

Developing Manufacturing Techniques for the Equation of State Campaign

Mark Lament¹, Suzanne Ali¹, Emma Floyd¹, Anna Murphy¹, Henry Wong¹, Nam Le¹, Chris Santos¹, Gino Mercado¹ Lawrence Livermore National Laboratory¹ (LLNL)

Introduction

- Target-Fabrication Team has been developing manufacturing techniques for High Energy Density materials. The Equation of State (EOS) campaign study helium implanted Pb (ImpPb) ramp compression experiments.
- These targets contribute to in-depth studies of the impact helium bubbles have on the compressibility of materials.
- Limitations in the implantation process mean this target is thin in comparison to previous Pb samples as well as two-piece PbImp step sample targets.
- The latest Equation of State step samples are manufactured from a single piece of PbImp that is machined down to an incredibly thin and accurate step sample making manufacturing and assembly quite challenging.
- The machining and handling of pure Pb at that level of precision and size is crucial and requires special handling techniques. The Equation of State step targets hold the tightest specification for any target build shot at National Ignition Facility (NIF).

He Implantation

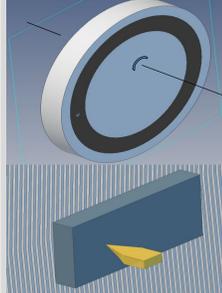
1st step is preparing the Pb bricks for the implantation process

- The bricks must be diamond turned to a specific thickness and surface finish requirement
- The remaining bricks are placed around the experiment to analyze the He implantation data.
- Criteria of EOS He Implanted Lead is similar to other experiments

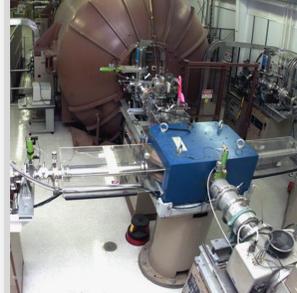
Diamond turning Lathe



Machined to required thickness / surface finish



EOS He Implantation



The remaining samples surround the two main He Pb samples and are used to measure the implantation using TEM (Transmission electron microscopy)

Fixture designed to work with the implantation



2 samples after the implantation (center)



The implantation process is very crucial and time consuming. We can only implant two bricks at a time.

Post Implantation process/machining

The 2 HePb bricks are carefully machine down to 300um thickness

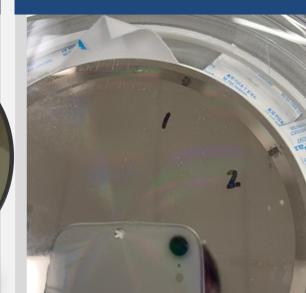
- The bricks are mounted on a precision EOS puck.
- Force sensor is used to ensure the material is not distorted
- The bricks are flipped 3-4 times to make sure they remain flat and parallel

Precision assembly station



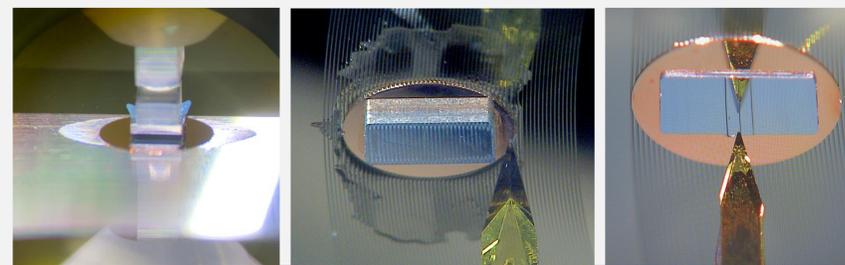
EOS brick being glued down for Diamond turning process

