# Study of Nitrogen ion beam interactions with Titanium(Ti) and their effects using SRIM simulation Software.

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Abstract

nitrogen ion beams when interacting with metals form an Alloy that is metal nitride. Nitrogen ion beams with energies ranging from 250eV to 1250eV are used for implantation in titanium metal. it is observed that the interaction of Nitrogen ions with different energies interacts with Ti substrate metal. It is one of the acts of forming the alloy at the surface of a material by bringing physical, chemical or biological characteristics. It is carefully examined the effect on a theoretical basis using SRIM software. In the present study, 250eV to 1250eV energy Nitrogen ions are used. And studied the effect of ion implantation in host-layered materials. Vacancies per ion are observed and they increase as ion energy increases, Longitudinal Ion range also varies as ion energy increases, and Backscattered ions decrease as ion energy increases.

Keywords: 250eV to 1250eV energy ions, Surface, ions, implanter, Nitrogen ions,

## 1.0 Introduction

Ion matter interactions are a topic of interest as when a spaceship travels through various radiations their effects on the matter that is on the spaceship create instantly nondetectable effects. everything to execute or perform in the laboratory is time-consuming and beyond the capacity hence Simulation techniques are quite feasible and easier to handle than actual radiations which are hazardous. In the spaceship, most of the sensitive detectors have electronic pieces of equipment, and exposure to such electronic devices with highly energetic particles in space can damage the detection system. Failure of detectors can cause tremendous loss to the spaceship to avoid it such effects of radiation can be simulated with the help of simulation software.

Avoiding radiation spaceship interaction protection by radiation shields [1] is a solution on it. Before the actual use of the material to be used for making a shield of the spaceship to be tested on at the laboratories, it is quite a tough job hence it is replaced by simulation techniques to simulate high-energy radiations and their interaction with matter is essential. In this work, SRIM software is used for the simulation of the interaction of energetic particles with multi-layered composition of target materials that is Aluminium, Copper, and Iron with various depths. Damages and displacements caused by 500 keV protons to the bilayer graphene/SiC target [2] are observed. The types of irradiation-induced defects and their migration are

Leadership, Education, Personality: An Interdisciplinary Journal ISSN: 2524-6178
www.sibe.rpress.co.in, Vol. 18, Issue 10 October 2023, UGC CARE 1

described as well as ordering phenomena that are observable under the non-equilibrium conditions of irradiation [3]. Using simulations based on analytical potential and DFT models, study of effects of ion irradiation on graphene [4]. Atoms are displaced in solids by radiation was studied by G H Kinchin and R S Pease [5]. Surface treatment and sculpting with focused ion beams, ion beam smoothing of surfaces, and ion-induced nanopattern formation [6]. In planetary science, ions from the solar wind or planetary atmospheres have significantly modified the surfaces of bodies such as the Moon or Mercury over billions of years [7,8]. Slow ion beams are a common tool for surface preparation or nano-structuring [9,10].

BCA simulates a large number of ion-matter interactions [11]. The Molecular Dynamics (MD) simulations produce accurate results at a fraction of the computational effort [12]. Formation of nitrides takes place in the present study Titanium nitrides form and it further penetrates. In the present simulation study Nitrogen (N) ions were taken into consideration while the substrate material was Titanium (Ti) metal with depths of 100 Angstrom, at 250 Angstrom respectively. As nitrogen ions energy increases diffusion of ion along with Titanium(Ti) penetrates deeply.

2.0 Simulation study using SRIM software :

Penetration of ions into substrate is energy dependent as more is energy more deeply ions will penetrate in surface as shown in fig1(a)& fig1(b). When energetic ions penetrate into substrate it follows certain path and it is straight it

traces a ranges as shown in Fig II(a) &II(b). In fig III(a)& III(b) Collision events of ions from 250eV N ions to 1000KeV N ions into surface penetration is shown.

