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Synthesis of hibiscus nanopetals like shapes of copper selenide by electron beam irradiation

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ABSTRACT

The electron beam irradiation could be used to control the dimensions of the electrodeposited copper selenide nanostructures in the nanometer scale. Copper selenide nanostructures with rose flower and hibiscus nanopetals of various dimensions and lengths were obtained by the electron beam irradiation. This study reports the effect of irradiation of 2 MeV electron beam on the crystal structure, surface morphology, optical properties and compositional analysis of copper selenide nanostructured thin films. Upon electron beam irradiation, the band gap energy of copper selenide decreases from 2.53 to 2.39 eV along with an increase in the crystal size for dose up to 45 kGy. Similarly, X-ray diffraction studies show that the crystal size of copper selenide decreases from 11 to 6 nm with electron dose of 50 kGy and the materials exhibit poor crystallization with increase in the band gap energy up to 2.62 eV.

1. Introduction

Radiation damages could change electrical properties of copper indium selenide thin films due to electron beam irradiation [1]. Improvement in the sensitivity of the gas sensor properties of copper sulfide thin films with the swift heavy ion irradiation treatment has been recently reported in the literature [2]. Irradiation studies are recently reported on the polyvinylidene fluoride films of different thicknesses [3]. Sathyamoorthy et al. has reported the surface irregularity of the CdTe films upon irradiation. They have shown that the surface irregularity gets increased and the grain size and the optical band gap energy were seen to be decreased [4]. Kumaravel and Rani explained decrease in band gap energy and grain size of CdO, SnO_2 with swift heavy ion irradiation [5,6]. Report is available on increase in gas sensing performance of tin dioxide, when thin films of tin dioxide are irradiated with electron beam [7]. Electron beam irradiation induces heterogeneous nucleation of ordered Au nanoparticles on the porous-surface of SiO_2/Si substrate [8]. Optical, electrical and surface properties of ion-beam irradiated gallium nitrate were studied [9]. Electron beam irradiation increases the water wettability of hydroxy apatites, which are studied for artificial bone [10]. It was reported that when Al–Sb bilayer irradiated with electron beam then the inter diffusion of bilayer takes place [11]. In this study, we report a very simple and inexpensive method as compared to the above-mentioned methods for deposition of nanostructured thin films, which exhibit different morphological patterns leading to a tuning of the associated properties upon electron beam irradiation. The present investigation is focused on the electron beam irradiation as a tool to induce changes and modifications in the morphological and optical properties of copper selenide nanocrystal films. The results specify substantial and significant modifications in surface morphology and the optical properties of CuSe.

2. Experimental

In the typical synthesis, the mixture of 0.15 M of $CuSO_4 \cdot 5H_2O$ and 0.10 M of SeO_2 in distilled water were used as source of copper and selenide. Solutions were prepared in double distilled water. The ultrasonically cleaned stainless steel and indium doped tin oxide (ITO) substrate are used to prepare the thin film samples. CuSe thin films were prepared on stainless steel substrate by the electrodeposition method with deposition time of 20 min. Electrolytic bath contains 15 ml $CuSO_4$ and 15 ml SeO_2 as sources of Cu and Se ions. The electron beam irradiations of the thin film samples were carried out at Bhabha Atomic Research Centre, Mumbai, India.

3. Results and discussion

X-ray diffraction study: The structure and formation of the copper selenide crystals were studied by characterizing the as

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deposited and irradiated thin films using the XRD technique. The X-ray diffraction peaks appeared at (2θ) values; 43.2°, 44.8°, 52.3°, and 74.4° in the recorded spectra of the thin films and the results are shown in Fig. 1(a–f). A comparison between these X-ray diffraction spectra are shown in Fig. 1, which indicates that the widths of each X-ray diffraction peak in Fig. 1(b–e) are smaller than that of the corresponding peak in Fig. 1(a, f). These X-ray diffraction results therefore, clearly indicate that the size of the copper selenide crystals irradiated with dose of 10, 20, 35 and 45 kGy increases with increasing

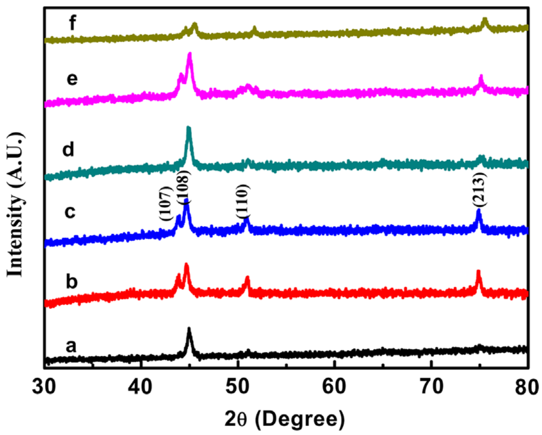

Fig. 1. XRD patterns of CuSe thin films (a) as deposited, (b) with electron dose rates of 10 kGy, (c) 20 kGy, (d) 35 kGy, (e) 45 kGy and (f) 50 kGy.

