Thin enriched ^{185}Re targets fabrication for nuclear reaction studies

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Introduction

In nuclear physics experiments, the fabrication of targets is a highly intricate and critical process. The success of these experiments largely depends on the quality and quantity of the targets used. For our proposed study of fusion-fission and quasi-fission (QF) reaction dynamics, we required isotopically enriched thin targets of ^{185}Re with exceptional uniformity. o produce an appropriate target, several manufacturing techniques can be employed, such as rolling (a mechanical process) , chemical vapor deposition (CVD), and physical vapor deposition (PVD).

K. Hajara reported the fabrication of ^{187}Re of thickness 200 μg /cm^2 with carbon backing [1]. Preparation of ^{187}Re of thickness 60 μg /cm^2 on carbon backed is reported by T. Banerjee.

For the first time, We were successfully able to fabricate enriched isotopic targets of ^{185}Re having thickness 200 μg /cm^2 on a carbon backing of 50 μg /cm^2 using evaporation technique. In this study, we conducted multiple trials to produce carbon-backed isotopic Rhenium (^{185}Re) targets with the desired thickness. For this purpose, we used approximately 100 mg of ^{185}Re powder, which is 94.80% enriched and was imported from Oak Ridge National Laboratory in Tennessee, USA. By applying the evaporation technique described in the literature, we successfully fabricated the ^{185}Re foil.

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Target Fabrication

The IUAC target laboratory in New Delhi is equipped with a range of advanced facilities, including an electron gun evaporation unit with adjustable power and vacuum settings, a mechanical rolling machine, and a resistive heating unit. Due to high melting point (3550°C) of carbon, the carbon film was deposited onto the substrate using an electron-gun (e-gun) evaporation technique within a thin film deposition unit (TFDU) operating at a vacuum level of approximately 10^{-7} mbar. We fabricated the carbon backing foils following the method outlined in [2]. The process began with the deposition of a releasing agent to ensure that the materials would separate smoothly from the substrate. Recent findings have shown that $BaCl_2$, when used as a parting agent, results in significant contamination compared to KCl. Therefore, for our work, we selected KCl (melting point: 962°C) as the releasing agent. After depositing KCl, we proceeded with the carbon deposition using the e-gun facility, which was located in the same chamber to maintain a consistent vacuum. Following the carbon deposition, we carefully removed the substrate holder. To relieve intrinsic stress, the carbon slides were annealed at 350°C in an argon atmosphere for one hour in a tubular furnace, and then allowed to cool slowly to room temperature. Following the success of several preliminary trials, we proceeded with the final deposition of the enriched ^{185}Re isotope onto carbon-coated glass slides. We took 100 mg of the isotopic material (powder form) and made a 4 mm pellet and placed it inside the copper crucible. For fabricating target foils of ^{185}Re having thickness $\approx$ 200 μg /cm^2, 72 mg of the isotopic material was consumed.

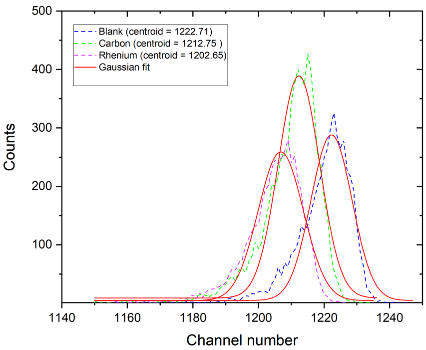

FIG. 1: Alpha Energy loss spectra for blank, carbon foil and carbon backed ^{185}Re target.

Characterization: Alpha Energy Loss Technique

he thickness of the target and carbon foil is determined using the α-energy loss method, which measures the energy loss of α-particles as they traverse the material. In this method, a potent 50 μCi radioactive ^{241}Am source emits 5.486 MeV α-particles, which lose energy as they pass through the foil. This energy loss is recorded by a silicon surface barrier detector (SSBD) positioned on the opposite side of the target film. The energy loss of the α-particles as they pass through a foil of thickness tt can be quantified using the formula given in eq (1):

$$\Delta t = \frac{\Delta E}{(\frac{dE}{dx})_{E_0}} \tag{1}$$

where $(\frac{dE}{dx})_{E_0}$ is the total stopping power of the foil for the initial energy of the α particle. Finally thickness of the target was evaluated using this energy loss and stopping power extracted from SRIM code of alpha particles in a ^{185}Re target. The ^{185}Re targets were observed to have thicknesses 200 $\mu g/cm^2 \pm 20$ $\mu g/cm^2$.

Conclusion

This target has been successfully used in nuclear physics experiment using the National Array of Neutrons at IUAC, New Delhi. Using natural material, several trial depositions were carried out for optimization preceding 77 mg of the ^{185}Re isotope were deposited using the e-gun method. Seven of these targets could be obtained and stored in an evacuated desiccator after these ^{185}Re deposited slides floated successfully. By utilizing α energy loss, We measured the thickness of foil and it was determined that the mean thickness of ^{185}Re was 200 $\pm$ 20 μgcm^2. The targets were used in the nuclear experiment to measure the neutron multiplicity for the reactions ^{16}O + ^{185}Re reaction. The targets will be utilized in upcoming studies and are currently kept in a vacuum desiccator at the IUAC target library.

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