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Photoluminescence properties of modified chemical bath deposited Copper Oxide thin film

P. B. Ahirrao[1], S. R. Gosavi[2], D. R. Patil[3], M. S. Shinde[4] and R. S. Patil[4,*]

[1]Dept.of Physics, S.V.S.'s Arts and Science College Dondaicha(India)
[2]Dept. of Physics, Arts, Commerce and Science College, Taloda(India)
[3]Dept. of Physics, R.C.P. Arts, Commerce and Science College, Shirpur
[4]Department of Physics, P.S.G.V.P. Mandal's Arts, Commerce and Science College, Shahada(India)

ABSTRACT

In the present study, we report the synthesis and photoluminescence properties of Copper oxide (Cu_2O) thin film. The Cu_2O thin films were synthesized on amorphous glass substrate by using simple chemical root namely, Modified Chemical Bath Deposition (M-CBD) method at room temperature. The deposition kinetics played important role to get good quality films with uniform thickness. The structural, surface morphological, and Photoluminescence properties of the films were investigated. Crystallization and growth processes obtained micro-spherical shaped grains of Cu_2O due to agglomeration of smaller nano-particles. The room-temperature photoluminescence study showed a green band at 503nm, 540 nm and a strong red emission at 627 nm.

Keywords: Cu_2O, M-CBD, Room temperature, Photoluminescence.

INTRODUCTION

Copper oxides (Cu_2O) have attracted significant attention as it is one of the first known p-type direct band gap semiconductor [1] with a band gap of 2·17 eV. This makes it a promising material for the conversion of solar energy into electrical or chemical energy [2]. Cu_2O thin film is a colored film ranging from yellow to red-brown. Cu_2O belongs to I-VI compound semiconductor material. Cu_2O can be prepared by many techniques such as, the anodic oxidation of copper through a simple electrolysis process [3], the thermal oxidation method [4], spray pyrolysis [5], r.f. magnetron sputtering [6], reactive evaporation [7], sol-gel method [8], Electrodeposition [9, 10], chemical vapor deposition [11], plasma evaporation [12], and chemical deposition methods [13]. The physical properties of the obtained films seem to be very sensitive to the detailed arrangement of Cu and O atoms, which in turn is influenced by the deposition method and the particular conditions.

In this paper, our emphasis is mainly focus on the study of structural, surface morphological, and Photoluminescence properties of Cu_2O thin films deposited by Modified Chemical Bath Deposition method at room temperature.

MATERIALS AND METHODS

To prepare Cu_2O thin films onto glass substrates modified chemical bath deposition (M-CBD) method was used. The glass substrates were washed with detergent (soap solution), rinsed in acetone and finally ultrasonically cleaned with double distiiled water before deposition of thin film. For the preparation of Cu_2O thin films the analytical grade (Merck chemicals) copper sulphate pentahydrate ($CuSO_4{,}5H_2O$), sodium thiosulphate ($Na_2S_2O_3{,}5H_2O$), and sodium hydroxide (NaOH) were used in an aqueous medium.

A 1 M NaOH solution was prepared in a Pyrex beaker and heated to 70 ^{o}C. A colorless solution of copper thiosulfate was prepared by adding 1M $Na_2S_2O_3$ in 1M $CuSO_4$ in the volumetric ratio (5:1) with constant stirring for 10 min. As a first step, the substrates were immersed in the hot NaOH solution for 20 s, and then transferred in the copper ion complex solution for 20 s. To deposit the metal oxide film, the solution of the metal ion complexes was maintained at room temperature. After each immersion of substrate into anionic and cationic precursors the substrate were rinsed in a beaker containing double distilled water for 10 sec. so that the unabsorbed ions were removed from the substrate. This completes one M-CBD cycle. It was observed that after 4 to 5 immersion cycles, a very thin, nearly transparent film appeared silvery in reflection. Increasing the number of immersion cycles the thickness of the film increases. The films were washed well with distilled water and dried in air at room temperature.

RESULTS AND DISCUSSION

X-Ray diffraction (XRD):-

X-ray diffraction patterns of the film were recorded on Model Bruker D8 advance AXS X-ray diffractometer with scanning angles in the range 20 – 80 degree using CuK_{α} radiation (λ=1.5406 Å). Fig.1 shows X-ray diffraction pattern of as-deposited Cu_2O thin film on glass substrate by M-CBD method. In the present diffraction pattern of XRD, two dominant peaks at 36.2^{o} and 42.2^{o} corresponding to the (111) and (200) planes of Cu_2O are seen with cubic crystal structure [14]. An average value of the crystallite size at the (111) plane can be obtained by applying the Debye-Scherrer's equation, $D = 0.9\lambda/\beta\cos\theta$ where, λ=1.5406 Å for CuKα, β is the full width at half maximum (FWHM) of the peak and θ is the diffraction/Bragg's angle. The sample as-deposited Cu_2O resulted in an average crystallite size of approximately 20 nm.

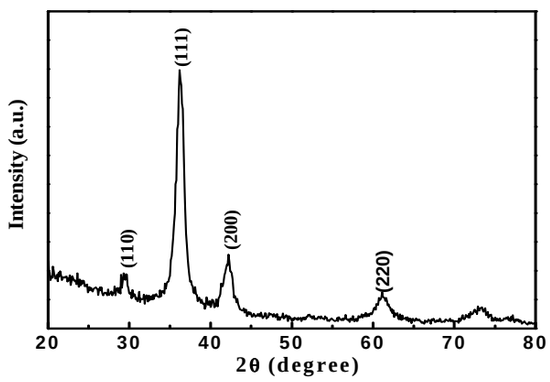

Fig. 1: The X-ray diffraction pattern of as-deposited Cu2O.

