JOURNAL OF NANO- AND ELECTRONIC PHYSICS
Vol. **5** No 1, 01020(2pp) (2013)

ЖУРНАЛ НАНО- ТА ЕЛЕКТРОННОЇ ФІЗИКИ
Том **5** № 1, 01020(2cc) (2013)

Short Communications

Optical Dispersion In Annealed Thin Films of S-doped a-Si:H Alloys

L.P. Purohit[1,*], H. Gupta[1], Pankaj K. Pal[1], A. Kumar[2], R. Kumar[1], R.M. Mehra[3]

[1] *Department of Physics, Gurukula Kangri University, 249404 Haridwar, India*
[2] *Department of Mathematics & Statistics, Gurukula Kangri University, 249404 Haridwar, India*
[3] *School of Engineering & Technology, Sharda University, Greater Noida, India*

(Received 30 December 2012; published online 28 March 2013)

S-doped amorphous hydrogenated silicon (a-Si,S:H) thin films were prepared by conventional PECVD method on corning glass substrates. The prepared thin films were subsequently annealed in vacuum ($\sim 2 \times 10^{-6}$ Torr) in the temperature range from 100 °C to 500 °C. The annealing effects at room temperature were examined by means of optical transmission spectra of the films in the wavelength range 300-1100 nm. Dispersion in optical constants such as transmittance, bandgap and refractive index were observed. Tailoring in optical constants was observed with respect to doping concentrations as well as the annealing temperatures.

Keywords: a-Si:H thin films, Doping concentrations, Annealing temperatures, Transmittance, Optical constants.

PACS numbers: 71.55 Jv, 71.55. Jv, 81.05. Gc, 81.40 Tv

1. INTRODUCTION

Hydrogenated amorphous silicon thin films and its alloys are the promising candidates for the realization of advanced opto-electronic devices. The doping in hydrogenated amorphous silicon and its impact on the devices has been studied by several groups, for example, tetrahedrally coordinated elements: C and Ge [1], helogen elements: F and Cl [2]. So far carbon doped hydrogenated amorphous silicon (a-Si, C:H) has emerged as leading contender in large bandgap alloys in amorphous silicon based photovoltaic devices by serving as photon energy absorbing window layers in multi-junction cells [3]. However, the long-term stability and the efficiency of the material have not been solved due to the photoinduced degradation in a-Si:H thin films, which is associated with light-induced metastable Si dangling-bond defect [4, 5]. The selection of Se and S as the doping element, terminate the silicon dangling bonds in the same way as hydrogen [6]. Annealing studies have emerged as an important tool that provide an insight to the various material property especially hydrogenated amorphous silicon thin films [6].

2. EXPERIMENTAL

The a-Si,S:H thin films were prepared using PECVD method of H_2Se and H_2S vapor mixed with silane gas (SiH_4) decomposition on 7059 corning glass at the substrate deposition temperature of 230 °C. The thicknesses of the films were ranged from 0.24 to 5.44 μm. The absence of sharp peaks in X-ray diffraction pattern confirmed the amorphous nature of the films. The samples were annealed at the temperatures of 100 °C, 200 °C, 300 °C, 400 °C and 500 °C, respectively, in vacuum furnace for an hour and then the transmittance response of these samples was subsequently measured after each annealing process. The optical transmission measurements were performed on S-doped a-Si:H thin films using a Shimadzu spectrophotometer (3700 UV-VIS-NIR).

3. RESULTS AND DISCUSSION

Fig. 1 shows the typical transmission spectra for the gas ratio of $H_2S / SiH_4 = 1 \times 10^{-4}$ with respect to annealing temperatures from 100 to 500 °C in vacuum for an hour. The maximum transmittance was observed at annealing temperature of 300 °C for all samples.

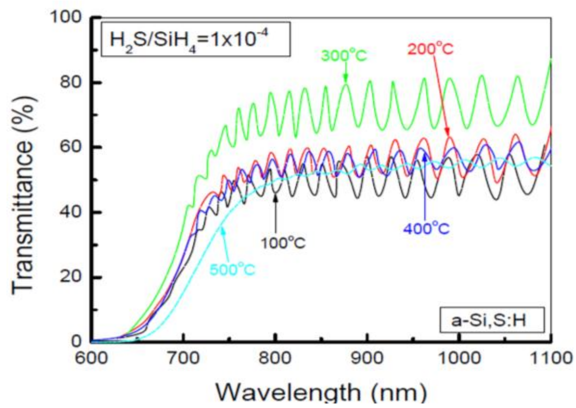

Fig. 1 – Transmission **s**pectra of a-Si, S:H thin films with respect to annealing temperature from 100 to 500 °C

The variation of absorption coefficient with annealing temperatures as well as doping concentrations for a-Si, S:H is shown in Fig. 2. The maxima and minima of the fringes in the transmission spectra were used to calculate the optical constants [7]. Optical bandgap, E_g, of a-Si, S:H thin films have been estimated from the transmission spectra which was taken in the wavelength range from 300-1100 nm after each heat treatment for all the samples. The optical bandgap of the films has been calculated using the Tauc's relation:

* lppurohit@gmail.com

$\alpha = (B / h\nu)\cdot(h\nu - E_g)^{\gamma}$, B is the proportionality constant, $h\nu$ is the photon energy. The variation of band gap for all S-doped a-Si:H thin films versus annealing temperature, as well as doping concentrations, are shown in Fig. 3.

