IJRAR.ORG E-ISSN: 2348-1269, P-ISSN: 2349-5138

INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS (IJRAR) | IJRAR.ORG

An International Open Access, Peer-reviewed, Refereed Journal

STRUCTURAL AND OPTICAL STUDIES OFELECRODEPOSITED YTTRIUM CHALCOGENIDE FILMS

U.K. Mohite

Department of Physics, M.B.S.K. Kanya Mahavidyalaya, Kadegaon,Dist. Sangli-415304(M.S.) India.

ABSTRACT: Electrosynthesis of yttrium chalcogenide films on the variety of substrates using non-aqueous bath has been carried out. Sulphur, selenide and telluride are taken as chalcogenide elements. All baths were prepared in formaldehyde solution. Sodium acetate was used as a comlexing agent for all non-aqueous baths.Corning glass vessel of volume 12cc was used as a bath container. High purity graphite plate of size $4 \times 2.5 \times 0.2 cm^3$ is used as a counterelectrode. In order to hold substrate and counterelectrode at appropriate distance a backelite holder was used. Saturated calomel electrode (SCE) was used as a reference electrode in. Substrate, temperature, chemical composition,terminal thickness etc., has been optimized for desired deposition potential for individual bath. For structural properties all films were deposited on to a stainless steel substrate and for optical properties they were deposited on to an ITO coated glass. The structural property of film was studied by X-ray diffraction and optical property was studied by optical absorption technique, which confirms thedeposited material and the band gap energy of respective compound.

Introduction:

Since from 19th century, due to vast consumption of non- renewable fossil fuels resulted in a severe anxiety for energy deficiency and the corresponding carbon emissions, creates new environmental issues. There is urgent need of clean, affordable and reliable energy that can substitute fossil fuels and limits the carbon emission issue. Therefore, the interest of researchers focused towards the development of technology to make availability of clean and renewable energy, especially the intermittent energy, energy conversion and storage [1, 2]. Many high-tech applications are found in rare earths due to their unique properties [3]. Currently rare earth several applications in modern technologies ranging from cell phones and televisions to LED light bulbs and wind turbine[4].Lokhande and et al have been reported electrodepositions of some of the rare earth metals chalcogenides from aqueous as well as non-aqueous media [5,6].Spray pyrolysis method also used to prepare thin films chalcogenides of various rare earths[7].Many theoretical models have been proposed with their electrical, magnetic, structural and other properties. Some field compounds have found to be high field technology applications [8-10]. Umbachhas shown that, in case of rare earth compounds only $HoMo_6S_8$ exhibits the co-existence of superconducting and ferromagnetic states [11]. Many researchersreported therare earth films and their characterization by various methods[12, 13]. As the rare earth metal exhibits different valance states, yttrium chalcogenide system may consists some apparent compounds.

In this paper we report on the structural and optical study of yttrium chalcogenides thin films from non-aqueous bath. Sulphur, selenide and telluride are taken as chalcogenide elements. By dissolving yttrium nitrate in formaldehyde, a non-aqueous bath of yttrium nitrate was prepared. Sodium acetate was used as a complexing agent. CH_3 $CSNH_2$was used as a sulphur ion source, S_eO_2 as a selenium ion source and non-aqueous $T_eO_2$solution as a telluride ion source.

Experimental Details:

The bath 0.05M Y $(NO_3)_3$ containing 0.05M CH_3 $CSNH_2$ and 0.05M CH_3COONa composition was suitable for electrodeposition of Y-S at room temperature (above 25^0C).About 0.5 micron thickness film was electrodeposited onto a stainless steel substrate and its structural property was studied by X- ray diffraction. Using same composition film was deposited onto a FTO coated glass and used for the optical study.The X-ray diffraction studies showed thefilms are polycrystalline and deposited material is to be $YS_{1.71\text{-}1.76}$. From optical absorption studies, the band gap energy was calculated to be 1.85eV.

