Effect of Ni and Mn dopant on thermoelectric power generation performance of ZnO nanostructures synthesized via hydrothermal method

Ubaid ur Rehman[1], Khalid Mahmood[2], Arslan Ashfaq[2], Muhammad Faisal Iqbal[3], Kashaf ul Sahar[4], Abbas Ahmad Khan[5], Ejaz Hussain[4]*

[1]*Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warsaw, Poland*
[2]*Department of Physics, Government College University Faisalabad, Pakistan*
[3]*Department of Physics, Riphah International University Faisalabad, Pakistan*
[4]*Department of Chemistry, The Islamia University of Bahawalpur, Pakistan*
[5]*Department of Electronic Engineering, Hanyang University, Seoul 04763, South Korea*

**Ubaid.hsp@gmail.com*

Abstract

In this article, we have presented a low-cost hydrothermal approach to enhance the thermoelectric performance of ZnO nanostructures via modulation doping. For this purpose, we have prepared a series of pure and X:ZnO (X= Ni & Mn) samples. The Seebeck value of the Mn-doped samples possesses the maximum Seebeck coefficient of -36 $\mu V/^oC$ compared to the pure and Ni-doped samples (-22 $\mu V/^oC$ & -27 $\mu V/^oC$) at room temperature. The highest value of the Seebeck coefficient for the Mn-doped samples is related to the formation of mid-gap energy band states due to the substitution of Mn^{2+} with Zn^{2+}. These mid-band states induce an imbalance in the DOS, by producing a spin polarization effect that leads to a high Seebeck value. In terms of electrical conductivity, the Ni-doped ZnO sample exhibits the highest electrical conductivity of about 122 S/cm, due to the incorporation of Ni metal ions inside the ZnO matrix (confirmed by XRD) and leads to a high carrier concentration. However, the highest Seebeck value for the Mn-doped sample results in the maximum thermoelectric power factor ~1.12×10^{-5} $Wm^{-1}C^{-2}$ at room temperature.

Keywords; ZnO, doping, XRD, Seebeck coefficient, Electrical conductivity, Power factor

Acknowledgment

The author would like to acknowledge the funding from Polish National Science Centre (NCN) Project No. UMO-2016/22/E/ST3/00553 for the accomplishment of this research work.