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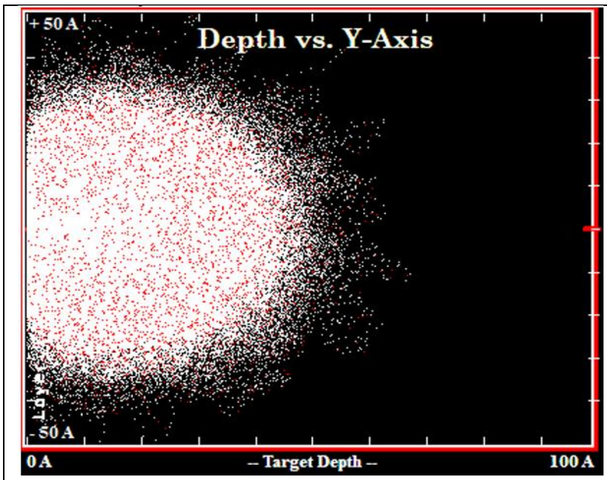
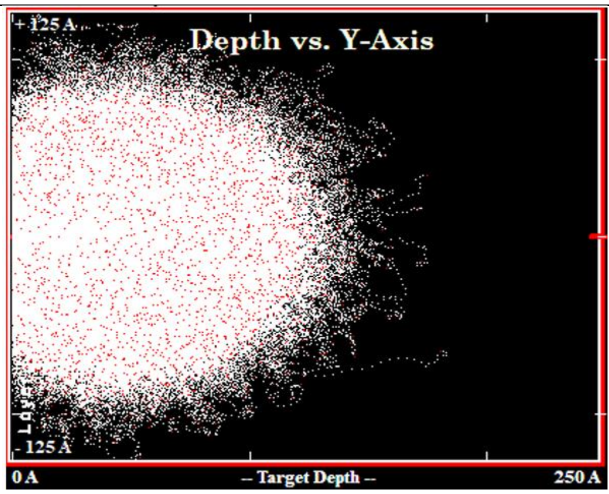
<tr><td>
</td><td>
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<tr><td>Fig.1(a): Depth(100A) Versus Y–axis at 250eV N ions</td><td>Fig.1(b): Depth(250A) Versus Y–axis at 1250eV N ions</td></tr>
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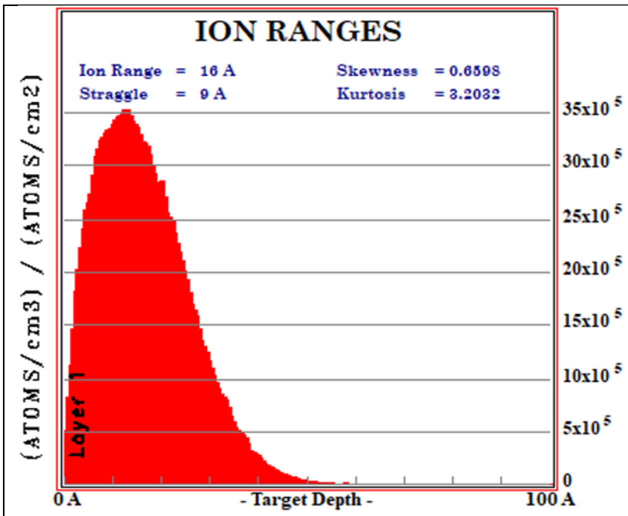


Fig.II(a): Ion ranges at 250eV N ions in Ti

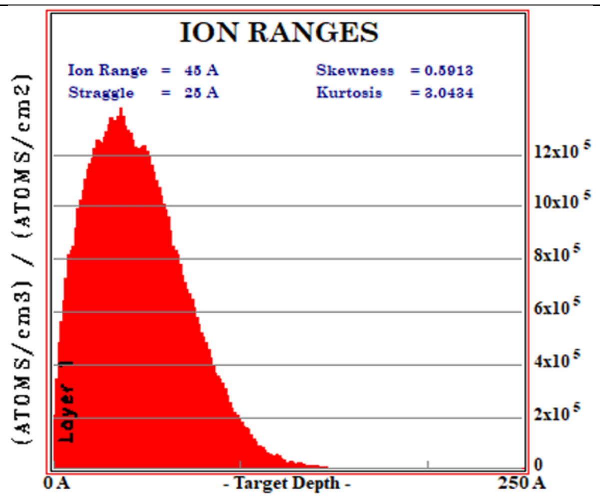


Fig.II(b): Ion ranges at 1250 eV N ions in Ti

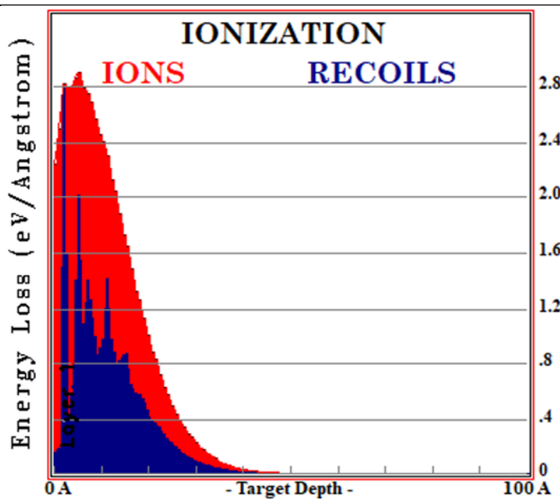


Fig.III(a): Ionization of ions 250eV N ions into Ti metal.

