Plutonium Manufacturing of National Ignition Facility Targets

Audience: Target Fabrication Meeting 2019

Target Team: Mark Wall, Jeff Stanford, Jessee Welch, Debra Rosa, Jean Jensen, Jeana Bigelow-Granillo, and Abbas Nikroo

Michael Wilson
Understanding the properties of Pu is critical to Stockpile Stewardship

- Plutonium (Pu) is a very important material in nuclear weapons.
- Understand the Equation Of State (EOS) and material properties of Pu is critical to predictive computer simulations.

NIF is a key facility to eliminate the need to do underground nuclear tests.
Pu target fab starts with winning Pu-242 metal from high-purity oxide

- Win Pu metal from oxide
- Purify metal
- Re-melt metal & near-net shape
- Polish to thickness
- Laser cut disc
- Assemble Pu/diamond physics package
- Assemble physics package to body
- Machine TARDIS body
- Assemble shields, alignment features
- Assemble physics package to body
- Final target metrology
- Target complete
Current capabilities: We can produce 8 targets a year.

We are expanding our capabilities to 12 targets per year by building a new lab space.
We have observed micron level delamination at the Pu layer which renders the target unusable.

Similar non-Pu targets do not change over time; however, Pu targets do.

Material Strength Target
RT

Used polymer components

Questionable Data
We performed offline tests that revealed radiation damage to polymer components of Pu targets.

<table>
<thead>
<tr>
<th>Test Conditions/Objective</th>
<th>Results</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malachite Lifetime w/242</td>
<td>Distorted by 25-30 µm</td>
<td>11</td>
</tr>
<tr>
<td>Al/Kapton w/242/LiF</td>
<td>Distorted the disk by ~20 µm</td>
<td>8</td>
</tr>
<tr>
<td>Wedding Cake</td>
<td>Distorted by ~10 µm</td>
<td>10</td>
</tr>
<tr>
<td>Stycast w/239</td>
<td>Distorted the disk by ~100 µm</td>
<td>14</td>
</tr>
<tr>
<td>PVDF w/239</td>
<td>Distorted the disk by &gt;20 µm</td>
<td>18</td>
</tr>
<tr>
<td>Kapton w/239</td>
<td>No distortion detected</td>
<td>11</td>
</tr>
<tr>
<td>PVDF w/242</td>
<td>Distorted the disk by ~10 µm</td>
<td>48</td>
</tr>
</tbody>
</table>

Kapton is the most promising component.

Glue used in sample preparation is also a polymer and hence susceptible to damage.
A systematic test of polymer/Pu interface on a RT target confirmed the delamination issue.

Image taken with microscope side on.

Delamination of the PVDF started 10 days after gluing.

Dimensions
Pu-242: 1mm diameter, ≈40µm thick
Au: 2mm diameter
PVDF: 50µm thick
Mo: 40µm thick
HDC: 500µm thick

Assembly:
Glue (Stycast) all layers together
No coining
Hydrogen dominates alpha-induced decomposition spectrum

The formation of Pu hydride due to hydrogen evolution from glue and plastic components could lead to failing joints and causing delamination.
Solving the hydride problem with a metal coating.

Ion Polishing/Etching System in B235 Glovebox

Test Al coating

Al or Ti coating

Stycast

Pu 242

Stycast

LiF

New Sputter Coater in Superblock (not installed)
Our current capabilities are limited, due to space and no Diamond Turning capability.

The current lab was developed with equipment not originally intended for target fabrication.
An encapsulation unit for critical Double Sided Interferometer (DSI) measurements for the diffraction experiments was designed and is in routine use currently.

To measure thickness and form of each component and glue thickness we are using the DSI setup.

References:
- Wilson, M. 2012 Double-Sided Interferometer for Profiling Measurements Simultaneously Determining Thickness and Form. Proceeding, Target Fabrication Meeting
- Ahrendes, L. 2019 Metrology Improvements for the TARDIS Platform. Proceeding, Target Fabrication Meeting
We upgraded to a hydraulic press to net shape the Pu and to coin sine waves onto thin foil for the Strength Targets.

10,000 pound hydraulic press can be used on a hot plate to increase the ductility of the Pu.

Previously use manual crank to apply pressure.
We have almost completed installation in a lager facility to increase target throughput.
We have installed a larger glovebox for sample preparation and a dedicated one with a diamond turning machine for EOS experiments

Reference: Castro, C. Diamond turning of high tool wear materials for Equation of State Targets. *Target Fabrication Meeting 2019*
Stycast free standing on 239 day 1
Stycast free standing on 239 day 14