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Boron ion irradiation induced defects in Selenium

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Abstract: The defects produced by homogeneous and mono-energetic irradiation have been compared in selenium using boron ion beam of 60 MeV at NSC Pelletron. The nature of defects and their density is characterized by positron lifetime spectroscopy. The annealing behavior of these defects has been studied by variation in positron lifetime parameters in temperature region 300K - 380K Results indicate the formation of columnar tracks in boron ion irradiated selenium.

Keywords: RIDs, Defect Distribution, Characterization, Positron lifetime spectroscopy.

INTRODUCTION

An energetic ion passing through a material loses its energy via collisions with the nuclei and the electrons of the target atoms. This phenomena results into the several changes in the microstructure of the target and is responsible to generate radiation induced defects (RIDs).

When an energetic ion passes into some materials amorphous tracks (columnar tracks) are formed due to electronic energy loss of the ion and these tracks are decorated by large number of inherent defects.

Radiation induced defects in solids has been studied by a number of groups since last decade as they have a large variety of practical importance. There are number of techniques to identify and characterize these radiation induced defects in solids. Among these techniques positron annihilation technique emerge as a most powerful and non destructive technique in the characterization of defects in solids, particularly, radiation induced defects in solids (1).

Selenium is p-type semiconductor and is finding many uses in electronics and solid state applications like photocopying. It has optical characteristics as well as the temperature dependence phase transition from crystalline to amorphous phase (2). It contains two kind of ordering namely polymeric chain and monomeric ring structure (3). It also has an inherent defect states called valance alternation pairs (VAP) when a covalent bond breaks due to external process (4). Defect study in selenium and its alloy was studied by Thomas A. M. Fiducia et. al. (5). Modifications induced by silver ion beam in selenium have been studied by S. Panchal et. al. (6). In this paper we are describing the boron ion irradiation induced defects and the effects of post annealing on these defects in selenium.

EXPERIMENTAL TECHNIQUE

Selenium samples of purity 99.9% were irradiated by boron ion beam of 60 MeV at Nuclear Science Centre in the form of pellets of thickness ~2 mm The irradiation were carried out in two steps. (i) Mono-energetic irradiation and (ii) Homogeneous irradiation. The positron life time measurements were obtained by fast-fast coincidence spectrometer. Each sample was isothermally annealed under 10 Torr vacuum for 30 minutes at different annealing temperatures in the range 300K - 380K.

RESULTS AND DISCUSSION

All positron lifetime spectra are analyzed in terms of two components after eliminating source contribution which is 3% in all spectra. The positron lifetime spectra are characterized by the decay rate of their exponential term, $\lambda=\tau^{-1}$ where τ is the positron lifetime in the sample.

Figure 1 and 2 shows the variation of positron lifetime component τ_1 and τ_2 with different annealing temperatures at different doses. Solid lines showing the positron lifetimes in homogeneous case while dark lines show the positron lifetimes in mono-energetic case.

The value of positron lifetime in well annealed un-irradiated selenium is found 237ps in good agreement with Jenson et. al.(7)

(a). Mono-energetic irradiation :

In case of mono-energetic irradiation the values of τ_1 and τ_2 increases. The value of τ_1 approaches to 310ps and τ_2 ~750ps. The large value of τ_2 in irradiated selenium is attributed to the positron annihilation from the columnar tracks. The large value of τ_1 also indicates the presence of VAP's around the path of

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these tracks. The annealing study of these irradiated samples show the decrease in both lifetime parameters and τ_1 reaches to ~237ps while τ_2 reaches to ~550ps.

The changes in the second component of positron lifetimes justify the presence of columnar type of tracks due to boron ion irradiation in selenium that are converted into the vacancy type of defects m sample after annealing. The decrease in τ_1 may be attributed to recrystallization and elimination of VAPs on annealing.

(b). Homogeneous irradiation:

In case of homogeneous irradiation the value of τ_1 does not change much while τ_2 approaches to 750ps as in the case of mono-energetic irradiation. Since in homogeneous irradiation the electronic energy loss of ions is responsible to generate columnar tracks of different length and in such case the VAP's around the tracks may be neutralized resulting in no variation in τ_1. On annealing, the value of τ_1 first increases slightly and, than decreases to well annealed value This may be attributed to the location of incident boron ion at interstitial positrons in selenium lattice, which may result in distortion in polymeric chain On annealing the imbedded boron pushed out to substitution sites resulting in relaxation in polymeric chain structure of selenium

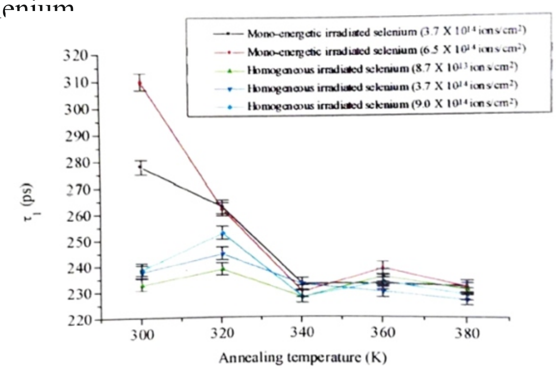
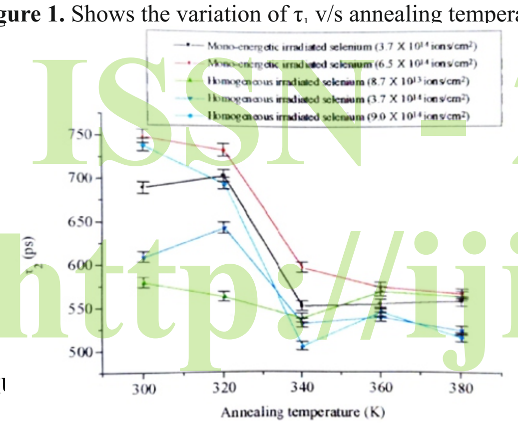


Figure 1. Shows the variation of τ_1 v/s annealing temperature.



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temperature.

CONCLUSION:

Based on the present study following conclusion drawn:

In selenium columnar tracks are likely defect states are formed by 60 MeV boron ion which are decorated with the VAP's and on annealing these tracks are converted in to the vacancy type of defects that are inferred by the positron lifetime.

On annealing the imbedded boron in the irradiated selenium relaxes the polymeric chain structure of selenium as indicated by position lifetime variation.

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