Fabrication of Isotopic Ba Target

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Introduction

Preparation of target plays an important role in nuclear physics experiments. The isotopic barium target (^{138}Ba) is required for one of the proposed experiments for the study of the effect of target neutron shell closure on fission in ^{50}Ti+^{138}Ba reaction. This experiment is planned to be carried out at IUAC using ^{50}Ti beam from Pelletron+LINAC and NAND detector setup for the measurement of neutron multiplicity as well as mass-energy distribution of fission fragments. Measurement of evaporation residue cross section is also planned for the above reaction using the same Barium targets.

Isotopic Ba targets were successfully fabricated in the target development laboratory of IUAC. Less amount of material and higher price of isotopic material, failure of carbon backing foil due to the force of Ba vapor during evaporation and preservation of Ba target after the fabrication were the major challenges in this work. Details of the fabrication procedure is presented in this report.

Target fabrication

Targets were fabricated on the backing of ^{12}C foils by vacuum evaporation method. An Al film was also coated on the Ba target to protect it from the reaction with gases in the atmosphere. 100mg of $BaCo_3$ powder was consumed in the target fabrication. Few trial attempts were made with natural $BaCo_3$ to perfect the method prior to the fabrication of isotopic targets. A diffusion pump based coating unit was used for the target fabrication. Carbon backing films were fabricated by electron beam bombardment technique and Isotopic Ba and Al were evaporated by resistive heating technique.
Fabrication of self-supporting carbon films were done initially. For the fabrication of carbon films, a 13 μg/cm^2 of $BaCl_2$ was evaporated on a set of clean glass slide by resistive heating technique. $BaCl_2$ acted as a releasing agent for the separation of carbon film from the glass slide. Fig. 1(a) shows the experimental set-up for the resistive heating. Soon after the evaporation of $BaCl_2$, ^{12}C of 50 μg/cm^2 was evaporated on $BaCl_2$ by using electron beam bombardment technique. High energy loss in thick carbon backing and failure of thin carbon backing during evaporation were the major factors used to optimize the carbon backing thickness of 50

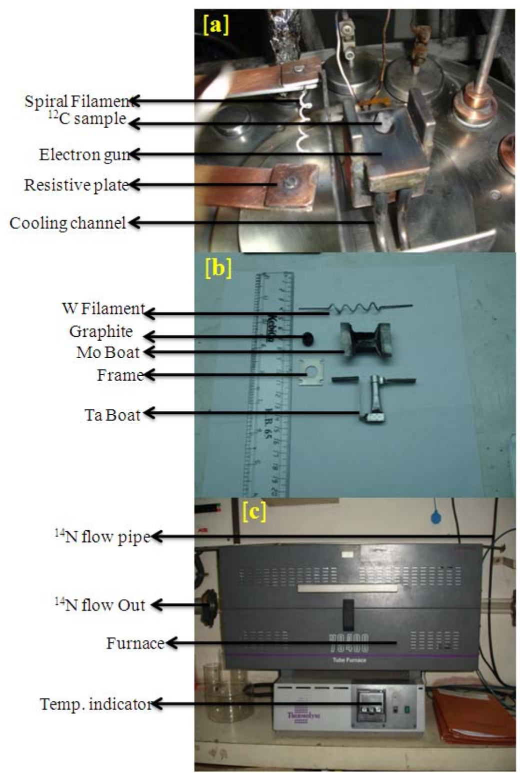

Fig. 1(a) Resistive heating set-up and electron gun. (b) Accessories used during the evaporation. (c) Tubular furnace used for annealed process μg/cm^2. Fig. 1(a) shows the electron beam set-up for ^{12}C evaporation. Accessories used for resistive heating as well as for electron gun method are shown in Fig. 1(b). After evaporation, the carbon coated slides were annealed for 1 hour in dry nitrogen environment at 325 ^{0}C for the purpose of stress relieving. Fig.1(c) shows the tubular furnace used for annealing. Carbon films were then cut into the size of target frame and floated in a distilled water bath. The films were carefully mounted on the target frames. It was observed that films having even small pin holes were not stable during the evaporation of Ba. Since the carbon films without any pin holes were the most important requirement for the success of this work, care was taken to fabricate good quality carbon films.

Initial step in the evaporation of $BaCo_3$ was to clean the vacuum chamber of the coating unit to minimize the contamination of other materials. The self supporting carbon films (mounted on the target frame) were then fixed in the chamber. Since the radiation of heat from the source badly affect the stability of backing foil and quality of target film, minimizing the source-substrate distance was not possible. Due to the higher amount of material consumption, more source-substrate distance also did not work. Finally a distance of 12 cm was optimized by trial and error method. A Tantalum boat of tubular form was used to contain the source material ($BaCo_3$ powder). Higher ratio of length and diameter of the boat minimizes the material wastage. The rate of evaporation of $BaCo_3$ was fixed at 0.1 nm/sec to minimize the force exerted on the carbon film. An Al layer of 5μg/cm^2 was also deposited on the Barium target. This Al layer acted as a protective cap between the atmosphere and target surface. A tungsten coil was used to evaporate the Al as shown in Fig. 1(b). All the evaporations were done at a vacuum of ~2x10^{-7} Torr. After the evaporation, the chamber was left for 2 hours for cooling and vented with dry nitrogen.

Conclusion

By using the above described method we were successful in the fabrication of six ^{138}Ba targets of thickness ~ 170μg/cm^2 on backing of ^{12}C of 50 μg/cm^2 and with a cap of Al of 5μg/cm^2.

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References

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