Plutonium Manufacturing of National Ignition Facility Targets

Audience: Target Fabrication Meeting 2019

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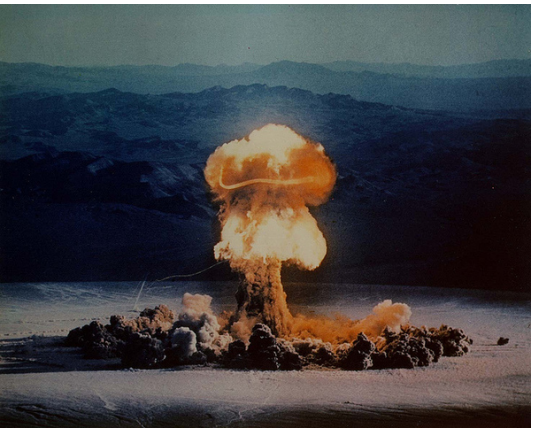
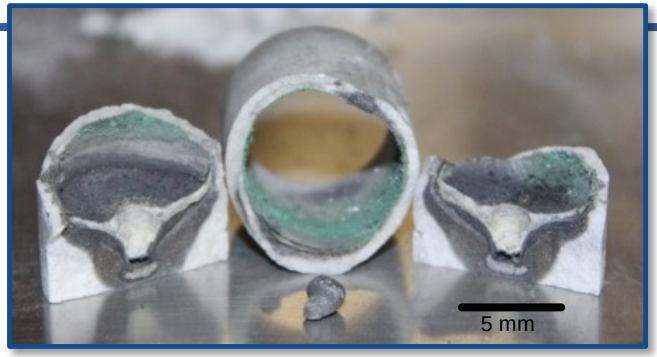
Understanding the properties of Pu is critical to Stockpile Stewardship

- 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.



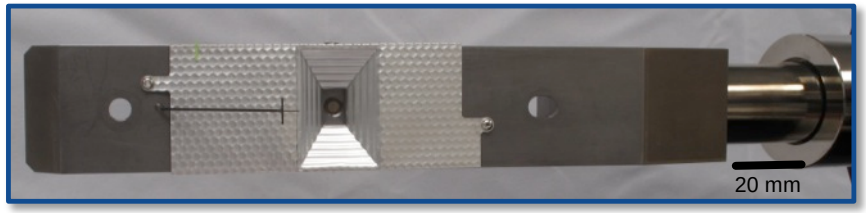
NIF is a key facility to eliminate the need to do underground nuclear tests.

Pu target fab starts with winning Pu-242 metal from high-purity oxide



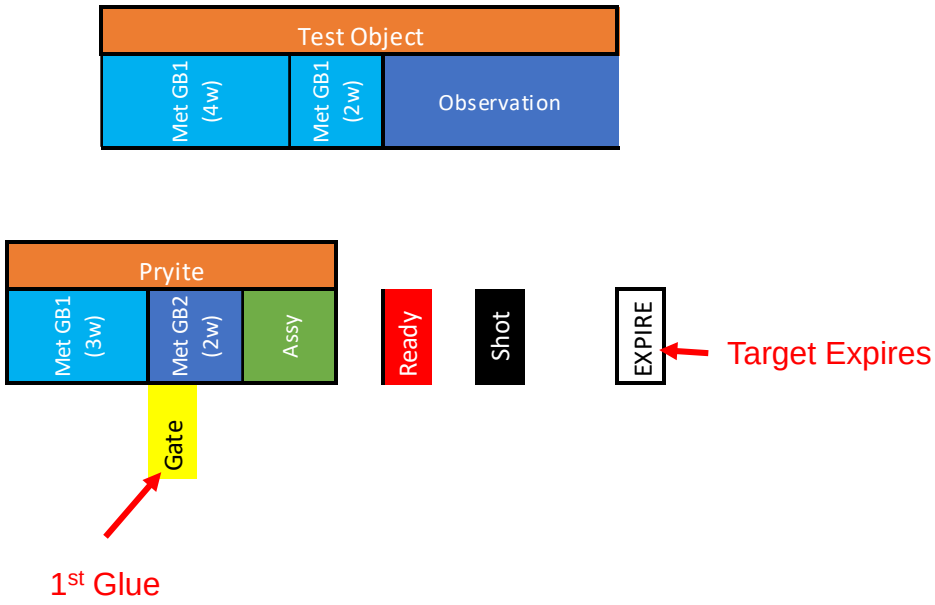
- Win Pu metal from oxide
- Purify metal
- Re-melt metal & near-net shape
- Polish to thickness
- Laser cut disc
- Assemble Pu/diamond physics package
- Assemble physics package to body
- Final target metrology
- Target complete

- Machine TARDIS body
- Assemble shields, alignment features



Current capabilities: We can produce 8 targets a year.

