Lithium fluoride target preparation for nuclear experiments

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The LiF target preparation on self-supporting Ag backing (LiF/Ag) is discussed in a detailed manner using the vacuum evaporation process. The target thickness is measured using the energy loss of three line alpha source. 183.74 μg/cm^2 thickness of LiF is achieved through the evaporation process. Target uniformity is seen to be good.Target non-uniformity is found within 6 %.

1. Introduction

Targets play a crucial role in the successful nuclear reaction. Achieving a quality target with optimum thickness is required for nuclear experiments. Preparation of a thin target is also a requirement for many reactions. LiF on self-supporting Ag backing is a crucial target for many proton and alpha-induced reactions. It can be used as good alternative to prepare thin targets as compared to metallic lithium or fluorine. LiF has been preferred for generation of mono-energetic neutrons [1, 2]. These targets are more important in the case of astrophysical reactions where cross sections are an order of nb or pb. In this work, the preparation of LiF targets on self-supporting Ag backing is discussed in a detailed manner with the analysis of prepared targets.

Deposition Setup

A sample holder (crucible), substrate holder, shutter, and Quartz crystal comprise the deposition setup. The sample that will be evaporated is within the crucible. The substrate holder is equipped with glass slides for collecting the evaporated samples. The Quartz is there to keep track of the sample's thickness. The shutter was used to initiate and terminate the deposition process. In this work, both thermal and e$^-$ beam evaporation method were used for depositing Ag and LiF samples. Figure 1 shows a schematic view of the setup.

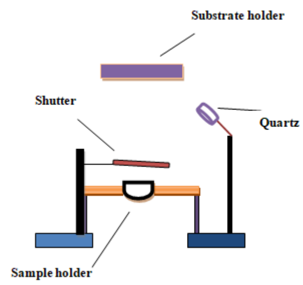

FIG. 1: Schematic view of deposition setup

2. Preparation Techniques

It consists of two steps 1) First, the parting agent $BaCl_2$ is applied to the glass slide coupled to the substrate holder. The Ag is then evaporated on the deposited glass slides and allowed to cool for a few minutes. The e$^-$ beam approach was used to start the Ag evaporation with an initial current of 33 mA. The evaporated Ag with $BaCl_2$ on glass slides is gently immersed in distilled water. As a result of $BaCl_2$ being water soluble, the Ag foil floats on the water's surface. The Ag foil is carefully placed on the Al target frame with an aperture of 8-10 mm in diameter.

2) Second, another substrate holder has been attached to the Ag placed on the Al frame. The evaporation began with an initial current of 60 A and keeps rising as the current

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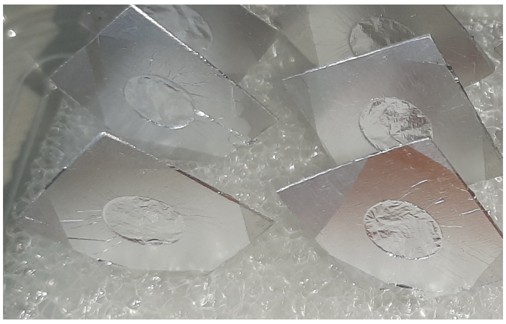

FIG. 2: Evaporated LiF on self supporting Ag foil

rises. During the Ag deposition, the distance between the crucible and the substrate holder was initially set at 22.5 cm. However, because of the low vapour pressure of the LiF sample, the distance was shortened to 10.5 cm.

3. Thickness Measurements

The thickness of LiF on self supporting Ag backing has been done in two steps. Ag foil was first placed in front of three linear alpha sources (^{239}Pu, ^{241}Am, and ^{244}Cm) to assess its thickness using the alpha energy loss method. For the aforementioned source, the energies corresponding to the three lines alpha are 5155 keV, 5486 keV, and 5805 keV respectively. The equation for estimating thickness using three lines of alpha energy loss is

$$x = \frac{\Delta E}{-\frac{dE}{dx}} \tag{1}$$

where, x= thickness of foil in μg/cm^2, ΔE = Energy loss through foil in KeV and -$\frac{dE}{dx}$ is the stopping power measured in KeV/ (μg/cm^2). The stopping power is calculated by the SRIM code [3]. Equation 1 has been used to compute the thickness of Ag foils, and the result is 398.62 μg/cm^2 (0.38 μm). The loss of alpha energy via Ag foils has been calculated using their average thickness. As a result, the initial energy available for the LiF sample evaporated on top of the Ag foil was the difference between the initial alpha energy incident on the LiF/Ag foil and energy lost through the Ag foil. So, after energy loss through Ag foils, the energy available for three alpha sources is

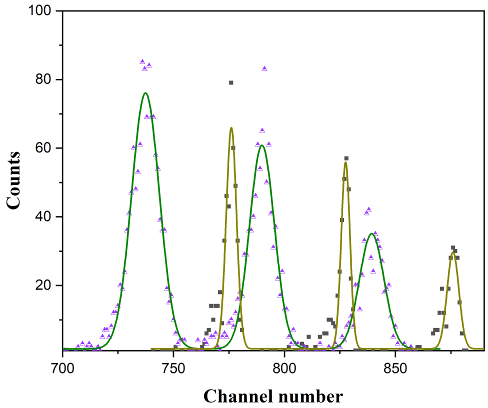

FIG. 3: Shift in peak of three line alpha for LiF/Ag sample

5031.96 KeV, 5367.35 KeV, and 5689.16 KeV respectively. So, using this energy as the starting energy for the LiF sample, the stopping power has been calculated.

Using equation 1, the thickness of LiF is determined to be 183.74 μg/cm^2 . The thickness variation is found to be within 6%. The desired thickness can be controlled by certain factors, such as the deposition time and evaporation current.

4. Conclusion

The LiF on self-supporting Ag backing was successfully deposited, along with a detailed explanation. The targets have been deposited using the vacuum evaporation process. This kind of target is crucial for high current accelerators as well as nuclear astrophysics processes. The thickness of the LiF is determined to be 183.74 μg/cm^2 with 6 % uncertainty.

References

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