Fabrication of self-supporting, isotopically enriched thin targets of ^{160}Gd for the study of nuclear fission dynamics

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Introduction

Heavy ion nuclear reactions have been under study for many decades, but yet not fully understood, because of the complexities involved. During the dynamical path of fusion-fission reaction, neutron emission is one of the dominant decay channel. Neutron multiplicity measurement and Fission fragment mass distribution have been used as an effective probe to study such kind of dynamical evolution of nuclear system [1]. For the present study of fusion-fission dynamics through neutron multiplicity measurements we have populated compound nucleus of ^{208}Rn through ^{48}Ti + ^{160}Gd entrance channel. The neutron multiplicity measurement requires, isotopically enriched, self-supporting 160Gd targets of thickness of ∼1.0 mg/cm^2 and for FF mass distribution, the estimated required thickness is ∼100-300 μg/cm^2 Few reports are available on the fabrication of Gd targets using different techniques. P. Maier-Komor et al. [2], deposited Gd film of having thickness of 4 mg/cm^2 on rolled Ta backing of thickness of 1-1.66 mg/cm^2, by electron beam evaporation technique at substrate temperature of 800 K. V. Kumar et al. [3], had fabricated an enriched 160Gd targets using reduction distillation technique, of thickness 632 mg/cm^2 on a tantalum backing of 1 mg/cm^2. Jasmeet Kaur et al. [4], prepared thick target of thickness ∼1 mg/cm^2. Gd have very oxidising nature and also have burning property by electric discharge on applying high pressure in rolling technique. Therefore, the preparation and storage of Gadolinium targets is quite challenging. In the present work, we have successfully fabricated self-supporting foils of 160Gd having various thickness ranging 320 μg/cm^2 to 1 mg/cm^2 by cold rolling technique using only ∼45 mg of enriched material at the Target Laboratory of IUAC, New Delhi.

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Fabrication Equipment

The schematic diagram rolling of machine is shown in Fig. 1. This machine was used to prepare thin target foils of isotopically enriched ^{160}Gd by cold rolling method. The material to be rolled was placed inside a pack of mirror polished stainless steel (SS) plate and rolled through especially hardened rollers. The gap between the rollers is reduced gradually to produce good quality foils.

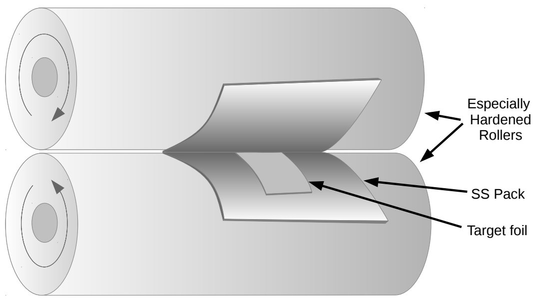

FIG. 1: Schematic diagram of rolling machine.

Rolling of Gd foil

To roll the target, we required the good quality SS pack. Therefore, a piece of SS plate of dimension 6 cm × 15 cm was folded to form a pack as shown in FIG. 2. The SS pack was heated up to ∼ 500^{o}C to avoid slackness in SS pack which can cause unwanted strain to the target foil. The empty pack was rolled out to make the inner surface smooth and non-sticky for target material. As the enriched material of ^{160}Gd is quite expensive, an initial attempt was made using natural Gd. The metallic bead (weight ∼45mg) of Gd was placed inside the SS pack. On rolling, the bead acquires the shape of circular foil and small cracks appeared at its edges. To avoid the propagation of cracks in the remaining foil, the edges of foil were removed immediately, resulting in rectangular foil. This process was repeated several times whenever cracks appeared. On rolling the foil up to the thickness of 2.5 mg/cm^2, foil becomes very sticky to SS pack, a sharp and clean piece of paper was used to remove it. On further rolling the size of foil

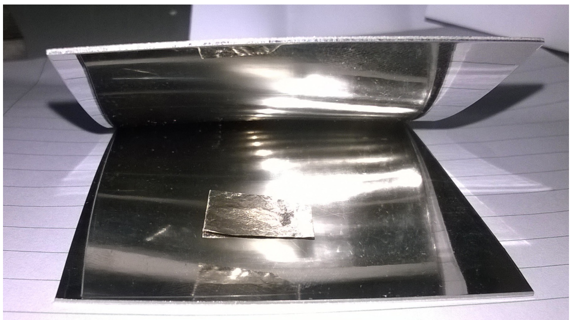

FIG. 2: Thin foil inside the SS pack

goes to ∼2.5 cm × 3.0 cm and the thickness to ∼1.8 mg/cm^2. As it is difficult to roll such a big size foil with equally distributed thickness, therefore, the foil was divided into small parts. Further rolling was carried very slowly for long duration and at uniform pressure. After the thickness of about ∼1.0 mg/cm^2, the foil starts sticking to SS pack very frequently. On applying a very thin alcohol layer in between the SS pack and the target foil, sticking reduced remarkably. Therefore, for further rolling we used thin alcohol layer between the SS plate and the target foil. However, again at such low thickness the use of piece of paper for edge-trimming started damage the foil, therefore, smooth wax-paper and floating of thin film on alcohol surface was used. Through this way, we were able to achieve a thickness of ∼ 500μg/cm^2. The thickness of foil was estimated by measuring area of the foil by graph-paper with the precision of 1 mm^2 and by measuring weight in electric micro-balance. During rolling of the foil, presence of dust particles on it causes tiny holes in the foil. Therefore, to prevent the foil from the dust particles, the target foil was washed very gently with alcohol. On further rolling , thickness of ∼320 μg/cm^2 and surface area ∼1 cm × 1 cm was achieved successfully. The targets of thickness ∼300μg/cm^2 are usually fabricated by evaporation technique and cold rolling is used to fabricate the target of thickness ∼1-2 mg/cm^2. We have not found any report in literature regarding the fabrication of Gd thin film of thickness ∼300 μg/cm^2 by rolling technique . In the present work, we have successfully fabricated the thin films of Gd without any heat treatment. Fabricated thin foils were mounted on the target holders. These targets were used for proposed experiment in National Array of Neutron Detectors (NAND) at IUAC, New Delhi for neutron multiplicity and FF mass distribution measurements.

Result and Conclusion

Self-supporting enriched ^{160}Gd targets of good quality and thickness ranging from ∼320 μg/cm^2 to 1.0 mg/cm^2 were fabricated successfully by rolling technique, without using any heat treatment. The amount of oxidation of targets was measured by Rutherford Back-Scattering (RBS) technique at IUAC and it was found within the acceptable level. The targets were stored in Argon environment to make it survive for a long duration.

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