aim of this work is intentional structuring of the material so as to give opportunity to analyze the combined influence of alloying, nanoscale precipitates and different-sized grain boundaries on thermoelectric parameters. As reported in the literature [2] and on the basis of our experiments, such procedure results in obtaining high quality thermoelectric material.

In order to achieve this goal PbTe ingot doped with Cr and I was obtained by the Bridgman method. Subsequently ball milling was conducted at different milling times (5, 15 and 25 h), which was followed by pressing and sintering.

In order to estimate crystallites diameters x-ray diffraction (XRD) was applied. The average diameters of crystallites after different milling times, using Scherrer formula, were 21, 16 and 13 nm (for milling times 5, 15 and 25 h respectively). The influence of different milling times on eventual grain sizes is analyzed. Studies of electrical and thermoelectric (TE) properties of materials versus grain sizes are performed and compared. In order to analyze the morphology and reveal presence of precipitates scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX) were performed. EDX analysis revealed presence of Cr-Te precipitates.

The mean values of κ for materials with 21 and 16 nm grains is 0,6 W/mK and 0,45 W/mK respectively at 673 K. The measured maximum values of the absolute Seebeck coefficient for 30 and 40 nm specimens were 220 μV/K and 240 μV/K respectively at 540 K.

[1] https://www.iop.org/resources/energy/
[2] K. Biswas, J. He, I.D. Blum, C.I. Wu, T.P. Hogan, D.N. Seidman, V.P. Dravid, M.G. Kanatzidis, *Nature* **489**, 414 (2012).