The Y-Se films were electrodeposited from bath containing 0.05M Y $(NO_3)_3$, 0.05M S_eO_2 and 0.05M CH_3COONa at room temperature on variety of substrates. The XRD pattern was obtained from film deposited onto a stainless steel substrate. The X-ray diffraction studies showed the peaks of YSe_2, having crystalline nature of the film. For optical absorption study, the film was deposited onto a FTO coated glass with same composition and band gap energy was calculated to be 1.96eV.

TeO_2 solution forms precipitate when mixed with non-aqueous solution of Y $(NO_3)_3$. Therefore, it is difficult to obtain electrodeposition by co-deposition method. Therefore Y-T_e films were deposited by using layer-by-layer process. Initially yttrium was electrodeposited from the complexed bath 0.05M Y $(NO_3)_3$ onto a stainless steel substrate at room temperature. Then layer of tellurium was electrodeposited over it, from the bath consisting of saturated solution of TeO_2 - 0.05M CH_3COONa at same condition and same substrate. The film was characterized by X-ray diffraction. The possible compounds of yttrium-telluride are YT_{e3}, Y_2T_{e3}, YT_{e2} and Y-$T_e$was observed. Optical absorption of Y-T_e films deposited on FTO coated glass in proper wavelength range shows the band gap energy equal to 1.74eV.

Results and Discussion:

Fig.1 shows the polarization curves for the reduction of yttrium chalcogenide (Y-S, Y-Se, Y-T_e) from desired baths onto a stainless steel substrate. The sharp nature of curves indicates single outset potential. The deposition potentials for the reduction of Y-S and Y-Se onto a stainless steel substrate were -0.75 and -0.27 respectively, while for reduction of tellurium onto a yttrium deposited stainless steel was -1.90. Fig 2 shows the polarization curves for the reduction of 1) Y-S, 2) Y-Se onto a FTO coated glass and 3) Te on yttrium deposited FTO coated glass.

Table 1 shows the estimated deposition potentials for the reduction of Y-S, Y-Se and Y-T_e onto a stainless steel and FTO coated glass substrate.

