Development of Cu, Ni-co-doped $Bi_2Te_{2.7}Se_{0.3}$ for Thermoelectric Energy Generation Using Pulsed Laser Deposition

Y.S. Wudil,[1,2]

[1] *Laser Research Group, Physics Department, King Fahd University of Petroleum & Minerals (KFUPM), Mailbox 5047, Dhahran 31261, Saudi Arabia.*

[2] *Interdisciplinary Research Center for Construction and Building Materials, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia.*

Abstract

This work reports the preparation of ternary Cu/Ni/$Bi_2Te_{2.7}Se_{0.3}$ nanocomposite thin films via pulsed laser deposition. For comparison, pure $Bi_2Te_{2.7}Se_{0.3}$ (BTS) and binary Cu/$Bi_2Te_{2.7}Se_{0.3}$ and Ni/$Bi_2Te_{2.7}Se_{0.3}$ nanocomposites were also synthesized. Morphological characterizations revealed the presence of abundant grains typical of the BTS sample. Energy-dispersive spectroscopy confirmed trace amounts of Cu and Ni within the films, while X-ray photoelectron spectroscopy indicated that both metals were present as unoxidized metallic atoms, free from telluride formation. Structural analyses using X-ray diffraction and Raman spectroscopy showed peaks consistent with the pure BTS structure, suggesting that the dopants were primarily located at the grain boundaries within the BTS matrix. The ternary nanocomposites were prepared using a specialized configuration at three different Cu/Ni concentrations. The highest room temperature thermoelectric figure of merit (ZT) of 0.97 was achieved at the optimal doping concentration (BTS-2Cu/Ni), attributed to a simultaneous increase in power factor (2988 μW/mK²) and a decrease in thermal conductivity (0.93 W/mK). The enhanced thermoelectric power factor resulted from the selective filtering of low-energy charge carriers, which improved the Seebeck coefficient. Additionally, the introduction of Cu and Ni into the nanocomposites created abundant grain boundaries that scattered phonons, reducing intrinsic lattice thermal conductivity and thereby enhancing the ZT value.