Fabrication of carbon backed thin targets of enriched ^{170}Yb

Divya Arora,* N. Saneesh, and S. R. Abhilash
Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi - 110067, INDIA

Introduction

The study of fragment mass distribution in the low energy fission of pre-actinide nuclei has attracted much attention due to the unexpected observation of asymmetric mass division in these nuclei [1]. Mass distribution measurements in these nuclei have been attempted using heavy ion reactions below the Coulomb barrier. Target thickness is one of the key parameters to be optimized in such measurements. Thin targets are to be fabricated to minimize the energy loss of the fission fragments especially at low excitation energy of the compound nucleus. The preparation and storage of isotopically enriched thin targets, especially of rare-earth metals, is a challenging task as they are chemically reactive in ambient atmosphere.
One of the experiment performed using NAND facility IUAC [2] required thin targets of enriched ^{170}Yb isotope on low Z backing to measure the mass distribution of fission fragmets in coincidence with the emitted neutrons in the reaction around the barrier energies. The target fabrication was carried out at IUAC, New Delhi.

Experimental setup

For preparation of enriched ^{170}Yb target, the in house facilities of IUAC: the Diffusion pump (DP) based evaporator and the Turbo pump (TP) based evaporator were used. The DP evaporator setup has dual mode functionality. It has resistive heating arrangement and a 2 KW electron beam gun which operates at a pressure of 10^{-7} torr range. The TP evaporator houses a resistive heating arrangement and a 6 KW electron gun, used with elements having high melting and boiling points and low vapour pressure, operating at a base pressure of about 10^{-8} torr. Both the evaporators are equipped with quartz crystal monitor for monitoring the thickness and the rate of deposition of the thin film .

Fabrication of backing

Fabrication of backing was carried out in two steps. First step involved the deposition of parting agent for a convenient extraction of thin film from the substrate for which pelletised KCl (167 mg) was kept in a tantalum crucible at a distance of 18 cm from the clean glass slides and the quartz monitor respectively, in DP evaporator chamber. A thin layer of about 20 μg/cm^2 of parting agent (KCl) was deposited on the glass slides on complete evaporation of the material. Second step involved the deposition of a thin layer of backing material (in this case carbon) of about 22 μg/cm^2 on the KCl layer using 2 KW electron gun in the same DP setup without disturbing the vacuum.
Before using carbon coated slides for evaporation of ^{170}Yb, the slides were annealed in nitrogen gas at 523K for a dwell time of about one hour and then cooled at room temperature in order to remove the internal stress in the cabon film.

Fabrication of ^{170}Yb layer

The available enriched ^{170}Yb was limited (100 mg), so the trials for optimization of the fabrication parameters were carried out using the natural Yb. Attempts were made for evaporation of pelletised ^{170}Yb on carbon backed slides in DP chamber with resistive heating arrangement at a pressure of no less than 10^{-6} torr but the deposited layer reported contamination from the copper electrodes used for

*contact at: indivyaarora@gmail.com

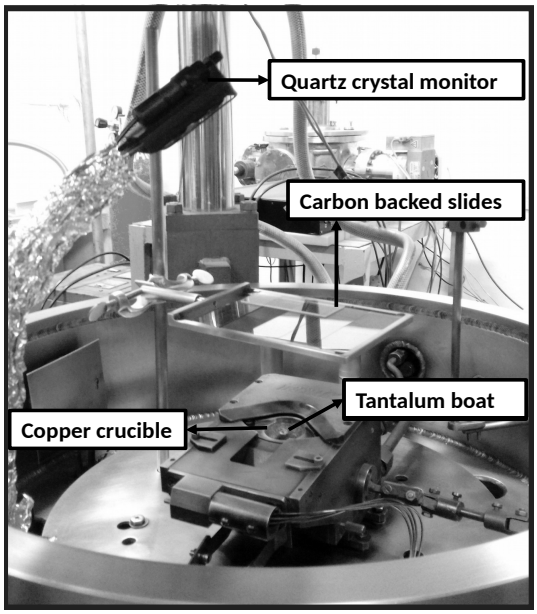

Fig 1: Picture of the Turbo pump based evaporator assembly

thermal evaporation. The next series of trials were made with 6 KW electron beam in TP evaporator where a tantalum crucible was used as a substrate holder in order to maximise the yield and was placed in one of the four water cooled copper crucible as shown in Fig 1. It was observed that when electron gun current exceeded 140 mA, it caused deformation in the tantalum crucible and significant tantalum contamination in the thin film was reported, contrary to a current of about 149 mA used in fabrication of enriched ^{174}Yb target [3].

In the final evaporation with pelletised enriched ^{170}Yb, the tantalum crucible was placed in TP evaporator at a distance of 23 cm and 8 cm from the quartz crystal monitor and the carbon deposited slides respectively. The chamber vacuum was maintained at a pressure of about 10^{-7} torr and the current across the electron gun was slowly increased to 70 mA where evaporation of material began, deliberately limited to 85 mA which was less than 96 mA used in the fabrication of ^{176}Yb [4] in order to avoid any tantalum contamination. A uniform deposition rate of about 0-0.1 Å/s was maintained at quartz crystal monitor with chamber pressure low 10^{-7} for three hours during ^{170}Yb evaporation. After the desired thickness of the thin film is obtained ,the electron beam was slowly turned down and the chamber was allowed to cool down after which the evacuation was carried out with nitrogen gas. The target thickness measurement was done with profilometer and RBS and the elemental composition measurement with EDAX in IUAC, New Delhi. Thin targets of enriched ^{170}Yb prepared with thickness of 165 μg/cm^2 on carbon backing of thickness 22 μg/cm^2 have been used in on-line experiment.

Acknowledgment

Authors acknowledge C. Schmitt for providing the enriched isotope, Umapathy, A. Jhingan, P. Sugathan and D. Kabiraj for their support.

References

[1] A.N. Andreyev et al., Phys. Rev. Lett. 105 (2010) 252502.
[2] P. Sugathan et al., Pramana Journal of Physics 83,(2014)807-815
[3] A. Rohilla et al., Nuclear Instruments and Methods in Physics Research, A 797,(2015)230-233
[4] T. Rajbongshi et al., Proceedings of the DAE Symp. on Nucl. Phys. 59,(2014)