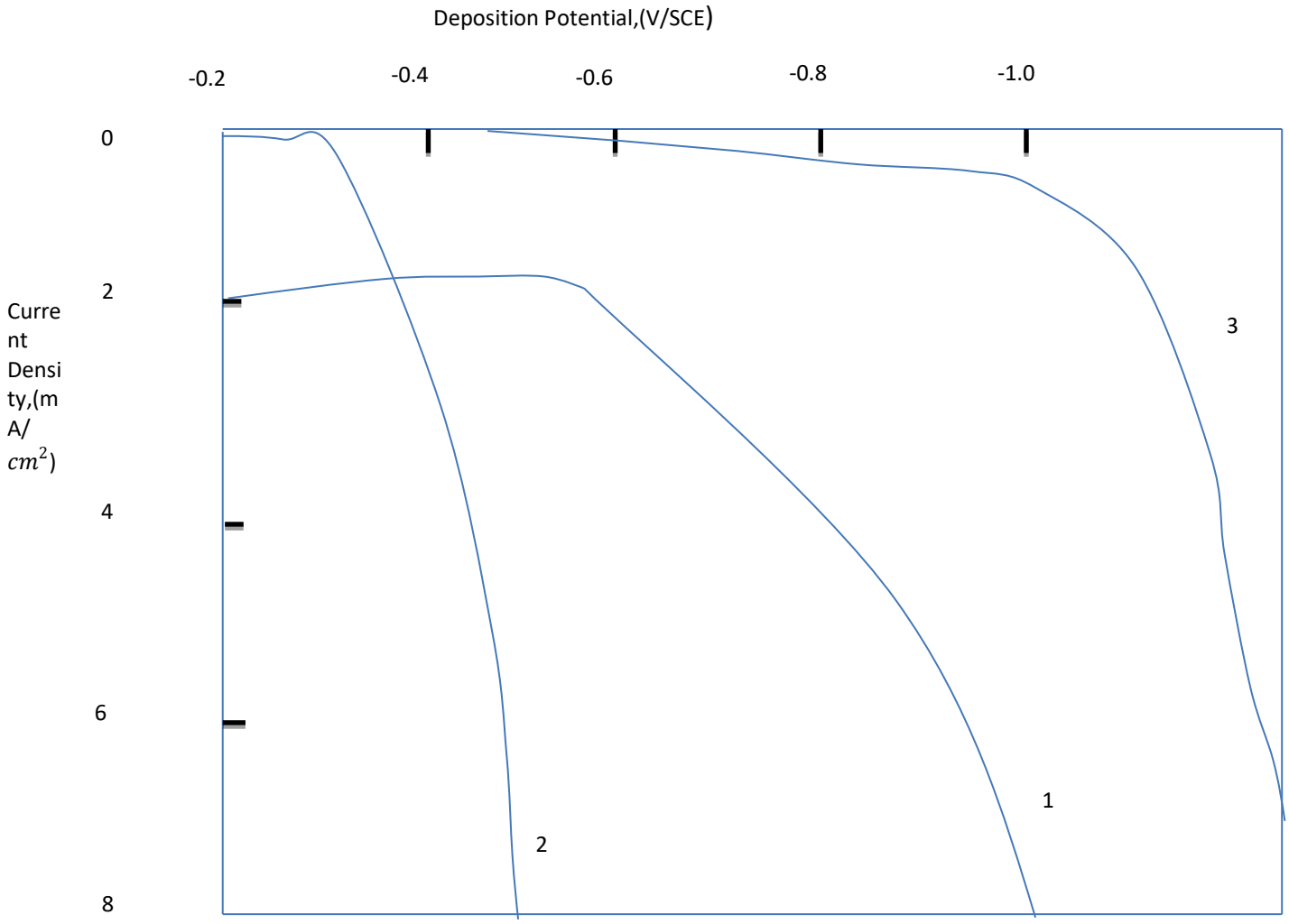

Fig.1: polarization curves for the reduction of 1) Y-S, 2) Y-Se onto stainless steel substrate and 3) Te on yttrium deposited