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Effect of pH on the morphology of chemical bath deposited ZnO nanowires

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ZnO is a non-toxic chemical compound that forms nanostructures like nanoparticles, nanowires, nanotubes, and so on. Among these nanostructures, ZnO nanowires have shown the potential for use in applications like light-emitting diodes (LED), lasers, light detectors, chemical and biological sensors, photovoltaic cells, field-effect transistors (FET), nanogenerators, and so forth. ZnO nanowires can be synthesised using a variety of techniques, such as chemical vapour deposition (CVD), chemical bath deposition (CBD), and hydrothermal methods. Among these methods, CBD is a cost-effective, simple method to fabricate well-crystalline ZnO nanowires. The morphology of the ZnO nanostructures greatly varies with the alteration of growth parameters like growth temperature, growth time, precursor concentration, and pH level of the precursor. Herein, pH is an easily controllable parameter that has a significant effect on the morphology of ZnO nanowires as well. In this research, we synthesised ZnO nanowires using the CBD method and investigated the effect of the pH level of the precursor on the morphology of the as-synthesised ZnO nanowires. The pH values 2, 4, 6, 6.5, 7, 8, and 10 were selected for the study, and the nanowires were grown on a seed layer for better crystallinity. First, the seed layer was deposited on a borosilicate glass slide by spraying the seed solution (3.69 g of $\text{Zn}(\text{CH}_3\text{COO})_2$, 18.9 ml of Ethanol, 0.1 ml of Monoethanolamine, 100 ml of deionised water) using the spray pyrolysis technique. Then, the sample was annealed at 300 °C for 1 hour. Next, the precursor solution (3.83 g of $\text{Zn}(\text{NO}_3)_2$, 2.82 g of Hexamethylenetetramine, 200 ml of deionised water) was subjected to pH alteration using dil. HCl or dil. NH_4OH and was then heated to 90 °C while magnetic stirring at 700 rpm. After that, the seed-layered glass slide was submerged in the solution for the chemical bath deposition for 2 hours. Finally, the sample was annealed at 300 °C for 30 minutes. The above-mentioned process was repeated for all the understudied pH values. Characteristics of the ZnO nanowire samples, such as average values of height, width, aspect ratio (height/width), surface-to-volume ratio, and wire density, were analysed using scanning electron microscopic (SEM) images. The outlook and the quantitative analysis of the SEM images showed that the most crystallised nanowires (hexagonal wurtzite shape) corresponded to pH 6.5, with the highest aspect ratio (10.308) and the lowest nanowire density (44 nanowires per μm^2). The highest surface-to-volume ratio was reported for the nanowires grown at pH 7 (1.049), followed by pH 6.5 (1.037). In general, ZnO nanowires grown at pH 6.5 showed the highest crystallinity in the understudied pH range.

Keywords: ZnO nanowires, pH, Morphology, SEM, Chemical bath deposition.