Wetting Properties of Hybrid Zinc Oxide Nanostructures

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Over the past few years, Zinc Oxide (ZnO) nanostructures have gained immense popularity owing to their unique biocompatibility[1] and wetting properties[2]. The study of wetting properties led to ZnO nanostructures usage in biomimetic applications such as anti-reflective coatings[3] and self-cleaning surfaces[4]. The wetting properties of ZnO nanostructures require thorough investigation including the work of adhesion and surface free energy.

In this work, we present the synthesis and characterization of unique ZnO nanowires (NWs) on nanoplate (NP) nanostructures (ZNWNP). These nanostructures were synthesized using a one-step process. The synthesis was performed by introducing a silicon (Si) substrate sputtered with 500 nm of thermal oxide, 500 nm of aluminum (Al) and 500 nm of zinc oxide (ZnO) into a precursor solution with a molarity of 2 mM. The precursor solution was heated at 90^{o}C from 6h to 17 h. At the end of 17 h, ZNWNP were produced on the Si substrate. Two different methods of synthesis were employed. In the first method, the synthesis was carried out exactly as described above whereas the second method included an additional filtration step. The filtration step removed all impurities formed in the precursor solution, such as zinc (Zn) crystals, resulting in a clean solution to facilitate uniform growth of ZNWNP on the Si substrates. The diameter of the NWs are in the range of 20 nm to 500 nm whereas the NPs thickness range from 120 to 140 nm. Fig 1 shows the ZNWNP synthesized using method 1 and Fig 2 shows ZNWNP synthesized using method 2. The wettability of the ZNWNP substrates, synthesized using methods 1 and 2, were investigated using a contact angle goniometer. Fig 3 and Fig 4 show optical images of sessile drops of deionised (DI) water, Ethanol:Water (1:9), and Ethylene Glycol (EG) on ZNWNP synthesized using methods 1 and 2, respectively. It should be noted that ZNWNP synthesized using method 1 was non-uniform and hence the wettability was different in the middle of the substrate compared to the edges. In contrast, introducing the filtration step (method 2), the ZNWNP substrate became hydrophobic and the wettability of the probe liquids was found to be uniform across the substrate with no difference seen from the middle or the edge of the substrate, as seen in Fig 4.

The contact angle measurements by using DI water as probe liquid for ZNWNP synthesised using method 1 and 2 are $35^{o} \pm 17^{o}$ and $121^{o} \pm 4^{o}$, respectively. Moreover, different surface theories were adopted to further elucidate the wetting properties of the ZNWNP nanostructures.

[1] Z. Li, et al., J. Phys. Chem, 112, 20114, 2008
[2] H. Ennaceri, et al., Surface and Coatings Technology, 299, 169, 2016
[3] S.-Y. Han, et al., J. Mater. Chem., 22, 22906, 2012
[4] M. Shaban, et al., RSC Adv., 7, 617, 201

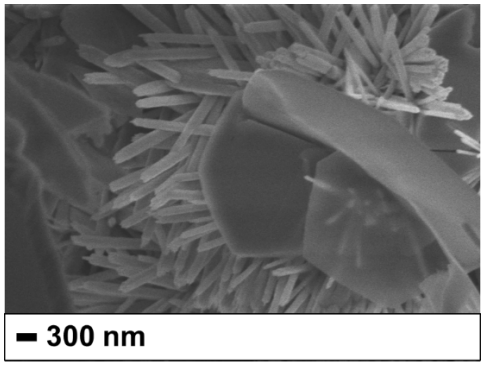

Figure 1. SEM images of ZNWNP synthesised by using method 1.

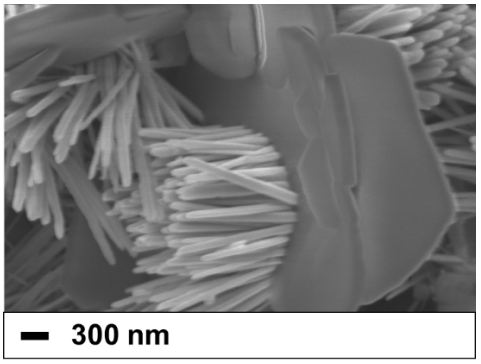

Figure 2. SEM Images of ZNWNP synthesised by using method 2.

