Controlling the properties of electrodeposited ZnO nanowire arrays for light emitting diode, photodetector and gas sensor applications.

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ABSTRACT

Electrochemical deposition (ECD) is a versatile technique for the preparation of ZnO nanowires (NWs) and nanorods (NRs) with high structural and optical quality. The bandgap of the ZnO NWs can be engineered by doping. Depending on the doping cation and concentration, the bandgap is increased or decreased in a controlled manner. The NW arrays have been grown on various substrates. The epitaxial growth on single-crystal conducting substrates has been demonstrated. By using p-type GaN layers, heterostructures have been fabricated with a high rectifying electrical behavior. They have been integrated in low-voltage LEDs emitting in the UV or in the visible region depending on the NW composition. For visible-blind UV-photodetector application, ZnO NW ensembles, electrochemically grown on F:SnO_2, have been contacted on their top with a transparent graphene sheet. The photodetector had a responsivity larger than 10^4 A/W at 1V in the near-UV range. ECD ZnO NWs have also been isolated and electrically connected on their both ends by Al contacts. The obtained nanodevice, made of an individual NW, was shown to be a H_2 gas sensor with a high selectivity and sensitivity. Moreover, it was shown that Cd-doping of ZnO NWs significantly improved the performance of the sensor.

Keywords: ZnO Nanowires, Electrodeposition, Doping, Light emitting diodes, Visible-blind UV-Photodetector, Nanosensor.

I. INTRODUCTION

ZnO is a II–VI group compound semiconductor with a hexagonal wurtzite crystal structure [1]. It has a wide and direct band gap of 3.37 eV at 300 K and a large free exciton binding energy of 60 meV [1]. Zinc oxide nanowires are the most promising one-dimensional (1D) nanostructures emerging as building blocks for active elements in various nanophotonics systems [2,3]. Moreover, by doping zinc oxide with new elements, it is possible to achieve desirable optical, electrical, magnetic or sensing properties which are important for multifunctional device applications.

Low dimensional ZnO structures have been reported for use in short wavelength optoelectronic devices [3–7]. They have unique physical and chemical properties, small footprint, high aspect ratio, enhanced light-matter interaction, cost-effectiveness and can be synthesized by various chemical and physical methods [3–8]. Among

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