

Optical Property of Fe^{+2} Ions implanted Silicon Substrate

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ABSTRACT

Chemically cleaned Semiconductor thin films of silicon (Si) were implanted with 200 keV Fe^{+2} ions with various fluences and characterized by using Fourier Transform Infrared Spectroscopy. The decrease in transmittance is due to mixing of iron ions near to surface of silicon samples layer which is less transparent as compared to virgin sample and also revealed the different sizes of clusters formed in samples.

Keywords: Silicon (Si), Fe^{+2} ion, implantation, FTIR spectroscopy.

INTRODUCTION

The synthesis of Au nanoparticles at the surface and embedded in the carbon rich matrix by low-energy ion-beam irradiation with 150 keV Ar ions at varying fluences of thin Au film substrate has been reported and shown different results of particles. Gold nanoparticles of very small size appeared at the surface at the ion fluence of 5×10^{16} ions cm^{-2} [1,2]. Synthesis of small sizes of particles on the surface and embedded in the matrix of samples by doping method thermal and ion beam irradiation is a promising method as reported in the literature [3]. 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 [4].

However, a very limited data is available for the modification of optical and structural properties by ion beam implantation method. The optical energy band gap and crystalline size of all samples 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 optical and structural properties of implanted silicon samples by iron ions at various fluences.

Experimental Details

The samples for the present work were prepared in the size of dimensions: 15 mm x 15 mm. Slides were first cleaned in de-ionized (DI) water and acetone to remove the impurities from the surface of the slides. All the cleaned samples were implanted with 200 keV Fe^{+2} ions using Electron Cyclotron Resonance Ion Sources (ECRIS) at IUAC, Delhi, India. The samples were implanted for various ion fluences varying from 1×10^{11} to 1×10^{13} 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 FTIR spectra of the all samples were recorded in the transmittance mode using the FTIR spectrometer in department of Physics, University of Mumbai.

RESULTS AND DISCUSSION

FTIR transmittance spectra of Silicon sample (a) and implanted with 200 keV iron ions with fluence of (b) 1×10^{11} (c) 1×10^{12} and (d) 1×10^{13} ions cm^{-2} is presented in Figure-1 (Figure 1 (a), (b), (c) and (d) respectively). The valley in all samples as shown by line -2 (L_2) in Figure-1 is found to shift towards the lower values and all shifted values are given in table. It indicates the formation of various sizes of clusters in all samples after mixing of iron ion at different fluences and it may tune the band gap of silicon samples for the better performance in the field of electrical conductivity.

