^{48}Ti Target Preparation at IUAC

H. Arora[1,*], Abhilash S. R.[2], D. Kabiraj[2], G. R. Umapathy[2] and B. R. Behera[1]
[1]Department of Physics, Panjab University, Chandigarh - 160014, INDIA
[2]Inter University Accelerator Center, Aruna Asaf Ali Marg, New Delhi – 110067, INDIA,
* email: honeyarora3191@gmail.com

Introduction

Titanium (Ti) is a strong material with low density and high strength. In its natural form it is a lustrous metal with silverish white color. Its melting point is 1668 ^{0}C but when Ti is heated above 430 ^{0}C, it loses its strength. The targets prepared were to be used in a nuclear fusion evaporation experiment, in which evaporation residues were detected using MWPCs kept at forward angles. For the evaporation residues formed to reach the detector, it was required that energy loss of the residues is minimum in the targets prepared. So, the optimal thickness for the self-sustaining targets is around 500 μg/cm^2. The self-supporting thin films of Ti were prepared in the ultra-high (UH) vacuum chamber at Inter University Accelerator Center (IUAC), New Delhi.

Vast literature is available for the preparation of self-supporting targets of ^{48}Ti. But all of them are based on either the substrate heating [1] or using various parting agents that required dry stripping to be performed [2]. The option to use substrate heating is not available with the current facility, so we tried preparing the targets and annealing them later, but the success rate was very low in that case. Also, using the method of dry stripping was not possible. So, to fabricate self-supporting targets of isotopic titanium with a very limited quantity (100 mg) was indeed a challenging task. Many trials were carried out using ^{Nat}Ti to find the appropriate parting agent which would be suitable to get the thin foils of desired thickness. Moreover, it was quite challenging to evaporate the required amount of Ti from the crucible in this case. With this limited material, around 6 thin self-supporting targets of ^{48}Ti of various thickness (318 μg/cm^2 to 548 μg/cm^2) were fabricated using electron beam evaporation method.
Various constraints faced during the trials and measures taken to overcome and finally obtain the desired targets is discussed in detail.

Experimental Details

The UH vacuum evaporator has a scroll pump (used as the backing) and two turbo molecular pumps has a multi-pocket e-gun (kW). The vacuum attainable in this chamber is 10^{-7}. As the melting point of Ti is quite high, so evaporation was performed using electron gun.
Due to high cost of the isotopic material, before final deposition of ^{48}Ti on the glass slide, various trials were carried out with ^{Nat}Ti. CaI_2 was found

Fig. 1 Chamber used for Ti fabrication.

as a suitable parting agent for floating titanium films. But as soon as the foils were floated in water, they curled. This was mainly because during evaporation the substrate temperature was comparatively cooler than the temperature of the substance being deposited. Due to this, the arrangement was not compatible and hence the films curled as there was still surface tension among the molecules in the film.

It was still easier to float thin films, as in those cases there was not much surface tension among different layers of the deposited material. The thinner film floats well as the thickness increases the film started curling inside into rolls or breaking and scattering while floating. Regarding this, vast literature is available for the fabrication of Ti targets using various parting agents. But in many of those cases, a method to heat the substrate while deposition is available, which was a huge constraint in the setup we had available to us. So, to overcome this we tried annealing the obtained samples at 200 ^{o}C for 1 hour and then cooling the sample slowly.

^{Nat}Ti was available in form of Ti crystals, it was observed from various trials that very little amount of Ti was actually getting evaporated. Earlier we were using tantalum (Ta) crucible, but as the voltage was increased for the evaporation of Ti, to get the desired thickness, it was observed that Ta also got somewhat evaporated. Contamination due to any substance is not desirable in nuclear physics experiments, so after few more trials, Graphite crucible was considered for further used. In initial trials, the length of crucible taken was around 10 mm, but then even the required amount of Ti was not evaporated and the films obtained were thinner than required for the experimental purpose. It was supposed that the electron beam was not directly hitting the actual target material but the crucible. And the graphite crucible was kept in the copper crucible which is continuously water cooled. So, due to this the total heat was not getting transferred to the material kept in the crucible and hence the evaporation of required amount was not taking place.

To overcome this difficulty, length of the crucible was reduced to half (i.e. 5 mm), so that beam can directly hit the target material now. This vastly increased the deposition of the material onto the glass substrate. For the final deposition of 48Ti, the material was in the powder for, so it was pelletized (3 mm diameter) as could be seen in Fig. 2.

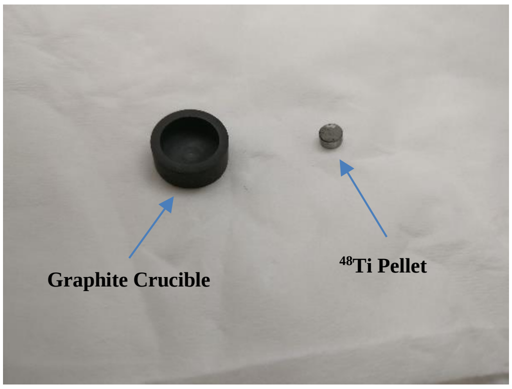

Fig. 2 The crucible and the target used in final deposition

Characterization of Targets

The target purity and thickness were measured using various techniques such as Alpha particle energy loss technique and Energy Dispersive x-ray Spectroscopy (EDS) measurement along with SEM. The image of sample obtained from SEM is as shown in Fig. 3. Clear hexagonal structures of Ti could easily be seen in the image along with the upper layer, which has lost any proper structure due to annealing.

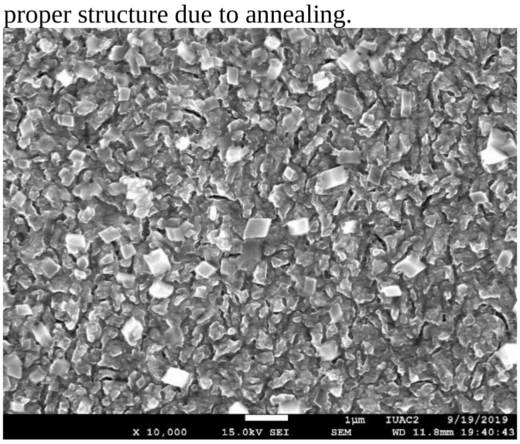

Fig. 3 EDSEM Profiles of 48Ti target

References

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