Q1								Q2													
11/2/2018	11/9/2018	11/16/2018	11/23/2018	11/30/2018	12/7/2018	12/14/2018	12/21/2018	12/28/2018	1/4/2019	1/11/2019	1/18/2019	1/25/2019	2/1/2019	2/8/2019	2/15/2019	2/22/2019	3/1/2019	3/8/2019	3/15/2019	3/22/2019	3/29/2019	4/5/2019	4/12/2019

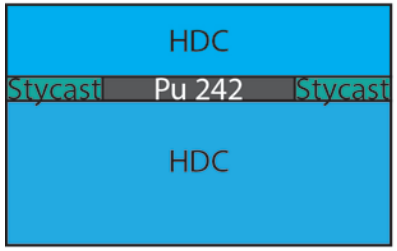


Ramp Compression

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.

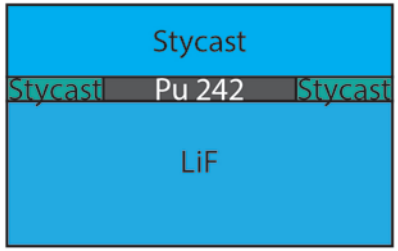
Ramp Compression



Diffraction Target
4 NIF Shots

Good Data

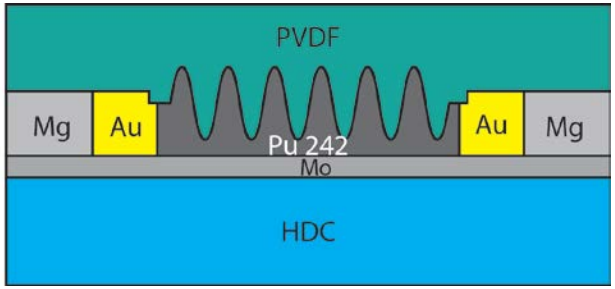
Shock Ramp Compression



Diffraction Target
3 NIF Shots

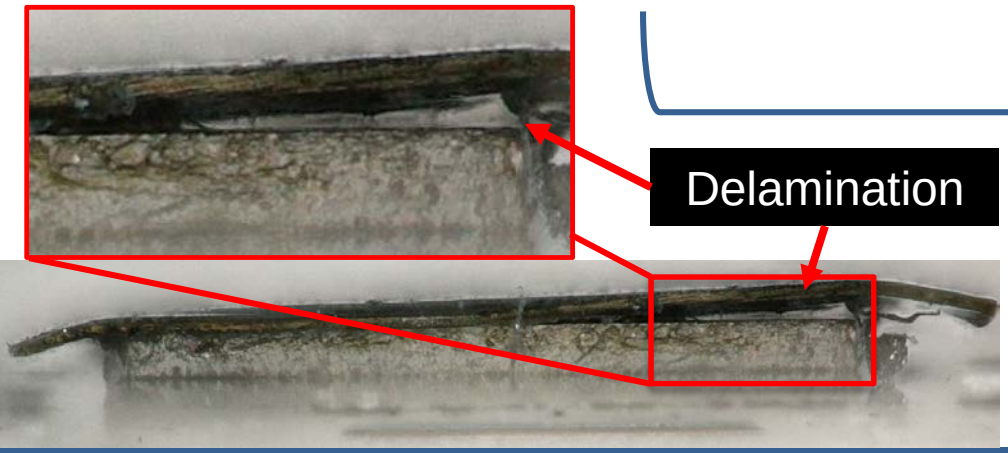
No Data

Strength Target RT



Material Strength Target
5 NIF Shots

Questionable Data

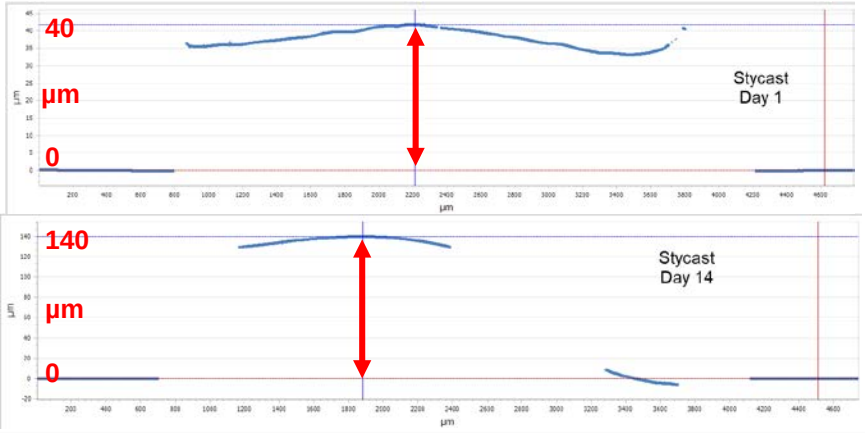


Used polymer components

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

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

Test Conditions/Objective	Results	Days
Malachite Lifetime w/242	Distorted by 25-30 µm	11
Al/Kapton w/242 /LiF	Distorted the disk by ~20 µm	8
Wedding Cake	Distorted by ~10 µm	10
Stycast w/239	Distorted the disk by ~100 µm	14
PVDF w/239	Distorted the disk by >20 µm	18
Kapton w/239	No distortion detected	11
PVDF w/242	Distorted the disk by ~10 µm	48



