Fabrication of ^{112}Sn target on ^{208}Pb-backing

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Introduction

Measurement of the lifetimes of excited nuclear states is crucial from the point of view of nuclear structure study as, this information is directly related to the understanding of different excitation mechanism responsible for the generation of angular momentum. Several techniques are used to measure the lifetimes of different order [1]. It is well known that the Doppler Shift Attenuation Method (DSAM) is the most suitable technique to measure the lifetime of sub pico-second order. For such kind of experiment, a thin target with thicker backing is used conventionally. The thickness of the backing has been chosen in such a way, so that, all the recoiling nuclei will be stopped inside the backing medium.

The motivation is to study ^{142}Tb nucleus by measuring the lifetimes of the excited states via ^{35}Cl induced fusion-evaporation reaction. To carry out this experiment, an enriched ^{112}Sn target of 2.44 mg/cm^2 thickness on 8.8 mg/cm^2 thick ^{208}Pb backing is required. Cold rolling of the ^{112}Sn ingot has been found to be the most suitable for this purpose as Sn is malleable in nature. The very low isotopic abundance (0.97% [2]) of ^{112}Sn makes it very costly. Therefore, the rolling process is again preferable as in this technique least amount of material is required to produce a foil of finite dimensions, but, the stickiness of metallic tin below 5 mg/cm^2 is challenging. In this paper, the fabrication procedure of a Pb-backed thin ^{112}Sn target has been discussed in details.

Preparation of ^{112}Sn ingot

^{112}Sn target material was available in metallic powder form. Firstly, ^{112}Sn metal ingot has been prepared by heating the metallic powder in furnace. Metallic tin has not been oxidized easily in open air. However, oxidizing starts with increasing temperature and humid conditions [3]. Therefore, a high vacuum-sealed quartz tube was used to prepare the ingot by avoiding the oxidation of ^{112}Sn.

FIG. 1: A photograph of vacuum tube sealing setup at Saha Institute of Nuclear Physics.

At first, 31.6 mg 99.6 % isotopically enriched ^{112}Sn metallic powder is taken in a quartz tube and vacuum-sealing was carried out. It was kept at high vacuum (2.7×10^{-5} mbar) through a turbo molecular pump for nearly five hours. A vacuum tube sealing setup at SINP has been shown in fig 1. After that, the vacuum sealed quartz tube containing the ^{112}Sn metallic powder was kept in furnace at 900 °C for four hours. Then the furnace was cooled down slowly to room temperature. It is found that one ingot has been formed inside the quartz tube. Final mass of the ingot is found to be 31.0 mg. It should be noted that material loss is negligible in this method. It has also been observed that vacuum sealed quartz tube has to be kept in furnace at minimum 900°C with four hours duration to form the one ingot from metallic ^{112}Sn powder. Using the same technique, another two ingots of mass 12 mg and 5 mg were prepared.

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FIG. 2: A photograph of rolling machine at SINP.

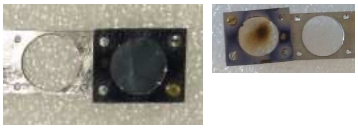

FIG. 3: ^{112}Sn target (2.44 mg/cm^2), before (left) and after (right) the experiment at TIFR.

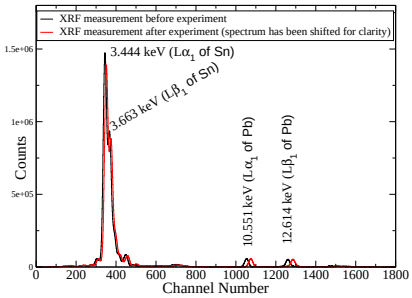

FIG. 4: Energy spectra obtained for backed ^{112}Sn (2.44 mg/cm^2) target before and after the experiment in XRF analysis.

Rolling of ^{112}Sn and ^{208}Pb

Thin or thick foils of uniform thickness can be prepared via cold rolling using the rolling machine of SINP, Kolkata (fig. 2). The rolling machine contains two rollers which are controlled by an electric motor. It can rotate in both clockwise and anti-clockwise direction. In the rolling technique the target material to be rolled is placed between mirror polished stainless steel plates (SS).

Inner surface of the SS plates was cleaned by alcohol and acetone to make it dust-free before inserting the target material inside it. Initially, a 12 mg ^{112}Sn ingot was taken in the folded SS sheet. The SS sheet with ^{112}Sn ingot was then inserted into the rolling machine. To avoid the sticking of Sn with SS plates Teflon foils were used during the time of rolling. After a number of rolling, the desired 10.26 mg/cm^2 thickness of the ^{112}Sn was achieved. The foil was cleaned using acetone and alcohol. Similarly, a 22.5 mg/cm^2 thick ^{208}Pb foil was placed inside the folded SS sheet and started rolling. We rolled it up to the desired thickness 15.6 mg/cm^2. To make the back target, the 10.26 mg/cm^2 ^{112}Sn foil and 15.6 mg/cm^2 ^{208}Pb foil are placed on top of each other. Then they are again rolled inside the folded SS sheet. The foils sticks together during this rolling, ensuring that there is no air gap in between. In this technique two ^{112}Sn target with ^{208}Pb backing were prepared at SINP. Target and backing thickness for first one are 10.26 mg/cm^2 and 15.6 mg/cm^2, respectively and for the second target are 3.42 mg/cm^2 and 14.7 mg/cm^2, respectively. On the other hand, two more ^{112}Sn target with ^{208}Pb backing has been prepared at TIFR rolling machine. Finally, the 2.44 mg/cm^2 thick ^{112}Sn with ^{208}Pb backing (8.8 mg/cm^2) target, was used in the online experiment at TIFR (fig. 3). X-Ray Fluorescence (XRF) measurements have been carried out for backed ^{112}Sn (2.44 mg/cm^2) target at SINP, before and after the in-beam experiment performed at TIFR (fig. 4). No significant change in the spectra has been observed (fig. 4), ensuring the elemental purity and stability of the target.

Acknowledgments

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