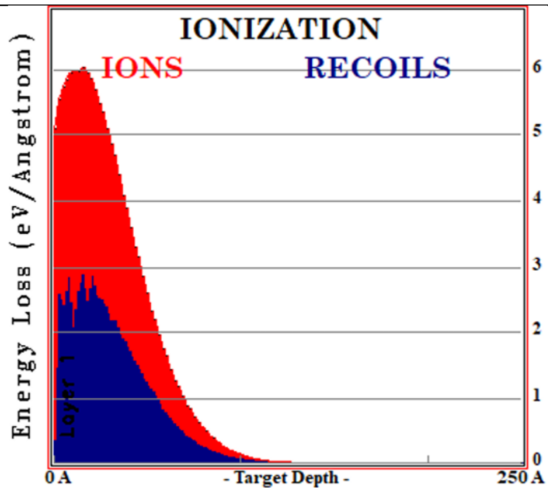


Fig.III(b): Ionization of ions 1250eV N ions into Ti metal.

2.1 SRIM-Based Simulation for Nitrogen Ion Ti - target material Interactions :

In the SRIM based simulation work is used for high energy Nitrogen Ions from 100keV to 1MeV were introduced into the composition of multi-layered (Aluminium, Copper & Iron) target material with depth of 1000:4000:3000 Angstrom. In the present work, a 100 KeV - 1000KeV simulated Nitrogen ion beam is used for implantation purposes and the depth of material is taken about 1000 angstrom, 5000 angstrom, and 5000 angstroms [13]. In the present work, A profile of about 100000 Nitrogen ions was observed. In this case, it is observed that a number of backscattered ions for 250eV Nitrogen ion irradiation it is 15762, and for 1250eV Nitrogen ion irradiation it is 12514 observed, vacancies per ions were observed 2.1 for 250eV and 11.8 eV at 1250 eV respectively it is observed that as ion energy increases vacancies per ion increases, longitudinal range of ions in the material is about 16 Angstrom at 250 eV while 45 at 1250 eV, similarly radial range of ions is about 14 Angstrom at 250 eV while 36 at 1250 eV. Lattice Binding energy is 3 eV, Surface Binding energy is 4.89 eV, and Displacement energy is 25eV.

When energetic Inos ions penetrate the surface of the substrate it lose energy as it travel a certain distance hence rate of spending energy with a change in distance is observed and written in tabular form in Table 1 below. Stopping Units = eV / (mg/cm2)

Table: Ion energy dependent parameters: Backscattered ions and Vacancies per

| Energy(eV) | For 100000 Nitrogen(N) ions | |
|---|---|---|
| | Backscattered ions | Vacancies per ion |
| 250 | 15762 | 2.1 |
| 500 | 14686 | 4.6 |
| 750 | 13785 | 7.0 |
| 1000 | 12899 | 9.5 |
| 1250 | 12619 | 11.8 |