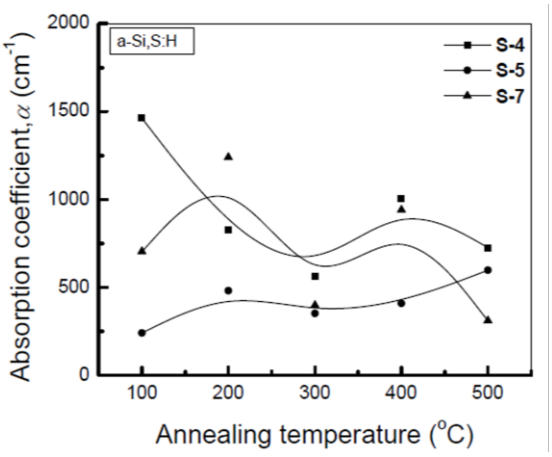

Fig. 2 – Absorption coefficient versus annealing temperature (°C) of a-Si, S:H thin films with respect to doping ratios S-4 (H_2S / SiH_4 = 10^{-4}); S-5 H_2S / SiH_4 = 1.1×10^{-5}); S-7 (H_2S / SiH_4 = 6.8×10^{-7})

The value of band gap was observed the highest at the annealing temperature of 300 °C for all the doping concentrations.

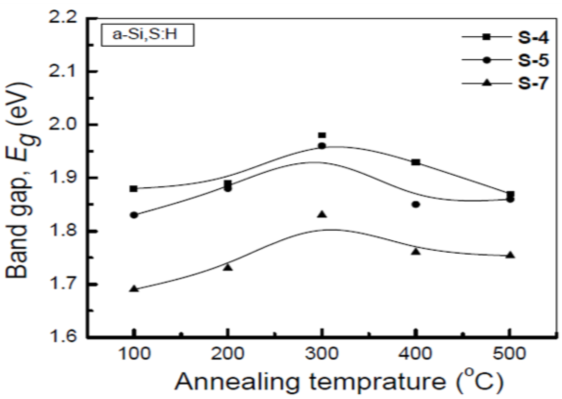

Fig. 3 – Variation of bandgap versus annealing temperature at a typical wavelength of 750 nm for a-Si, S:H thin films

The variation of refractive indices of S-doped a-Si:H thin films at typical wavelength, λ = 750 nm, versus annealing temperature is shown in Fig. 4. The values of n were observed the lowest at around the annealing temperature of 300 °C for all S-doped samples. The decrease in refractive index with S- doping in a-Si:H might be due to the increase in internal strain. Optical absorption measurements show that the incorporation of S in a-Si:H films increases the bandgap of the material and the results in increased disorder and higher defect densities [7]. It might be expected that the annealing can remove many of the defects which are responsible for the performances in the devices. Thus, it appears that there is an improvement in the quality of a-Si, S:H films up to annealing temperature of 300 °C and deterioration beyond this temperature. Finally, it is suggested that the annealed S-doped a-Si:H films at 300 °C in vacuum for an hour, could be a viable alternative to a-Si, C:H as a wide band gap semiconductor materials.

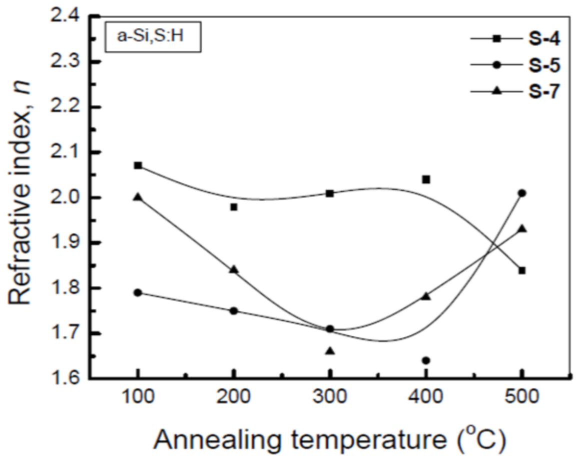

Fig. 4 – Variation of Refractive indices versus nnealing temperature at a typical wavelength of 750 nm a- Si, S:H thin films

4. CONCLUSION

The films were subsequently annealed, and annealing temperature was optimized to 300 °C for better optical constants of S-doped a-Si:H thin films. The dispersion of optical properties, viz. transmittance, absorption coefficient and refractive indices were observed. It is also seen that the incorporation of S in a-Si:H films increases the bandgap of the material and results in increased disorder and higher defect densities.

REFERENCES

1. J. Chevallier, H. Wieder, A. Onton, C.R. Guarnieri, *Solid State Commun.* **24**, 867 (1977).
2. S.A. Dallal, S. Kalem, J. Bourneix, J. Chevallier, M. Tolemonde, *Philos. Mag. B* **50**, 493 (1984).
3. M. Hossain, J. Roberto, S. Perez, J.M.R. Rivera, K. Gangopadhyay, S. Gangopadhyay, *J. Mater. Sci.* **20**, 412 (2009).
4. V. Nadazdy, R. Durny, M. Zeman, *J. Non-Cryst. Solids* **352**, 1059 (2006).
5. J. Melskens, G.V. Elzakker, Y. Li, M. Zeman, *Thin Solid Films* **516**, 6877 (2008).
6. S.K. Sharma, J. Baveja, R.M. Mehra, *phys. stat. sol. (a)* **194**, 216 (2002).
7. G.A.M. Amin, *Opt. Mater.* **29**, 562 (2007).