IJCPS Vol. 10, No. 3 , May-Jun 2021
www.ijcps.org
DOI Prefix:10.30731/ijcps

International Journal of Chemical and Physical Sciences
(Peer-Reviewed Journal)
ISSN:2319-6602

Study of Optical Property of PEDOT: PSS/Ge Nano-Composite Thin Films

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Abstract

Semiconductor thin films ofgermanium (Ge) was deposited on conducting polymer poly (3,4ethylene dioxythiophene): polystyrene sulfonate (PEDOT: PSS) films coated on quartz glass by spin coating technique. Thin films of germanium (Ge) of thickness 50 nm, 75 nm and 100 nm were deposited on PEDOT: PSS by electron beam gun evaporation system. The prepared composite thin films were implanted with 200 keVAr^{++} ions with various fluences and characterized by using Fourier Transform Infrared Spectroscopy.The decrease in transmittance is due to deposition of germanium layer which is less transparent as compared to PEDOT: PSS.

Keywords: Polymer-PEDOT: PSS, germanium (Ge), Ar^{++} ion, implantation, FTIR spectroscopy

Introduction:

Synthesis of nanoparticles on the surface and embedded in the matrix by thermal annealing (leading to diffusion of nanoparticles into polymer matrix) and ion beam irradiation is a promising method as reported in the literature [1].The formation of spherical and uniform Pt nanoparticles on SiO_2 surface have been reported as a result of 800 keV Kr ions irradiation of thin Pt film [2]. The synthesis of Au nanoparticles at the surface and embedded in the carbon rich matrix by low-energy ion-beam irradiation with 150 keVAr ions at varying fluences of thin Au film on the PET substrate has been reported.The isolated Au nanoparticles (45 ± 20 nm) appeared at the surface at the ion fluence of 5×10^{16} ions cm^{-2}[3]. Formation of self-assembled Au nanoparticles with controlled size and distributions was reported using focused ion beam (FIB) irradiation (5 keV Ga^{+}) of thin Au films on amorphous carbon films [4]. Multiple vibrations are reported in FTIR-Reflectance Study of PEDOT: PSS/Ge Nano-Composite Thin Films due to new chemical bonding in composition of material [5]. Formation of clusters of different sizes and optical property are reported in Raman and UV-VIS- NIR Study of GaAs Implanted by Fe^{+2} Ion [6].

However, a very limited data is available for the modification of optical properties by ion beam irradiation. The optical energy band gap and crystalline size of polymer nano composite can be controlled by ion beam treatment by controlling beam parameters (current, energy, fluences etc.). The main objective of this work was to study the opticalproperties of Cadmium Sulphidenano crystalline films on poly (3,4ethylenedioxythiophene): polystyrene sulfonate (PEDOT: PSS) irradiated by Ar ions at various fluences.

Experimental:

The samples for the present work were prepared on quartz glass substrates of dimensions: 15 mm x 15 mm x 1mm. Slides were first cleaned in de-ionized (DI) water andacetone to remove the impurities from the surface of the slides. Slides were further cleaned in a solution of trichloroethylene (TCE) for 10 minutes and rinsed in hot water. A programmable spin coater (Model No. Spin NXG-P1, Apex Equipment, Kolkata, India) was used to prepare the PEDOT: PSS films on quartz glass substrates. The acceleration time (second), rotation time (second) and revolution per minutes (rpm) during spin coating process were 5, 60 and 1500 respectively. The Electron Beam Gun Evaporation system(HINDHIVAC VACUUM COATING UNIT MODEL "12A4D" and an Electron Beam Power Supply Model "EGC-3kW" has been used in the present work to deposit a thin films of germanium (Ge) of different thickness 50 nm, 75 nm and 100 nm on the spin coated surface of PEDOT: PSS. The thickness (75 nm) of the germanium (Ge) film was measured by quartz digital thickness monitor.The samples prepared by electron beam gun system were implanted with 200 keVAr^{++} ions using Electron Cyclotron Resonance Ion Sources (ECRIS) at T.I.F.R., Mumbai, India. The samples were implanted for various ion fluences varying from 1 x 10^{13} to 1 x 10^{15} ions cm^{-2} at room temperature. After implantation, the samples were cleaned in electronic grade Trichloroethylene, Acetone and Methanol and rinsed in de-ionized water. The samples were dried and stored in desiccators for characterization. The effect of argon ion implantation on the structural and optical properties of PEDOT: PSS/ Ge composite thin films were investigated for non-implanted and samples implanted with various ion fluencies using Fourier Transform Infrared Spectroscopy (FTIR) [5-7].

Results and Discussion:

Variation of nuclear energy loss and electronic energy loss as afunction of ion energy for Ar ions in germanium are presented in figure -1. From figure-1, it is found that at 200 KeVAr^{++} ions energy both losses are nearly same that indicates no more changes in structural property of material but slightly changes can be seen in optical [5].