stainless steel substrate.

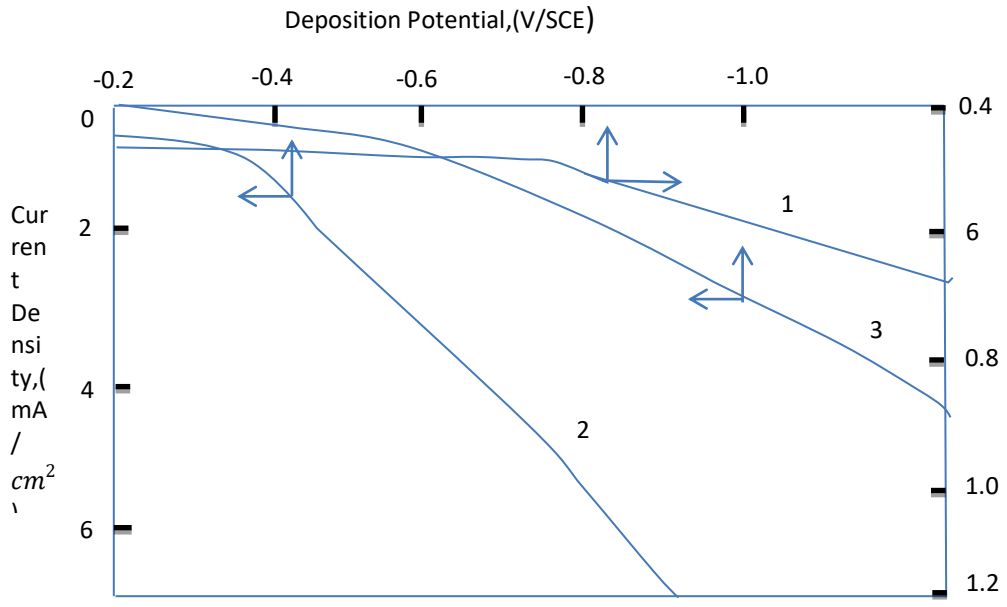

Fig.2: polarization curves for the reduction of Y-S, Y-Se and Y-Te on FTO coated glass.

