Cadmium target preparation for nuclear reactions

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The Cadmium (Cd) target on Aluminium (Al) backing by vacuum evaporation method is discussed in detail. The target thickness of $339.05\mu g/cm^2$ and $285.48\mu g/cm^2$ on $88\mu g/cm^2$ self supporting Al is measured by energy loss of 3-line alpha source. Target thickness was achieved by modification of Telemark multi-pocket e-beam setup and self-designed crucible. XPS analysis confirms the presence of Cd on Al backing.

1. Introduction

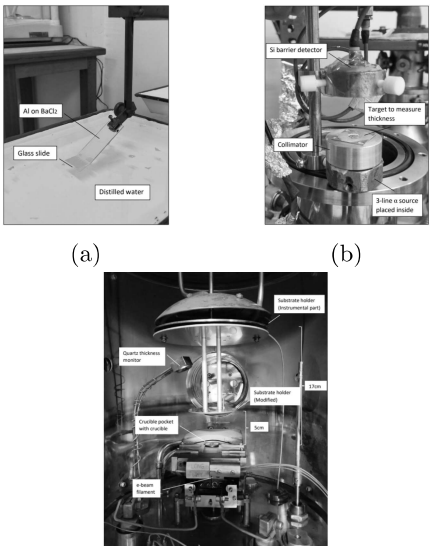
The primary important phase of experimental nuclear physics is target preparation. Target characteristics, such as thickness, purity, and homogeneity of the target material, affect experimental analyses. Cross-sections for the nuclear astrophysics experiments are in the order of nb and pb with large error bars. So the thickness measurement and purity check are also important part of the experiment.

^{106}Cd and ^{108}Cd are the p-nuclei. The formation of p-nuclei are different from two kind of neutron capture processes. Cd on Al target is essential to study the mechanism of the formation of ^{106,108}Cd. High vapour pressure materials like Cd, Zn, Ca, or Mg do not readily condense on the substrate and are thus challenging to deposit using vacuum evaporation processes. Here the target preparation of Cd is discussed in detail.

2. Experimental Setup

The Al for the target backing was deposited on a thin layer of $BaCl_2$ by using an evaporation-condensation method in a high vacuum. $BaCl_2$ and Al were deposited using the BT300 setup without any extra modifications.

To create the self-supported Al backing, the deposited Al was floated over distilled water and collected at the target frame (FIG. 1(a)). The Cd has a high vapour pressure and was deposited on Al backing by creating a high density vapour stream at the Telemark Multi-pocket e-beam setup. For that a few modifications have been made and shown in the figure (FIG. 1(c)).



(a) (b)

(c)

FIG. 1: (a)Floating and fishing technique (b)Thickness measurement (c)Modified Telemark setup.

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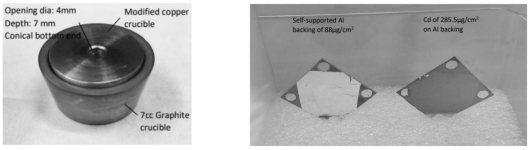
i. Separation between substrate holder and crucible was 17cm, which was extended down to 5cm (FIG. 1(c)).
ii. The opening of the compatible 7cc crucible was 28mm. To reduce the solid angle, it was decrease down to 4mm (FIG. 2(a)).

3. Target Preparation

The Cd deposition on Al was not that trivial. $285.48\mu g/cm^2$ was finally deposited on self-supported Al foil after many trials and tribulations. 29.6mg of ^{nat}Cd of purity 99.99% and for the Al backing, Al of purity 99.99% was used. The steps are discussed below.
1. The BT300 system was used to deposit $BaCl_2$ on glass slides using electron-gun evaporation method. $BaCl_2$ powder was placed in a 5cc graphite crucible in pocket 1, and pure Al was placed in a different graphite crucible in pocket 2. The substrate holder had glass slides mounted on it at a height of 22.5 cm from the crucible pockets. A deposit of $BaCl_2$ was made where pocket 1 was at the gun spot at a base pressure of 8.7×10^{-7}mbar.
2. After the thin layer of $BaCl_2$, pocket 2 was put in the gun spot, and al was evporated and condensate there at a pressure of 8.6×10^{-7}mbar.
3. The glass slide was placed on a distilled water bath (FIG. 1(a)). Al floats and is linked to the target frame by fishing as the $BaCl_2$ dissolves in the water.
4. Once the frames were fully dried. Al thickness was measured by the α-particles energy loss from a 3-line alpha source (^{239}Pu, ^{241}Am, ^{244}Cm) (FIG. 1(b)).
5. A self-designed crucible of Cu was prepared for 7cc crucible pocket of Telemark multi-pocket e-beam setup (FIG. 2(a)). A 29.6mg of ^{nat}Cd was used. A new substrate holder, where the self-supported Al frames were attached, was extended down to 5cm from crucible pocket (FIG. 1(c)). The evaporation starts at the base pressure of 3.7×10^{-7}mbar, where the e-beam emission current was 4mA. The entire material evaporated and a specified thickness was reached after about 12 minutes of deposition. Because the Cd is extremely toxic, the appropriate safety measures were performed.
6. Thickness was measured as (4), to confirm the required thickness was achieved.



(a) (b)

FIG. 2: (a) modified crucible (b) Al film on a target frame and Cd deposited on Al

TABLE I: Melting points and the important parameters for the e-beam evaporation (Electron-gun filament voltage, BT300, 5.06KV and Telemark setup, 5.95KV)

	MP(^oC)	Setup	Current(mA)
$BaCl_2$	962	BT300	10-15
Al	660.3	BT300	40-45
Cd	321.1	Telemark	3-7
Cu	1085	BT300	60-80

4. Results and Conclusion

The XPS analysis confirms the presence of Cd and no Cu impurities. The Cd target thickness of $339.05\mu g/cm^2$ and $285.48\mu g/cm^2$ on $88\mu g/cm^2$ of self supporting Al was confirmed (FIG. 2(b)).

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