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Rapid deposition and thermoelectric properties of ytterbium boride thin films using hybrid physical chemical vapor deposition

Gabin Guélou,[a] Maya Martirossyan,[a] Kazuo Ogata,[a] Isao Ohkubo,[a] Yohei Kakefuda,[a] Naoyuki Kawamoto,[a] Yuuki Kitagawa,[b] Jumpei Ueda,[b] Setsuhisa Tanabe,[b] Kazuhiko Maeda,[c] Katsumitsu Nakamura,[d] Takashi Aizawa[a] and Takao Mori[a,e*]

[a] International Center for Materials Nanoarchitechtonics (WPI-MANA), National Institute for Materials Science (NIMS), Namiki 1-1, Tsukuba 305-0044, Ibaraki, Japan
[b] Graduate School of Human and Environmental Studies, Kyoto University, Sakyo-ku, Kyoto 606-8501, Japan
[c] School of Science, Tokyo Institute of Technology, 2-12-1-NE-2 Ookayama, Meguro-ku, Tokyo 152-8550
[d] College of Humanities and Sciences, Nihon University, 3-25-40 Sakurajosui, Setagaya-ku, Tokyo 156-8550, Japan.
[e] Graduate School of Pure and Applied Sciences, University of Tsukuba, Tennoudai 1-1-1, Tsukuba 305-8671, Japan

*Corresponding author: MORI.Takao@nims.go.jp

Thin films of YbB_4 and YbB_6 have been deposited on sapphire substrates via hybrid physical chemical vapor deposition (HPCVD) using elemental ytterbium and decaborane, $B_{10}H_{14}$, as sources. The deposition condition dependence of the composition, purity, crystallinity and electrical properties has been investigated using x-ray diffraction (XRD), reflection high-energy diffraction (RHEED), profilometry and thermoelectric property measurements. A YbB_6 thin film (~2.5 μm) was produced with a power factor reaching *ca*. 200 μW m^{-1} K^{-2} at the highest investigated temperature, 563 K. Such performance slightly surpasses that of bulk material and offers a positive prospect for high-temperature thermoelectric application.
Key words: Thermoelectric, thin film, ytterbium, boride.

In view of today's world energy crisis, the need for sustainable energy sources is crucial. In this context, thermoelectric power harvesting devices are desirable to be implemented in industrial processes operating at high temperature. In these processes, a considerable amount of energy is often wasted as a by-product of useful energy generation through exhaust gas, heat dissipation, friction, liquid cooling, etc. In thermoelectricity, the performance of a material is illustrated by its figure of merit, $ZT= (S^2\sigma)T/\kappa$. Typically, commercially available thermoelectric devices are made of materials with a ZT around unity over the desired temperature range, but often contain heavy or toxic elements such as Bi, Te or Pb.[1] Thus, three main characteristics are desirable: a high electrical conductivity, σ, a high absolute Seebeck coefficient, S, and a low thermal conductivity, κ. There are some contradictory features to these requirements, and therefore novel principles and materials are being actively investigated.[2]

Boride materials are a promising group of materials for high-temperature thermoelectric energy harvesting[3,4] because of their extremely high thermal stability, and also generally