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PII: S0925-8388(14)01597-7
DOI: http://dx.doi.org/10.1016/j.jallcom.2014.07.018
Reference: JALCOM 31646

To appear in: *Journal of Alloys and Compounds*

Received Date: 4 February 2014
Revised Date: 21 May 2014
Accepted Date: 2 July 2014

Please cite this article as: P.H. Le, C-N. Liao, C.W. Luo, J. Leu, Thermoelectric properties of nanostructured bismuth-telluride thin films grown using pulsed laser deposition, *Journal of Alloys and Compounds* (2014), doi: http://dx.doi.org/10.1016/j.jallcom.2014.07.018

Thermoelectric properties of nanostructured bismuth-telluride thin films grown using pulsed laser deposition

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Abstract

Nanostructured n-type bismuth telluride (Bi_2Te_3) thin films were grown on SiO_2/Si (100) substrates at argon ambient pressure (P_{Ar}) of 80 Pa by pulsed laser deposition (PLD). The effects of film morphologies, structures, and compositions on the thermoelectric properties were investigated. At a substrate temperature (T_s) of 220–340 °C, stoichiometric films with highly (00l)-oriented and layered structures showed the best properties, with a carrier mobility μ of 83.9 – 122.3 cm^2/Vs, an absolute Seebeck coefficient $|\alpha|$ of 172.8 – 189.7 μV/K, and a remarkably high power factor (PF) of 18.2 – 24.3 $\mu Wcm^{-1}K^{-2}$. By contrast, the Te-rich films deposited at $T_s \leq 120$ °C with (015)-preferred orientations and columnar–small grain structures or the Te-deficient film deposited at 380 °C with Bi_4Te_5 polyhedron structure possessed poor properties, with $\mu < 10.0$ cm^2/Vs, $|\alpha| < 54$ μV/K, and PFs ≤ 0.44 $\mu Wcm^{-1}K^{-2}$. The morphology of highly (00l) oriented–layered structures and the stoichiometry predominantly contribute to the substantial enhancement of μ and $|\alpha|$, respectively, resulting in remarkable enhancement in PF.

Key words: Bi_2Te_3, thermoelectric properties, nanostructures, pulsed laser deposition (PLD).