Fabrication of ^{94}Zr thin target for RDM lifetime measurement

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Introduction

The aim of the activity was to make a thin target of isotopically enriched ^{94}Zr for lifetime measurement experiment to be done with the plunger setup at the Inter University Accelerator Center (IUAC) Delhi. Technically, to obtain the precise value of the level lifetimes via recoil distance Doppler shift method (RDM), essentially a thin target (thickness ~ 1 mg/cm2) and a thick stopper (usually of Au or any other heavy element of thickness ~ 8-10 mg/cm2) is required. The reliability of the measurement heavily depends on the smoothness of the target and the stopper surfaces in the setup. For this vary reason, so far RDM measurements have been done mostly with target and the stopper made with the controlled rolling method. Doing such measurement with targets made by any other (e.g. evaporation) technique is a challenging task and required a lot of efforts. This activity was the one such attempt to make target by evaporation technique. This target has been successfully used in a recent RDM experiment at IUAC.

The experimental setup

For the preparation of this target, the Rolling machine (fig. 1) and Ultra High Vacuum (UHV) Evaporator (fig. 2) at the target lab of IUAC were used. Rolling machine is used to prepare thin foils. In this method the target material is placed between a bended mirror polished stainless steel plate and it is rolled by the help of spatially hardened rollers. A cryo pump based UHV Evaporator is used to prepare thin target of high melting point by electron beam deposition method. Vacuum inside the chamber can be achieved of the order of 10^{-8}-10^{-9} Torr. It has 6 kW electron gun which is used to evaporate the target material kept in a water cooled copper crucible. An important feature of this system is that it has four pockets for the samples and hence multi layers target can be prepared without disturbing the vacuum inside the chamber. This system is also equipped with a quartz crystal thickness monitor which can give the thickness of deposition as well as the rate of evaporation on the crystal. A spatially designed new substrate holder was used to make the target for RDM lifetime measurement.

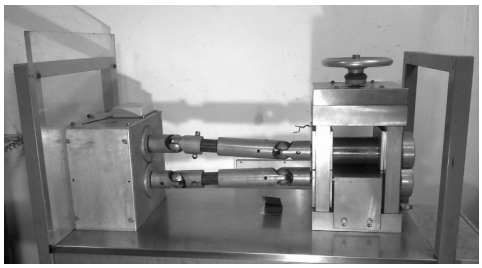

Fig. 1 : A picture of Rolling machine.

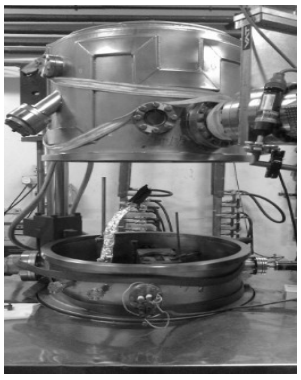

Fig. 2: A picture of UHV evaporator in open position.

New Substrate Holder

For the success of RDM lifetime experiment, the target should be smooth and target thickness should be as uniform as possible. To achieve our goal, a new substrate holder (fig. 3) was made for the evaporation of the target material on the backing foils.

Plunger device has a combination of spatial target frame and cone (fig. 4). Target is sticked on the target frame and after the proper sticking, it is stretched by using the cone. For a trial, natural Zr was evaporated on the tantalum foil which was properly sticked on the target frame but the foil was cracked violently during evaporation. For this vary reason, a new substrate holder was made for evaporation. It has two parts which can hold the backing foils properly so that the sticking of foil is not necessary. The reason for the L-shape of the substrate holder is to fabricate three targets of almost same thicknesses at a time.

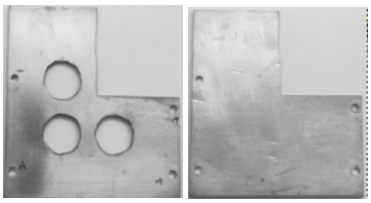

Fig. 3: Two parts of a New Substrate Holder.

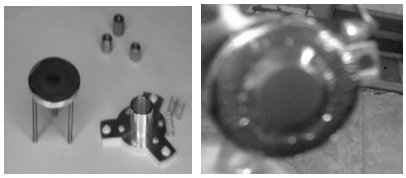

Fig. 4: Frame and cone of plunger device before stretching and after stretching.

Preparation of tantalum foils

Tantalum foils of thicknesses ~ 3.4 mg/cm^2 and dimension 2.5 cm * 2.5 cm and gold foils of thicknesses ~ 10 mg/cm^2 were prepared by controlled rolling method.

Fabrication of ^{94}Zr targets

The available enriched ^{94}Zr was in the form of granules which was pelletized by using hydraulic pellet press before placed in pocket 3 of the crucible. Gold was placed in the pocket 2 of the crucible. Substrate and crystal monitor was kept 6 and 23 cm to the material respectively. After mounting the tantalum foils with new substrate holder, gold and isotopic material, the UHV chamber was evacuated to a pressure better than 10^{-8} Torr. After getting this pressure current was increased slowly from 0 to 100 mA. Evaporation started at 100 mA current. Now current was increased slowly from 100 to 285 mA in such a way that rate of deposition maintain 0.1 Å/s. After the completion of evaporation of ^{94}Zr, a gold layer of ~ 40 μg/cm^2 thickness was evaporated by using the gold material in pocket 2. The idea to evaporate very thin layer of gold on ^{94}Zr was to protect the outer layer of ^{94}Zr from the environment and increase the smoothness of the outer layer of the target.

Finally, the rough estimates show that the obtained thickness of gold layer was found to be 40 μg/cm^2 whereas the thicknesses of ^{94}Zr and tantalum backing were found to be 600 μg/cm^2 and 3.4 mg/cm^2 respectively. Attempts have been made to measure the deposited thickness of the material with XRF technique at Punjab University, Chandigarh.

Conclusion

^{94}Zr isotopic targets with gold layer have been successfully prepared by electron beam deposition method on tantalum foils. The thickness of the deposited target and gold layer were measured using XRF measurement. This target has been used in the recent lifetime measurement by Recoil Distance Method at IUAC.

References

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