UNIVERSITI TEKNOLOGI MARA

SYNTHESIS AND CHARACTERISATION OF LOW-DIMENSIONAL ZINC OXIDE NANOSTRUCTURES BY SOLUTION-IMMERSION AND MIST-ATOMISATION

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ABSTRACT

Zinc oxide (ZnO) nanostructures on gold-seeded silicon (Si) substrate were prepared using a low-temperature solution-immersion method. Optimised ZnO structures were then used as a template to grow a second layer of ZnO nanostructures by mist-atomisation method. Low-dimensional, vertically-aligned ZnO nanorods were successfully synthesised by the solution-immersion method through optimisation of the reaction parameters, such as concentration of precursor, ratio of stabiliser, alignment of substrate in solution, heating medium, gold-seeded substrates and its thickness, transition metal-seeded substrates, immersion temperature and time, pH of precursor solution, annealing temperature and doping with Mg.

SEM, FESEM, TGA, FTIR, XRD, EDX, PL-Raman and I-V were the selected characterisation tools to analyse the structural, morphological, bonding, optical and electrical properties of the nanostructures. TGA and FTIR analyses gave evidence that the prepared ZnO nanostructures were pure with no traces of starting material or contamination.

The results give evidence that 6 nm thickness of gold-seeded on Si substrate immersed for 4 hours at 70°C in precursor concentration of 0.005 – 0.05 M zinc nitrate hexahydrate ($Zn(NO_3)_2.6H_2O$) and hexamethylenetetramine (HMTA) at 1:1 ratio has successfully formed (002) plane, *c*-axis, aligned ZnO nanorods with diameter of approximately 60 ± 20 nm. The nanorods prepared at low immersion temperatures were found to be readily crystalline with no additional heat treatment. Precursor solution of pH 6.8 and 5 produced ZnO nanorods, while at pH 9 produced ZnO flower-like structures. 1 atomic % of Mg-doped ZnO nanorods were found to produce the highest electrical conductivity relative to as-prepared ZnO, and higher doping content of 3, 5, 7 and 9 atomic %. PL emission spectra of ZnO nanorods consistently produced UV (362-388 nm) and visible emissions (400-800 nm), confirming the formation of a semi-conducting ZnO. The relevant chemical equations were suggested throughout the study, while a novel growth mechanism of ZnO nanorods on gold-seeded Si was proposed.

The optimised thin-film of ZnO nanorods was applied as a seeding template for the growth of ZnO nanoparticles deposited by mist-atomisation method, and was found to form the smallest crystallite size of 6.34 nm at substrate temperature of 400°C. The chamber box, which was specially designed to contain the mist, was found to be practical, functional and an effective invention. The mist-atomisation deposition of ZnO produced nanogranular structures in the range of 50-120 nm.

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