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Growth and Characterization of Cuprous Oxide (Cu2O) Nanorods by Reactive Ion Beam Sputter Deposition (Ibsd) Method

Authors : Assamen Ayalew Ejigu, Liang-Chiun Chao

Abstract : In recent semiconductor and nanotechnology, quality material synthesis, proper characterizations, and productions are the big challenges. As cuprous oxide (Cu2O) is a promising semiconductor material for photovoltaic (PV) and other optoelectronic applications, this study was aimed at to grow and characterize high quality Cu2O nanorods for the improvement of the efficiencies of thin film solar cells and other potential applications. In this study, well-structured cuprous oxide (Cu2O) nanorods were successfully fabricated using IBSD method in which the Cu2O samples were grown on silicon substrates with a substrate temperature of 400°C in an IBSD chamber of pressure of 4.5 x 10-5 torr using copper as a target material. Argon, and oxygen gases were used as a sputter and reactive gases, respectively. The characterization of the Cu2O nanorods (NRs) were done in comparison with Cu2O thin film (TF) deposited with the same method but with different Ar:O2 flow rates. With Ar:O2 ratio of 9:1 single phase pure polycrystalline Cu2O NRs with diameter of ~500 nm and length of ~4.5 µm were grow. Increasing the oxygen flow rates, pure single phase polycrystalline Cu2O thin film (TF) was found at Ar:O2 ratio of 6:1. The field emission electron microscope (FE-SEM) measurements showed that both samples have smooth morphologies. X-ray diffraction and Rama scattering measurements reveals the presence of single phase Cu2O in both samples. The differences in Raman scattering and photoluminescence (PL) bands of the two samples were also investigated and the results showed us there are differences in intensities, in number of bands and in band positions. Raman characterization shows that the Cu2O NRs sample has pronounced Raman band intensities, higher numbers of Raman bands than the Cu2O TF which has only one second overtone Raman signal at 2 (217 cm-1). The temperature dependent photoluminescence (PL) spectra measurements, showed that the defect luminescent band centered at 720 nm (1.72 eV) is the dominant one for the Cu2O NRs and the 640 nm (1.937 eV) band was the only PL band observed from the Cu2O TF. The difference in optical and structural properties of the samples comes from the oxygen flow rate change in the process window of the samples deposition. This gave us a roadmap for further investigation of the electrical and other optical properties for the tunable fabrication of the Cu2O nano/micro structured sample for the improvement of the efficiencies of thin film solar cells in addition to other potential applications. Finally, the novel morphologies, excellent structural and optical properties seen exhibits the grown Cu2O NRs sample has enough quality to be used in further research of the nano/micro structured semiconductor materials.

Keywords : defect levels, nanorods, photoluminescence, Raman modes
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