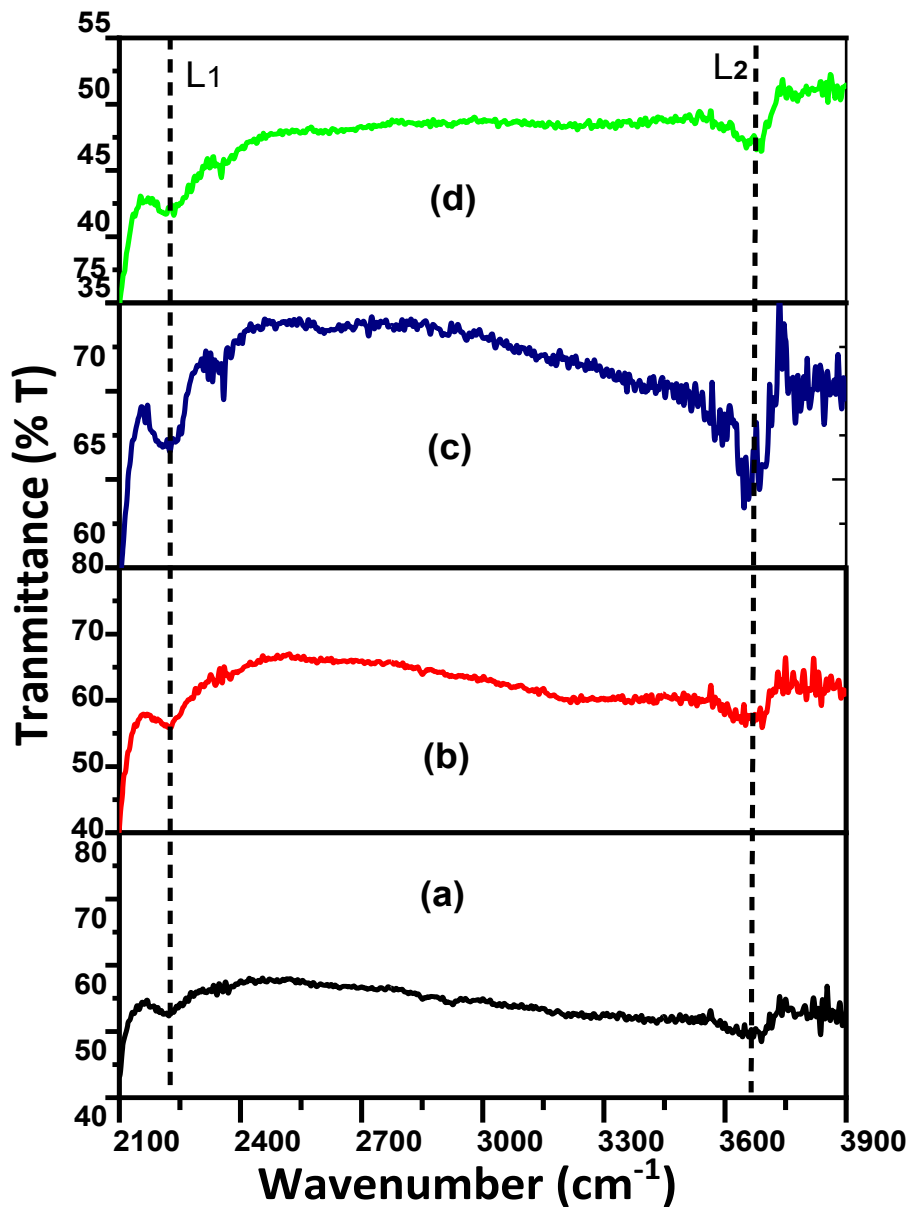


Figure 1 FTIR Transmittance (% T) spectra of Silicon sample (a) and implanted with 200 keV iron ions with fluence of (b) 1×10^{11} (c) 1×10^{12} and (d) 1×10^{13} ions cm^{-2} .

Table: Extracted the values of transmittance in percent and shifting of the peaks in the following samples from the FTIR Transmittance (% T) spectra of Silicon sample (a) and implanted with 200 keV iron ions with fluence of (b) 1×10^{11} (c) 1×10^{12} and (d) 1×10^{13} ions cm^{-2} .

Samples Details	Transmittance Values (%)	Shifted Values of Wave No (cm^{-2})
a	53.221	3667.237
b	56.827	3665.219
c	67.088	3653.177
d	42.153	3653.018

The percentage transmittance values in samples are as reported from graph (Figure-1) in table, indicates in From the Table it is found that the values of transmittance for silicon sample (a) and implanted with 200 keV iron ions with fluence of (b) 1×10^{11} (c) 1×10^{12} are increasing slightly, indicates the formation of different sizes of clusters in the samples. In the sample [(d) iron ion fluence of 1×10^{13} ions cm^{-2}], transmittance is found less than pure sample indicates the recrystallization of samples at higher values of iron ion mixing.

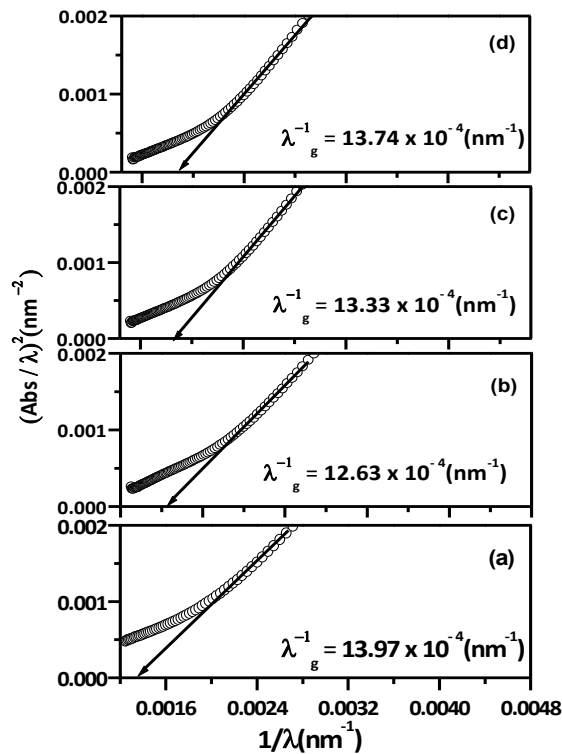


Figure 2. The plot of $(\text{Abs}/\lambda)^2$ Vs $(1/\lambda)$ for Silicon sample (a) and implanted with 200 keV iron ions with fluence of (b) 1×10^{11} (c) 1×10^{12} and (d) 1×10^{13} ions cm^{-2} .

The band gap of Silicon sample (a) and implanted with 200 keV iron ions with fluence of (b) 1×10^{11} (c) 1×10^{12} and (d) 1×10^{13} ions cm^{-2} were found to be 1.32 eV, 1.23 eV and 1.27 eV respectively as compared to 1.29 eV for non-implanted samples. This is due to the mixing of ion inside of compound matrix as ion implantation take place during the implantation of iron ion at low energy.

CONCLUSION

The decrement of transmittance in spectra recorded by Fourier Transform Infrared Spectroscopy was seen in higher values of iron ion due to atomic mixing. Percentage transmittance 53.221 %, 56.827 % and 67.088% were found for samples implanted with 200 keV Fe^{+2} ions for various fluences (1×10^{11} , 1×10^{12} and 1×10^{13} ions cm^{-2} respectively) for various sizes of clusters generated in samples after atomic mixing.

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