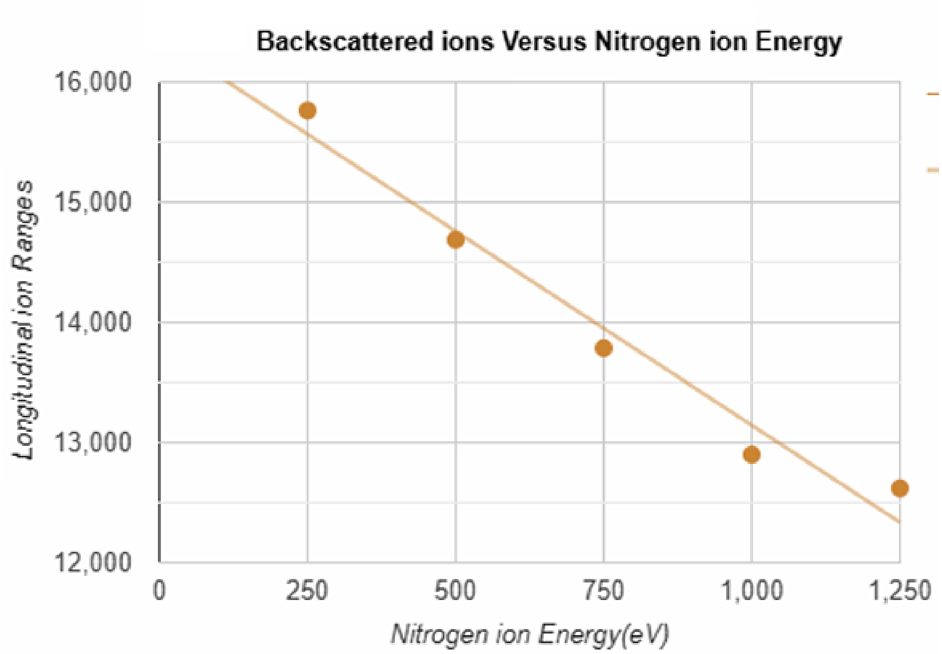


Fig.(i): Backscattered Ions versus Nitrogen ion energy

Fig.(i) graph shows that the Backscattered Ions versus Nitrogen ion energy graph shows that as Nitrogen ion energy increases Backscattered Ions decrease.

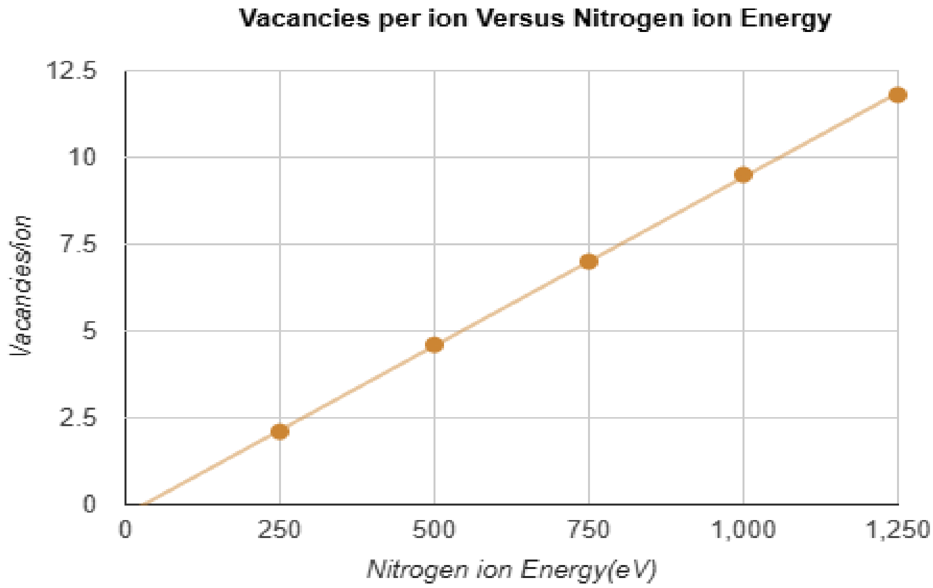


Fig.(ii): Vacancies per ion versus Nitrogen ion energy

In Fig.(ii) Vacancies per ion versus Nitrogen ion energy graph shows that as energy of the Nitrogen ion increases Vacancies per ion also increases.

Table2: Ion energy dependent parameters: Longitudinal, Projected and Radial ion Ranges, Straggle versus Nitrogen ion energy

| N ion Energy(eV) | Longitudinal ion | | Lateral Projected ion | | Radial ion | |
|---|---|---|---|---|---|---|
| | Ranges A | Straggle A | Ranges A | Straggle A | Ranges A | Straggle A |
| 250 | 16 A | 9 | 9 A | 11 | 14 A | 8 |
| 500 | 25A | 14 | 13A | 16 | 20A | 11 |
| 750 | 32 A | 18 | 17 A | 21 | 26 A | 14 |
| 1000 | 39 A | 22 | 20 A | 25 | 31 A | 17 |
| 1250 | 45 | 25 | 23 | 29 | 36 | 20 |

