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Non-planar nanoscale *p–p* heterojunctions formation in $Zn_xCu_{1-x}O_y$ nanocrystals by mixed phases for enhanced sensors

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Abstract

The copper oxides are advanced materials due to their remarkable sensing, optical, electrical, thermal and magnetic performances. Nanostructuring and doping of copper oxides enhance further the possible features of these important and attractive materials for various applications. In this work, we report for the first time on enhanced performances of p-type semiconductor sensors due to Zn-doping in copper oxides and formation of two distinctly different phases of such nanocrystals, namely Cu2O:Zn, CuO:Zn, as well as mixed phases of CuO:Zn/Cu2O:Zn bi-layer structures. Zinc-doping in cuprite and tenorite (ZnxCu1−xOy) nanocrystallite layers has been identified by XPS and indicates that the bilayer CuO:Zn/Cu2O:Zn nano-heterojunction with mixed phases in nano-crystals has been obtained by rapid thermal annealing (RTA) at 525 °C in 60 s. By doping with Zn in copper oxide and forming a nano-heterojunction by RTA for 60 s it was possible to change the sensing properties from the ethanol vapour (pure copper oxide) to hydrogen gas (zinc-doped copper oxide). The gas sensing characteristics in dependence of the zinc-doping level and film thicknesses were evidenced and found a highly efficient nanomaterial based on 3.0 wt% Zn–doped CuO:Zn/Cu2O:Zn nanoscale p–p heterojunction. Relatively fast response and recovery times for hydrogen gas sensors based on ZnxCu1−xOy bi-layers were obtained. The involved gas sensing mechanism of these nanostructures has been proposed and described. The obtained results will be of high interest for the development of p-type semiconductor based gas sensors.