~~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

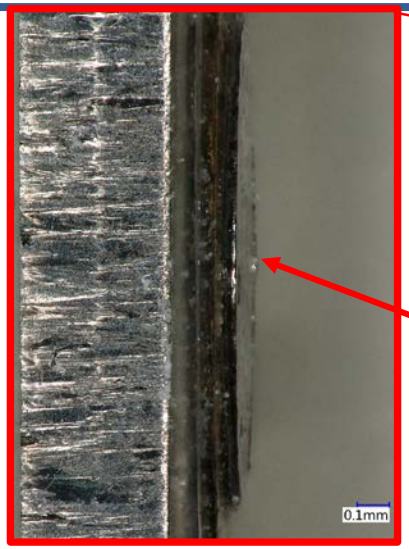
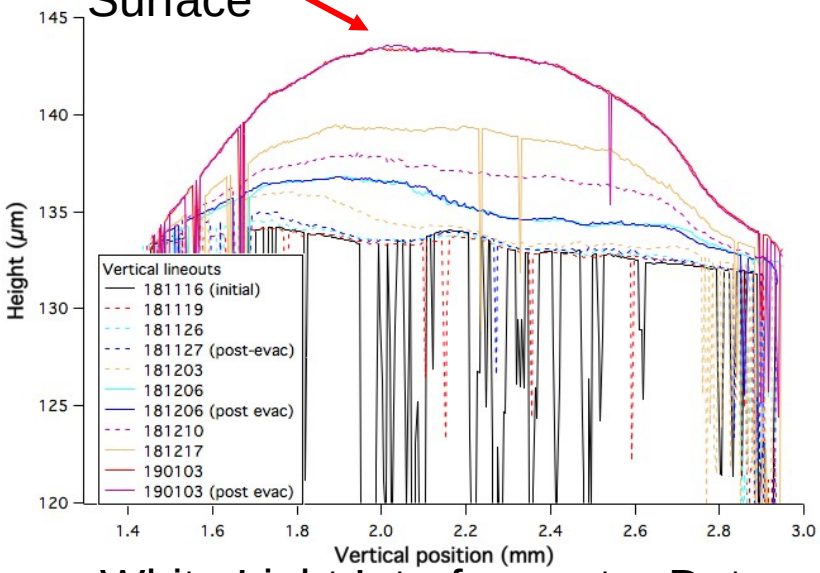


