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Zinc oxide nanotetrapods with four different arm morphologies for versatile nanosensors

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Abstract

The structural morphology of metal oxide nano- and microstructures plays a crucial role in the performances of sensors and especially of nanosensors. Here, a simple approach on the synthesis of three-dimensional (3D) highly porous ZnO nano- and microstructure networks with four different arm morphologies in the same process is reported. Systematic studies about the growth of micro- and nanotetrapods were performed and the corresponding mechanism has been discussed in detail. The difference in the morphologies of the obtained structures was understood on the basis of synthesis temperature variations, content of Zn vapor and oxygen in the furnace at different locations, which result in different growth rates along the ZnO c-axis. The approach developed in this work gives the possibility to simultaneously grow the interconnected networks of nano-ZnO-tetrapods (T), ZnO-T, with complex arm morphologies, ZnO-T-nanosheets, and ZnO nanowires (NW)-T. The obtained free-standing network material was integrated in an electronic device for gas/vapor sensing investigations. The individual structures with different morphologies (NW with a diameter down to 30nm, two interconnected NWs, microsheets, and nanotetrapods with a diameter of the arms in the range of 40–80 nm) were integrated into nanosensor devices in order to investigate the influence of the morphology on the electrical and gas sensing properties. The results showed higher (S≈510–2500 ppm) ammonia vapor sensing properties of ZnO-T compared to ZnO-T-nanosheets and ZnO-NW-T, revealing the importance of nano-junctions in nano-sensor devices. The presented approach offers the possibility to understand the importance of exposed facets and junctions on the sensing properties of such nanostructures. These results offer new opportunities for further experimental and fundamental studies of oxide morphologies in the context of nanosensor applications for environmental monitoring.