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On the High Pressure Consolidation of Bi_2Te_3

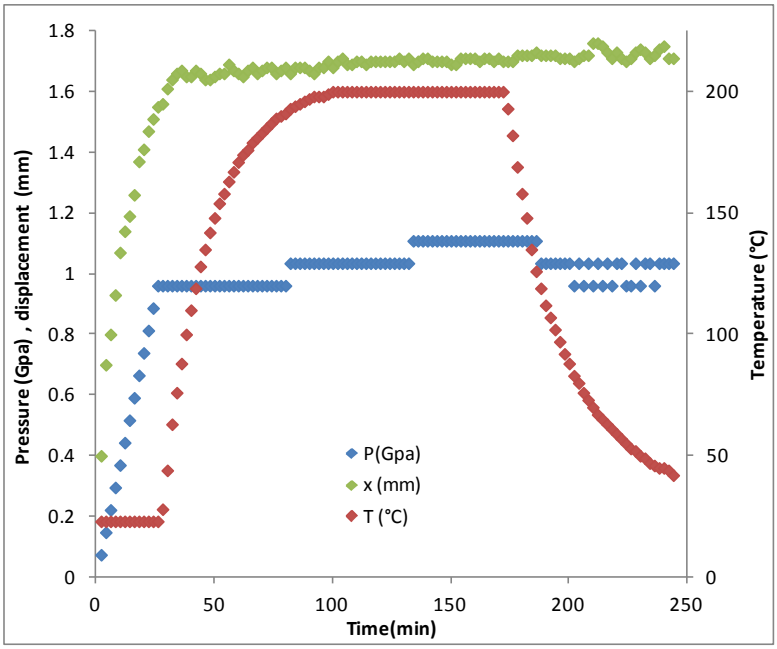
K. Boutzi, S. Varitis, S. Kassavetis, E. Hatzikraniotis,
S. Logothetidis, T. Karakostas, K.M. Paraskevopoulos

Solid State Physics Section, Physics Department, Aristotle University of Thessaloniki, Greece

High-efficiency thermoelectric (TE) materials are very important for solid-state refrigeration as well as for power-generation devices. The conversion of wasted heat into electrical energy and vice-versa may play an important role in our challenge to develop alternative energy technologies. Bismuth telluride (Bi_2Te_3) and its alloys are widely used as materials both for commercial TE refrigeration (TEC) and as TE generators (TEG) when the temperature of the heat source is moderate. Optimized Bi_2Te_3-based alloys have a figure of merit ZT~1, $ZT= (S^2\sigma/\kappa).T$, with S, σ, κ and T being the Seebeck coefficient, the electrical and thermal conductivity, and the temperature.

A TE device consists of p-type and n-type pairs of legs, connected electrically in series and thermally in parallel. The fabrication of a TE module starts from powders of polycrystalline material which are consolidated into pellets to improve the mechanical properties. One route for the consolidation is by cold pressing at high pressure (typically 0.8-1 GPa) and subsequent sintering of the cold pressed pellets at temperatures in the range of 200-500°C. Another route is by hot-pressing or SPS, at much lower pressures (typically 50-60MPa) at temperatures 400-550°C.

In this study, we report the consolidation of Bi_2Te_3 using a 13mm diameter hardened steel dry pressing die, capable of being heated up to 250°C and withstanding pressures up to 1.5GPa. Several heating/pressing profiles were applied, with holding times up to 2h. The maximum density of the obtained pellets reached 95% of the theoretical value. Knoop micro-hardness & nano-hardness and TE-properties on the pellets are presented.



A heating/pressing profile for high pressure consolidated Bi_2Te_3 pellet