

EFFECT OF PRECURSOR VOLUME PROPORTIONS ON SPRAY DEPOSITED EuS THIN FILMS

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Abstract. Europium sulphide (EuS) thin films are successfully deposited on non-conductive bare silicon glass substrates by spray pyrolysis technique at various precursor volume proportions of europium chloride and thiocacetamide. The films were studied by XRD, SEM and UV-Visible spectrometry. The effect of varying precursor volume proportions was studied on morphological and optical properties. The XRD conformed polycrystalline nature. Study enlightens the foremost impact of precursor volume proportions on morphological and optical properties.

1. Introduction

Twentieth century has experienced a tremendous development of solid state physics, both in understanding and applications. The birth of quantum theory contributed a great deal to our current understanding of the entire gamut of interesting properties exhibited by bulk solid surfaces. It is now accepted and well known that, the developments in solid state Physics have an incredible impact on industrial sector. Rare earth chalcogenides, in particular, the europium mono chalcogenides, attract considerable experimental and theoretical attention due to their intricate electronic properties relating to the highly co-related f-electrons [1-4]. It is a promising material in the fields of solid state quantum information processing and spintronics. The properties of the europium monochalcogenides EuO, EuS, EuSe and EuTe had found interest for the initial hope of technological applications. Basically the europium sulphide is a ferromagnetic semiconductor [5-7]. Ferromagnetism has been found in several divalent europium compounds. Some of these materials are particularly simple in their crystal and magnetic structure and are ideal for experimental and theoretical study [8-11].

The researchers are concentrating for studying the basic material properties of semiconductors, metals, ceramics and polymers. Europium is a divalent but its compounds can occur in divalent and also in trivalent configurations [12, 13]. The properties of thin films can be altered by varying precursor volume proportion. The precursor volume proportions have major impact on stoichiometry of EuSe thin films [14, 15]. So far the magnetic and electronic properties of europium chalcogenides have been studied widely [16-18]. Several methods of film deposition, such as vacuum evaporation (VE), chemical vapour deposition (CVD), chemical bath deposition (CBD), spray pyrolysis (SP), electro-deposition (ELD) etc. have been employed for the deposition of thin films [19-21]. The grain size at the surface of the films is found to depend on deposition technique also on film thickness [22, 23]. Surface morphology of the films is strongly correlated with the amount of precursor deposited [24-27].

The XRD studies revealed that the spray deposited EuS films are of polycrystalline in nature with cubic structure. The observed diffraction peaks of films are found at 2θ values of 42.394, 42.884, 43.220, and 61.300 corresponding to the hkl planes (400), (220), (220), and (400) respectively.

The different peaks in the diffractogram were indexed and the corresponding values of interplanar spacing ' d ' were calculated and compared with the standard values [28]. The optimum temperature for deposition of good quality EuS thin films is found to be 573 K for all observations. At this temperature, the films are found to be well crystallized as indicated by sharp XRD peaks represented in Fig. 1.

It is found that the deposition temperature 573 K leads to the formation of well crystallized films of spray deposited EuS thin films. The height of (400) and (220) peaks in X-ray diffraction pattern for EuS thin films, deposited at temperature 573 K has observed sharper and FWHM data have resulted in the enhancement of crystallite size in the deposited films at temperature 573 K.

X-ray diffraction patterns of EuS thin films synthesized at substrate temperature 573 K are also analysed by FWHM data and Debye-Scherrer formula to calculate the crystallite size of films. The variation of crystallite size with precursor volume proportion of Eu:S from 1:6 to 6:1 for EuS thin films deposited at temperatures 573 K is shown in Fig. 2. From Fig. 2 it is observed that films deposited with above proportion 6:1 are found to have maximum value of crystallite size.

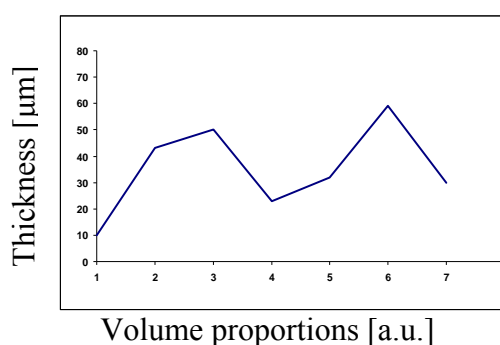


Fig. 2. Variation of crystallite size with precursor volume proportion of Eu:S from 1:6 to 6:1.

3.2. Morphological characteristics. Surface morphology of the samples prepared at substrate temperature 573 K was studied using scanning electron microscope SEM Model: Quanta 200 ESEM System, manufactured by Icon Analytical Equipment Pvt. Ltd, Mumbai. Figure 3 shows the 12000 X magnified micrograph of sample for precursor proportion 1:6 of Eu:S and Figure 4 shows the micrograph of sample for precursor proportion 6:1 of Eu:S.