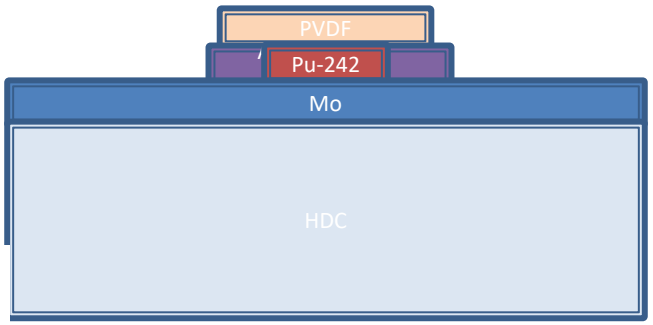
Image taken with microscope side on

PVDF Surface



White Light Interferometer Data

Proposed object

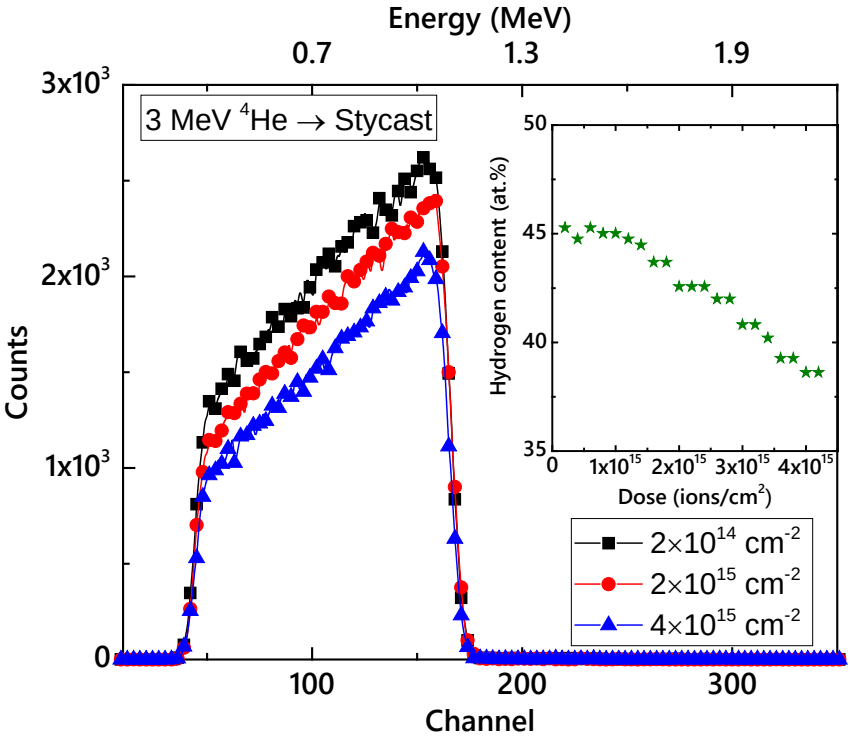


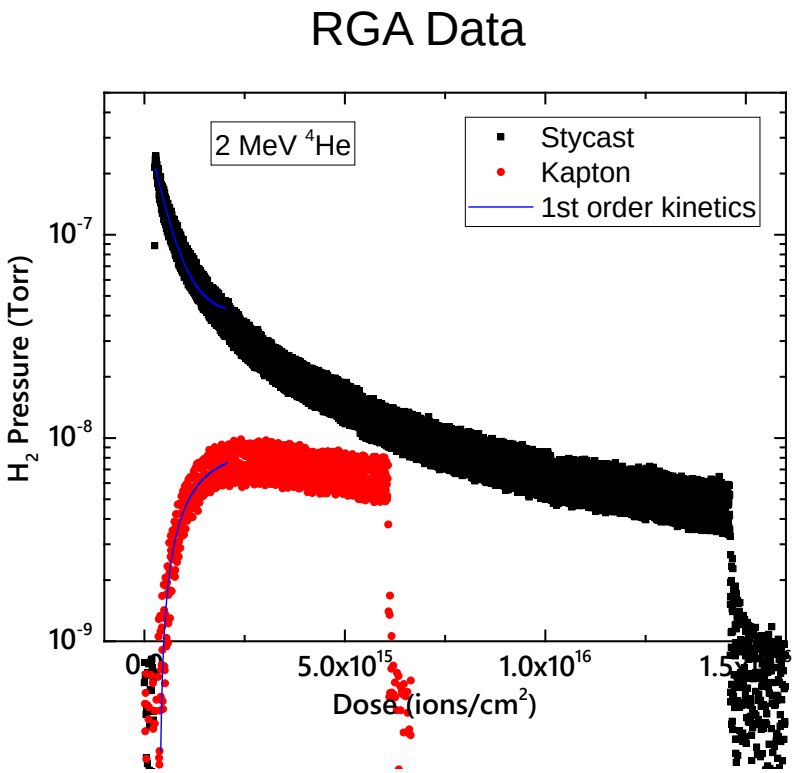
Dimensions
Pu-242: 1mm diameter, ≈40μm thick
Au: 2mm diameter
PVDF: 50μm thick
Mo: 40μm thick
HDC: 500μm thick

Assembly:
Glue (Stycast) all layers together
No coining

Delamination of the PVDF started 10 days after gluing.

Hydrogen dominates alpha-induced decomposition spectrum





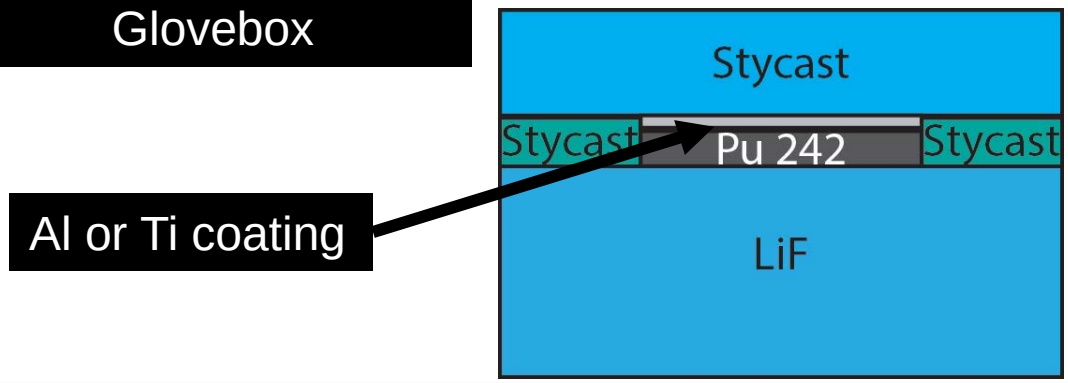
The formation of Pu hydride due to hydrogen evolution from glue and plastic components could lead to failing joints and causing delamination.