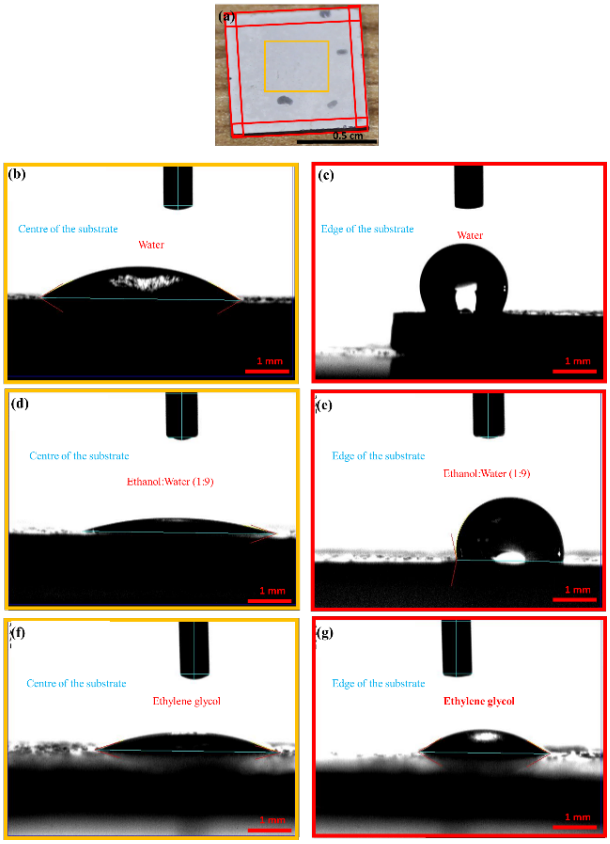

Figure 3. Optical images of sessile droplets of DI Water, Ethanol:DI Water (1:9), and Ethylene Glycol (EG)of ZNWNP synthesised by using method 1.

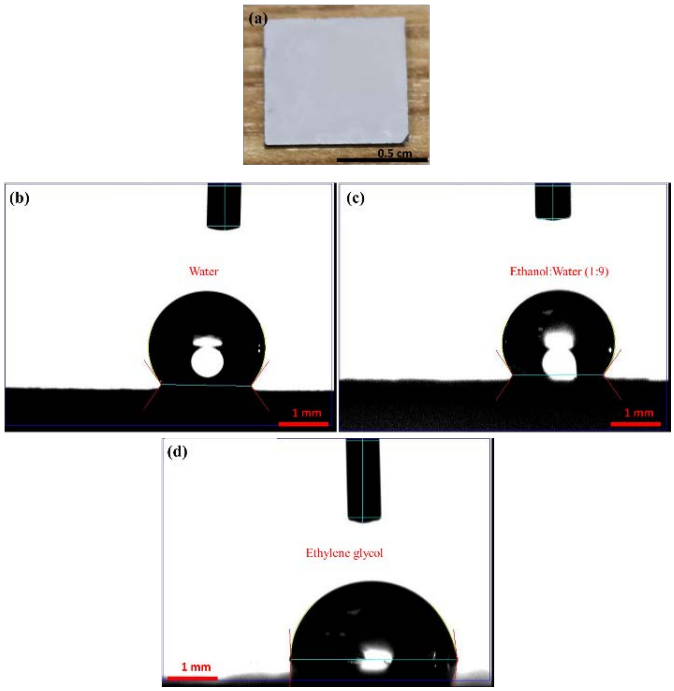

Figure 4. Optical images of sessile droplet of DI Water, Ethanol:DI Water (1:9), and Ethylene Glycol (EG)of ZNWNP synthesised by using method 2.