Fabrication of the tungsten targets for the nuclear reaction studies at IUAC

N. K. Rai[1],* Vivek Mishra[1], Abhilash. S. R[2], D. Kabiraj[2], and Ajay Kumar[1]
[1] *Department of Physics, Banaras Hindu University, Varanasi-221005, INDIA*
[2]*Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi - 110067, INDIA*
· * *email: nkrai233231@gmail.com*

Introduction

In the area of experimental nuclear physics, to study the nuclear reaction the target has an important role. We do different kind of measurements like evaporation residue excitation function, fission fragment mass distribution, measurement of neutron multiplicity, and particle evaporation. In the different areas of research, targets used having different thickness like for the fission fragment mass distribution, we select thin target due to the energy loss of the residue inside the target but in case of the neutron multiplicity, we select thicker target because reaction yield is proportional to the target thickness. In the literature, the tungsten targets are prepared using different techniques. In one method tungsten was deposited on Cu foils accelerating between two parallel electrodes and after it Cu foils were removed by etching [1]. In another method tungsten targets were prepared by tungsten oxide powder [2] and P.D Shidling et al [3] had prepared a thin tungsten target with carbon backing.

In one of our experiments, we have planned to do the measurement of neutron multiplicity. Therefore, we need a thicker target of tungsten isotopes ^{182}W, ^{184}W, and ^{186}W. We have tried to fabricate the self-supported tungsten target at IUAC, New Delhi but it was not successful. Therefore, we have prepared the thicker tungsten targets with the carbon backing.

Experimental Setup

The evaporation of the tungsten material was done using the Turbo pump based coating unit, which had the vacuum of the order 10^{-8}Torr with the help of Cryo pump and Turbo pump. An electron gun of 6kW was used, which can evaporate the materials at a high melting point. The ultra-high vacuum chamber had four Crucibles, which were continuously cooled by the chilled water supply. The systematic view of the experimental setup is shown in Fig. 1.

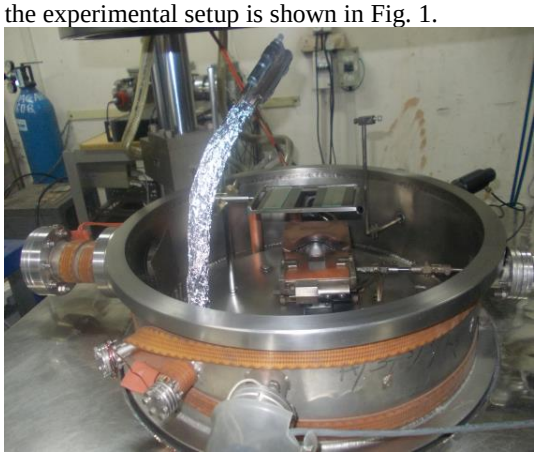

Fig. 1: Experimental setup for the deposition of the tungsten isotopes ^{182}W, ^{184}W, and ^{186}W.

Preparation of Carbon backing

For the preparation of the carbon backing, we had used the Diffusion pump based coating unit, which had the vacuum of the order 10^{-7}mbar. The experimental view of set up is shown in Fig. 2.

Fig. 2: Experimental setup for the preparation of the carbon backing.

To achieve the vacuum of order 10^{-7}mbar, a diffusion pump with rotary oil pump was used. This chamber contains thermal evaporation as well as electron gun evaporation facility. Firstly, $BaCl_2$ was evaporated using the thermal evaporation technique up to the thickness of 100nm. $BaCl_2$ works as a parting agent to separate the carbon from the glass slide. The carbon material was evaporated using the electron gun with a rate of 0.1A°/s, for which carbon pellet of the diameter 9mm was used.

Preparation of tungsten targets

We had done many trials with the natural tungsten powder. The pellet size was 6 mm in diameter and the distance of the substrate from the source was 6 cm to achieve the required thickness. The thickness of the deposited material was measured with the help of a Crystal Monitor. The distance of the crystal monitor was 24cm from the source, the approximate thickness can be measured using the following formula:

$$T_1 = (R_2/R_1)^2 * T_2$$

Where,
T_1 = Thickness of the deposited material
T_2 = Thickness in the crystal monitor
R_1 = Distance of the substrate from the source
R_2 = Distance of the crystal monitor from source

After the deposition, the deposited material was placed for the annealing at the temperature 350^0C to reduce the stress in the target foil. The annealed slides were floated in the hot distilled water. The details of the prepared targets are shown in Table 1.

Table 1: Details of the prepared targets.

Sample	Thickness (µg/cm^2)	C-Backing thickness (µg/cm^2)	No. Of Samples
^{182}W	430	25	2
^{184}W	770	40	5
^{186}W	637	40	6

Characterization

After the preparation of targets, we have done the EDAX measurement using the EDAX facility available at IUAC, New Delhi, to see the presence of the impurity level in the fabricated target. The EDAX spectra for the isotope ^{184}W are shown in Fig. 3. A distinct pick can be seen for the tungsten with respect to the carbon and oxygen. It represents the absence of any heavy impurity in the target.

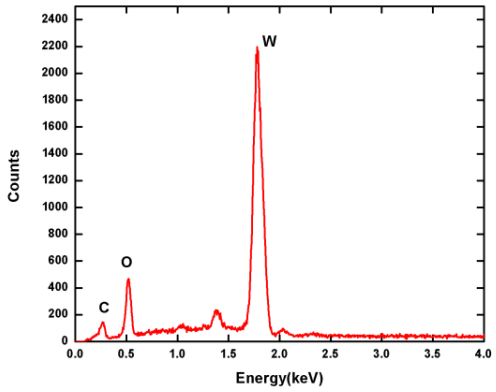

Fig. 3: Spectra of the EDAX measurement for the isotope ^{184}W.

Conclusion

We have prepared the thicker target of the tungsten isotope ^{182}W, ^{184}W, and ^{186}W with the carbon backing. The details of the thickness are given the Table 1. The EDAX measurement of the prepared targets shows the absence of heavy impurity in the targets.

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