Scanning Electron Microscopy (SEM):

The surface morphology was studied by scanning electron microscopy (SEM) using a Model JOEL, JSM 6360A. The microstructure SEM image of the Cu_2O thin film on amorphous glass substrate is as shown in figure 2. The as-deposited film shows uniform surface morphology for Cu_2O on glass substrate. Micrometer size spherical grains (100-150 nm) are observed. These bigger size grains are formed due to agglomeration of small size nanoparticles since the particle size estimated by structural studies is 20 nm.

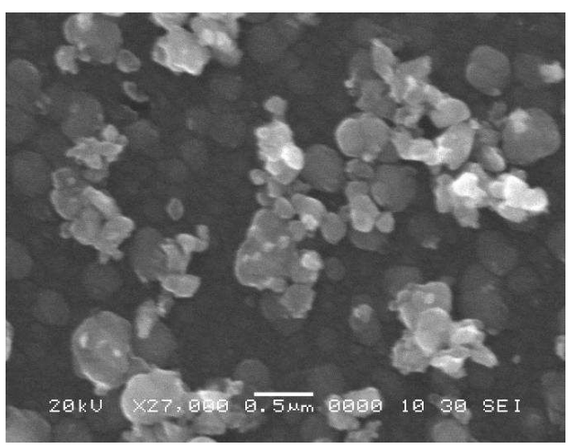

Fig 2: The surface morphology of as-deposited Cu_2O on glass substrate at room temperature.

Photoluminescence (PL)

The Photoluminescence spectra were performed using Perkin Elmer LS55 florescent spectrophotometer. Figure 3 represents three emission bands at 503, 540 and 627 nm respectively, along with green and red emission are exhibited in Cu_2O thin film [15] when excited with 450 nm. The peak 627 nm are more intense than 503 nm and 540 nm peaks. A central factor of this discussion is the nature of the characterized samples. It must be pointed out that the Cu_2O samples used to study the PL behavior are usually synthesized with distinct methods. Furthermore, the relative peak intensities of each peak depend also on the corresponding radiative recombination efficiency. Thus PL spectra of the Cu_2O samples demonstrate that the produced material has enough quality to be used in the research of semiconductor devices.

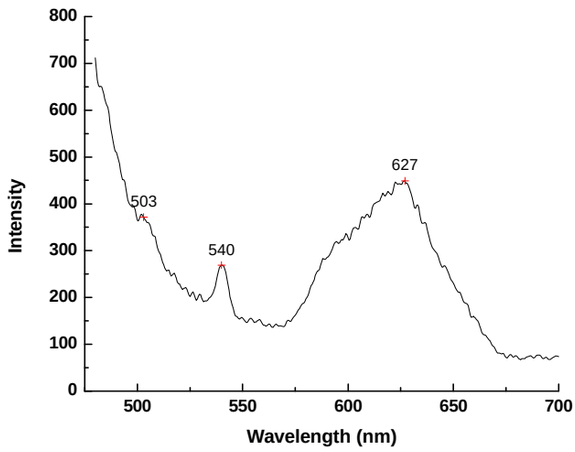

Fig 3: The PL spectra of as-deposited Cu_2O on glass substrate at room temperature.

CONCLUSION

A simple and low cost method, namely, modified chemical bath deposition (M-CBD), was employed to deposit Cu_2O thin films on glass substrates. Structural studies showed that the Cu_2O films has mainly (111) and (200) crystalline orientations. PL spectra of the Cu_2O samples demonstrate that the produced material has enough quality to be used in the research of semiconductor devices.

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REFERENCES

[1] Briskman R N, *Sol. Energy Mater. Sol. Cells*, **1992**, 27, 361
[2] Grozdanov I ,*Mater. Lett*., **1994,** 19, 281
[3] D. P. Singh, Jai Singh, P. R. Mishra, R. S. Tiwari and O. N. Srivastava, *Bull. Matter. Sci*., **2008**, 31,319-325.
[4] Y. S. Gong, C. Lee and C. K. Yang, *J. Appl. Phys*.**1995**, 77, 5422**.**
[5] M. Parhizkar, S. Singh, P. K. Nayak, N. Kumar, K. P. Muthe, S. K. Gupta, R. S.Srinivasa, S. S. Talwar and S. Major, *Colloids Surf. A: Physicochem. Eng. Asp*. **2005**, 257, 277.
[6] M. Hari Prasad Reddy, P. Narayan Reddy and S. Uthanna, *Indian Journal of Pure and Applied Physics*,**2010**, 48, 420.
[7] B. Balamurugan and B. R. Mehta, *Thin Solid Films*, **2001**, 296, 90.
[8] S. Szu and C. L. Cheng, *Mater. Res. Bull*.**2008**, 43, 2687.
[9] Y Li, J Liang, Z Tao and J Chen, *Mater. Res. Bull*, **2008,** 43, 2380,
[10] W Shang, X Shi, X Zhang, C Ma and C Wang, *Appl. Phys*. A, **2007**, 87, 129.
[11] T. Maruyama, *Jpn. J. Appl. Phys*, **1998**, 37, 4099,
[12] K. Santra, C.K. Sarkar, M.K. Mukherjee and B. Ghosh, *Thin Solid Films*, **1992**, 213, 226, .
[13] J. M Valtierra, S Calixto and F Ruiz, *Thin Solid Films*, **2004**, 460, 58.
[14] ASTM data card file No.78-2076.

[15] Pallavi Page, Rahul Ghildiyal, K. V.R. Murthy. *Materials Research Bulletin*, **2008**, 43, 353-360.