Fabrication of Cr target for nuclear structure studies

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Introduction

Target fabrication is a vital part of any nuclear physics experiment because the results of the experiment depend heavily upon the quality of the target. Hence, fabrication of a proper target according to the requirement of the experiment is very desirable. Here we report on the fabrication of two sets of chromium target of different thicknesses required in spectroscopic and lifetime measurement for nuclear structure studies. Natural Cr is a hard, brittle metal which consists of ^{52}Cr isotope with relative abundance of 84%, ^{53}Cr with 9%, ^{50}Cr with 4% and ^{54}Cr with 2%. For lifetime studies, Doppler shifted attenuation method(DSAM) is a well known technique which requires a thin target on a high Z thick backing, so as to stop the recoil products inside the backing. The physical vapor deposition method [1] is commonly used for fabrication of thin films of brittle material. Using this method, we have fabricated Cr target of thickness ∼0.6 mg-cm^{-2} on a ∼9 mg-cm^{-2} thick Au backing for DSAM and another of ∼1 mg-cm^{-2} on a ∼10 mg-cm^{-2} thick Au backing for spectroscopic studies at target preparation facility of Inter University Accelerator Center(IUAC), New Delhi.

Fabrication details

Gold backing

For preparation of Au backing, a rolling machine(Fig.1) was used. In this method of rolling, the material to be rolled is placed in a folded polished stainless steel plate and rolled slowly by a spatially hardened roller, till the required thickness is achieved. For our work 99.99% pure Gold foils were rolled to desired thicknesses according to our requirement. The thickness was measured using a weighing machine and a graph paper.

Cryo pump based coating unit

A cryo pump based coating unit(Fig.2) was used for evaporation, which consists of a 6 kW electron gun for melting the target kept in a water cooled copper crucible. The electron gun can be controlled precisely for achieving a focused beam spot and controlled rate of evaporation. The coating unit is also equipped with a quartz crystal monitor which measures the deposited thickness as well as the rate of deposition on the crystal. A constant pressure of ∼10^{-8} mbar can be maintained inside the coating unit using a roughing pump, a turbomolecular pump and a backing pump.

FIG. 1: Rolling machine at IUAC.

Deposition without substrate heater

In the trial run, the rolled gold foil was mounted on a substrate holder and placed overhead at a distance of ∼23 cm from the crucible containing the natural Cr sample. Then

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the evaporation was started by slowly increasing the current to 60 mA. The deposition continued for about 1 hr at a pressure of $\sim 10^{-7}$ mbar with an average rate of deposition $\sim$4 Å/sec. After completion of deposition, it was observed that the deposited material was peeling off and the deposition was uneven. Available literature [2] shows that the quality of the film can be improved by heating the gold foil. Later a substrate heater was used to maintain a constant temperature of the substrate(Au foil)for improving the quality of deposition of the hot evaporated vapor of the sample.

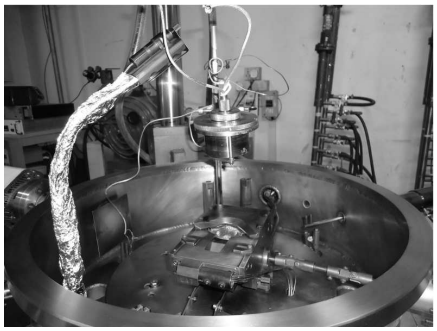

FIG. 2: Coating unit in an open position with a substrate heater above the crucible.

Deposition with substrate heater

In the next run, the rolled Au foil was carefully placed on a substrate heater(Fig.3) with the help of two clips attached with the heater. A small silicon wafer was also kept on the substrate along with the Au foil for estimating the thickness of deposition. The heater was then place at a distance of $\sim$12 cm with Au foil overhead of the crucible containing natural Cr. As quoted above, the deposition took place for $\sim$45 minutes at a current of 65 mA with average rate of deposition $\sim$0.4 Å/sec at a pressure of $\sim 10^{-7}$ mbar. A constant temperature of 473 K was maintained in the substrate heater throughout the period of deposition. After deposition, it was observed that the use of substrate heater had significantly improved the quality of deposition. The deposition was found to be smooth polished looking surface. This procedure was then repeated to deposit target material of different thickness on Au backing as according to our requirement.

FIG. 3: Fabricated target placed on a substrate heater.

Results

In conclusion, we have successfully fabricated two sets of Cr target of different thicknesses required for our experiment. A rough estimation of the target thickness was done with a contact profilometer. The thickness was measured from the deposited Cr on the silicon wafer kept on the substrate heater along with the Au foil during evaporation. We have further plans to measure thickness and purity of the target using X-ray fluorescence(XRF) technique.

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