Fabrication of ^{121}Sb isotopic targets with ^{197}Au backing

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1. Introduction

In nuclear structure studies, the heavy ion fusion-evaporation reaction was used to populate the high spin states of the nucleus of interest. In order to explore the high spin phenomenon [1], a large statistics data from in-beam γ-ray spectroscopy is required. Therefore, target foils of good quality and particular thickness depending on the aim of interest in nuclear structure and reaction dynamics are required. In present, for an experiment to investigate the high spin phenomenon using Indian National Gamma Array (INGA) [2] facility at IUAC, New Delhi, the isotopic ^{121}Sb target was required. For the measurement of lifetime of nuclear excited state by Doppler Shift Attenuation Method (DSAM) [3], the recoil nucleus should be stopped and for this purposed a thin target with a thick backing of high Z material is preferred. ^{197}Au was found to be ideal for our interest and was chosen as the backing material for the present target fabrication. In literature, there are few reports on the fabrication of different Sb targets using Physical Vapor Deposition (PVD) method [4–6]. In their reports they mention about the poor efficiency of deposition.

To fulfill the requirements of the interested studies, isotopic ^{121}Sb target of intermediate thickness with ^{197}Au backing was fabricated using the diffusion pump based coating unit which is installed at target laboratory of IUAC. The methods adopted and the technical setup used to improve the efficiency of the deposition was discussed in the following sections.

2. Fabrication setup

The the diffusion pump based coating unit at IUAC can attained a vacuum of the order of $\sim 3 \times 10^{-7}$ Torr. In this chamber, evaporation can be done by two different methods - resistive heating method and electron beam bombardment method, respectively, which are usually used for the evaporation of low melting point and high melting point target materials. The chamber is also equipped with a quartz crystal monitor which can be used to monitor the film thickness and the deposition rate.

3. Deposition of Antimony (Sb)

The isotopically enrich (99.9%) ^{121}Sb was deposited on ^{197}Au foil of thickness range 10 - 12 mg/cm^2. Sb has melting point of 630.74°C, therefore resistive heating method was adopted for the deposition. A specially designed pin-hole graphite boat (1 mm opening diameter) [7] was used and stainless steel (SS) plates was kept in between the graphite boat and the substrate holder leaving a small gap for the evaporating material. This SS plates acts as a heat dissipater. A glass slide was also kept on the substrate holder to estimate the thickness of the deposited Sb films using profilo meter. The setup was arranged in such a way that two foils of almost equal thickness can be deposited in one deposition run. This helps in minimizing the lost of material in the deposition. The parameters such as deposition efficiency and the amount of material required for the desired thickness were optimized by conducting several trial depositions with the natural Sb. It was able to achieve 1.7 mg/cm^2 thickness of Sb using 5.3 mg of natural Sb, with a distance of 1 cm between the graphite boat and the substrate

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holder. The final deposition was done with enriched isotopic ^{121}Sb. The distance between the graphite boat and the substrate holder was kept at 5.8 cm and the SS plate was kept at a distance of 3 cm from the graphite boat.

4. Characterization of Target foils

(a) Thickness measurement : Areal thickness of the fabricated Sb targets was calculated from the deposited Sb film on the glass slide using a stylus profilo meter. The profile of the stylus profilo meter gives a vertical displacement due to a step between the film and the glass substrate and therefore this vertical displacement measure the thickness of the deposited film. The thickness of the target foils are found to be $\sim$ 1250 - 1350 $\mu g/cm^2$ and are given in TABLE 1.

(b) Purity measurement : The Energy Dispersive X-ray Analysis (EDXA) was employed to examine the presence of any other elements in the target which can be present as impurity in the enriched material itself or can be added inevitably during the deposition of target material. The energy spectra of the characteristic X-rays of the composite element was analyzed to identify the corresponding element of the X-ray peaks. The intensities of the X-ray peaks also give the information on relative proportions of the elements present in the sample. The EDXA spectrum of the ^{121}Sb is shown in FIG 1(a). In the spectrum there is K_α lines of C and O along with the L and M lines of Sb. The C might be added from the graphite boat which was used in the deposition and the O might be due to surface oxidation of the target.

TABLE I: Thickness of the prepared ^{121}Sb targets.

Target	Target thickness $\mu g/cm^2$	Backing (Thickness)
Target 1	$\sim$ 1320	^{197}Au (12 mg/cm^2)
Target 2	$\sim$ 1250	^{197}Au (10 mg/cm^2)

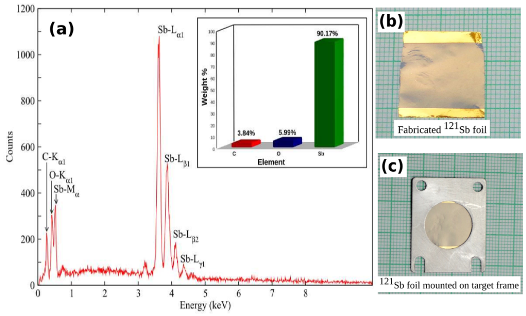

FIG. 1: (a) EDXA spectra of ^{121}Sb target. Inset is the ralative proportion of the elements present in the target in weight percentage (b) Fabricated ^{121}Sb foil with ^{197}Au backing (C) ^{121}Sb foil mounted on target frame.

5. Conclusion

^{121}Sb foils with thick ^{197}Au backing were fabricated successfully by resistive heating method. Two foil of thickness $\sim$ 1250 - 1350 $\mu g/cm^2$ were produced with only 45 mg of enriched ^{121}Sb material in a single deposition run. The results of the EDXA analysis also ensure the purity of the targets.

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