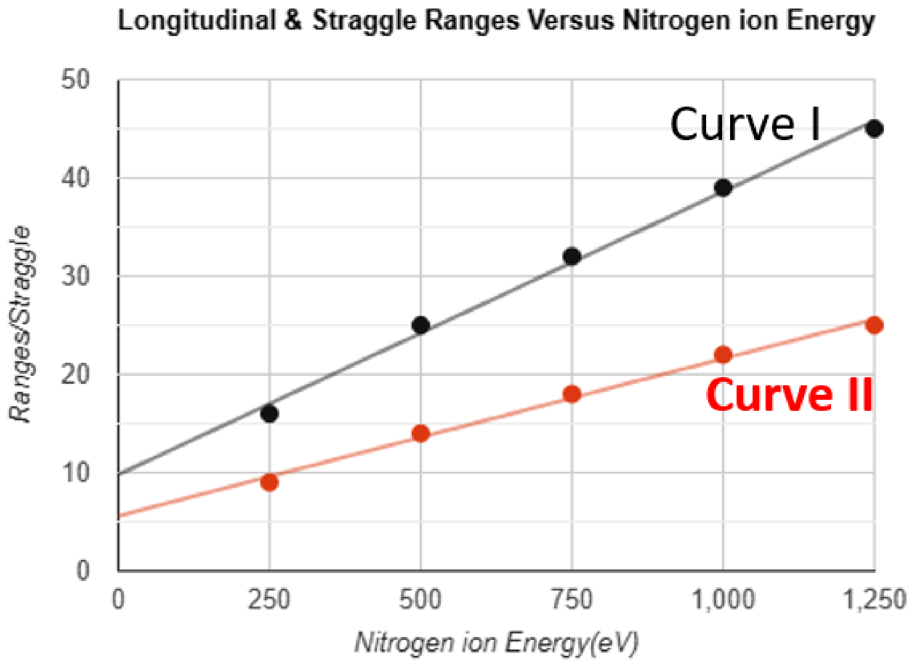


Fig.(iii): Longitudinal ion Ranges/straggle versus Nitrogen ion energy

In Fig.(iii) Longitudinal ion Ranges/straggle versus Nitrogen ion energy graph shows that in Curve I as energy of the Nitrogen ion increases Longitudinal ion Ranges also increases similarly in Curve II as energy of the Nitrogen ion increases Longitudinal ion straggle also increases .

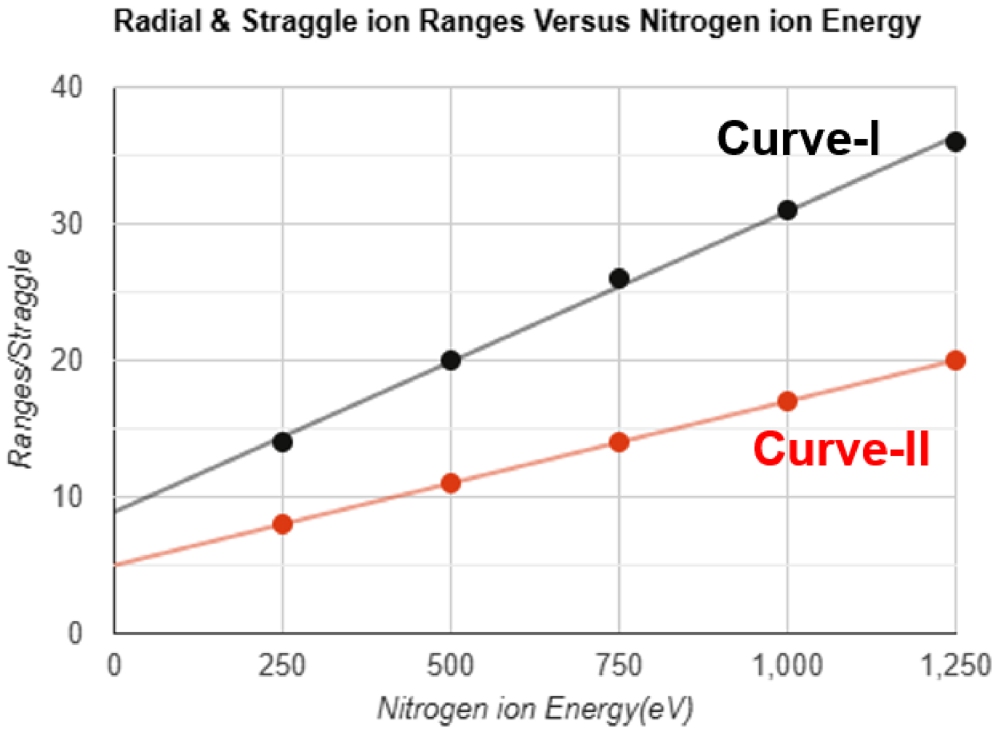


Fig.(iv): Radial & Straggle Ion ranges versus Nitrogen ion energy

In Fig.(iv) Radial ion Ranges/straggle versus Nitrogen ion energy graph shows that as energy of the Nitrogen ion increases from Curve I it shows that Radial ion Ranges while in Curve II it shows that Radial ion straggle also increases.

