Preparation of ^{92,96}Zr targets on thin carbon backing for nuclear reaction studies

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Introduction

Preparation of a target of good quality is crucial for the success of any nuclear physics experiment. To study the reaction mechanism around the coulomb barrier energy, self supporting enriched target is desirable for extracting the precise information for the parameters of interest. Further, thin targets are required to minimize the energy loss in the target and to improve the resolution of the spectrum.

In the present study, to investigate the dynamics of fusion and transfer reactions in medium mass region using Heavy Ion Reaction Analyzer (HIRA) [1], ^{92,96}Zr targets were required. To minimize the energy spread and loss due to low energy heavy ion reaction products, self supporting thin targets were preferred. In the past years, several groups fabricated self supporting targets of thickness in the range 50-300 μg/cm^2 by using NaCl [2], $BaCl_2$ [3], mixture of Betainmono-hydrate and Saccharose d^+ [4] as the parting agents. Kalkal *et al.* prepared Zr targets on 45 μg/cm^2 carbon backing using electron beam evaporation method [5].

Our aim was to prepare Zirconium target on thin backing material. Several attempts have been made to prepare a target of thickness $\sim$230 μg/cm^2 on $\sim$20 μg/cm^2 carbon backing. In the following section, preparation technique for ^{92,96}Zr targets has been given.

Experimental Procedure

Targets were prepared using diffusion pump based coating unit (high vacuum evaporator) and cryo pump based coating unit (ultra high vacuum evaporator) [6] in target laboratory of Inter University Accelerator Centre (IUAC).

Preparation of Carbon backing

Resistive heating method was used to prepare $BaCl_2$ film which acts as a parting agent. A $BaCl_2$ pellet was prepared using hydraulic pellet press. The pellet was kept in a molybdenum boat in diffusion pump based coating unit. Carbon material was taken in the form of carbon rod of 6 mm diameter and placed in a water cooled copper crucible of same coating unit. Electron beam evaporation method was used for carbon deposition. Glass slides were used as substrate and kept at a distance of 17 cm from the crucible and boat. A 100 nm layer of $BaCl_2$ was deposited on the substrate. Later, around 20 μg/cm^2 carbon was evaporated over $BaCl_2$ using 2 kW electron gun. The deposition rate was kept at 0.1 nm/s for $BaCl_2$ and 0.1-0.3 nm/s for carbon. After deposition, chamber was vented with air and glass slides were transferred to cryo pump based coating unit for zirconium deposition.

Preparation of ^{92,96}Zr targets

For zirconium deposition high vacuum ($\sim 10^{-8}$Torr) and high power electron gun (6 kW) was used. Limited amount of enriched material of ^{92}Zr and ^{96}Zr was available in metallic and oxide form respectively. Hence, several trial runs were taken with both metallic and oxide natural Zr to optimize the parameters in the preparation. Since ^{96}Zr was in powder form, a pellet was prepared using hydraulic pellet press. Material (metal foils in case of ^{92}Zr & pellet in case of ^{96}Zr) was kept in one of the copper crucibles of cryo pump based coating unit as shown in FIG.1. The

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carbon deposited glass slides were placed at a 7 cm distance from the crucible. A mechanical shutter was placed below the carbon deposited glass slides in the beginning of evaporation to avoid the deposition of impurities or contaminants on the surface of material. The current was kept below 100 mA for few minutes for helping the outgassing of material. A quartz crystal was used to monitor the evaporation process. Final deposition was carried out by increasing current slowly upto 300 mA. Since thermal conductivity of ZrO_2 is very low (1.7 Wm^{-1} K^{-1}), a very low current (78 mA) was required for evaporation. Mechanical shutter was also detached once deposition of material started. After deposition, chamber was cooled down for 6 hrs and later vented with air. To relieve stress, these slides were kept for annealing at 325^0C for 1 hr in nitrogen atmosphere in tube furnace. Finally, these films were made to float in warm distilled water and were lifted on 10 mm diameter stainless steel target frames. Targets so formed are shown in FIG.2.

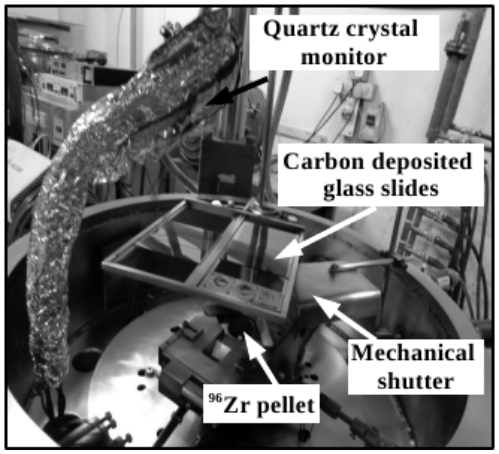

FIG. 1: Set up for ^{96}Zr deposition in cryo pump based coating unit.

Thicknesses of these targets were measured through stylus profilometer by creating a physical step on the glass slide during evaporation whereas carbon thickness was measured through alpha energy loss method. Thickness of both targets was found to be $\sim$230 μg/cm^2 with $\sim$20 μg/cm^2 carbon backing.

Summary

Enriched ^{92,96}Zr targets of thickness $\sim$230 μg/cm^2 were prepared on thin ($\sim$20 μg/cm^2) carbon backing. In the target preparation, 57 mg, 90.5 mg material was used for ^{92}Zr and ^{96}Zr respectively. Both these targets were used recently for measurement of fusion cross-sections in HIRA at IUAC.

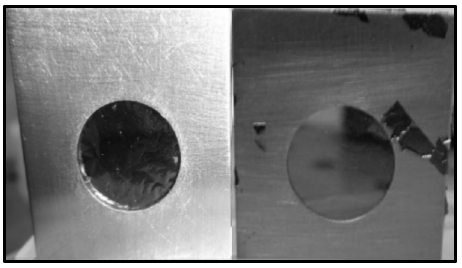

FIG. 2: Enriched ^{92}Zr (Left) and ^{96}Zr (Right) nuclear targets.

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