Solving the hydride problem with a metal coating.

Ion Polishing/Etching System in B235 Glovebox

Test Al coating

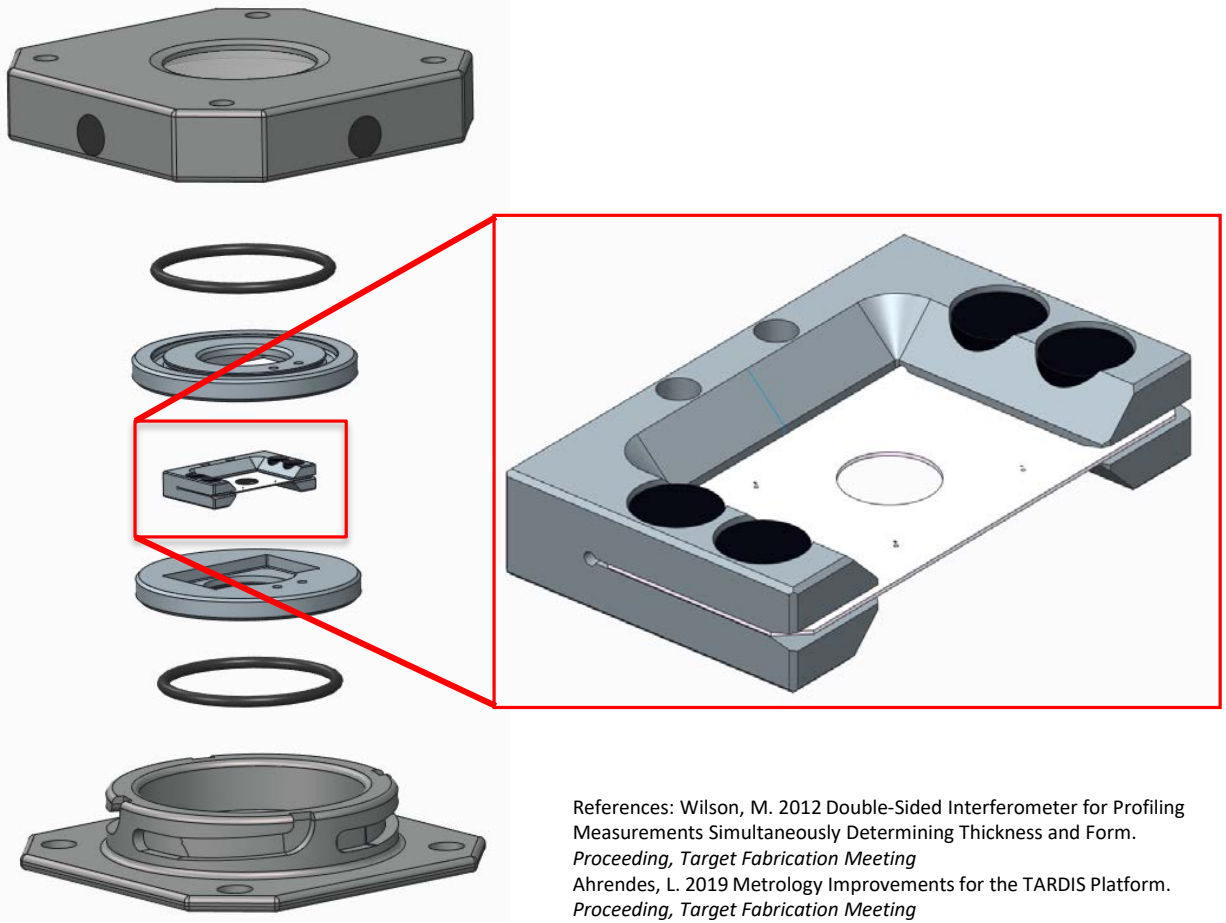
New Sputter Coater in Superblock (not installed)

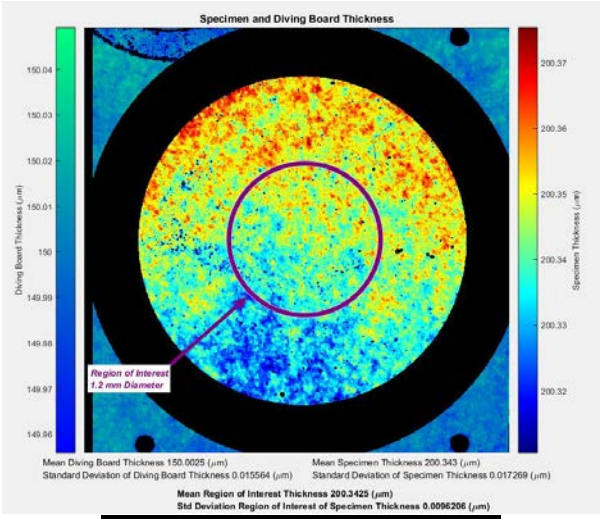


Our current capabilities are limited, due to space and no Diamond Turning capability.

