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The Effects of Substrate Orientation on Galvanic Growth of ZnO Structures

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Abstract. Electrochemical route has been a favorite technique for the fabrication of ZnO as it is relatively cheap and capable of producing abundance amount of materials. In this paper, we investigate the morphologies of hydrothermally synthesized ZnO structures assisted by galvanic process on conducting Au-coated silicon substrate. To induce the galvanic process, the substrate was in contact with aluminum so that the difference in the reduction potentials between the two materials provided the driving force for the formation of the ZnO structures. The galvanic process was found to promote compact and anisotropy growth of ZnO nanorods along the (001) plane. It was also found that substrate orientations in the electrolyte solution had an important bearing on the morphologies of ZnO. Well aligned periodic hexagonal arrays of ZnO nanorods of homogeneous diameters were obtained on gold-coated Si substrate with face-down orientation in the electrolyte solution.

Introduction

ZnO has been a favorite candidate for functional nanostructures used in sensors, cosmetics, liquid crystal display, light-emitting diodes, piezoelectric and photovoltaic devices due to its unique electrical, mechanical and magnetic properties [1-2]. It has wide band gap (3.37 eV), large piezoelectricity, large excitation binding energy (60 MeV) at room temperature and rich surface activity [3]. ZnO also has the flexibility of forming various morphologies like rods, wires, tubes, fibers and flowers-like structures depending on the synthesis methods and conditions used. Generally, well-aligned and uniform structures are preferred as they exhibit excellent performance in many applications [4].

There are several ways of producing vertically aligned and high throughput ZnO such as hydrothermal [5], physical vapor deposition or combined laser interference lithography with hydrothermal growth on patterned substrate [6]. Some of the methods require the preparation of sputtered or spin-coated seed layers as homoepitaxial nucleation sites for ZnO growth. In this work, we synthesized ZnO structures using a facile one-pot galvanic process proposed by Zheng et al. [7]. The advantage of this method is that it is a seedless approach and is applicable to different conducting substrates. It has been known that the morphologies of ZnO vary with the synthesis temperature and time. We investigated the role of another parameter which is the substrate orientations in the electrolyte solution and its influence on the ZnO growth was elucidated in relation to the nucleation and growth mechanism occurred during the synthesis process.

Materials and Method

Au-coated silicon substrates were sonicated in acetone followed by isopropyl alcohol for 15 min before rising with deionized water (DI) and blown-dry with nitrogen gas. The edges of the substrates were then wrapped around with Al foils. An aqueous solution containing 25 mM zinc