Fabrication of isotopically enriched thin ^{191}Ir targets on carbon backing for the study of fusion-fission dynamics

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Introduction

The study of fusion fission dynamics induced by heavy ions have been under investigation since past few decades. However these reactions are not yet fully understood, because of their complex nature. Evaporation residue (ER) emission is one of the dominant decay modes during the dynamical path of fusion process. The measurement of ER cross-sections have been used as an effective probe to study the dynamics of such reactions. In the present study of fusion-fission dynamics via ER cross-section measurements, we have formed compound nucleus ^{210}Rn through ^{19}F + ^{191}Ir reaction. The thin film fabrication (targets) in accordance to our experimental requirement is the very first step of the preparation. During fabrication, one needs to be careful about the uniformity of the thickness distribution across the deposition area of the target material along with the chemical purity of the deposited films [1]. The isotopic ally enriched ^{191}Ir target in the thickness range of 50-100 μg/cm^2 is needed for the experiment. To the best of our knowledge, few reports are available on the fabrication of thin iridium target. A fluorination technique was used to prepare Iridium samples [2]. The ^{193}Ir target of thickness 17 mg/cm^2 on 100 μm Al backing was prepared by centrifugal technique [3]. On the other hand, the ^{193}Ir target of thickness 80 μg/cm^2 on carbon backing was also fabricated at Inter University Accelerator Centre (IUAC), New Delhi, India [4].

In the present work, the isotopic ^{191}Ir targets were successfully fabricated in the target development laboratory at IUAC, New Delhi, India using the turbo pump based coating unit with a vacuum of the order of 10^{-7} mbar. In this paper, we have reported the various steps followed to fabricate good quality enriched ^{191}Ir targets on carbon backing.

Fabrication details

It is very difficult to prepare the thin self-supporting targets and most often backing material is needed to support such thin targets. Here in the beginning, we have used thin foil of carbon (~20 μg/cm^2) as backing and $BaCl_2$ as the parting reagent. Carbon foils were made by electron beam deposition using another diffusion pump based coating unit. Glass slides used as a substrate were kept at 26 cm away from the material. In first step, the parting reagent $BaCl_2$ was deposited on the glass slides using resistive heating arrangement. Carbon was deposited on the glass slides after the successful deposition of releasing agent. The quartz crystal monitor was used for the the in-situ measurement of the rate of evaporation and thickness. These carbon coated glass slides were annealed in a tubular furnace at 250°C for 1 hour in nitrogenous atmosphere to remove any internal stress on the deposited films. The high vacuum evaporator, used for target deposition, has a scroll pump (used as the backing) and two turbo molecular pumps. This evaporator has a multi-pocket e-gun (kW). The vacuum attainable in this chamber is 10^{-7} mbar. The melting and boiling points of iridium (Ir) are 2446^{0}C, and 4130^{0}C respectively which are quite high, hence the electron gun evaporation technique was adopted. Due to high cost of the isotopic material, before final deposition of isotopic ^{191}Ir on the glass slide, several trials were carried out with natural iridium to optimize different parameters of the deposition process.

The high vacuum evaporator has 6 KW electron gun arrangements. This system is also equipped with a quartz crystal thickness monitor for

controlling the thickness as well as the rate of deposition. However, the monitor was not lying within the solid angle coverage of evaporation during the evaporation of iridium, and real thickness was not monitored. The thickness was just estimated looking into the density of material deposited on glass slides and by estimating the duration of deposition. The inside view of the high vacuum evaporator assembly is shown in Fig. 1. A few trials were first carried out using natural iridium due to the reasons mentioned above in the text. Carbon films were floated in warm water, taken on target frames and then transferred to the HV chamber. However, the deposition of iridium in the carbon foils on target holders created very much pin holes in the target. Hence, the annealed carbon deposited glass slides were put on the HV chamber and the target deposition was done on such glass slides.

In the final deposition with enriched material ^{191}Ir, due to the limited quantity of the enriched material, substrate had to be kept very close ≈9 cm distance from the material pellet to achieve required thickness.

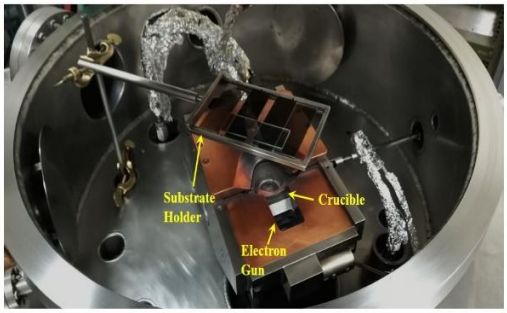

Fig. 1 Inner view of the high vacuum evaporator assembly at IUAC, New Delhi, India.

Results and Discussion

About ten targets of enriched ^{191}Ir (≈99.9 % enrichment) with carbon backing have been successfully prepared using the electron gun method in high vacuum evaporator chamber at IUAC, New Delhi, India. To prepare all these targets ≈100 mg target material was utilized. To measure the thickness of the target Rutherford backscattering (RBS) measurement was done. The thickness of ^{191}Ir target was found to be ≈60 μg/cm^2. Fig. 2 shows the RBS spectrum of the enriched ^{191}Ir target. The prepared targets have already been used for the ER cross-sections measurements using recoil mass spectrometer HIRA at IUAC, New Delhi.

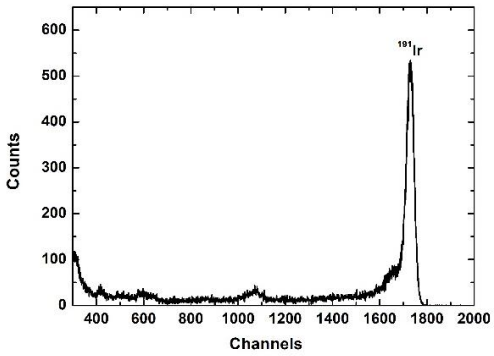

Fig. 2 A typical recorded RBS spectrum of ^{191}Ir target.

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