Investigating the effect of morphology on hydrophobicity of ZnO nanostructures

Vahid. Ghafouri [1,*]
[1] Department of physics, Research Institute of Applied Sciences, Academic Center of Education, Culture and Research (ACECR) , Shahid Beheshti University, P. O. Box 19615-1171 Tehran, Iran.
Email address: vahid.ghafouri@ut.ac.ir

ABSTRACT

In this work, a study on effect of morphology on hydrophobicity of ZnO nanostructures is presented. A case study was performed on the relationship between wetting states of aligned and unaligned ZnO nanowire arrays and the contact angle of a water droplet on a ZnO nanowires surface. Contact angle of 135° on surface with aligned ZnO nanorods and contact angle of 50-57° on surface with ZnO nanowires, is confirmed. This is in accordance to ZnO nanowires surface wettability to the Cassie-Baxter model. The surface wettability and hydrophobic nature of ZnO play a crucial role in biosensing, biomedical and microfluidic applications.

Keywords: ZnO, nanowire, nanorod, wettability, hydrophobicity, thermal evaporation.

1. INTRODUCTION

Surface wettability is as a vital importance for a verity of biological, chemical and electronic applications [1] . Currently, there has been lots of interest in studying the wetting behaviors of nanostructures of various materials, such as ZnO [2-3] Al_2O_3 [4] TiO_2 [5] Si [6] and carbon nanotubes [7].

As regards nanostructures have intrinsic surface roughness, this nanowire surface enables air to be trapped easiness under water droplets and thus a lot of the water droplets sit on a layer of the air. Also, the surface energy of the material can be lowered through chemical modifications. By combining the surface roughness and chemical modification, a modified nanostructure surface can prevent water penetration down into spaces between nanowires.

The surface properties (hydrophilic or hydrophobic nature) of ZnO play a crucial role in biosensing, biomedical and microfluidic applications [8]. Adsorption/adhesion of the cells, biomolecules (such as protein, RNA, DNA) on the surface and their reaction depends on the surface energy and it closely relates to the wetting nature of the surface, and strongly correlates with the biological interactions [9]. ZnO nanowires tend to show hydrophobic nature [13] and therefore, presumably decelerate the biological surface interactions in the aqueous environments. Also, it has been reported that a biomaterial surface with moderate hydrophilic nature improves the biological interactions [10]. However, the major problem arises in the control over surface wettability which is significant for improving the biological interaction between the surfaces and surrounding medium.

In this work, we report the effect of morphology on superhybrophicity of dimentional ZnO namostructures on glass substrates, and then we compare the superhybrophicity of these structures in comparison to the flat surfaces of glasses without any coating. With attention to already models suggested before, the superhybrophicity of ZnO nanowires truly explain, and confirm completely this effect for these structures, and we could exploit it on adsorption or adhesion of the cells, biomolecules (such as protein, RNA, DNA) on the surface.

2. MATERIALS AND METHODES

In order to synthesize ZnO nanostructures, first, a thin layer of metalic Zinc was deposited in vaccum condition by physical vapor deposition method. Then the films were annealed in oxygen atmosphere. The corning 7059 glass was used as substrate and tungsten boat was used as heating suorce for evaporation. The precursor used was grannular zinc with a purity of 99.99%. Details of the deposition of metallic zinc in a vacuum chamber are summarized in table1. The samples annealed an oxidized in a two-step process in a furnace under atmospheric condition. Details of annealing process are given in table 2. All samples were annealed for 8 hours in the annealing step.