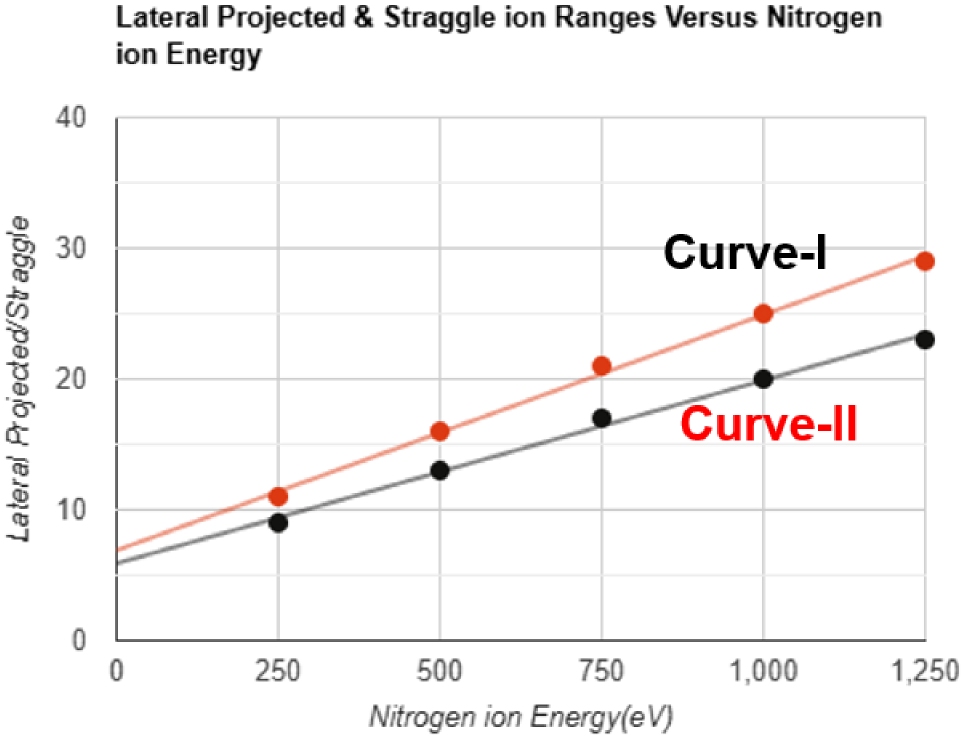


Fig.(v): Lateral Projected Ion ranges/straggle versus Nitrogen ion energy

In Fig.(iv) Lateral Projected Ion ranges/straggle versus Nitrogen ion energy graph shows that as in Curve I energy of the Nitrogen ion increases Lateral Projected ion Ranges also increases as well in Curve II energy of the Nitrogen ion increases Lateral Projected ion straggle also increases.

## 3.0 Results and Discussions:

In the present paper, simulation-based Nitrogen ion beam interaction with Titanium(Ti) Metal with depths of 100 angstroms and 250 angstroms is studied. Whatever results are shown graphically and in tabular form. Nitrogen ions penetrate Titanium Metal and produce structural changes into Titanium(Ti) up to a depth limited within the range of angstrom. This simulation-based study gives profound knowledge about ion beam interactions this can be further implemented experimentally and results can be verified.

## 4.0 Conclusion

simulation-based Nitrogen ion beam interaction with Titanium(Ti) Metal with depths of 100 angstroms to 250 angstroms is studied. Whatever results are shown graphically and in tabular form. Nitrogen ions penetrate Titanium Metal and produce structural changes into Titanium(Ti) up to a depth limited within the range of angstrom. This simulation-based study gives knowledge about how backscattered ion varies with ion energy vacancies per ion also increase as N ion energy increases from 250eV to 1250eV.

Acknowledgement:

Thankful to SRIM software developers.

5.0 References:

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