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Preparation Of Aluminum Foil-Supported ZnO Nanocoral Reef Films

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Abstract
In this work, an aluminum (Al) foil was strongly adapted as substrate to provide vertically ZnO nano-sized coral reef structures. Coral reef-like nanostructured ZnO are synthesized instantly onto unoxided aluminum foil via metallic zinc powder evaporation by non-catalytic vacuum thermal evaporation technique at high temperatures. The surface morphology and crystal structure of the as-synthesized coral reef-like nanostructured of the ZnO films were characterized by field emission scanning electron microscope (FE-SEM) and X-ray diffraction (XRD). XRD analyses showed that the hexagonal wurtzite structure of ZnO coral reef-like nanostructures were of polycrystalline structure. The optical characteristics of the ZnO nanocoral reefs were characterized via excitation spectra photoluminescence (PL) at room temperature (RT). The PL spectrum peak position in ZnO nanocoral reef film is blue-shifted with respect to that in unstrained ZnO bulk. This can be clarified by the approximately smaller statistical area spreading of the nanostructures.

Keywords: *ZnO, nanocoral reefs, thermal evaporation, Al foil*

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I. INTRODUCTION

ZnO thin films are applied in much utilization comprising solar devices, catalytic, photocatalytic processes, LEDs, and fuel cells. Nanostructured zinc oxide (ZnO) materials have discovered their way into numerous utilizations because of their extraordinary electrical and optical properties [1-3]. With direct bandgap energy of 3.37 eV at 300 K for bulk ZnO, it is proper for functional devices utilizations. Nanosized semiconductors are extensively applied in various commercial products for example sensors, solar cells, and transparent electrodes.Physical properties for example high exciton binding energy (about 60 meV) in ZnO crystal assures more efficient excitonic emission at room temperature [4-6]. Furthermore, ZnO is translucent or transparent to visible light (while absorning so me the light) and can be form highly conductive through doping. ZnO exhibits photocatalytic characteristics by which it could breaking up complex organic molecules toward smaller organic or inorganic pieces under the UV light [3, 7-9].

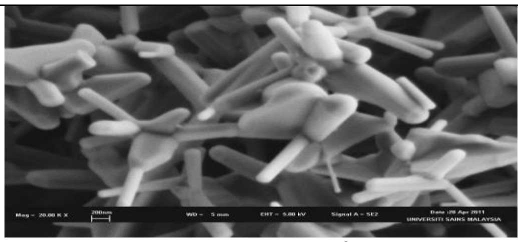
One dimensional (1-D) ZnO nanostructures have been broadly investigated by numerous researchers because of their novel properties. Nanomaterials have a very high surface area to volume ratio in nanostructures and also because of the quantum confinement effect in semiconductor, nanocrystalline materials reveal various properties as distinguished to their bulk counterparts [3]. Furthermore, ZnO can be produced in differing morphologies, for example nanotubes, nanowires, nanoprisms, nanotowers, nanobelts, nanovolcanoes, nanorods, nanorods, and nanoflowers [10–12].ZnO nanostructured films can be obtained by various methods for example pulsed laser deposition, sputtering chemical bath deposition, sol–gel and spray pyrolysis [13,14]. Thermal evaporation is a simple and cost effective method to get films with desired morphologies, thickness on substrates with various shape and large area thin films, which make it assuring for industrial utilizations. Nevertheless, nearly all of these processes demand growth temperature higher than 900 °C, which could hold different outdiffusion of impurities from substrates. In addition, different of these schemes need the apply of a metal catalyst to aid growth. It enhances the opportunity of unintentional impurity doping of the nanowires, which has notable negative impact on the physical properties of semiconductors [14]. As far as we know, there is rare information on preparing coral reef-like nanostructured ZnO films on aluminium (Al) foil by non-catalytic vacuum thermal evaporation technique.

II. EXPERIMENTAL

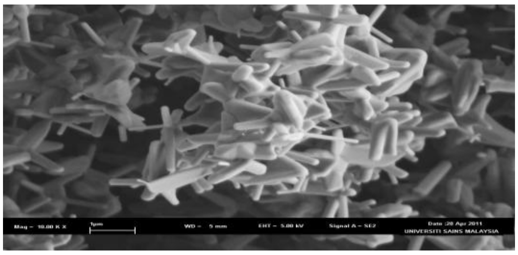
The ZnO nanostructures were synthesized inside the small quartz tube was heated to 800 °C. An aluminum substrate (aluminum foil) (1cm x 1cm) was successfully applied as substrate to prepare ZnO nanostructures. Metallic Zn (99.9%) powder as the source material. The ZnO nanostructures were fabricated on aluminum foil substrate via simple thermal evaporation of Zn powder without the appearance of carbon powder. The substrates were situated inside the furnace on top of a ceramic boat with the faces aligned toward the metal Zn powder (99.9%). The boat in the inner tube of a horizontal tube furnace. The furnace was heated to temperature 800 °C under a controlled flow of argon and oxygen gases. The flow rate was 350 sccm and was maintained to be constant for 1 h. After evaporation, the boat was slowly pulled out of the furnace and cooled slowly cooled in ambient air. A white colored layer produced on the aluminum foil substrate.The surface morphology of the ZnO nanostructures is studied via field emission scanning electron microscopy (FE-SEM). Structural characterization using X-ray diffraction (XRD) (PANalytical X'pert PRO MRD) was carried out. Photoluminescence (PL) measurements were conducted at room temperature using Jobin Yvon HR800UV system. He-Cd (325 nm) laser were used as excitation sources for PL measurement [15].

