LOW POWER PLASMA TREATMENT FOR THE GROWTH OF SnSe THIN FILMS FOR PHOTOVOLTAIC APPLICATIONS

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Tin selenide thin films were prepared by plasma treatment of tin thin films at low substrate temperature and at low rf power. The plasma treatment was carried out in H_2Se atmosphere. The SnSe phase was confirmed by XRD analysis. Films are highly absorbing in the visible region. Band gap of 1.9 eV was obtained from the optical transmission spectra of the thin films. SnSe being an important material with applications in solar cells this low temperature and low power technique can have important application in the photovoltaic industry.

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1. Introduction

The current scenario in thin film photovoltaic technology revolves around three major materials classes namely Si, CdTe and CIGS. The efforts to reduce the cost of the solar panels concentrate more on making the process for these technologies cheaper. Another alternative is to look for materials that are cheaper than those which the present technology uses, viz Si, Te and In. Tin based solar cells offer a cost effective alternative. Tin chalcogenides offer a range of optical band gaps suitable for various optical and optoelectronic applications. SnSe is an important material which has been the center of research for a long time. SnSe is a narrow band gap binary 1V–VI semiconductor with an orthorhombic crystal structure. SnSe is also used as memory switching devices, holographic recording systems, and infrared electronic devices. Various authors have reported the growth and characterization of this material (1-7) underlining the importance of this material. This report presents some results of SnSe thin films prepared by plasma treatment of tin thin films prepared at low substrate temperature and low rf power. To the authors knowledge it is the first time this technique of plasma treatment of tin thin films is used for preparing SnSe thin films.

2. Experiment

SnSe thin films were prepared by reacting tin thin films with H_2Se. The thin films of tin were deposited on glass substrates by thermal evaporation. H_2Se gas was produced in the lab by reacting hydrogen gas with elemental selenium at 400 ^{o}C in a furnace. The H_2Se gas produced in the furnace was carried to the vacuum chamber by purging with hydrogen gas. The substrate temperature of 200 ^{o}C and the rf plasma of 15 W was used for 20 minutes in a flow of H_2Se for preparing the SnSe thin films. The tin films were not converted into SnSe in the absence of the rf plasma.

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The x-ray diffraction (XRD) of thin films were done on a Rigaku X-ray diffractometer with Cu Kα radiation (λ = 1.54056 ˚A). The XRD pattern obtained is shown in figure 1.The phases of SnSe are indexed using the standard SnSe phases from the JCPDS data 48-1224. The thickness of the thin films was 460 nm.

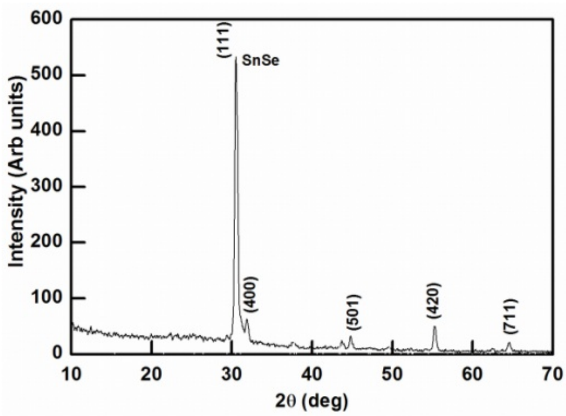

Fig. 1 XRD pattern of the SnSe thin film.

The optical transmission was determined using Jasco spectrophotometer. The optical transmission of the SnSe thin film is shown in the figure 2. The bandgap as calculated from the transmission data is 1.9 eV. The inset of the figure 2 shows $(\alpha h\nu)^2$ vs. hν graph for the determination of bandgap.

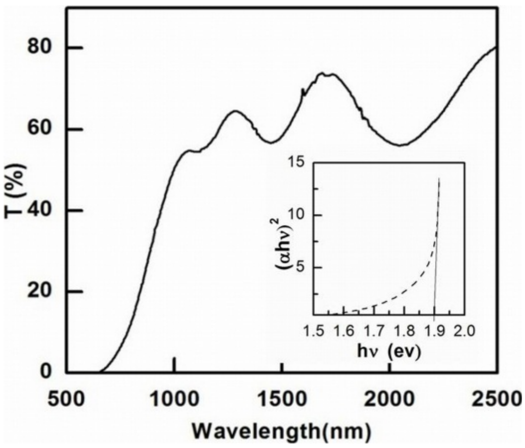

Fig. 2 Optical transmission spectrum of the SnSe thin films.
Inset shows the bandgap of the film (1.9 ev).

The SEM images were obtained with a Hitachi, FESEMS-5500 microscope.The scanning electron micrograph shows the polycrystalline growth of SnSe (fig 3). The SEM analysis shows that the films are composed of smooth crystallites of dimensions of 1 to 2 μm^2 separated by rough features (inset of figure 3). These films are being studied for use in solar cells as absorber layers

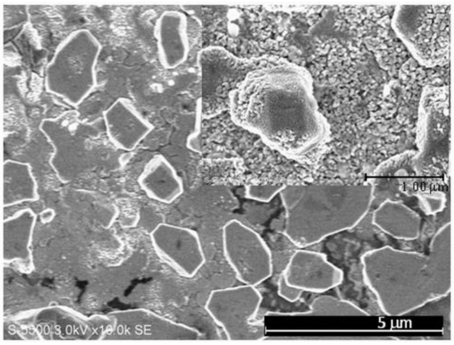

Fig. 3 SEM micrograph of the SnSe thin films the inset shows the inter grain space.

3. Conclusions

Tin selenide thin films were prepared by treatment of thin films of tin in rf plasma in presence of H_2Se gas. The XRD pattern shows the growth of SnSe. The films are found to be highly absorbing in the visible range. SnSe being an important material with applications in solar cells this low temperature and low power technique can have important application in the photovoltaic industry. The films are being investigated for application in solar cells.

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References

[1] K. Bindu, P. K.Nair, Semicond. Sci. Technol. **19,** 1348 (2004)
[2] M. Popescu, F. Sava, A. Lorinczi, G. Socol, I.N. Mihailescu, A. Tomescu, C. Simion, Journal of Non-Crystalline Solids **353**, 1865 (2007).
[3] NicolasD. Boscher, Clarie J. Carmat, Robert G. Palgrave, Ivan P. Parkin, Thin Solid Films **516** 4750 (2008).
[4] Matthew A. Franzman, Cody W. Schlenker, Mark E Thompson, and Richard L. Brutchey, J. Am Chem. Soc. **132**, 4060 (2010).
[5] N. Kumar, V.Sharma, N.Padha, N.M.Shah, M.S. Desai, C.J.Panchal, I.Yu.Protsenko, Cryst. Res. Technology **45**, 53 (2010).
[6] Mustafa Bicer, Ilkay Sisman, Applied Surface Science **257**, 2944 (2011).
[7] R.Mariappan, M.Ragavendar, G. Gowrisankar, Chalcogenide Letters **7,** 211 (2010).