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Optimization of spark plasma sintering conditions for antimony-doped bismuth telluride

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Antimony-doped bismuth telluride (Sb-doped Bi2Te3) is one of the best and most-used p-type thermoelectric materials for near-room-temperature application [1, 2, 3]. It has a stacked two-dimensional (2D) layered crystal structure, and exhibits the anisotropic thermoelectric properties [4]. In this work, we investigated the correlations between spark plasma sintering (SPS) conditions and the thermoelectric properties of Sb-doped Bi2Te3 samples. After sintered using SPS, the Sb-doped Bi2Te3 samples showed distinctive density, microstructure, and crystalline preferential orientation as the sintering conditions (temperature, pressure, and ramping rates) changed. Accordingly, different thermoelectric properties were also observed by these samples. An optimized sintering condition was found and an in-plane figure of merit $ZT$ up to 1.3 at 298 K was achieved. Such high $ZT$ was supported by the excellent in-plane electrical transport properties, which was mainly resulted from a high degree of c-plane orientation. A high in-plane power factor of $4.79 \times 10^{-3}$ W m$^{-1}$ K$^{-2}$ was shown compared with the out-of-plane value of only $2.76 \times 10^{-3}$ W m$^{-1}$ K$^{-2}$. On the other hand, the micron-scaled grains along the in-plane directions were resulted from SPS sintering; these grains are very effective to scatter acoustic phonons while giving minor harm to electrical transport. This work gives an insight for manipulating the spark plasma sintering conditions and anisotropic thermoelectric properties of Sb-doped Bi2Te3.

References: