Fabrication of thin sandwiched ^{175}Lu, ^{169}Tm targets

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Introduction

A nuclear reaction experiment needs a target to be bombarded by a beam. For fission fragment angular distribution measurements, two lanthanide targets namely ^{175}Lu and ^{169}Tm were required.

Richaud [1] used centrifugal method to prepare lutetium targets ($^{175,176}Lu_2O_3$) of thickness more than 1 mg/cm^2 for β and γ in-beam spectroscopy. ^{169}Tm had been deposited by the vacuum evaporation technique on an Al foil [2]. Mohanto et al. [3] found the successful preparation of such sandwiched lanthanide targets to be sensitive to substrate temperature, deposition rate, duration of in-situ annealing etc. The fabrication details of ^{175}Lu and ^{169}Tm targets and their characterization are reported here.

Experimental Details

The diffusion pump based coating unit at the target laboratory, IUAC, was used to prepare these targets. This is also called High Vacuum (HV) Evaporator. First, a 22 μg/cm^2 layer of ^{nat}C was deposited on the $BaCl_2$-coated substrates by electron gun evaporation in the same HV unit. A smooth graphite rod was used as the source. Target materials were evaporated by resistive heating method, using a tantalum boat as the material holder, without disturbing the vacuum. The arrangement in the HV unit for the evaporation of Tm and Lu is shown in Fig 1.

High current was made to pass through Ta boat. The source materials were melted by Joule heating which was followed by evaporation. Target materials were deposited on annealed carbon coated glass slides. For ^{175}Lu, current was slowly increased upto 280 A (voltage = 2 V). Pressure inside the chamber during evaporation was maintained at 3.2×10^{-6} Torr. For ^{169}Tm, maximum current was 190 A (voltage = 1 V). Evaporation went on for 1 hour and 15 minutes. Chamber pressure during evaporation was kept at 7.8×10^{-7} Torr. Rate of deposition was maintained at 0.1 Å/s for both the cases.

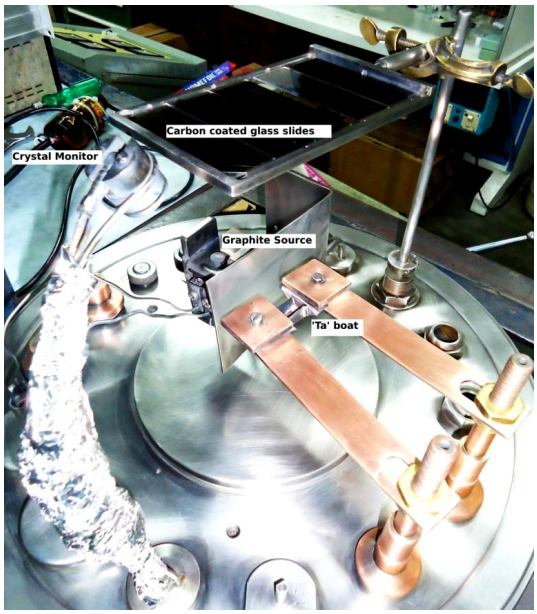

FIG. 1: Arrangement in the HV unit for deposition of Lu and Tm.

The distance between the source and the substrates was kept 10 cm initially. Some portions of the films were found to be damaged (melted) due to extreme heating. $BaCl_2$, having low melting point (962 °C), was getting degraded at high temperatures, consequently

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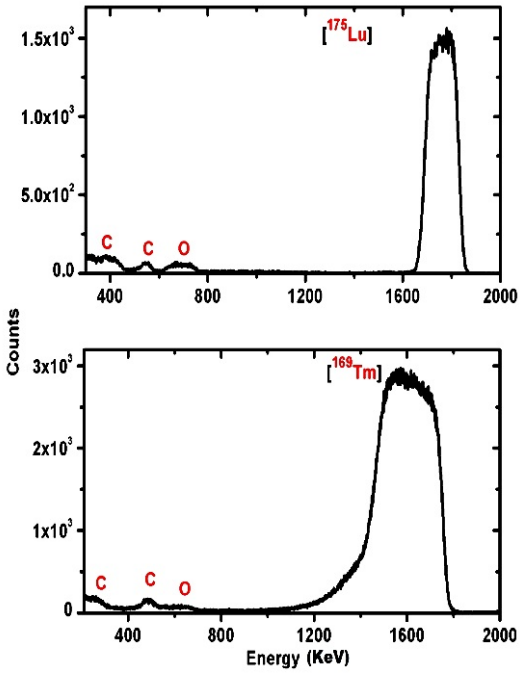

FIG. 2: RBS spectra for Lu and Tm targets.

damaging the whole film. So, the distance between the source and the substrate was increased to 14 cm.

As lanthanides tarnish in air, for both the cases, a thin carbon capping layer of 20 μg/cm^2 was deposited on the layer of target material by e-gun evaporation without disturbing the vacuum. The deposited slides were then kept into a tubular furnace for annealing at 325°C in nitrogenous environment for 1 hour to release any stress which might develop during deposition. Finally, the sandwiched films were floated in water and mounted on stainless steel (SS) target frames.

Characterization of the Targets

The fabricated targets were characterized for purity using the Rutherford back scattering (RBS) at IUAC. ^{4}He beam of 2 MeV energy, was bombarded on the target material and back-scattered projectiles were detected by a silicon surface barrier detector (SSBD), mounted at an angle of 166° with respect to the beam direction. By fitting the RBS spectrum, we got thickness and composition of the targets. Thicknesses were found to be 110 and 270 μg/cm^2 for ^{175}Lu and ^{169}Tm, respectively. Fig. 2 shows the RBS spectra for the prepared targets. It is evident that no heavy impurity is present in the targets. Presence of the carbon peak is due to the ^{nat}C backing and the oxygen peak suggests oxidation of the target material.

Conclusion

Two lanthanide targets namely ^{175}Lu (110 μg/cm^2) and ^{169}Tm (270 μg/cm^2) were fabricated using physical vapor deposition method. The target materials were sandwiched between two thin carbon layers. These targets have been used in one experiment performed in last one year and are surviving till date.

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References

[1] J.P. Richaud, Nucl. Instr. Meth. **167**, 97 (1979).
[2] Manoj K. Sharma et al., Phys. Rev. C **70**, 044606 (2004).
[3] Gayatri Mohanto et al., J. Radioanal. Nucl. Chem. **299**, 1129 (2014).