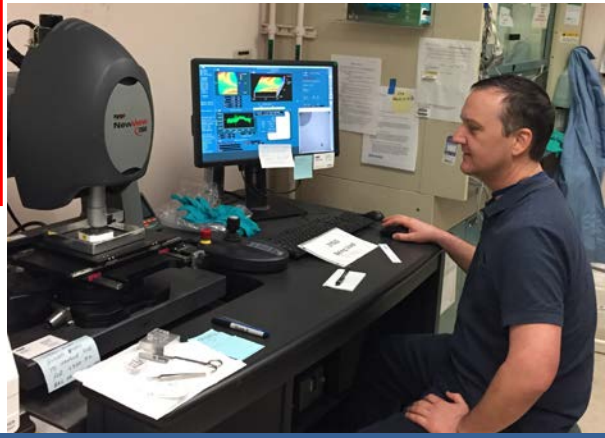
The current lab was developed with equipment not originally intended for target fabrication.

An encapsulation unit for critical Double Sided Interferometer (DSI) measurements for the diffraction experiments was designed and is in routine use currently





Example of DSI data set



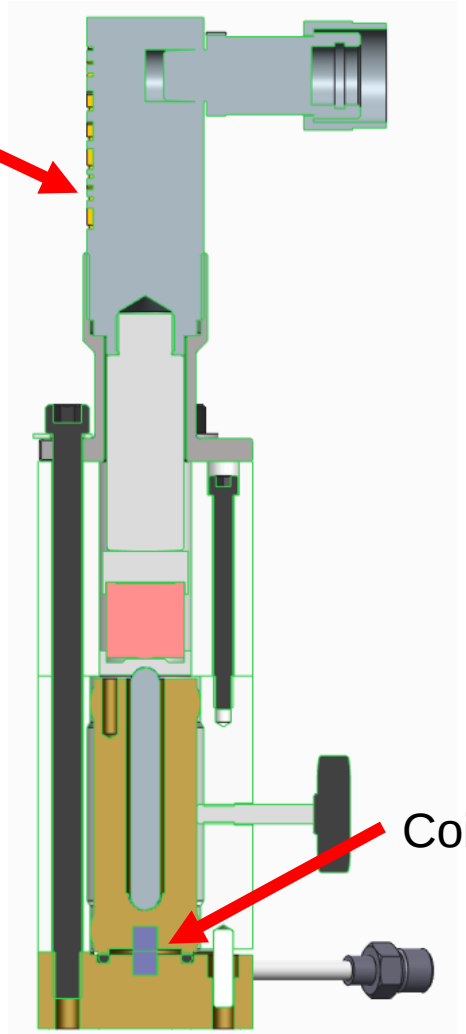
References: Wilson, M. 2012 Double-Sided Interferometer for Profiling Measurements Simultaneously Determining Thickness and Form. *Proceeding, Target Fabrication Meeting*
Ahrendes, L. 2019 Metrology Improvements for the TARDIS Platform. *Proceeding, Target Fabrication Meeting*

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

We upgraded to a hydraulic press to net shape the Pu and to coin sine waves onto thin foil for the Strength Targets.

