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Enhanced Thermoelectric Properties of Antimony Telluride Thin Films with Preferred Orientation Prepared by Sputtering a Fan-Shaped Binary Composite Target

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p-Type antimony telluride (Sb_2Te_3) thermoelectric thin films were deposited on BK7 glass substrates by ion beam sputter deposition using a fan-shaped binary composite target. The deposition temperature was varied from 100°C to 300°C in increments of 50°C. The influence of the deposition temperature on the microstructure, surface morphology, and thermoelectric properties of the thin films was systematically investigated. x-Ray diffraction results show that various alloy composition phases of the Sb_2Te_3 materials are grown when the deposition temperature is lower than 200°C. Preferred *c*-axis orientation of the Sb_2Te_3 thin film became obvious when the deposition temperature was above 200°C, and thin film with single-phase Sb_2Te_3 was obtained when the deposition temperature was 250°C. Scanning electron microscopy reveals that the average grain size of the films increases with increasing deposition temperature and that the thin film deposited at 250°C shows rhombohedral shape corresponding to the original Sb_2Te_3 structure. The room-temperature Seebeck coefficient and electrical conductivity range from 101 μV K^{-1} to 161 μV K^{-1} and 0.81×10^3 S cm^{-1} to 3.91×10^3 S cm^{-1}, respectively, as the deposition temperature is increased from 100°C to 300°C. An optimal power factor of 6.12×10^{-3} W m^{-1} K^{-2} is obtained for deposition temperature of 250°C. The thermoelectric properties of Sb_2Te_3 thin films have been found to be strongly enhanced when prepared using the fan-shaped binary composite target method with an appropriate substrate temperature.

Key words: Thermoelectric thin films, antimony telluride, thermoelectric properties

INTRODUCTION

Thermoelectric devices have attracted much attention for application as power generators, coolers, and thermal sensors or detectors due to their particular ability to interconvert heat and electric energy directly.[1,2] The performance of thermoelectric devices is evaluated by the materials' dimensionless figure of merit (*ZT*) or the power factor. *ZT* is defined as $\alpha^2\sigma T/\kappa$, and the power factor is $\alpha^2\sigma$, where α is the Seebeck coefficient, σ is the electrical conductivity, κ is the thermal conductivity, and T is the temperature.[3] Antimony tellurium (Sb_2Te_3) is a well-established thermoelectric material that is used in the temperature range of 200 K to 400 K due to its high Seebeck coefficient and good electrical conductivity.[4] Significant progress has been made in recent years, and it has been found that thin-film technology can significantly reduce the thermal conductivity and increase the figure of merit *ZT* of thermoelectric materials.[5,6] Fabrication of thin-film thermoelectric materials and devices with high performance has attracted much

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