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Silver-doped zinc oxide single nanowire multifunctional nanosensor with a significant enhancement in response

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ABSTRACT

Enhanced performances were obtained for nanosensors based on a single nanowire of silver-doped zinc oxide (ZnO:Ag). Arrays of crystalline ZnO:Ag nanowires were synthesized by electrodeposition on F-doped tin oxide coated substrates and studied by SEM, EDX, TEM, HRTEM, SIMS, XPS, PL and micro-Raman spectroscopy. Integration of a single nanowire or a single microwire on the chip was performed by employing metal maskless nanodeposition in the dual beam focused electron/ion beam instrument. The ultraviolet (UV) response and hydrogen (H_2) gas response were studied for nanodevices and microdevices based on a single ZnO:Ag nanowire. We found that ZnO:Ag nanowire based nanosensor possesses a much faster response/recovery time and a higher response to UV radiation and hydrogen gas (~50%) than those reported in literature. An increase in current value of about two orders in magnitude I_{UVON}/I_{UVOFF} was observed under exposure to UV light. Faster response/recovery times of about 0.98 s/0.87 s were observed. The ZnO:Ag nanowires and microwires can serve as nano-building materials for ultrasensitive and ultra-fast sensors with reduced power consumption. The mechanisms for such improved responses to UV and H_2 were discussed. The developed nanomaterial is of great scientific interest for further studies as promising candidates for fabricating multifunctional nano-sensors, LEDs and photodetectors by bottom-up and hybrid nanotechnologies.

1. Introduction

Development of multifunctional nanosensors based on new advanced functional nano-materials is in the focus of the research community nowadays, since it is the largest and fastest evolving market segment, with revenues expected to surpass several trillion Euros soon. Scientific research on nano-materials contributes to miniaturization and improvements in the size, detection range, reliability, selectivity and sensitivity of existing solid-state sensors and light/image detectors, which are the key components of many electronic and optoelectronic circuits. Nanodevices which can perform multiple tasks are of high demand for intelligent portable device with small sizes (e.g. a cellphone, smartphone, sensors) and other applications (ranging from high-capacity information storage to biochemical sensing, chemical and biological analysis, and astronomy) due to very low power consumption. In this context, rapid detection of ultraviolet (UV) radiation, such as emission from combustion flames, is an important issue for industrial safety, especially when highly flammable gasses are involved (for example H_2) [1–5]. Of course, leakage of flammable gases should be detected first and it is desirable to be done by the same device. Development of such multifunctional detectors/sensors is in high demand to protect human health due to several critical factors, namely UV level is increasing due to ozone hole which latter may cause damage/cancer to the human skin, as well as highly flammable H_2 became a clean source of energy and starts to be used widely

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