EOS Puck with two ImpPb bricks



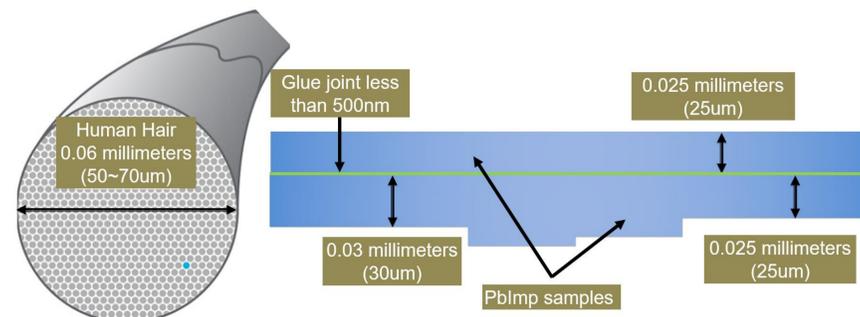
Puck ready to go on the machine

The ImpPb brick gets mounted onto the Cu copper

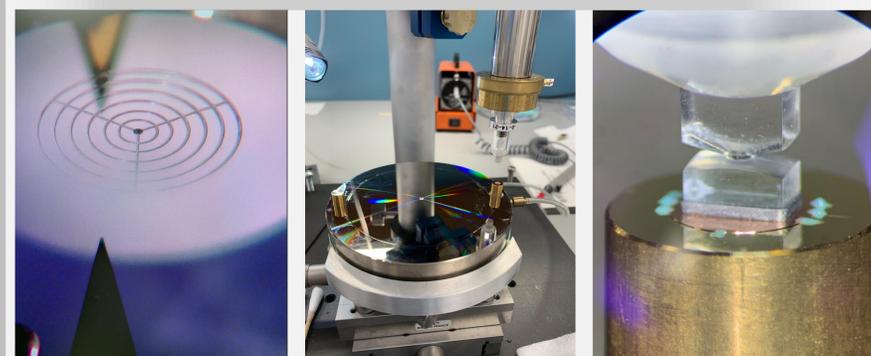


A double-sided measurement is required for each step and is documented to ensure parts meet the tolerance requirements

Two-piece ImpPb EOS example



Tooling/fixturing

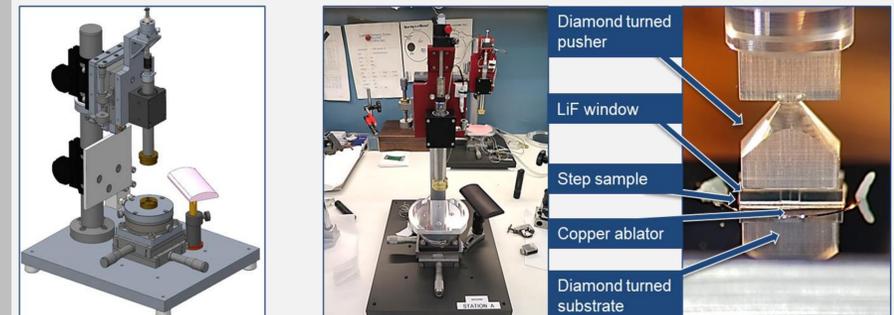


Unique vacuum fixture was designed and manufactured to allow for double sided measurement during process inspection

Assembly and inspection

Equation of State (EOS) Assembly

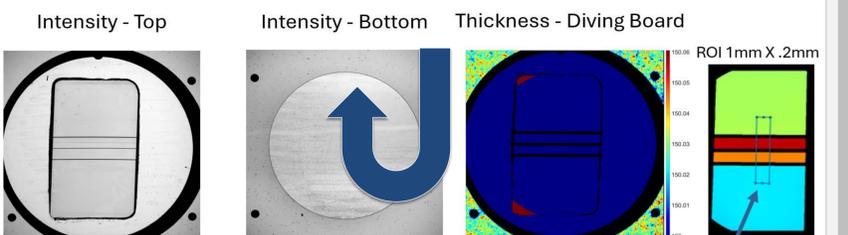
- EOS targets must be assembled on extremely accurate assembly stations to achieve precise specifications
- Assembly stations often need to be set up individually for specific targets



White light interferometer



Measures Every Step of Production



name	all_peak	all_HWHM	ROI_peak	ROI_HWHM
Diving Board	150.030	0.009	150.030	0.009
Surface 1	104.674	0.030	104.691	0.005
Surface 2	106.559	0.034	106.603	0.031
Surface 3	108.683	0.038	108.686	0.003
Surface 4	110.641	0.026	110.674	0.004

Final Target-built data

	Measured Data				Error bar	Diving board thickness
	Step 1	Step 2	Step 3	Step 4		
Cu		70.841			0.1	150.03
Pb brick 2		276.902			0.15	400.03
Cu/Pb brick 2/Epoxy		347.517			0.21	449.98
Epoxy between Cu and Pb brick 2		-0.226			0.1	
Pb step sample (+/- the glue)	25.476	30.444	35.487	40.491		
Cu/Pb steps	96.317	101.285	106.328	111.332	0.1	150.03
LiF (coated Ti/AR)	300.943	295.963	290.961	285.970	0.1	400.03
LiF/Pb/Cu (Physics Package)	397.173	397.173	397.173	397.173	0.18	449.98
Epoxy between Pb and LiF	-0.087	-0.075	-0.116	-0.129	0.1	
LiF/Pb/Cu (Expected)	397.200	397.200	397.200	397.200		
Delta (Expected to Measured)	-0.027	-0.027	-0.027	-0.027		

Document entire process, compile data and, present it to the physics and technical team