The SEM images indicate the uniform film deposition and coverage of the substrate by small circular grains. The grain size increases remarkably with highest proportion of Eu in S. The films grown by spray pyrolysis mechanism with increasing volume proportion of Eu demonstrate the increase in coverage deposition area on the flat substrate surface. The 'driving force' of crystal growth in the islands is the gradient of concentration of Eu material, which reaches the surface of glass substrate as spraying flow with carrier gas as air. Since the Ostwald ripening has a certain role in the crystal growth leading to the growth of perfect and bigger crystals [29].

5.68 to 5.95 eV. It reveals that there is makeable increase of band gap more particularly for the highest proportion of Eu in EuS.

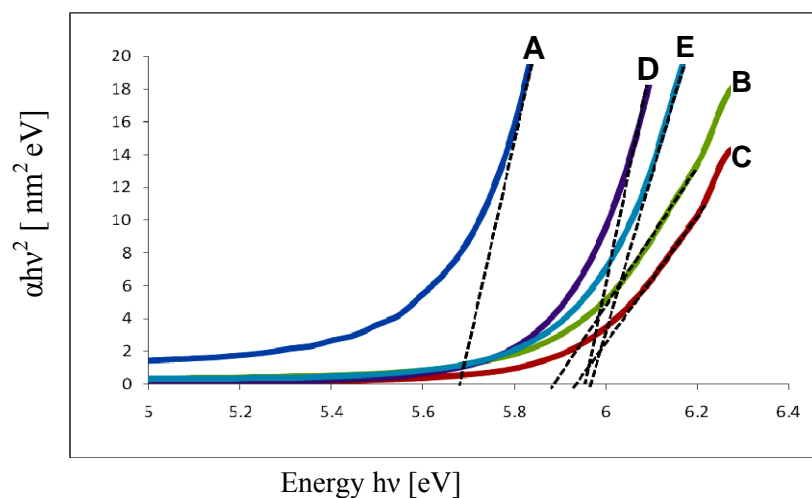


Fig. 5. Plot of $(\alpha hv)^2$ versus photon energy at 548 K.

Figures 6 and 7 display the absorption and transmission spectra for EuS thin films.

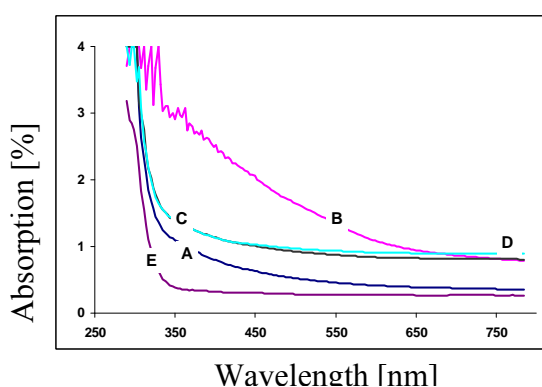


Fig. 6. Absorption spectra of EuS thin films.

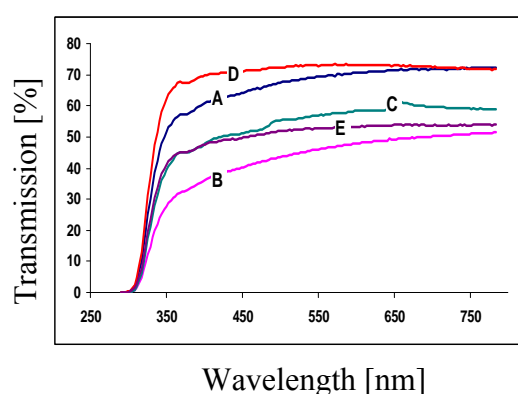


Fig. 7. Transmission spectra of EuS thin films.

Absorption increases rapidly from wavelength 250 nm to 275 nm and it acquires a nearly constant nature beyond 350 nm. The maximum transmission has observed for 5:2 volume proportion of Eu:S and that of minimum for 2:5. Transmission decreases rapidly from wavelength 250 nm to 350 nm and it acquires a nearly constant nature beyond 350 nm. The absorption increases with increase of volume Eu in EuS.

4. Conclusion

The europium chalcogenide (EuS) thin films were successfully deposited by spray pyrolysis technique, on non conductive bare silicon glass substrates with varying precursor volume proportions of Eu:S, from 1:6 to 6:1, at constant substrate temperature 573 K. X-ray diffraction analysis confirmed that the deposition EuS films have a cubic structure. Structural parameters such as thickness of film, crystallite size are calculated and found to depend upon

precursor volume proportions. The crystallinity of the films increased with increasing volume proportions Eu:S from 1:6 to 6:1. Optical study indicate that the deposited films have direct band gap energy ranging from 5.68 to 5.95 eV for volume proportions 1:5 to 5:1 of Eu:S. The percentage of absorption was found to increase with increasing volume fraction of the Eu in comparison with S.