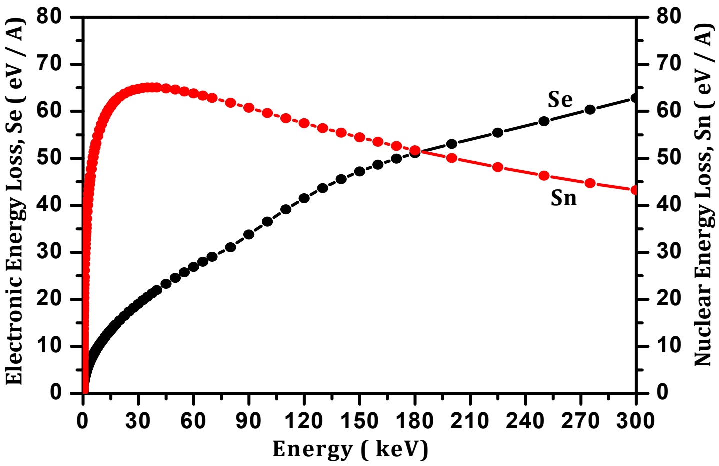

Fig. 1: Variation of nuclear energy loss and electronic energy loss as a Function of Ion energy for Ar ions in germanium

FTIR transmittance spectra of PEDOT:PSS film of 100 nm thickness and PEDOT: PSS/Ge composite films of germanium thickness 50 nm, 75 nm and 100 nm on PEDOT:PSS layer are shown in Figure 2 (a), (b), (c) and (d) respectively. The valley in PEDOT: PSS transmittance spectra at 3678 cm^{-1} in Figure 2 (a) is shifted to 3680 cm^{-1}, 3684 cm^{-1} and 3694 cm^{-1} for PEDOT: PSS/Ge composite films with germanium film thickness of 50 nm, 75 nm and 100 nm respectively (Figure 2 (b), (c) and (d)).Change of size of valley peak is found in PEDOT: PSS transmittance spectra at 3678 cm^{-1} in Figure 2 also. This change indicates that the various chemical bonds are present of different sizes in prepared sample.

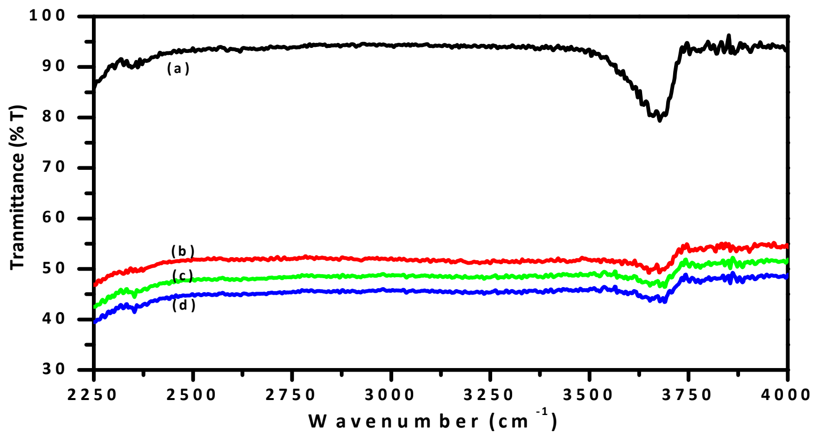

Fig. 2: FTIR Transmittance (% T) spectra of (a) PEDOT: PSS and PEDOT: PSS/ Ge composites films of thickness (b) 50 nm (c) 75 nm and (d) 100 nm.

The percentage transmittance decreases from 94 % for PEDOT: PSS film to 52 %, 48 % and 45 % for PEDOT: PSS/Ge composite films with germanium thickness of 50 nm, 75 nm and 100 nm respectively. The decrease in transmittance is due to deposition of germanium layer which is less transparent as compared to PEDOT: PSS.

Figure 3 shows the transmittance spectra of the PEDOT: PSS/Ge composite films after Ar^{++} ion implantation. It can be seen that the percentage transmittance increases from 48 % for non-implantedsample to 56 %, 65 % and 73% for samples implanted with fluences of 1×10^{13}, 1×10^{14} and 1×10^{15} ions cm^{-2} respectively. No changes are seen in chemical bonding of materials due to no huge changes present at peak position 2250 cm^{-1} in Figre-3 for ion fluences of 1×10^{13}, $1 \times 10^{14} cm^{-2}$ respectively but it is seen two peaks approximate at same position in 1×10^{15} ions cm^{-2}. This indicates formation of clusters in side of materials [8].

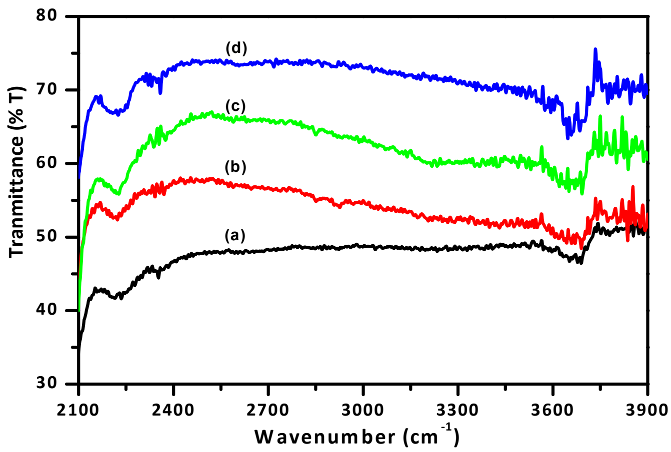

Fig. 3: FTIR Transmittance (% T) spectra of PEDOT: PSS/ Ge composites films as prepared (a) and implanted with 200 keV argon ions with fluence of (b) 1×10^{13} (c) 1×10^{14} and (d) 1×10^{15} ions cm^{-2}.

Conclusion:

The decrement of transmittance in spectra recorded by Fourier Transform Infrared Spectroscopy was seen in deposited germanium layer which is less transparent as compared to PEDOT: PSS. Percentage transmittance 56 %, 65 % and 73% were found for samples implanted with 200 keVAr^{++} ions forvarious fluences (1×10^{13}, 1×10^{14} and 1×10^{15} ions cm^{-2} respectively).Formation of different types of clusters inside the materials has been found at higher ion fluences.

Conflict of Interest:

The author declared that he has no conflict of interest.

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