RAPID HYDROTHERMAL SYNTHESIS OF ZINC OXIDE NANORODS ON SINGLE CRYSTAL SAPPHIRE SUBSTRATE

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Abstract *For development of ZnO nanorods-based heterostructures an environmentally benign synthesis process and fabrication route are required. Zinc oxide nanorod arrays have been grown on (0001) sapphire substrates by a rapid hydrothermal method (in 15 min) from a solution of zinc sulfate and sodium hydroxide. Two different synthesis regimes have been identified which give different morphologies of depositions shown by SEM. The structural properties of the depositions have been characterized by X-ray diffraction. Vibrational properties have been investigated by Micro-Raman spectroscopy. Detailed discussions of the experimental data are shown.*

Keywords: ZnO nanorod, sapphire, hydrothermal, heterostructure.

1. INTRODUCTION

Zinc oxide (ZnO) low-dimensional structures have attracted considerable attention for applications in short-wavelength optoelectronic devices due to its wide bang gap of 3.34 eV and large exciton binding energy of 60 meV [1]. It has potential applications in various devices, such as dye-sensitized (photoelectrochemical, quasisolid, and solid-state) solar cells (DSSCs), sensors, varistors, surface acoustic wave devices, transparent conducting oxide electrodes and light-emitting devices [2-5]. ZnO nanorods arrays for such applications are prepared by diverse methods such as sol-gel, sputtering, chemical vapor deposition (CVD), aqueous synthesis and spray pyrolysis [1-2,6-7]. For higher-quality ZnO epitaxial layers forming heterostructures in optoelectronic devices, there are more sophisticated growth methods been developed, such as metalorganic chemical vapor deposition (MOCVD) or laser-assisted molecular beam epitaxy (L-MBE), etc. However, these techniques have the disadvantage of high equipment cost, expensive vacuum and cleanroom cost. Recently, aqueous or hydrothermal synthesis has been shown as an alternative to grow high quality ZnO material at lower expenses. More recently the growth of ZnO nanorod arrays by the hydrothermal method has been reported [8-10].

In this contribution, we implemented the growth of ZnO nanorod arrays on sapphire substrates by the hydrothermal method. We compared two regimes for the purpose of investigating the potential of our process for the possible epitaxial growth of ZnO nanorods on single crystalline sapphire substrates. ZnO nanorods were synthesized on (0001) sapphire by a rapid method in 15 min and properties were investigated and discussed in details.

2. EXPERIMENTAL

In our experiment, the polished sapphire wafer was used, which is a single crystal Al_2O_3-Sapphire with 3" in diameter with *c*-plane (0001) surface orientation. In this process standard cleaning chemistries was used to clean the sapphire surface. Cleaning procedures involved included $HF:H_2O$, $NH_4OH:H_2O_2:H_2O$ and $HCl:H_2O_2:H_2O$ cleaning solutions and then rinsed in de-ionized (DI) water (~ 18.2 MΩ·cm). This cleaning procedure was found to be adequate for generating a uniformly wettable substrate surface. For the cleaning procedures we investigated two regimes with 10 and 20 min time intervals. The samples are denoted as #1 and #2. Zinc sulfate $[Zn(SO_4)\cdot 7H_2O]$ and sodium hydroxide [NaOH] (Fisher Scientific, reagent grade, without further