Thin Film Deposition for Scintillator Detectors

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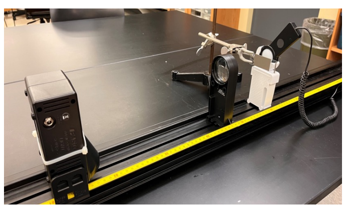
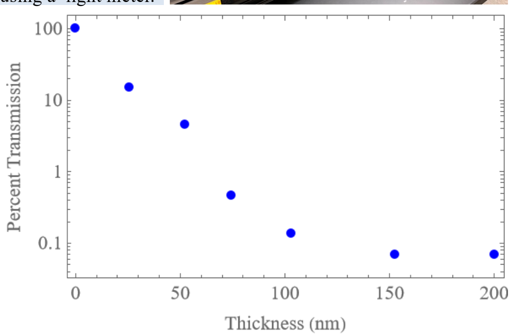
Introduction & Motivation

A plastic scintillator detector was developed for an experiment carried out at the Laboratory for Laser Energetics (LLE) at the University of Rochester. Scintillators can be used as detectors of energetic charged ions; for this experiment at LLE, scintillators were used to detect protons and deuterons accelerated by laser light during the experiment. However, uncoated scintillators are sensitive to visible light as well as charged particles, and the residual laser light interferes with the measurement of the ions. The Thin Film Evaporator at SUNY Geneseo was used to coat the scintillators with a metal film thick enough to absorb the visible light and thin enough so that the energy loss of the ions was minimized. The optimal film thickness was found to be 200 nm of Aluminum; this thickness was found to block out external visible light without significantly degrading the energy of the charged ions. Samples were mounted above an aluminum source in the bell jar and a base pressure of 10^{-6} Torr was achieved. By passing a high current through the source holder, a thin film of aluminum was deposited while the thickness of the deposition was monitored using a rate deposition monitor. For some scintillator samples, multiple depositions were required to coat all sides of the scintillator. The coated scintillation detectors performed as expected for the LLE experiments.

Transmission of Light through Aluminum

White light was incident on glass slides with aluminum films of various thicknesses and the transmitted light was measured using a light meter.



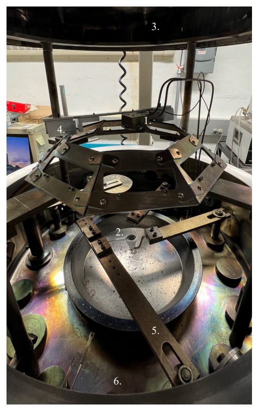


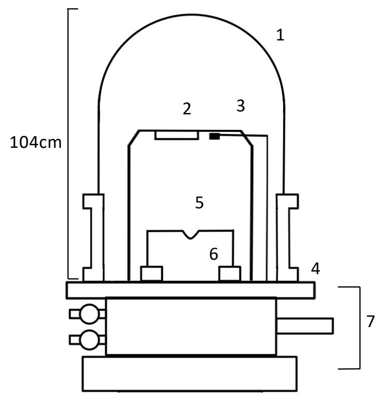
A 200-nm film effectively prevents the transmission of light. The plot above shows the percent transmission through each thickness of aluminum with a logarithmic scale on the Y-axis.

Procedure

In the SUNY Geneseo Thin Film Evaporation system, high electrical currents are used to heat a sample in the basket inside the bell jar under high vacuum (~10^{-6} Torr). The aluminum sample evaporates, and the target is uniformly coated. The thickness of the film is detected using the rate deposition monitor.

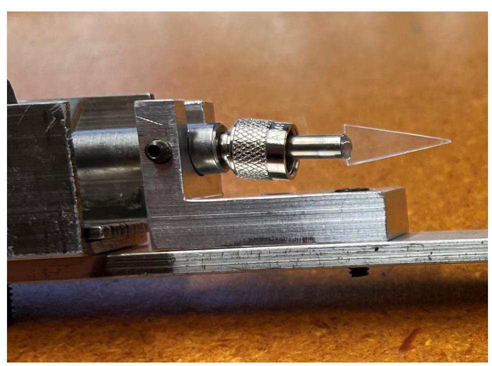
Deposition System





Key:

1- Glass Bell Jar	5- Deposition Material
2- Substrate/Scintillator Holder	6- High Current Feedthrough
3- Rate Deposition Monitor	7- Stainless Steel Collar
4- Base Plate	

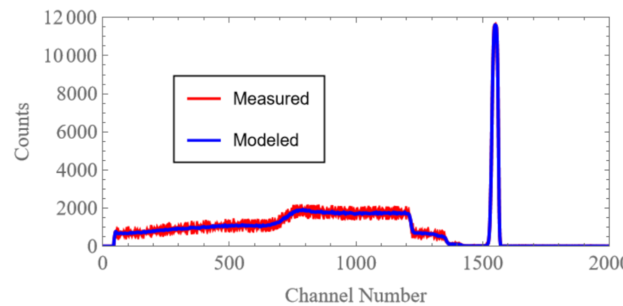


To the left is an image of an uncoated wedge scintillator connected to a fiber optic cable. Aluminum was used to coat all four faces of the detector. Each face was coated individually; after each deposition, the chamber was opened, and the scintillator was rotated manually.

The average thickness coated on the scintillator was 205 nm.

Film Thickness Calibration

To calibrate the rate deposition monitor, a sample of gold plated on a glass slide was analyzed by Dr. Freeman's group using Rutherford Backscattering Spectroscopy (RBS) at SUNY Geneseo's 1.7 MV Tandem Pelletron Accelerator. RBS utilizes the coulombic interactions between a target material and an accelerated ion to determine the thickness of films. A sample of gold was used because thin targets with high density allow for easier spectral analysis. The thickness of the gold film calculated through RBS was 216 nm. The thickness measured by the rate deposition monitor was 222 nm. The spectrum below illustrates the accuracy between the measured energies of the ions scattered from the target film and results for a model assuming a 216 nm gold layer.



Results and Future Plans

Using the deposition technique, we coated several scintillation detectors with 200-nm films:

1. One wedge scintillator coupled to a fiber optic cable was coated with a gold film.
2. Three wedge scintillators were coated, on all sides, with an aluminum film and later attached to a fiber optic cable. These detectors were not light-tight.
3. Two wedge scintillators, coated on all sides and coupled to a fiber optic cable, were coated with aluminum films. These coated scintillators were introduced in an LLE experiment, successfully reduced noise, and providing experimental results.

When coating multiple sides of the same scintillator the deposition chamber must be brought up to air, the scintillator must be adjusted and then the system must be pumped back down to a sufficient vacuum. This process can take upwards of two hours and greatly decreases efficiency in multi-coat projects. A rotary system is being designed to allow the sample to be rotated so that multiple sides of a substrate can be coated within breaking vacuum. The system will use a rotary feedthrough to connect a mount in the chamber to a manual handle on the outside.

Acknowledgements

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