III. RESULTS AND DISCUSSION

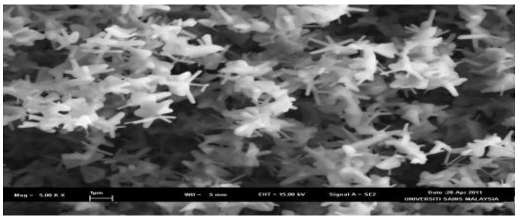
Figure 1 shows the top view SEM micrographs of ZnO coral reef on aluminium foil substrate. The coral reefs have around 900 nm in length and it also has about 400 nm in average diameters. The diameter become smaller as it goes to the tip. X-ray diffraction is accomplished to study the crystal structure of the studied samples. Figure 2 show typical X-ray diffraction (XRD) profile of the ZnO nanocoral reef grown on the aluminium foil substrate. For Figure 2, the peak from wurtzite ZnO are observed. XRD pattern confirmed that the ZnO nanocoral reef were of polycrystalline structure. No other impurity phase was found. The XRD results are consistent with the SEM images. In perceive to the aluminium foil substrate, the ZnO layers were polycrystalline as deposited. The as-synthesized ZnO layer on Al foil can be elucidated by taking into account the very large dissimilar in the lattice constant between the aluminum (Al) foil surface and ZnO thin films, which makes very hard the c-axis oriented growth on Al substrate. Furthermore, the average domain size *(D)* of a ZnO film grown on aluminium foil substrate was calculated from XRD data by the Scherrer's equation [16,17]. The mean domain size is 80 nm.



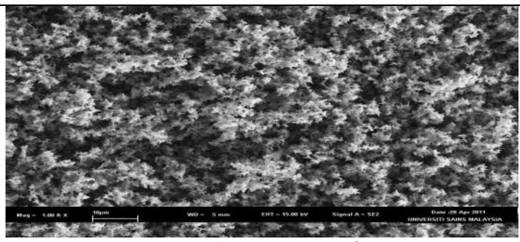
(a) 20,000x magnification



(a) (b) 10,000x magnification



(a) (c) 5,000x magnification



(a) (d) 1,000x magnification

Fig. 1. High and low magnification SEM images of ZnO nanocoral reef on aluminium foil substrate.

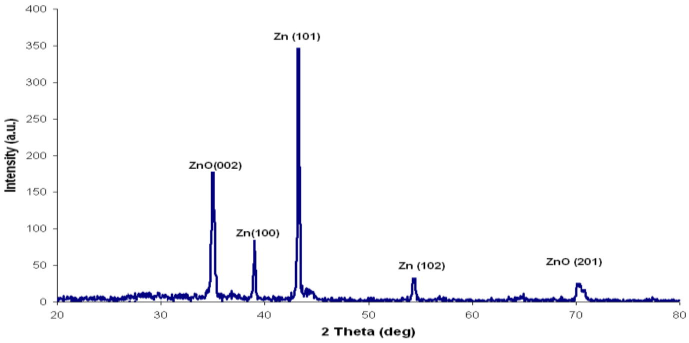


Fig. 2. X-ray (Cu-Kα_1) diffraction patterns of the ZnO nanocoral reef grown on aluminium foil.

PL spectra excited by a He-Cd laser. The PL spectra obtained from the surfaces of the ZnO coral reef is showed in Figure 3. The PL analysis indicates that the growth of ZnO nanocoral reef without the presence of the defect-related band. No yellow band emission is seen in Figure 3; this indicates that the film is of good optical quality. The UV emission around 376 nm could be related to a near band-edge transition of ZnO [18,20]. The PL spectral peak position in ZnO nanocoral reef on aluminium foil substrate are blue-shifted with respect to that in unstrained ZnO (381nm). Photoluminescence spectra show a weak green band, it show ZnO nanocoral reef have a good crystal quality with few oxygen vacancies [21].

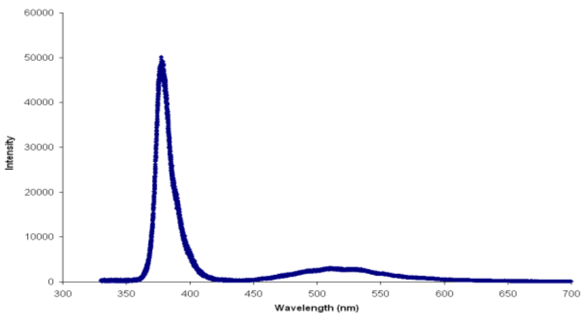


Fig. 3. The PL spectra obtained from the surfaces of the ZnO nanocoral reef.

IV. CONCLUSIONS

In summary, ZnO nanocoral reefs were synthesized on aluminium (Al) foil substrates by a simple route catalyst-free thermal evaporation method in ambient atmosphere at temperature of 800 °C. XRD, SEM, and PL analyses reveal that the nanostructures are pure hexagonal wurtzite structure ZnO. Room-temperature PL spectrum of the ZnO nanostructures shows a UV emission peak at ~376 nm and a broad green emission peak, which can be assigned to the near band-edge emission and the deep-level emission.

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