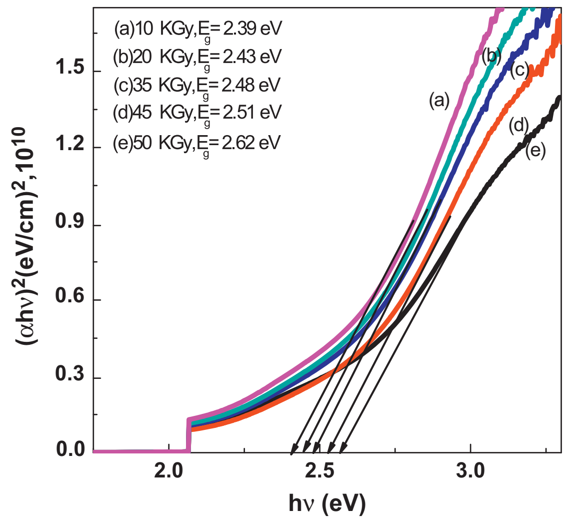

Fig. 3. The optical band gap energy of CuSe thin film with electron dose rates (a) 10 kGy, (b) 20 kGy, (c) 35 kGy, (d) 45 kGy and (e) 50 kGy.

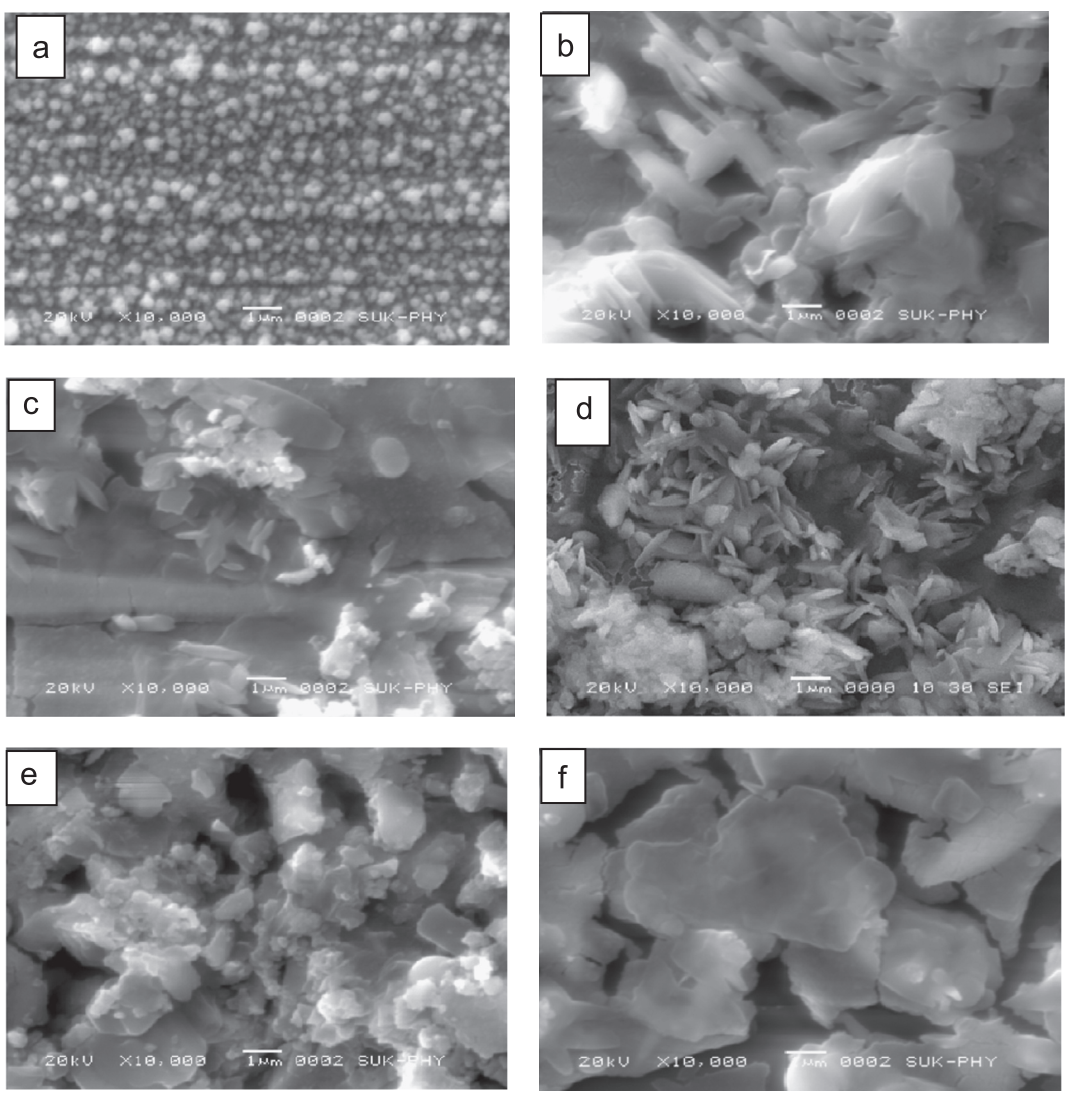

Fig. 2. SEM images of CuSe thin films (a) as deposited, (b) with electron dose rates of 10 kGy, (c) 20 kGy, (d) 35 kGy, (e) 45 kGy and (f) 50 kGy.