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Title : Fabrication And Characterisation Of Aligned Zinc Oxide Nanorod Array-Based Ultraviolet Photoconductive Sensors

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Ultraviolet (UV) photoconductive sensors have been fabricated using undoped and aluminium (Al)-doped zinc oxide (ZnO) nanorod arrays and novel nanostructures, such as nanohole-enhanced, aligned Al-doped ZnO nanorod arrays and Al-doped ZnO nanorod-nanoflake network thin-film structures. These nanostructures were deposited using a novel technique known as the sonicated sol-gel immersion method. The use of Al-doped nanostructures in UV photoconductive sensor applications has not been widely discussed in the literature. The nanorod array properties and the fabricated sensor performances were analysed using field-emission scanning electron microscopy, energy-dispersive X-ray spectroscopy, transmission electron microscopy, X-ray diffraction, atomic force microscopy, micro-Raman spectroscopy, photoluminescence spectrometry, ultraviolet–visible–near-infrared spectrophotometry, atomic force microscopy, thickness profilometry, two-probe current-voltage measurement system, and UV photocurrent measurement system under a 365-nm UV lamp. In this study, several parameters were studied regarding the growth of ZnO nanorod arrays for use in UV photoconductive sensor applications, including the doping process (undoped and Al-doped), the precursor volumes (50-1,000 ml), the annealing temperatures (300-500°C), the ambient annealing environment (air, vacuum, and oxygen environments), the immersion times (10-300 min), the sonication times (0-50 min), and the coating processes (intrinsic ZnO and poly(vinyl alcohol)). Additionally, the effects of the metal contact gap and the bias voltage on the UV sensor performance were also investigated. For each experimental parameter, the UV photoconductive sensor responsivity, sensitivity, rise time constant, and decay time constant were thoroughly studied. Based on this investigation, it can be concluded that the performance of the sensors was closely related to the nanorod dimensions (i.e., the diameter and length), crystallinity, surface condition, stress, impurities, resistance, bias voltage, and gap between the metal contacts. Notably, a significant responsivity of 1,350.84 A/W was achieved for the UV photoconductive sensor using the nanohole-enhanced, aligned Al-doped ZnO nanorod arrays prepared with a 50-min immersion time, which had a small thickness of approximately 600 nm. Additionally, the sensitivity of the device was improved by lowering the dark current value of the sensor. This condition was achieved by lowering the annealing temperature, by carrying out the annealing process in an oxygen environment, or by growing the Al-doped ZnO nanorod arrays in a precursor solution that had been sonicated for a long period of time. Notably, growing the Al-doped ZnO nanorod arrays in the precursor solution that had been sonicated for the longest amount of time for the UV photoconductive sensor application yielded better results as both the dark current and the time constants of the sensor were reduced. The fabrication of UV photoconductive sensors using a novel sensor configuration of the Al-doped ZnO nanorod-nanoflake network thin film was also performed in this study. The sensors exhibited a responsivity of 46.4 mA/W, a sensitivity of 17.5, a rise time constant of 10 s, and a decay time constant of 84 s. Throughout this study, it was found that the performance of the fabricated ZnO nanorod array-based UV photoconductive sensor was very promising and demonstrated high responsivity, sensitivity, and fast response.