JIRCMS Vol.: 03 II Issue 02 II Pages 13-14 II Jun 2019

ION Beam Moderation Using Aluminium Foil

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Abstract: The concept of homogeneous irradiation for the study of irradiation induced defects in bulk samples is discussed in the present paper using the TRIM software. A beam moderator has been designed using Aluminum foils of different thicknesses mounted on a 8" disc, rotating at very low speed motor. This system has been tested successfully at NSC Pelletron Material Science Beam Line.

KEY WORDS: Ion Irradiation, Electronic energy loss, Nuclear energy loss, Mono energetic and homogeneous defect distribution, Ion beam energy moderator.

INTRODUCTION:

The development of high energy particle radiation sources like Synchrotron, Cyclotron, LINAC have generated considerable interest and researches in material science to study the irradiation induced effects. The impact of irradiation causes changes in the micro structure of the materials and results into several new properties of the materials which may find interesting applications.

Energetic ions have been widely used to evaluate the irradiation tolerance of structural materials for nuclear power applications and to modify material properties. The study of irradiation induced effects become important because of their application in material technology.

Swift heavy ion irradiation induced defects are of great importance during last decades. It is important to understand the defect production, annihilation and migration mechanisms during and after collision cascades (1). When an energetic ion penetrates through the condensed medium it loses its kinetic energy in two modes namely (i) Nuclear and (ii) Electronic stopping. The nuclear energy loss introduces disorders near the projectile's range in the form of clusters, vacancies, interstitial and cascade of atoms. While electronic energy losses at high energy (MeV) are responsible for reversible and irreversible excitation in the electronic subsystem of the material near the surface region (2), which may increase the mobility of defect forming atoms near the surface. To study the irradiation induced defects in bulk sample uniform irradiation distribution of the projectile required. Since mono-energetic irradiation induced effects provide the information of irradiation from a particular site at which the irradiation take place. Keeping it in mind, the concept of beam moderator for uniform distribution of projectile ion is developed. The beam moderator is able to provide uniform irradiation throughout the bulk sample. TRIM (Transport of Ion in Materials) Computer simulation program provides tremendous information about the projectile ion in the target material (3). With this program one can get the ion beam profile of the projectile in the target material. Defect distribution in ion-irradiated pure tungsten at different temperatures was studied by Zhexian Zhang, et. al. (4). Effect of Ion Irradiation Induced Ion implantation and Defect Engineering in materials is of great interest in material science (5, 6).

EXPERIMENT:

When the projectile ion reaches to its penetration depth in the target material vacancies, clusters, interstitial and cascade of atomic disorders are introduced due to nuclear stopping. So to study such type of disorders due to nuclear energy loss in the bulk sample we have designed a beam moderator using Aluminum foils of different thickness. This moderator was successfully tested at NSC (Inter-University Accelerator Centre) Pelletron for 60 MeV projectile Boron ions. Since the range of 60 MeV Boron ion in the Aluminum target is 108.60um (±4.18um). The depth profile of Boron ion of 60-MeV in Aluminum target is shown in figure 1.

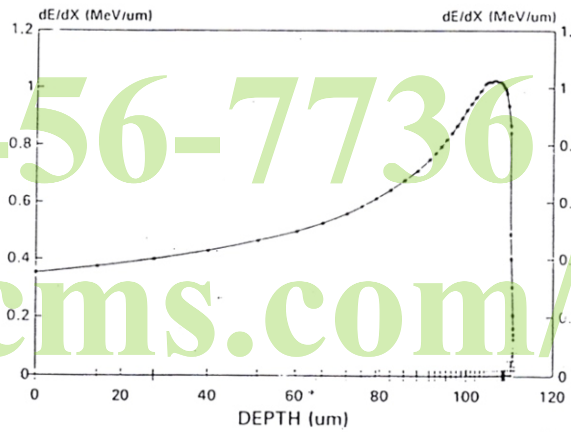

Figure-1. Depth Profile of 60MeV Boron Ion Beam in Aluminum

This provides that a boron ion can penetrate with less energy from the Aluminum foil of thickness less than this range. Using this concept we have calculate the thickness of Aluminum foils such that they may give the energies of Boron ions after penetration from the foils from 0-60 MeV. A typical calculation for moderator output energies for different Aluminum foils are given in the Table 1. Similar calculation can be done for other ions and at different maximum energies; the Aluminum foil thickness will be different. Such type of foils were mounted on a 8" diameter Aluminum disc containing four slots and each slots containing four Aluminum foils of different thickness. This disc was connected to a low speed motor (30 revolution per hour) for the rotary motion. The speed of the motor was chosen low so that long exposure time for each foil takes place. This moderator was kept between the beam line and the target ladder (figure 2).

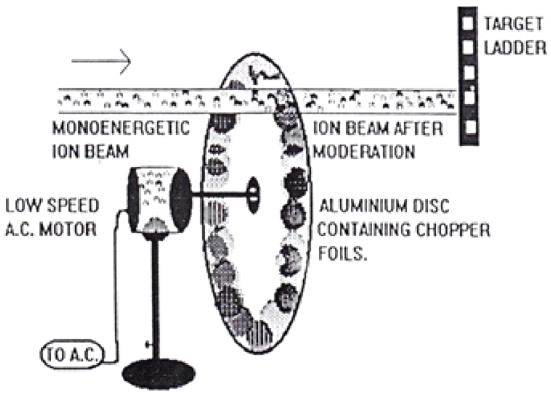

Figure-2. Sketch of Beam Moderator between beam line and target ladder.

Table 1. A typical calculation of Moderator output energy for Boron ion of energy 60 MeV

Thickness of foils	Energy after Moderation
0 μm	60 MeV
12 μm	57 MeV
27 μm	50 MeV
39 μm	44 MeV
51 μm	38 MeV
63 μm	32 MeV
66 μm	30 MeV
78 μm	24 MeV
81 μm	20 MeV
93 μm	15 MeV
99 μm	07 MeV
110 μm	0 MeV

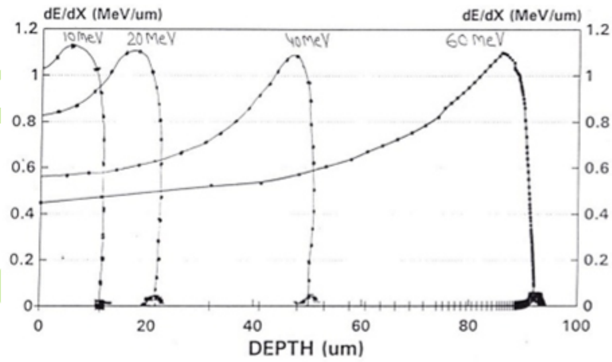

Figure 3. Depth Profile of Boron Ion Bean in Selenium

CONCLUSION:

The ion beam energy moderator was successfully tested under the high vacuum (10-6 Torr.) at NSC Pelletron with boron ion beam of 60 MeV. The depth profile of Boron ion beam of different energies in bulk Selenium target are shown in Figure 3, which shows the uniform effect of irradiation throughout the sample. The study of Boron ion induced irradiation defects in the bulk Selenium by Positron Annihilation Technique shows significant variation in defects for mono-energetic and homogeneous irradiation..

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