# Fabrication of thin $^{124}$Sn target on Al-backing using vacuum evaporation technique at IUAC, New Delhi

Pankaj K. Giri[1], Sneha B. Linda[1], D. Singh[1,*], S. R. Abhilash[2], Harish Kumar[3], R. Kumar[2], S. Muralithar[2], R. P Singh[2] and D. Kabiraj[2]

[1]Centre for Applied Physics, Central University of Jharkhand, Ranchi-835205, India

[2]Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi 110067, India

[3]Department of Physics, Aligarh Muslim University, Aligarh-202 002, India

*email-dsinghiuac@gmail.com

## Introduction

The study of complete fusion (CF) and incomplete fusion (ICF) dynamics in heavy ion (HI) induced reactions has been a growing interest from past few decades for the nuclear physics experimentalist. In CF process, the projectile completely fuses with the target and formed highly excited compound nucleus decays by emitting evaporating nucleons and alpha particle at equilibrium stage. In ICF process, only a part of the projectile fuses with the target and remaining part moves in the forward direction with almost incident ion beam velocity.

Excitation function (EFs) and recoil range distribution (RRD) measurements of evaporation residues are important tools to study the CF and ICF dynamics in heavy ion induced reactions at intermediate energies [1]. It is not clearly established that ICF processes are governed by the entrance channel dynamics or by the nature of the formed composite system due to the fusion of only a part of the two fragments in the vicinity of target nuclear field. Thereby, it is an active area of research at intermediate energies. To reach on some discrete conclusions related to ICF reaction mechanism, we have planned to perform a series of EF and RRD measurements using the alpha and non-alpha clusters ion-beam with enriched $^{124}$Sn target. This study will provide the some definite information regarding the dependence of ICF on various entrance channel parameters like imparted angular momentum, projectile energy and structure and mass-asymmetry of the target-projectile system. For the present planned experiments, the thin targets of $^{124}$Sn deposited onto a thin Al-backing are required. The uniformity in thickness of the target is an effective benchmark for any experiment. For this purpose, the vacuum evaporation technique provides an effective way for the preparation of targets having the uniform thickness. It becomes most important when the availability of the target material is very small. Keeping in view the above aspects, an attempt has been made to prepare thin targets of enriched $^{124}$Sn by depositing onto a thin Al-backing using the evaporation technique in a High Vacuum evaporation chamber.

## High Vacuum Evaporation Chamber

The evaporation of the enriched $^{124}$Sn target material on thick Al-backing was carried out in High Vacuum evaporator chamber in the target laboratory of Inter University Accelerator Centre (IUAC), New Delhi, India. Vacuum of the chamber during the evaporation of $^{124}$Sn material on Al-backings was achieved and sustained of the order $10^{-6}$ mbar using diffusion pump, which is connected to the Vacuum Chamber. The target material was evaporated using two methods (i) resistive heating and (ii) a 2 kW electron gun for multilayer deposition. Both techniques were used one after another [2]. The evaporator was equipped with a quartz crystal thickness monitor, which gives the thickness of deposited material as well as the rate of evaporation on the crystal.

## Procedure of Fabrication

In the first step, Al-backing foils were prepared of thicknesses 1.2-1.7 mg/cm$^2$ by rolling machine technique for the deposition of $^{124}$Sn material [3]. The thickness of aluminum and deposited $^{124}$Sn material was determined by weighing individual Al-backing foils before and after deposition of target material and alpha transmission method using $^{241}$Am source. $^{124}$Sn isotope is a very sensitive material in target preparation purpose. Several attempts were made in the deposition of $^{124}$Sn material on Al-backing to identify the right position of the substrate from the boat so that we may reach on the required thickness. After getting the required thickness using less amount of the natural Sn material, the distance between substrate and boat was noted. The suitable distance of Tantalum boat to substrate is found to be 5.5 cm and Tantalum boat temperature was 3017 °C during the test deposition of natural Sn material on Al-backing. A photograph taken after the testing of natural Sn evaporation is shown in Fig. 1(a). To reduce the temperature effect on the backing material of substrate, a special Tantalum boat was used and is shown in Fig. 2(b). a properly designed boat is to direct the maximum heat generated downward during the evaporation,.

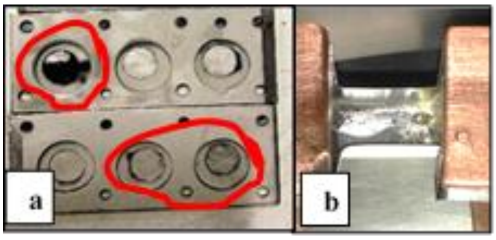


**Fig. 1(a):** Substrate after the deposition of natural Sn on Al-backing and **(b)** Ta- Boat for the evaporation.

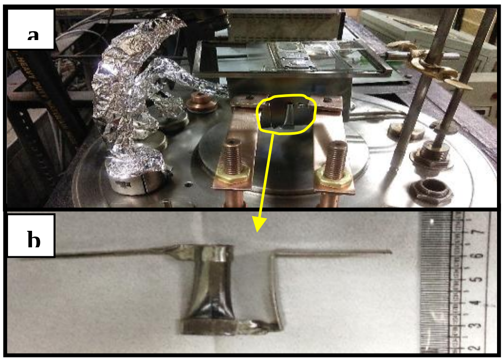


**Fig. 2(a):** High Vacuum Evaporation setup for the evaporation of target material with Ta-Special boat, **(b)** Special Ta- Boat used for the evaporation.

After completing the testing with natural Sn material evaporation, the setting of all parameters and adjustment of vacuum chamber for the enriched $^{124}$Sn material evaporation on Al-backing has been done. The distance between tantalum boat and substrate was fixed at 5.5 cm. The quartz crystal monitor has been fixed on a distance of 9 cm. $^{124}$Sn (enrichment ≈ 97.4%) material of quantity ≈ 50 mg has been put inside the tantalum boat. Then, we achieved the vacuum inside the chamber ~$10^{-7}$ mbar (i.e. $1.08 \times 10^{-7}$ mbar) using diffusion pump. The diffusion process was started at the current ~ 170 Amp in the resistive heating process. The deposition rate was sustained below 0.1 nm/sec for the uniform deposition of enriched $^{124}$Sn material on thick Al-backing foils by increasing the current very slowly. Disposition was stopped on reaching the required thickness of $^{124}$Sn material on thick Al-backing. The thickness of the deposited material was calculated using the profile meter. Further, the thickness of deposited $^{124}$Sn (enriched) material was also verified by α-transmission method using $^{241}$Am source. We have prepared eighteen thin enriched $^{124}$Sn targets on Al-backings of thicknesses ranging from ≈ 200-350 μg/cm$^2$ using the vacuum evaporation technique from the very less amount of material.

**Fig. 3:** Prepared $^{124}$Sn (enriched) targets on Al-backing by vacuum evaporation method.

## Acknowledgments

Authors are thankful to the Director, IUAC, New Delhi for providing the necessary facilities for Target fabrication. The authors gratefully acknowledge the S. R. Abhilash and D. Kabiraj of Target Lab IUAC for their help and cooperation during this work. Pankaj K. Giri is also thankful to the IUAC for the financial support under the research project (Ref: IUAC/XIII.3/UFR/54321).

## References

[1] D. Singh et al., Nucl. Phys. A **879**, 107 (2012)
[2] G. Mohanto et al., J. Radioanal. Nucl. Chem. **299** (2014) 1129.
[3] Navneet Kaur et al., Proc. DAE Symp. Nucl. Phys. **56** (2011) 1130.