Hydraulic Cylinder

Vacuum Fitting



Coining Dies

Previously use manual crank to apply pressure

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

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*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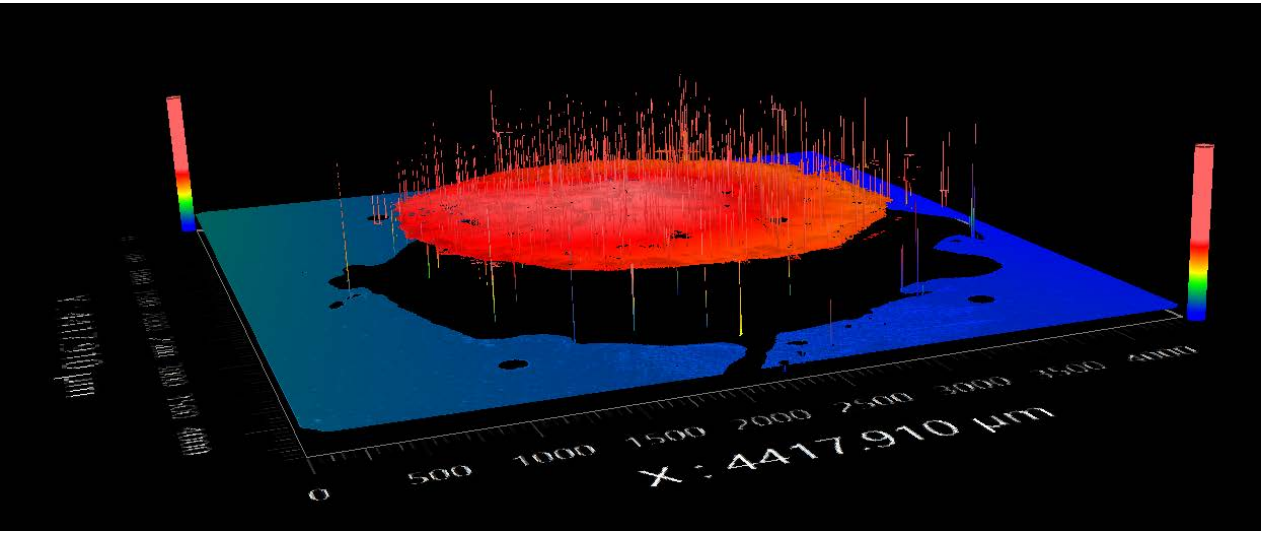
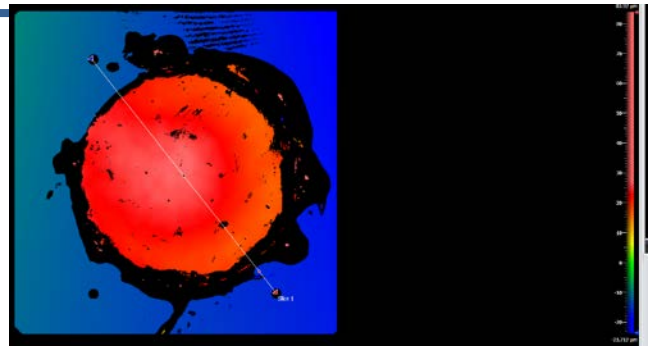
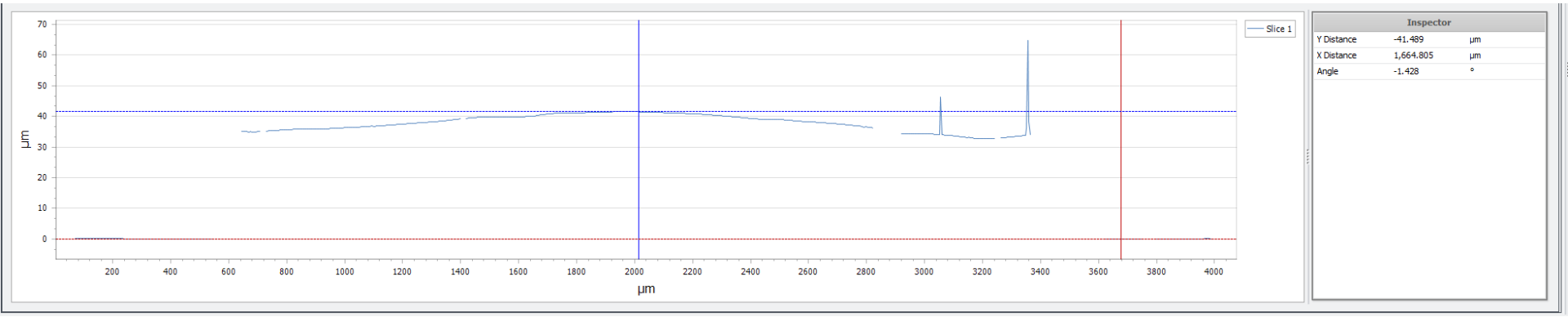
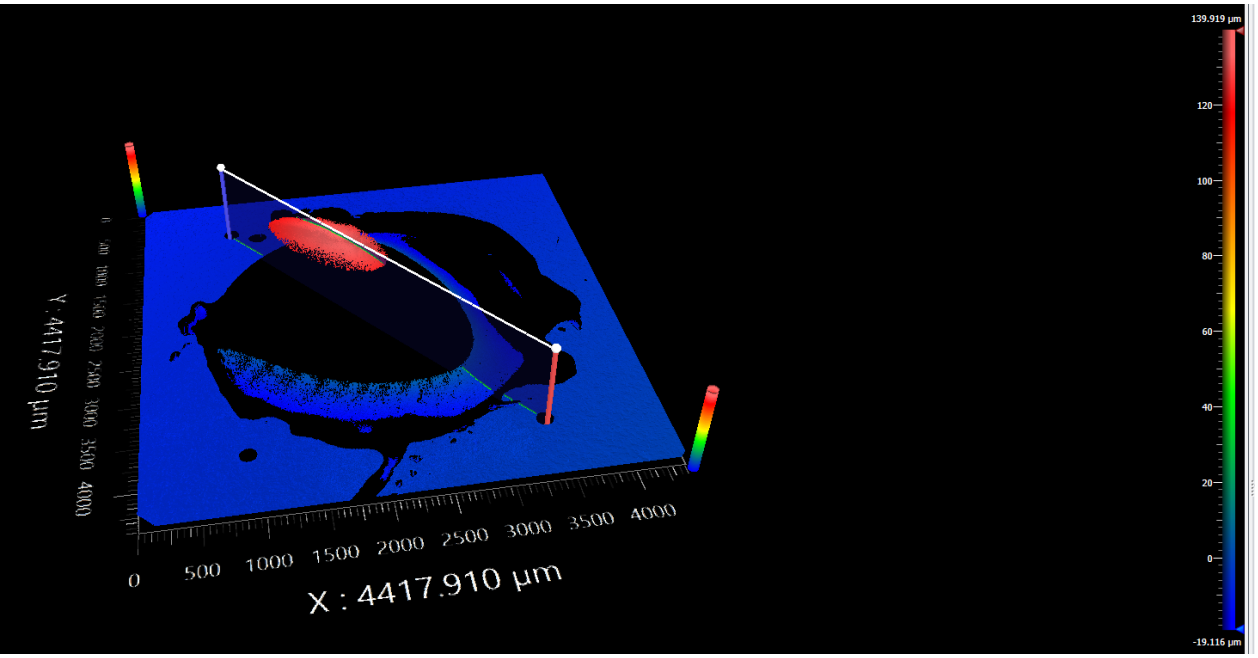
Stycast free standing on 239 day 1

