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Published in:

Book of Abstracts - 34th Annual International Conference on Thermoelectrics (ICT 2015) and 13th European conference on Thermoelectrics (ECT 2015)

Publication date:

2015

Document Version

Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):

Han, L., Van Nong, N., Le, T. H., Pham, H. N., Hegelund Spangsdorf, S., Roch, A., ... Pryds, N. (2015). Optimization of spark plasma sintering conditions for antimony-doped bismuth telluride. In Book of Abstracts - 34th Annual International Conference on Thermoelectrics (ICT 2015) and 13th European conference on Thermoelectrics (ECT 2015) [8A.3]

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BOOK OF ABSTRACT

**34TH ANNUAL INTERNATIONAL CONFERENCE
ON THERMOELECTRICS (ICT 2015)**

AND

**13TH EUROPEAN CONFERENCE
ON THERMOELECTRICS (ECT 2015)**

JUNE 28TH – JULY 2ND, 2015 DRESDEN, GERMANY



WWW.CPFS.MPG.DE/ICT2015

8A.3

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 $4.79 \times 10^{-3} \text{ W m}^{-1} \text{ K}^{-2}$ was shown compared with the out-of-plane value of only $2.76 \times 10^{-3} \text{ W m}^{-1} \text{ K}^{-2}$. 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.

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