Structural, optical, and photocatalytic properties of the spray deposited nanoporous CdS thin films; influence of copper doping, annealing, and deposition parameters

Materials Science in Semiconductor Processing 56 (2016) 329–343

Mohamed Shaban[1,*], Mona Mustafa[1], A.M. El Sayed[2]

[1] Nanophotonics and Applications (NPA) Lab, Department of Physics, Faculty of Science, Beni-Suef University, Beni-Suef 62514, Egypt

[2]Department of Physics, Faculty of Science, Fayoum University, Fayoum 63514, Egypt

Abstract

Nanoporous thin films of $Cd_{1-x}Cu_xS$ ($0 \leq x \leq 0.06$) were grown on a heated glass substrate employing a home-made spray pyrolysis technique. The influences of [Cu]/[Cd] and the annealing in the range 300 – 500 ^oC on the structural and morphological properties of the films were investigated by X-ray diffraction (XRD), Fourier transformation infrared spectroscopy (FTIR), field emission scanning electron microscope (FE-SEM) and atomic force microscopy (AFM). The influences of Cu doping ratio, solution flow rate, and the deposition time on the optical properties and photocatalytic activity of these films are also reported. The films are of polycrystalline nature and hexagonal structure. Increasing the Cu doping ratio and annealing temperature improve the (1 0 1) preferential orientation. The crystallite size is ranged from 23.82 to 32.11 nm. XRD and FTIR reveal the formation of CdO in the 6% Cu-doped CdS film annealed at 400 ^oC and in all films annealed at 500 ^oC. The pure CdS film is of a porous structure and the close-packing and porosity of the films increase with increasing Cu%. Also, the pore diameter can be controlled from 50 to 15 nm with the increase of Cu content. The films showed transmittance below 70%. The optical band gap of the films is decreased from 2.43 to 1.82 eV with increasing Cu% and flow rate/deposition time. Additionally, the refractive indices and dispersion parameters of the films are also affected by the deposition conditions. Cu doping enhanced the films' photostability as well as the photocatalytic removal of methylene blue (MB).

Keywords: Cu-doped CdS; Nanoporous films; Deposition parameters; Refractive index; Optical constants; MB removal.