Fabrication of Thin Targets of ^{92,100}Mo

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Introduction

The target of appropriate thickness plays a very crucial and centered role in experimental nuclear physics. Depending on the purposes, the thickness may vary and needs special attention in terms of energy loss. In nuclear reaction experiments, the thin targets are of very high importance [1]. Along with the thickness, the factors like uniformity in thickness, sustainability against heavy ion beam, isotopic purity, good tensile strength etc. are of core importance and should be taken care properly while fabricating the targets. One of the attempt for self-supported target of Molybdenum was drawn in frame by John P. Green and George E. Thomas [2]. They experimented with different parting reagents and concluded to utilize $BaCl_2$ **(**having melting point 962°C). They made self supported ^{92,98}Mo with thickness > 200 μg/cm^2 keeping evaporation timing short so that temperature rise can be prevented within the film. The fabricated film was floated and mounted on target frame but it exhibited very short life time in front of 1 pnA beam of 181 MeV of ^{36}S ion. As per available knowledge, no other method has been tried before except the description above. We hereby fabricated Mo isotopes thin film using carbon backing of approximately 22 μg/cm^2 and deposited Mo isotopes sequentially over it in different runs. The work was carried out at IUAC target lab facilities.The experimental details of the facilities and fabrication procedure is reported below.

Experimental Details

The purpose was fulfilled by using high vacuum (HV) evaporator chamber, an ultra high vacuum (UHV) evaporator chamber, tabular furnace. The physical vapor deposition (PVD) technique was exploited with e-gun evaporation. The HV setup is accommodating diffusion pump along with liquid nitrogen trapper for oil droplets to achieve pressure of order 10^{-8} mbar. The UHV evaporator is facilitated with turbo molecular pump and cryopump to achieve pressure of the order 10^{-11} torr. The multi pocket advantage are always there so that the sequential deposition of required material can always be fulfilled. The cryopump helps towards reducing more contaminations like carbon. Both the evaporator units possess a piezoelectric crystal based thickness monitor at a distance from the source to always indicate the activity inside. The schematic diagram of both the chambers along with details can be found in T. Banerjee et al.[3].

Target Fabrication

(a) Natural carbon baking

The deposition started after the thorough cleaning of the HV chamber and attaining the requisite pressure . The pressure was maintained at $3.4x10^{-6}$ mbar during the deposition. Inside the chamber, the glass substrate holder was placed over which the film was to be deposited. KCl having very low lattice energy was good choice for parting reagent was deposited with the fixed rate till the thickness monitor indicates the 100nm thickness. The natural carbon, in form of pellets, was exposed to e-beam to obtain the thickness of 22μg/cm^2. After the deposition, the chamber was in cooling process for almost 8 hours.

Due to deposition, the thin films are in stress so in order to contrive, annealing was done at 250°C for one hour in inert argon environment and allowed for argon as well natural cooling. This leads to post-deposition of the material

leading recrystallization or chemical reaction depending on the temperature and time.

(b) Molybdenum deposition

In the UHV chamber, the annealed carbon slabs were loaded to furnish Mo deposition at some

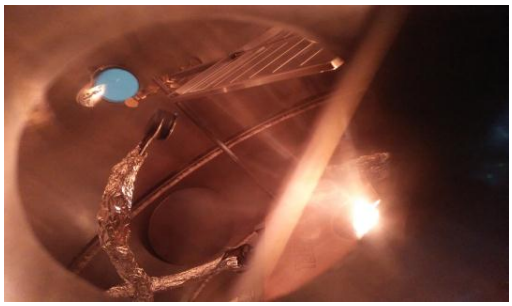

Fig 1: Deposition process of ^{92}Mo.

Fig 2: Internal view of the chamber after deposition.

prominent distance. There were several trials with natural Molybdenum to check out the texture, sustainability and floating properties of the film. After optimizing the parameters with natural Mo, the UHV chamber was cleaned thoroughly for isotopic film deposition. The pure isotopes were supplied from Oak Rigde Laboratory, USA. The isotope ^{92}Mo was in rod form and the ^{100}Mo was in form of powder, molded to a pellet of 3mm diameter to secure minimum loss of the material. ORL claims 99.05% enrichment for ^{100}Mo. The pressure was maintained at the order of 10^{-7} torr during the deposition. The substrate was kept at optimized distance from the source. After attaining a pressure of 10^{-11} torr the deposition of ^{92}Mo was carried out at current of 170 mA/A with rate 0.1 Å/s till the thickness of 211 nm. The same parameters were fixed for ^{100}Mo deposition also for another set of carbon deposited slabs to achieve thickness of 297 nm. The chamber was allowed to cool for 8-10 hours after each run of isotopes.

(c) Annealing

The thin films were allowed to go for annealing at 250°C for 1 hour in argon environment and undergo natural cooling. This process supported post growth of the films as described earlier.

(d) Target Preparation

The thin films of isotopes were floating in lukewarm deionized water, were taken carefully on ss target frame holder. One of the blank slab was there in each run to have the isotope deposition and afterward it is used to measure the thickness of the deposited film using stylus profilometer.

Conclusion:

We could make 20 targets of ^{92}Mo of thickness 217 μg/cm^2 and 16 targets of ^{100}Mo isotopes of thickness 305 μg/cm^2 with carbon backing of 20 μg/cm^2 .The backing layer is thin and possess low atomic number, leads to very small energy loss of the beam, thus makes the targets as good as self-supported. This method helps to secure large number of targets as well.

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