Table 1: Estimated deposition potentials for the reduction of Y-S, Y-Se and Y-T_e onto a stainless steel and FTO coated glass substrate.

Film Deposited	Bath composition	Deposition potentials (V/SCE)	
		St.Steel	FTO coated glass
Y-S	0.05M $Y(NO_3)_3$ - 0.05M CH_3CSNH_2 - 0.05M CH_3COONa.	-0.72	-0.79
Y-Se	0.05M $Y(NO_3)_3$ - 0.05M S_eO_2- 0.05M CH_3COONa.	-0.27	-0.36
Y-Te	Sat. TeO_2 - 0.05MCH_3COONa	-1.9	-1.95

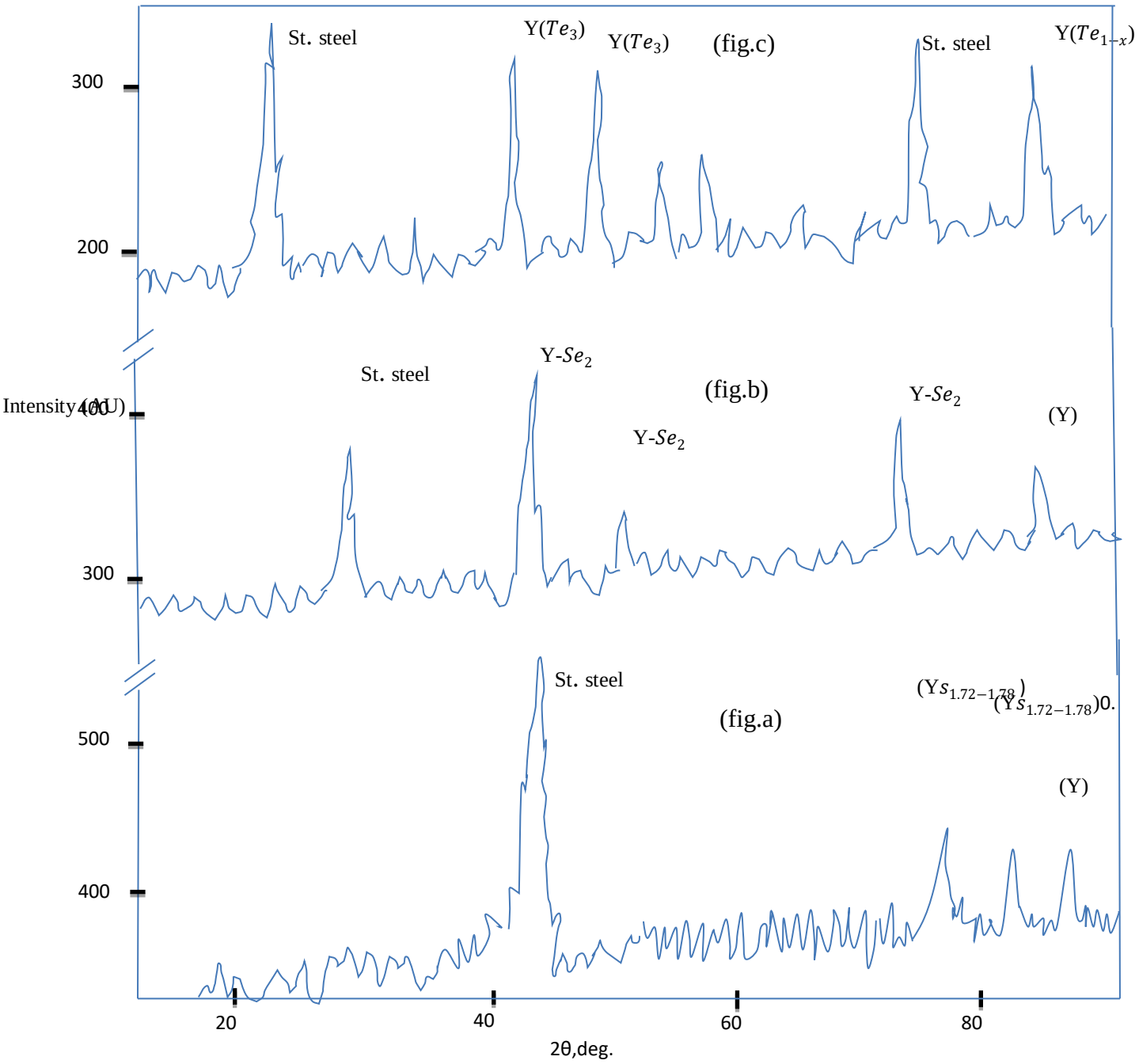

Fig. 3: XRD pattern of Y-S, Y-Se and Y-Te film deposited onto stainless steel

The structural properties of yttrium chalcogenide films are studied by X-ray diffraction technique. The study has been carried out with the films deposited onto stainless steel substrate. A different concentration of chalcogenide ions was tested, however, 0.05M concentration is found to be suitable for them, in which there is no yttrium hydroxide presence. Fig.3 shows the XRD pattern of Y-S, Y-Se and Y-Te films deposited onto a stainless steel substrate.

Table 2: Comparison of interplaner distances''d' for Y-S, Y-Se and Y-Te films

Deposited film	Bath Composition	Observed 'd' values	Standard 'd' values	Compound formed	references
Y-S	0.05M $Y(NO_3)_3$ -0.05M CH_3CSNH_2 - 0.05M CH_3COONa.	1.27 1.09	1.26 1.07	$(Ys_{1.72-1.78})$ $(Ys_{1.72-1.78})$	14
Y-Se	0.05M $Y(NO_3)_3$ -0.05M S_eO_2- 0.05M CH_3COONa.	1.26 2.72 1.80	1.26 1.74 1.80	Y-Se_2 Y-Se_2 Y-Se_2	15
Te on yttrium (Y-Te)	Sat. TeO_2 - 0.05M CH_3COONa	2.06 1.91 1.79	2.07 1.93 1.79	$Y(Te_3)$ $Y(Te_3)$ $Y(Te_{1-x})$	16,17

