Fabrication of the ^{82}Se isotopic target on ^{197}Au backing

Anuj [*], S. Kumar, Karsimran Singh, Amit Kumar, Ankit Kumar Rao, and Amarjeet Kaur

Department of Physics & Astrophysics, University of Delhi, Delhi-110007.

1 Introduction

Heavy-ion fusion evaporation reactions are used in nuclear structure studies to examine the quantum states of nuclei by populating the high spin states [1, 2]. To improve the selectivity of reaction channels, an isotopically enriched target of the desired thickness, depending on the physics of interest, such as nuclear reaction and structural dynamics, is needed [3]. Fabrication of such a target needs specific techniques, depending on the physical and chemical characteristics of the materials such as, adhesion, thermal and chemical stability, etc [4, 5]. To prevent contamination and other interfering processes, isotopically enriched targets are required for the majority of experimental studies. As isotopically enriched target materials are usually very expensive, therefore, it is very crucial to minimise their consumption during the fabrication process.

The isotopically enriched ^{82}Se target on ^{197}Au backing were fabricated by the resistive heating method using the Molybdenum boat in the diffusion pump based coating unit at the Department of Physics & Astrophysics, University of Delhi, New Delhi, India. The description of the setup used and procedure of fabrication is given in section 2. The thickness of fabricated target was measured using an optical profilometer. The ^{82}Se(^{7}Li,xn) reaction was performed using the fabricated target at 28, 33 and 36 MeV beams.

2 Procedure of fabrication

2.1 Fabrication setup

The fabrication setup (as shown in Fig. 1) is a resistive heating based coating unit at the Department of Physics & Astrophysics, University of Delhi, New Delhi, India. A vacuum of 10^{-5} mbar can be achieved in the evaporation chamber via liquid nitrogen (LN_2) and crushed ice cooling. Additionally, the evaporator has a height-adjustable substrate holder, and source to substrate distance can be adjusted according to the requirements of the deposition. The evaporator is further integrated with a liquid nitrogen (LN_2) and crushed ice cold container to reduce the oil contamination from the diffusion pump. During the deposition process, the deposition rate and thickness can be monitored using the quartz crystal monitor equipped with the evaporator.

Fig. 1: Diffusion pump based coating unit used for the evaporation of ^{82}Se on ^{197}Au foil at the Department of Physics & Astrophysics, University of Delhi, New Delhi, India.

2.2 Rolling of the ^{197}Au backing foil

The ^{197}Au foils with a thickness 3-7 mg/cm^2 were made using a rolling machine based on the cold rolling method at Inter University Accelerator Center(IUAC), New Delhi, India [6]. The gold foil(0.01 mm, 99.9% enriched, Alfa Aesar) was sandwiched between uniform, smooth research grade stainless steel plates, and the stainless steel plates were rolled between two rolling machine cylinders under constant pressure until the desired thickness was reached. The thickness of the rolled gold foil was determined by weighing using an electronic weighing balance and measuring its area with graph paper.

[*]email: anujsih10@gmail.com

2.3 Evaporation of ^{82}Se on ^{197}Au backing

The isotopically enriched ^{82}Se (99.93%, Isoflex, USA) powder was evaporated on ^{197}Au backing using the evaporator with extreme care as Selenium(Se) is bit toxic. Since Se has a melting point of 220.8 °C, resistive heating method was adopted for the evaporation process. Prior to evaporating the isotopically enriched Se, the setup was optimised using natural Se, and a thickness of 1.8 mg/cm^2 on the backing was attained using the 130 mg of natural Se. After the parameters were optimised, 60 mg of ^{82}Se was added to the molybdenum boat, and target substrate was placed at a 4 cm distance from boat to minimize the solid angle of evaporation. Voltage was raised in stages of 10 V every 3 minutes after a vacuum of 10^{-5} mbar was reached, and once it reached 60 V, it was maintained at that level for 12 minutes to allow for complete evaporation. After evaporation, the setup was given three hours to cool before being progressively vented. In order the obtain the precise value of thickness, the optical profilometer method was adopted, and a target of desired thickness of 706 $\mu g/cm^2$ on ^{197}Au backing was achieved as shown in Fig. 2.

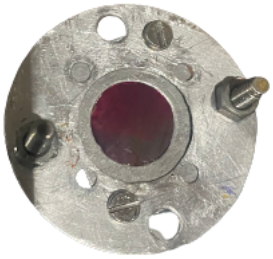

Fig. 2: ^{82}Se target with ^{197}Au backing placed at the target ladder of INGA facility in IUAC, New Delhi.

The ^{82}Se deposited on ^{197}Au foil was placed on Aluminium frame having circular opening diameter of 1.5 cm.

3 Results

The experiment was performed at the Indian National Gamma Array(INGA) facility at the IUAC, New Delhi with the above prepared target using the ^{7}Li beam having energy 28, 33 and 36 MeV. Fig. 3 is showing the projection spectrum at 33 MeV observed from the ^{7}Li+^{82}Se reaction. The characterization of the material to find the purity of sample is in progress.

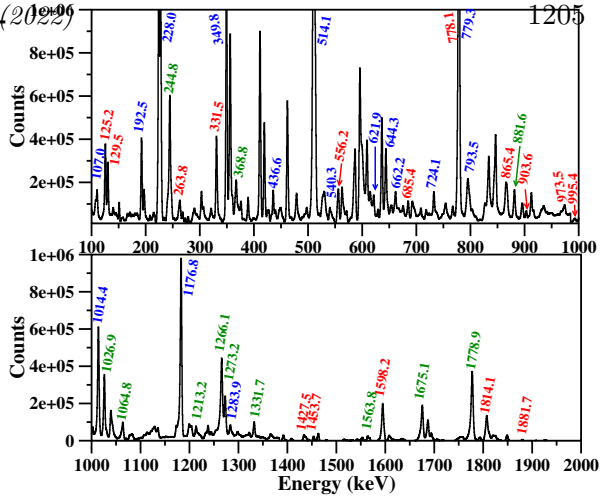

Fig. 3: The projection spectrum showing the γ-ray transitions observed in the ^{7}Li+^{82}Se reaction at 33 MeV. The blue color transitions are from ^{85}Rb nuclei, red color transitions are from ^{86}Rb nuclei and green color transitions are contaminants from the neighboring residual nuclei populated in the ^{7}Li+^{82}Se reaction.

Acknowledgement

One of the authors(Anuj) acknowledges the financial assistance provided by CSIR, in the form of Senior Research Fellowship(09/045(1597)/2018-EMR-I). Also, S. Kumar expresses gratitude for the funding provided by the Institute of Eminence under the faculty research programme (FRP) at the University of Delhi for the research grants (lOE/FRP/PCMS/2021/12 and lOE/FRP/PCMS/2022/199.

References

[1] M.A. Riley, J. Simpson, E.S. Paul, Phys. Scr. **91**, 123002 (2016).

[2] S. C. Pancholi, Exotic Nuclear Excitations (Springer, New York, 2011).

[3] Neelam *et al.*, Vacuum, **170**, 108961 (2019).

[4] S. Lakshmi *et al.*, Nucl. Phys. A **761**, 1–21 (2005).

[5] K. Rojeeta Devi *et al.*, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment **893**, 35-38 (2018).

[6] S.R. Abhilash *et al.*, J. Radioanal. Nucl. Chem. **305**, 749–753 (2015).