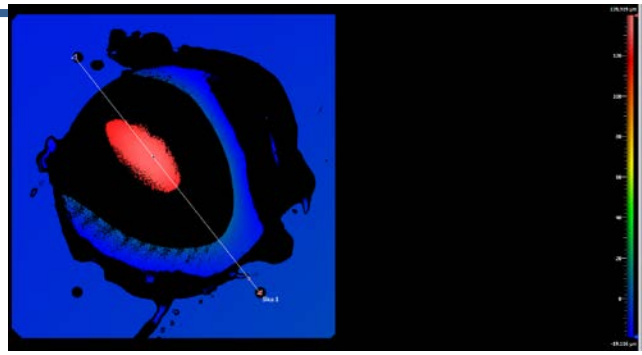


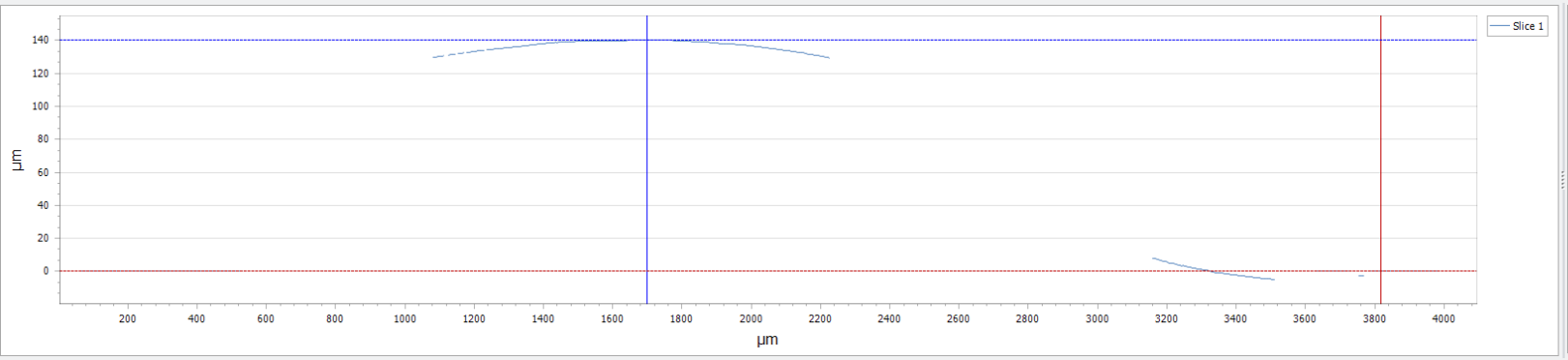




Stycast free standing on 239 day 14







Inspector		
Y Distance	-140.271	µm
X Distance	2,115.783	µm
Angle	-3.793	°