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References

- [1] J.N. Beukers, J.E. Kleibeuker, G. Koster, D.H.A. Blank, G. Rijnders, H. Hilgenkamp, A. Brinkman // *Thin Solid Films* **518** (2010) 5173.
- [2] A.E. Esparza García, M. García, C. Falcony // *Superficies y Vacío* **9** (1999) 74.
- [3] A. Svane, G. Santi, Z. Szotek, W.M. Temmerman, P. Strange, M. Horne, G. Vaitheeswaran, V. Kanchana, L. Petit, H. Winter // *physica status solidi (b)* **241** (2004) 3185.
- [4] Horea Iustin Naşcu, Violeta Popescu // *Leonardo Electronic Journal of Practices and Technologies* **4** (2004) 22.
- [5] N.S. Gaikwad, C.H. Bhosale // *Materials Chemistry and Physics* **76** (2002) 198.
- [6] Ž. Antić, R. Krsmanović, V. Đorđević, T. Dramićanin, M.D. Dramićanin // *Acta Physica Polonica A* **116** (4) (2009) 622.
- [7] S. Von Molnar, D. Read // *Proceedings of the IEEE* **91** (5) (2003) 715.
- [8] L. Kowalczyk, M. Chernyshova, T. Story, A. Yu. Sipatov // *Materials Science-Poland* **24** (3) (2006) 809.
- [9] S.A. Safran // *Journal de Physique Colloques* **41** (1980) C5-223.
- [10] M.W. Shafer // *J. Appl. Phys.* **36** (1965) 1145.
- [11] T Taka-aki Adachi, Atsushi Tanaka, Yasuchika Hasegawa, Tsuyoshi Kawai // *Thin Solid Films* **516** (2008) 2460.
- [12] Kenichi Kojima, Takeshi Komaru, Tadamiki Hihara, Yoshitaka Koi. // *J. Phys. Soc. Jpn.* **40** (1976) 1570.
- [13] Jennifer A. Aitken, Jerry A. Cowen, Mercouri G. Kanatzidis // *Chem. Mater.* **10** (1998) 3928.
- [14] S. Keller, J.; Parker, J.; Stankiewicz, J.; Xiong, P.; von Molnar, S. In: *Magnetics Conference, 2002. INTERMAG Europe 2002. Digest of Technical Papers. 2002 IEEE International* (Amsterdam, The Netherlands Netherlands, 2002), p. CC10.
- [15] Raymond L. Kallaher, *Electron Tunneling Transport Across Heterojunctions Between Europium Sulfide and Indium Arsenide. Ph. D. Thesis* (The Florida State University, USA, 2007).
- [16] Paul Larson, Walter R.L. Lambrecht // *Journal of Physics: Condensed Matter* **18** (49) (2006) 11333.
- [17] Carl R. Evenson, Peter K. Dorhout // *Inorganic Chemistry.* **40** (10) (2001) 2409.
- [18] Assem Bakry // *Egyptian Journal of Solids* **31** (1) (2008) 11.
- [19] Jack L. Boone, Thomas P. Van Doren, Alok K. Berry // *Thin Solid Films* **87** (1982) 259.
- [20] H.M. Pathan, C.D. Lokhande // *Bulletin of Materials Science* **27** (2) (2004) 85.
- [21] Goran Branković, Zorica Branković, José Arana Varela, Elson Longo // *Journal of the European Ceramic Society* **24** (6) (2004) 989.

- [22] J.B. Mooney, S.B. Radding // *Annual Reviews. Materials Research* **12** (1982) 81.
- [23] C.Z. Wagner // *Z. Electricchem.* **65** (1961) 581.
- [24] Toyohiko J. Konno, Norihiro Ogawa, Kimio Wakoh, Kenji Sumiyama, Kenji Suzuki // *Jpn. J. Appl. Phys.* **35** (1996) 6052.
- [25] A. Ashour // *Turk. J. Phys.* **27** (2003) 551.
- [26] M.M. Betkar, G.D. Bagde // *Materials Physics and Mechanics* **14** (2012) 74.
- [27] Kuniaki Murase, Takeshi Honda, Masaki Yamamoto, Tetsuji Hirato, Yasuhiro Awakura // *J. Electrochem. Soc.* **148** (2001) C203.
- [28] P. Wachter // *Critical Reviews in Solid State and Materials Sciences* **3** (1972) 189.
- [29] Johnathon Holroyd, Y. U. Idzerda, Shane Stadler // *J. Appl. Phys.* **95** (2004) 6571.
- [30] M.M. Betkar, G.D. Bagde // *Global Advanced Research Journal of Agricultural Science* // **1** (6) (2012) 143.
- [31] T. R. McGuire, M. W. Shafer // *J. Appl. Phys.* **35** (1964) 984.