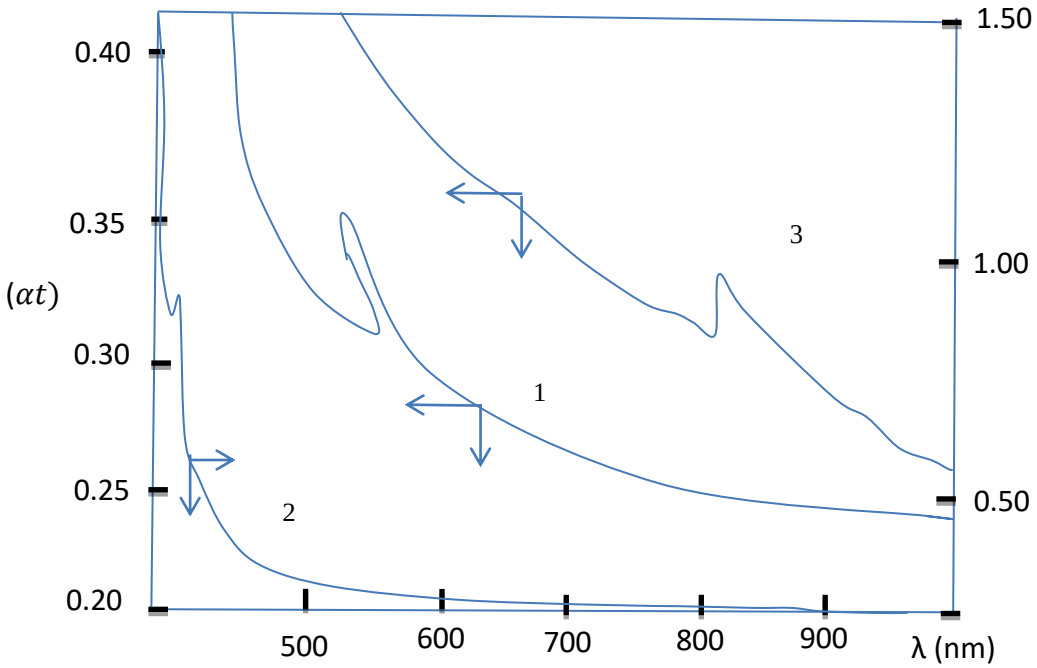

Fig 4: Optical density (αt) versus wavelength (λ) spectra of of 1) Y-S, Y-Se and Y-Te film.

Table 2 shows the Comparison of observed'd' values with 'd' values from standard ASTM data [14-17], which shows that material deposited corresponding to Y-S, Y-Se and Y-Te.

We have carried out optical absorption of yttrium chalcogenides films deposited on conducting (FTO coated) glass substrates at room temperature (27^0C) in the wavelength range 400 to 1,000 nm.

Fig.4 shows that optical density 'αt' starts decreasing up to 700nm, which is large towards the shorter wavelength side.The absorption coefficient 'α' is if the order of 10^2-$10^3 cm^{-1}$.

In order to estimate bandgap 'Eg' of the Y-S, Y-Se and Y-Te, a plot of $(\alpha t h\nu^2)$ versus (hν) is plotted as shown in fig.5. The 'Eg' were estimated to be 1.85, 1.96 and 1.86 respectively.

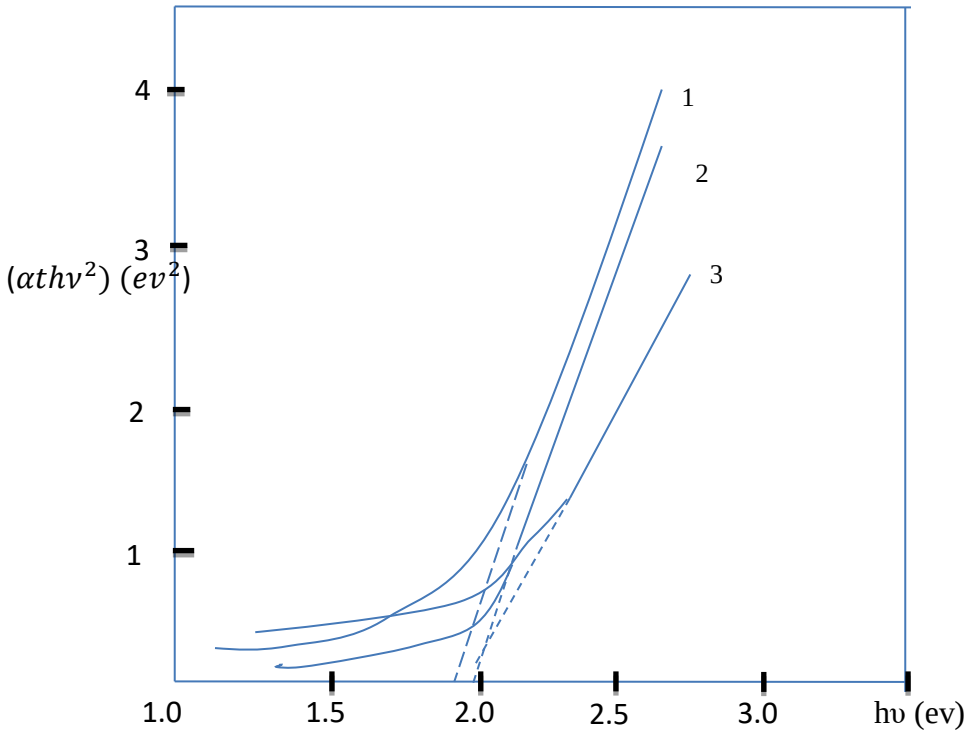

Fig. 5 : Graph of (αthv^2) versus (hυ) for 1) Y-S, 2) Y-Se and Y-Te Films

Conclusions:

