Novel Techniques for Preparation of Thin Self Supporting Platinum Targets using Evaporation Techniques

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Introduction:

Presently one of the main aims of Nuclear physics research is the synthesis of heavy and super heavy elements. To achieve this goal, understanding of fusion-evaporation and fusion-fission dynamics is essential. One of the major requirements for this study are availability of thin, self supporting and uniform isotopic targets of high atomic number (Z) elements. Target with some backing may cause problems like loss of projectile energy before it hit the actual target and it may also result in the stoppage of fission fragments or evaporation residue produced in fusion-fission or fusion-evaporation processes. Thick self-supporting targets can also give rise to similar problems. Hence, use of thin self-supporting target is always essential for precise nuclear reaction measurements.

A number of trials were carried out at different conditions, to develop suitable technique for preparation of thin self supporting Platinum targets using evaporation technique at the target development laboratory of Inter University Accelerator Center (IUAC), New Delhi. Two different independent methods were developed for fabrication of these targets. These methods were used in fabrication of enriched isotope targets of ^{194}Pt, ^{196}Pt and ^{198}Pt.

Main problems encountered during fabrication of the targets were the formation of alloy of Platinum with source materials (like Tungsten (W), Molybdenum (Mo) and Tantalum (Ta) etc.), relieving of internal stress in the films and mounting of the film after etching. Besides above issues the limited amount of Platinum material was also the major constrain in this work. Finally, different analysis like Energy Dispersive X-ray Fluorescence (EDXRF) and Elastic Recoil Detection Analysis (ERDA) were carried out to check the purity of foils.

Methodology:

In order to avoid the alloying of Platinum with regularly used sources like Tungsten (W), Molybdenum (Mo) and Tantalum (Ta), a specially designed graphite boat was used as evaporation source. It was found that; huge amount of heat was generated during electron beam bombardment. However it was experienced that until 80 mA current, the Platinum films were free from contamination of Carbon. Self supporting Platinum targets were prepared using two different methods using same graphite boat.

In the first method, thin Copper foils of thickness 2 mg/cm^2 was made using rolling machine. These Copper foils were washed with dilute Nitric acid and water in order to remove any impurities from the surface of foils. Foils were kept in air for nearly 2 hours for drying and then pasted on glass slides using silver paste. Graphite boat containing 100 mg Platinum material was placed in Copper crucible. Glass slides with Copper foils were kept over the graphite boat on the slide stand at a distance of 8 cm from the source in Cryo-Pump based unit. After attaining a vacuum of 3 x 10^{-8} mbar Platinum material was evaporated using 6 kW electrons beam at rate of 1 A^o/Sec. Copper foils with Platinum deposited on it were removed from glass slide. Due to presence of internal stress the foils were getting curled. In order to remove the internal stress, these foils were annealed at different temperatures (325^o C and 225^o C) [1] for one hour in Nitrogen atmosphere. Motivation for annealing at different temperatures was to find the temperature at which the diffusion of Copper to Platinum could be minimized. After annealing, these foils were dipped in dilute Nitric acid (100 ml HNO_3 + 500 ml Distilled Water) for nearly one day for

selective etching of Copper. When Copper was fully dissolved, Pt foils were removed from the Nitric acid solution. Foils were cleaned using distilled water and mounted on target frame.

In the second method, different parting reagents were used to remove the target film from glass slides. For this Teepol, Barium Chloride ($BaCl_2$), Zipcon (Solution of Collodoin and Amyl-Acetate (1:1 ratio)) and Potassium Iodide (KI) parting reagent were used [2]. A thin layer of thicknesses 100 μg/cm^2 of $BaCl_2$/KI was deposited by thermal heating in diffusion pump based coating unit. Evaporation was done at vacuum of $3x10^{-7}$ mbar. Then the slides were placed in Cryo-pump based coating unit for platinum evaporation. Platinum was evaporated under the same condition as explained above. Film deposited on different releasing agents except Zipcon was tried to float in hot distilled water. Film with Zipcon as releasing agent was tried to float in Methanol. It was found that in case of Teepol, $BaCl_2$ and Zipcon the target foils did not float from glass slide, where as in case of Potassium Iodide foil get floated only for freshly deposited KI. Hence, it was decided to evaporate KI and Platinum in same unit without breaking the vacuum.

Here the glass slides were placed on a stand that can be rotated from outside without effecting the vacuum. Distance of glass slides from the source was 10 cm. Lower distances (like 8 cm and 9 cm) were also tried, but in that case the foils formed were cracking may be because of heating affects. In this evaporation first glass slides were kept over the Ta boat containing KI pellet and a thin layer of ~ 100 μg/cm^2 of KI was deposited on glass slides. After that glass slide's stand was rotated to keep it over the graphite boat containing Platinum material. It was evaporated using 2 kW electron beam. In order to remove the internal stress, annealing at 325^o C in Nitrogen atmosphere was done. Finally the films were floated in hot distilled water and mounted on target frame.

Purity of Targets:

There may be possibilities of Copper and Carbon contamination in targets. Hence different techniques were used for checking the purity of targets. Since Energy Dispersive X-ray fluorescence (EDXRF) is sensitive for detection of elements with atomic number above 20, therefore this technique was used to check the contamination of Copper. EDXRF was done at Panjab University, Chandigarh. It was found that target annealed at 325^{o}C and 225^{o}C have Cu contamination of 40 wt. % and 2 wt. % respectively as shown in figure 1.

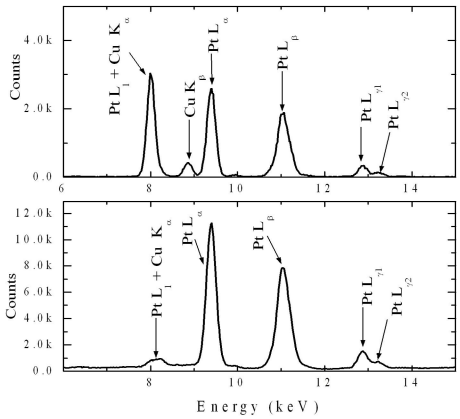

Figure 1: EDXRF spectra of Pt target fabricated using Cu substrate annealed at 325^{o}C is shown at top, whereas the spectrum for target formed by annealing at 225^{o}C is shown at bottom.

For determination of Carbon content, Elastic Recoil Detection Analysis (ERDA) was performed using ^{107}Ag beam of 120 MeV from the Pelletron at IUAC, New Delhi. Experimental data was fitted using SIMNRA simulation code. It was found that 2.5 wt. % of C and 97.5 wt. % of Pt were present in target.

Conclusions:

We have developed new techniques for the fabrication of self-supporting Pt targets. The graphite boat can be used for evaporation of the Platinum material. Platinum targets can be made using Copper substrate, followed by dissolution of Cu in dilute Nitric acid. Here the substrate or annealing temperature should not be more than 225^o C, higher temperatures will result in diffusion of Cu into Pt. Freshly prepared Potassium Iodide acts as a good parting agent for floating the Pt foil deposited on glass slides.

References

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