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Al-Doped ZnO Nanowires by Electrochemical Deposition for Selective VOC Nanosensor and Nanophotodetector

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Nanomaterials for new nanosensor systems with selective detection of hazardous volatile organic compounds (VOCs) vapors are of great demand nowadays. In this paper, the use in nanosensors of electrochemically deposited (ECD) Al-doped ZnO (ZnO:Al) nanowires (NWs) is reported. The NWs are characterized by micro-Raman and optical measurements. Individual ZnO and ZnO:Al NWs are integrated into nanosensor devices for room temperature UV and gas sensing. It is shown that, compared to undoped ZnO NW with irreversible response, the doped ZnO:Al NWs have faster response (≈5 s) and recovery (≈55 s), as well as enhanced UV response (≈4.8, about 2 times higher). The room temperature gas sensing investigations demonstrate that an individual ZnO:Al NW can detect volatile organic compounds (VOCs) vapors such as 2-propanol, *n*-butanol and ethanol at room temperature with a relatively fast response time of ≈10 s and a reversible signal (the recovery time being 30–40 s). This shows the possibility to use it with further development as indoor air quality monitor.

1. Introduction

Due to regulations regarding indoor air quality, in many countries of the world the monitoring of VOCs has become a serious task in order to avoid the environmental and health impact.[1,2] However, many instruments that have the ability to measure low concentrations of VOCs, such as gas chromatography, are large, bulky, and costly.[2,3] Therefore, new nanomaterials for low-cost, low-power, portable, selective, and user-friendly sensors to detect or distinguish various hazardous VOCs vapors are of great demand for chemical industry and indoor monitoring.[1,2]

Zinc oxide (ZnO) is a wide bandgap semiconductor (3.37 eV at room temperature), which is widely used in gas sensing and optoelectronic applications due to its low cost processing, wide variety of morphologies, as well as high exciton binding energy (60 meV).[4] Among all morphologies, the one-dimensional (1D) micro- and nanostructures of ZnO have attracted a great interest due to their high surface-to-volume ratio which leads to novel electrical, mechanical, chemical and optical properties.[5] In this context, individual 1D nanostructures are ideal nanosystems for studying the fundamental phenomena in low-dimensional systems and to fabricate nanodevices with high performances.[5,6]

For example, different investigations on electron transport in individual ZnO NWs showed that resistivity of NW is highly dependent on the surface reactions and surface states.[6–9] This gives the possibility to fabricate high performance photodetectors and gas sensors based on individual ZnO NWs.[8,10,11] For example, Lupan et al. fabricated a selective hydrogen gas (H_2) nanosensor with fast response at room temperature using an individual ZnO NW.[12] ZnO also has been used in a large extent in photodetectors.[13] Zhang et al. described a photodetector made of an array of electrodeposited ZnO NWs

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