Fabrication of thin self supporting ^{156}Gd, ^{165}Ho and ^{166}Er targets

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Introduction

Fabrication of the targets of appropriate thickness is the first and foremost requisite for performing any nuclear physics experiment. In our proposed experiment, to comprehend the process of complete fusion (CF) and incomplete fusion (ICF) reaction dynamics near and above the Coulomb barrier, we required thin self supporting target foils of ^{156}Gd, ^{165}Ho and ^{166}Er. In order to cover a wide energy range (≈ 4-7 MeV/nucleon) and to study the effect of various alpha and non alpha clustered projectiles on ICF, nearly seventy targets were required. Since the quantity of material available was limited and the number of targets required was more, hence we preferred the rolling technique. Also by using the rolling technique, we can have target foils more uniform in thickness. The major challenges during the fabrication of targets were their large density and the oxidizing nature of ^{156}Gd and ^{166}Er. The enriched isotopes of ^{156}Gd and ^{166}Er were procured from Oak Ridge National Laboratory, USA whereas ^{165}Ho was purchased locally. The initial average thickness of ^{156}Gd, ^{165}Ho and ^{166}Er was around 295 mg/cm^2, 230 mg/cm^2 and 102 mg/cm^2 respectively. The isotopes ^{156}Gd and ^{166}Er were in the form of small metallic chips as shown in Fig. 1.

Fig.1 (a) Gadolinium-156 **(b)** Erbium -166

Fabrication by cold Rolling

It is quite easy to roll the materials, which are malleable and density is very low, but it is quite difficult to prepare thinner foils of the materials with high density. As lanthanide targets are chemically active, their fabrication and storage is very complex and requires some extraordinary efforts [1, 2]. For the preparation of ^{156}Gd targets, the amount of material available was quite limited and was in the form of three thin small chips with an average size of 0.3 × 0.5 cm^2. In order to prepare the ^{156}Gd target foils of appropriate thickness, the better quality of stainless steel (SS) plates with inner surface highly polished were folded. In order to minimize the time consumption, all the three chips of ^{156}Gd with a proper gap in-between were placed in a SS plate and rolled in a rolling machine at very low pressure, to avoid any damage to the material. The schematic view of rolling is shown in Fig.2.

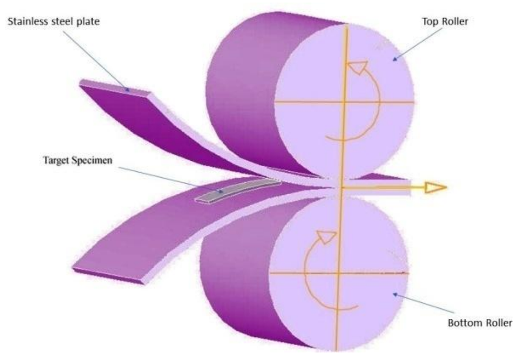

Fig. 2 Schematic view of rolling machine.

During the rolling the spots were visible on the SS plate due to the large thickness of the isotopic material, hence the position of the material and the SS plates were continuously altered. The process was continued till the size of the foils increased and their surface became shiny. The foils were further rolled individually, to reach the required thickness. The major problems that were faced during the rolling of ^{156}Gd targets were sticking of the foils to the SS plate surface and it's burning, when the size of the foils was around 2-3 mg/cm^2. A few of the foils got damaged while taking them out from the SS sheet, this was probably because of the production of spark in-between the tip of the forceps and the isotopic material. To avoid this, a smooth wax paper was used instead of metal forceps. It took several days to prepare nearly twenty eight targets of ^{156}Gd, whose thickness was in the range of 0.5-1.4 mg/cm^2.

The ^{165}Ho was available in a perfect square sheet with an initial size of 0.9 × 0.9 cm^2. The Holmium foil was rolled in the same manner as applied for Gadolinium isotope. During the rolling, the SS plate was continuously replaced by new one. Also maximum care was taken to avoid the contamination of dust or any other external particle. The pressure of the rolls was slowly and gradually increased with the increment in the surface area of Holmium foil. It took several hours to achieve the thickness of nearly 2 mg/cm^2. Upon further rolling, the foils folded up inside the SS plate, this is because of the high density of the Holmium. However no sticking of the foils to the plate surface was observed. The foils were then carefully removed with the help of wax paper and put under a heavy and uniform pressure till they were flattened. Again they were fed to the roller under high pressure and were continuously rolled till the required thickness was achieved. The number of ^{165}Ho targets fabricated was twenty five, whose thickness was ranging from 0.7-1.5 mg/cm^2.

Erbium slowly reacts with the oxygen and moisture at room temperature [3], hence the preparation and storage of erbium is also quite difficult. The ^{166}Er foils were irregular in shape and had various grooves as may be seen from Fig. 1(b). In order to prevent the developing of further fissures, the foils were initially trimmed with an utmost care. The initial average size of the foils was around 0.5 × 0.8 cm^2. Since the required number of targets was more and the quantity of erbium material was very limited, hence again rolling method was preferred. The Erbium foils were rolled via applying the same procedure as that for ^{156}Gd and ^{165}Ho. During the rolling of Erbium foils, when the thickness of the order of 4 mg/cm^2 was achieved the foils started sticking to the SS plate surface. Various procedures like heating of the SS plate, use of Silicone oil were initially tried but were found to be ineffective. However, with the use of few drops of alcohol the Erbium foil got separated from the SS sheet. It is important to mention that when the thickness of Erbium foils was further lowered, the foil started splitting into layers. Despite a number of rigorous attempts, we could only fabricate seven targets of ^{166}Er by rolling technique as the Erbium material continued to split into layers. The thickness of the targets achieved was in the range of 1-1.4 mg/cm^2. The thickness of all the foils was measured by micro-balance as well as by using the alpha transmission method. Fig.3 shows the image of the targets prepared. All the target foils were stored in the Argon atmosphere.

Fig.3 ^{156}Gd, ^{165}Ho and ^{166}Er target foils pasted on Al-holders.

Conclusion

A thin, uniform in thickness, self supporting target foils of ^{156}Gd, ^{165}Ho and ^{166}Er were successfully fabricated at Target Development Laboratory, IUAC, New Delhi and were successfully utilized for performing the CF and ICF measurements.

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