Fabrication of thin ^{208}Pb targets using evaporation technique

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Introduction

Now a days, the topic of synthesis of super-heavy elements is of great importance in nuclear physics. The understanding of fusion-evaporation and fusion-fission dynamics is necessary as it helps in the optimum selection of target and projectile to maximize the formation probability of super-heavy nuclei. These elements can be produced via two processes: cold fusion and hot fusion. In cold fusion, super-heavy elements are synthesized using stable targets like ^{208}Pb/^{209}Bi. It is well known that as we go for heavier mass region, along with fusion-fission there is a significant contributions from quasi-fission processes. A number of probes exists to disentangle these processes like mass-energy correlation, mass distribution and mass gated neutron multiplicity. But the precise study of such measurements requires thin targets.

The isotopic Lead (^{208}Pb) target is required for one of our proposed experiments to study the role of shell effects on mechanism of fusion-fission and quasi-fission processes in our project for fission studies. This experiment will be carried out using Pelletron + LINAC and NAND facility at IUAC, New Delhi. Thin enriched isotopic ^{208}Pb targets have been successfully fabricated in high vacuum environment at Target Development Laboratory of IUAC.

Experimental Setup

Since it was very difficult to prepare thin self supporting ^{208}Pb targets, very thin carbon foil (20-30 μg/cm^2) was chosen as the backing material. By using vacuum evaporation method, ^{208}Pb targets were fabricated on the backing of ^{12}C foils. Diffusion pump based coating unit (High Vacuum Evaporator) having resistive heating arrangement and a single pocket electron beam gun of 2 KW power supply was used for the deposition of ^{208}Pb as well as ^{12}C. Fig. 1 depicts the outer and inner view of high vacuum evaporator chamber. Due to lesser availability of isotopic material, many trials were taken with natural Pb prior to the fabrication of isotopic targets to make the technique of fabrication more perfect and accurate.

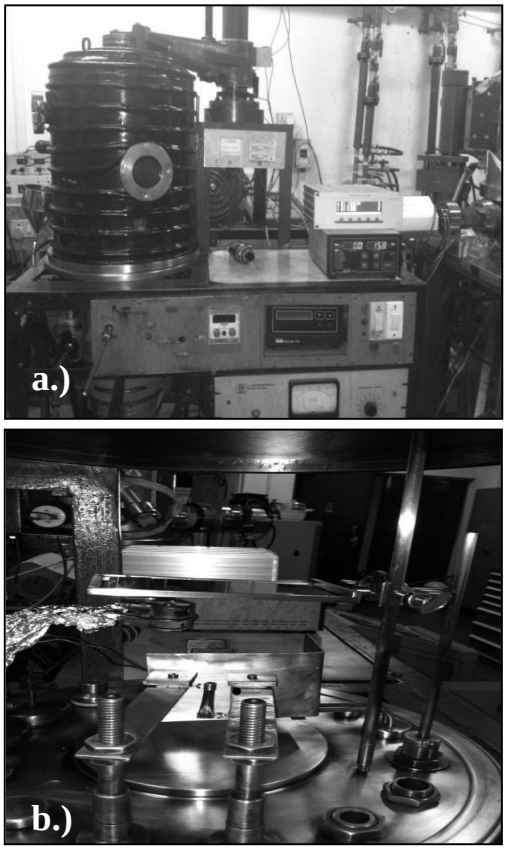

Fig. 1 High Vacuum Evaporator: a.) Outer view, b.) View inside the chamber.

The details of preparation of ^{12}C backing foils and ^{208}Pb targets are described as follows:

Preparation of backing foil

Backing foil ^{12}C was deposited by electron gun bombardment technique. 100 nm of Barium Chloride ($BaCl_2$) was deposited on clean glass slides kept at a distance of 19 cm from source by the resistive heating technique prior to ^{12}C deposition. The deposition rate was 0.1 nm/sec. Here, $BaCl_2$ was used as releasing agent [1] for the separation of carbon from glass slide. Then the chamber was allowed to cool to room temperature. Carbon was deposited on the slides after the successful deposition of the releasing agent film without disturbing the vacuum inside the chamber. During the evaporation of C, the current was 130 mA. The vacuum of 2.5×10^{-6} mbar was achieved and maintained during the whole evaporation process. The quartz crystal setup was used for the online monitoring of thickness of film deposited. The thickness of the carbon films deposited was around 20 μg/cm^2. The chamber was allowed to cool for 6 hours after the deposition of carbon film. Due to internal stress developed, the carbon coated films were not stable. So, these slides were annealed to 325^{o}C for one hour in argon gas environment to make them stress free and then cooled to room temperature.

Preparation of ^{208}Pb targets

For ^{208}Pb deposition, the resistive heating method was used. ^{208}Pb was deposited on the carbon coated films placed at distance of 13.5 cm above the source in Ta boat. The vacuum of 3.4×10^{-6} mbar was achieved and maintained during the whole evaporation process. The deposition rate was 0.1 nm/sec at current of 117 A. At last, the targets were separated from the glass slides by floating them in warm distilled water and then ^{208}Pb targets of thickness ~150 μg/cm^2 were taken into respective target frames of 10 mm diameter.

Targets Purity

Normally, Pb is oxidizing in nature. In order to determine the oxygen contents and to know the purity of targets, Rutherford Backscattering Spectrometry (RBS) was done using Pelletron Accelerator RBS-AMS Systems (PARAS) at IUAC. Data reduction of experimental backscattering spectra was done using software RUMP [2]. Fig. 2 clearly shows that the contents of oxygen are very negligible as compared to ^{208}Pb which reveals the purity of targets.

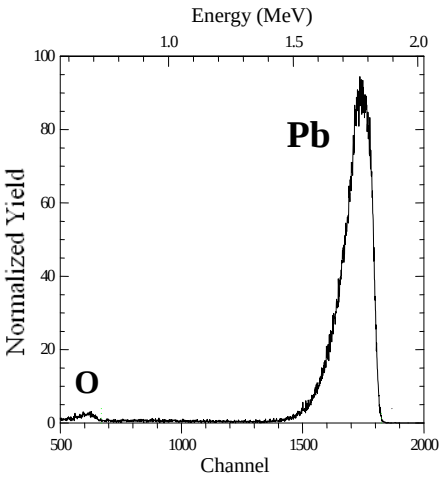

Fig. 2 Experimental RBS Spectrum of ^{208}Pb.

Results and Conclusions

Thin ^{208}Pb targets of thickness ~150 μg/cm^2 with carbon backing of ~20 μg/cm^2 thickness were successfully fabricated. Purity of targets was checked by using RBS technique. These targets are kept in argon environment and will be used for our proposed experiment in near future.

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