Synthesis, characterization and thermoelectric properties of fine grains Gd-doped ZnO

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Abstract:
Oxides, composed of nontoxic, naturally abundant, light, and cheap elements, are expected to play an important role in extensive thermoelectric applications.¹ Among them, ZnO-based materials are considered one of the best n-type thermoelectric oxides, with a thermoelectric figure of merit that reaches ZT = 0.65 at high temperature.² Our group is interested in improving the thermoelectric properties via doping with rare earth ions.

In this study, we report on the preparation of GdₓZn₁₋ₓO (nominal x = 0.0005 to 0.03) nano-size powders by using the modified-Pechini method. Experimental data (XRD, FEG-SEM) indicate that Gd incorporates into the ZnO wurtzite structure as well as the diminution of the grain size with increasing of Gd nominal concentration (down to 20 nm for x = 0.03). Attempts to dope higher Gd quantity (nominal 5 at. %) revealed unsuccessful with the formation of Gd₂O₃. The powders are then densified into pellets via Spark Plasma Sintering (SPS), with an increase of the grain size up to 50-180 nm. We observed Gd₂O₃ phase segregation after SPS step for high Gd doped concentrations (starting from 1 at. %). Temperature-dependent thermoelectric properties have been measured with two distinct conditions: as-obtained after SPS; and with a post-SPS annealing in air. The obtained results suggest the formation of defects, during SPS process. After a post-SPS heat treatment, the best properties at room temperature are observed for nominal 0.2 - 0.3 at. % Gd-doped ZnO, with an electrical resistivity of about 1.10⁻² (Ohm.cm⁻¹) and Seebeck coefficient of -160 μV.K⁻¹, corresponding to a power factor (S²·σ), ~ 0.28 mW.m⁻¹.K⁻². Therefore, this family of materials is promising and is worth being studied in more detail.

References: