Preparation of Deuterated Polymer Films for the OMEGA Magnetic Recoil Spectrometer

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Motivation

To measure the neutron energy spectrum produced in inertial confinement fusion (ICF) implosions. Quantifying the neutron energy spectrum is important because the majority of energy released in the fusion reaction is contained in the kinetic energy of ejected neutrons.

Objective

To prepare uniform deuterated polyethylene (DPE) films on tantalum substrates to be used for Magnetic Recoil Spectrometer (MRS) experiments at the OMEGA laser system at The University of Rochester's Laboratory for Laser Energetics. In this work we compare two procedures.

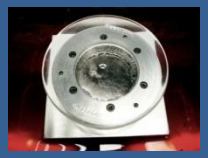
Design Specifications

Area (cm^2)	Diameter (cm)	Thickness (μm)
2.0	1.6	40
5.0	2.5	60
8.0	3.2	80
13.0	4.1	130
13.0	4.1	190
13.0	4.1	290
13.0	4.1	390

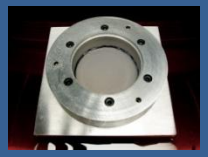
Polymer thickness to be characterized within 5% with less then 5% thickness variation throughout the sample.

Evaporation Deposition Procedure

A heated bath is used to maintain the aluminum casting mold at a constant temperature. A tantalum substrate is fixed to the bottom of the mold. Due to the toxic nature of xylene the procedure must be held under a fume hood.



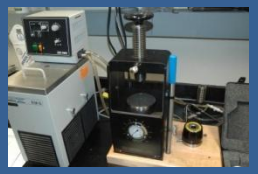
The bath temperature is set to 140^0 C and the appropriate amount of DPE powder and xylene are added to the headed mold. A watchglass is placed over the mold so that condensed xylene will drip back into the mold until all the DPE powder is dissolved.



After the DPE powder is fully dissolved the watchglass is inverted allowing for the xylene vapor to escape and the bath temperature is reduced to 120^0 C.

After the xylene is fully evaporated the film is removed from the bath and allowed to cool. The film is then removed from the mold and is detached from the tantalum substrate.

Heated Press Procedure

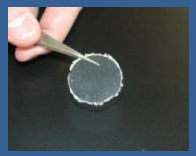


A 20 ton heated press is used to create DPE films.

22 μm Kapton films are placed between the two polished press plates. A spacer ring is added to achieve the desired film thickness.

DPE powder is spread out uniformly between the Kapton films and is placed into the heated press.

The press is heated to 110^0 C, set to 6 tons of pressure and the DPE is pressed for 10 minutes.

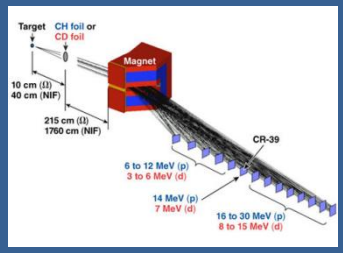


The heated plates are removed from the press. The Kapton films are peeled away leaving the DPE film.

Method Comparison

- The heated press procedure takes around 20 minutes whereas evaporation deposition takes 2-4 hours depending on the quantity of xylene used.
- The heated press method is safer because it does not involve the use of xylene.
- Evaporation deposition can easily produce a range of film thicknesses due to the linear nature of DPE powder used vs film thickness where as the heated press method can only create film thicknesses corresponding to available spacer rings.
- Films created using evaporation deposition have a greater visual uniformity than heated press films.
- The heated press method has a near 100% success rate where as the evaporation deposition method can have complications due to gas bubble formation in the DPE/Xylene solution and failure to separate from the tantalum substrate.

The MRS at OMEGA



The MRS is designed to measure the neutron energy spectrum produced in ICF implosions at OMEGA and The National Ignition Facility (NIF). Neutrons ejected from the fusion reaction collide with DPE films ejecting charged deuterons. These deuterons pass through a magnetic field and their trajectories are bent according to their kinetic energy.