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Multifunctional devices based on 3D hybrid networks of ZnO and 3D carbon nanomaterials

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Abstract

In this work, the room temperature UV and gas sensing properties of the three-dimensional (3D) networks based on zinc oxide (ZnO) tetrapods coated with carbon-based two-dimensional (2D) nanomaterials were investigated. Therefore, highly porous (~94%) cylindrical pellets of ZnO tetrapods were infiltrated with dispersions of graphene oxide (GO), electrochemically exfoliated graphene (EG) and reduced graphene oxide (rGO), resulting in the formation of nano-porous few-layer membranes on the surfaces of the individual tetrapods, that affect both, their gas and UV sensing properties. It was found, that by coating ZnO with rather insulating materials such as GO, the UV response of ZnO networks can be improved from ~ 5 to ~ 17 at an applied bias voltage of 10 V. On the other hand, the addition of conductive carbon-based nanomaterials, such as EG and rGO, results in a decrease in UV response compared to the pristine ZnO networks. The decrease is associated with the formation of percolating pathes through the ZnO network, that shunt the effect of potential barrier modulation between the ZnO tetrapods under UV illumination. However, while decreasing the UV response, EG enabled gas sensing. The EG based 3D networks were capable of detecting NH3 at room temperature, showing a gas response of ~ 1.15. The gas response could even be slightly increased by removing the underlying ZnO template, creating ultra-lightweight NH3 sensors. This study illustrates, that creating 3D hybrid networks based on ZnO and carbon based 2D nanomaterials has huge potential for synergistic effects that achieve new unique sensing properties at room temperature.

Keywords: *graphene oxide, zinc oxide, 2D nanomaterials, gas sensor, multifunctional*

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