Our study shows that yttrium chalcogenide (Y-S, Y-Se and Y-Te) films can be deposited at room temperature onto a stainless steel substrate and ITO coated glass using suitable complexing agent. The deposited yttrium chalcogenide films had the compositionYS$_{1.72\text{-}1.78}$,Y-Se_2 ,Y(Te_3) and Y(Te_{1-x}) with the band gap energies 1.85, 1.96 and 1.86 eVrespectively.

Acknowledgement:

The author thankful to Principal Dr. V. Y. Kadam, M.B.S.K. Kanya .Mahavidyalaya, Kadegaon, Dist. Sangli for encouragement and provision of necessary facilities. The auther is thankful to research guide Dr. C. D. Lokhande and all departmental faculty for kindly shairing their knowledge, for their suggestions and fruitfull discussions.

References:

[1] Z Qifeng, U Evan, L Stephanie, A. Candelariaz and C Guozhong. 2013. Nanomaterials for energy conversion and storage.Chem. Soc., Rev.,(42):3127-3171.

[2] T Hanifawati. 2005. Nanostructured materials for advanced energy conversion and storage devices. Nature Materials, Rev.,(4):366-377.

[3]Amaral C,Machado R, Barros J, Virgilio A , Schiavo D, Nogueira A, and Nóbrega J.2017.Determination of rare earth elements in geological and agricultural samples by ICP-OESSpectroscopy, 32 (10): 32-36.

[4] V. Balram 2019. Rare earth elements: A review of applications, occurrence, exploration, analysis, recycling, and environmental impact. Geoscience Frontiers, 10(4): 1285-1303.

[5] S. B. Jundale and C. D. Lokhande 1991.Electrodeposition of samarium from tartrate bath,Materials Chemistry and Physics,3(27): 265-278.

[6] U. K. Mohite, K. M Gadave .and C. D. Lokhande 1995.Electrosynthesis of Yttrium from non-aqueous bath.Ind. J. Engg. and Mater. Sci., (2):93-96.

[7] G. D. Bagde, V. S. Yermune and C. D. Lokhande 2000.Preparation and characterization of lanthanum sulphide thin films deposited by spray pyrolysis Technique..Ind. J. Engg. and Mater. Sci.,(7): 390-394.

[8] Mitsuhiro Motokawa, 2004.Physics in high magnetic fields,Reports on Progress in Physics, (67):1021-1026.

[9] M, Wake T Shintomi, x M Shintomi and H Hirabayashi .1983.Use of Superconducting Alloys in High Field Magnet, High FieldMagnetism, (53):339-342

[10] B. Turck 1990.Recent developments in superconducting conductors,Proceedings of the 16th Symposium on Fusion Technology,London, U.K., 135-154.

[11] C.P. Umbach 1982. Ph.D. Thesis. University of Minnesota, Minneapolis.

[12] M,KukliK and M. Ritala 2006. Rare-earth Oxide thin films for Gate Dielectrics in Microelectronics. J. Alloys Compod.,418(1-2):27-34

[13] L Markku and R. Mikko 2003. Rare-earth oxide thin films as gate oxides in MOSFET transistors. Journal of Solid State Chemistry, 171(1-2): 170-174.

[14]ASTM data card No. 16-467.

[15] ASTM data card No. 20-1415.

[16] ASTM data card No. 19-1451.

[17] ASTM data card No. 24-1214.