Recent Nuclear Target Development Activities in IUAC

Abhilash S R*, Ambuj Mishra and D Kabiraj
[1]InterUniversity Accelerator Centre, Aruna Asaf Ali Marg, New Delhi-110067, INDIA
* email: abhilashiuac@gmail.com

Introduction

For an accelerator based nuclear physics experiment, the target development has more significance and the development of targets having superior qualities poses lots of challenges. According to the experimental need, both thick and thin targets in the form of either a self-supporting target or with backing target are used for nuclear physics experiments with ion beam. In experiments like fusion evaporation study, the presence of backing material may lead to an increased energy loss and undesirable results. So, the self-supporting targets are preferred for such studies. Due to the involvement of huge amount of heat, target development of high melting point metals using evaporation techniques remains as a challenging task. Extensive works have been done in Inter-University Accelerator Centre (IUAC) in the target development of high melting point metals.
Contrary to the condensation of high melting point metals in evaporation techniques, volatile metals (metals having high vapor pressure) generally needs forced condensation by substrate cooling which may have practical difficulties. Target development laboratory (TDL) in IUAC has successfully developed several targets of volatile metals by simple evaporation techniques without substrate cooling and without doing major modifications in the vacuum coating unit.

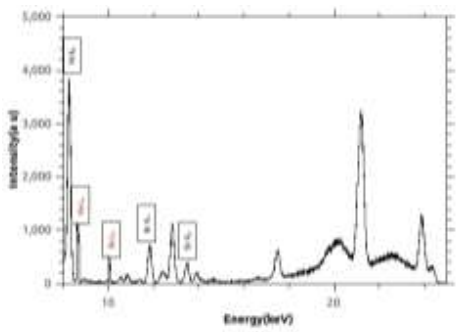
In order to meet the demand from accelerator user community, new e-beam evaporation facility, target library of nuclear targets and indigenously developed sources for high evaporation yield are the latest facility additions to the TDL. Recent target development activities at IUAC and latest facility additions in IUAC for target development will be discussed in the report.

Experimental procedure

1. Developments of targets of high melting point metals

E-beam bombardment is one of the best methods for the thin target fabrication of high melting metals. TDL in IUAC is equipped with four e-beam evaporators ranging from 2kW to 6kW. Due to the high melting point of the target materials, enormous heat is developed at the e-beam source while using evaporation techniques. The heat is transferred to the surrounding through the thermal radiation. The effect of radiant heating over the substrate surface during evaporation and the intrinsic stress developed in the target film are the major constraints during the target development.

Figure.1: XRF spectra of ^{187}Re target



Target lab is successful in optimizing few parting agents which can withstand the high temperature. Thin foils of carbon film with KCl, NaCl, $BaCl_2$ of 100nm as parting agent consistently withstand the substrate temperature during the e-beam evaporation. A standard procedure for stress relieving of the target film has also been developed in IUAC. The annealing of the targets in argon or nitrogen environment at 200-325^{0}C significantly minimizes the stress. The stress relived targets exhibit remarkable stability during the experiments. The XRF spectra of the target of ^{187}Re, the metal with the second highest melting point is shown in Figure.1. The spectra indicate that the targets developed by this procedure are free from major contamination of high Z element. TDL has successfully developed and supplied several targets of high melting point metals with maximum evaporation yield, viz. W,Re,Ir,Ta and Mo for the nuclear physics experiments in IUAC and other Accelerator labs in India[1,2].

2. Development of targets of metals with high vapor pressure.

Vacuum evaporation by resistive heating technique is preferably used for the fabrication of thin targets of volatile metals. Due to the low melting point of target material, the re-evaporation of the condensed vapor is a major difficulty in the vacuum evaporation. So, forced condensation by substrate cooling is widely used for the target development of volatile metals. In many cases, the addition of substrate cooling set-up needs major mechanical modification and such modification sometimes results clumsiest source-substrate set-up. TDL has recently done appreciable amount of work to develop simple and novel evaporation techniques for the volatile metals. Minimizing the time duration of evaporation remarkably minimizes the re-evaporation. However, if the available target material is few milligrams only (>10mg), the source-to-substrate distance should be as minimum as possible. In order to minimize the re-evaporation in such cases, TDL has indigenously developed crucible sources which can be mounted upside down. Recently, TDL has successfully developed ^{116}Cd targets of 150μg/cm^2 with ~6mg of material. The source to substrate arrangement is shown in figure.2. In, self-supporting target preparation of volatile metals, the crystal structure plays a crucial role. If the crystal structure of the parting agent is similar to the target material, the probability of parting of the target film from the substrate is enhanced. Several volatile targets, viz. Zn,Cd,In,Bi,and Pb (in self-supporting form and with backing) have been prepared and successfully used in recent experiments in IUAC. [3, 4]

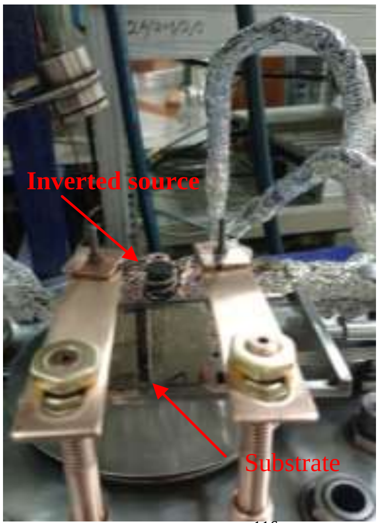


Figure.2: Inverted source for ^{116}Cd evaporation

3. Recent target facility upgradations in IUAC

Target development using isotopic material involves enormous sums of money. In-order to strengthen the isotopic target supply to accelerator user community with minimal cost, TDL is successful in developing indigenous crucible sources which are efficient than commercially available sources. More than 500 nuclear targets are part of the target library which was initiated recently in IUAC. A new e-beam evaporation unit was also added to TDL in recent past for the preparation of good quality carbon films which are regularly used as stable backing for isotopic targets.

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