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Effect on the electrical and morphological properties of Bi incorporation into ZnO:Ga and ZnO:Al thermoelectric thin films

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This work reports the effect on the electrical and morphological properties of co-doping ZnO thin films with Bi and Al/Ga. To do so, a confocal sputtering geometry was used with a Bi target and two intrinsically doped ZnO:Ga and ZnO:Al targets. By depositing at an intentional heating of 200 ºC and applying a post-deposition thermal treatment at 350 ºC and 300 ºC, for ZnO:Ga,Bi and ZnO:Al,Bi, respectively, electrical resistivity values of 1.3×10-3 Ω·cm and 4.8×10-4 Ω·cm were achieved, with an optical transmittance above 80%. The X-ray diffraction data shows that all doped ZnO films have a wurtzite hexagonal structure with preferential crystal growth perpendicular to the (002) plane. The Seebeck coefficient was measured for the ZnO:Al,Bi films, where a maximum value of -48 μV·K-1 was registered. The optimized electrical properties were correlated with the preferential crystalline texture along [001] and the corresponding current density applied to the Bi dopant target, J(Bi). ZnO:Al,Bi films present out-of-plane compression stress, which concomitantly increases with J(Bi), due to higher compact volume of unit cell with lower lattice parameter c when compared with the undoped ZnO. By controlling the incorporation of Bi, the deposition temperature and the post-deposition thermal treatment temperature, improvements on the thermoelectric power factor of ZnO:Ga and ZnO:Al thin films can be achieved. Thermal conductivity results were correlated with the thermoelectric results in order to attain a thermoelectric figure of merit.

Keywords: Thin films, ZnO, Seebeck coefficient, thermoelectric, TCO

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