LASER-SHOCK TARGET FABRICATION

Introduction

This document details target preparation procedures necessary for successfully conducting laser driven shock experiments at the Dynamic Compression Sector (DCS). Additional questions regarding sample preparation – including how to design targets to avoid edge and release waves during x-ray measurements – may be directed to your designated DCS Point of Contact (POC). If a DCS POC has not been assigned to you, please email dcs.admin@wsu.edu.

Materials Needed

Item	Purpose	Brand or Supplier
Pressure sensitive film	Evaluating/troubleshooting pressure uniformity of press	FUJIFILM PRESCALE® LLW
Releasable Press Pad	Assisting uniformity of pressure and temperature	PACOTHERM™ TRIPAK
Low viscosity adhesive/epoxy	Adhering layers together	ANGSTROMBOND® AB9110LV
Ablator (30nm Al-coated Kapton)	Shock wave generation	30nm Al-coated 50 µm Kapton from Goodfellow recommended for laser intensities above that generated from the 10ns pulse with attenuator 3. For intensities less than this, 75 µm Kapton is recommended to avoid a multi-wave temporal profile out of the Kapton.
Window (LiF)	Interferometry	4x8 mm LiF from Asphera. The thickness typically ranges from 0.5 to 2 mm.
Sample	Material to be studied	Thickness is typically less than 30µm thick to avoid overtake by the release wave before breakout.

Tools/Equipment Needed

Item	Purpose	Brand / Details
Press	Capability to adjust pressure and temperature	CARVER®
Metrology	Ability to measure individual layers to 0.2 µm	Optical or soft-touch contact
Scissors	Separating/Cutting apart Kapton between samples	Surgical type works best
Swabs	Applying adhesive	Plastic cleanroom ones work well
Large Optical Flats	Used to provide a nice flat surface to press upon.	
Vacuum Wand and/or Tweezers	Precisely and carefully handle samples	

Press Surface Setup

To generate the necessary level of flatness in the target assembly, an optical flat is used as the surface for pressing the target materials together. A thin silicone sheet is placed underneath to prevent the optical flat from cracking from non-uniformities or debris in the press or flat bottom. Placing the optical flat on a precision ground stainless steel (SS) flat or similar support structure will ease handling and protect the optical flat and press in case wetting of the surfaces occurs.

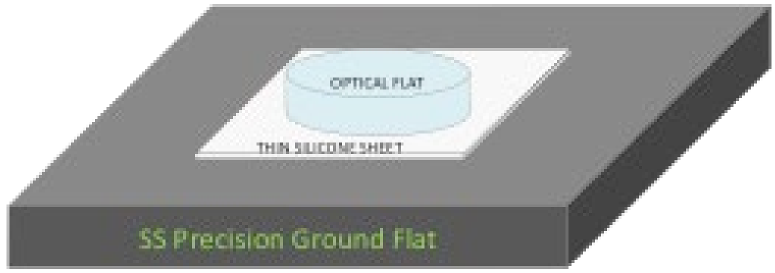


Figure 1. Press surface setup diagram

Depending on your press size one can easily have multiple optical flats but be sure to balance the load. An uneven load will not be able to generate enough uniform pressure for making targets and may damage the press. Be sure to measure the relative heights and adjust accordingly for everything placed on the press surface. As a final step, place pressure sensitive film between the flat surface and a press pad and apply 160 PSI to the film. A useable surface should darken the film as shown on the left in Fig. 2 as compared to the film on the right. While the press pad can accommodate up to 500μm in total thickness, this should be reserved for differences in sample thicknesses rather than non-uniformities to the surface flatness.

At DCS the press has a minimum force of 1000lbs and increases in 100lbs increments. To achieve the desired 160 PSI, we distribute the pressure onto more surface than just the sample. Spacers can be created to match the combined height of the optical flat and samples for this purpose. The spacers shown on the front and back in Figure 3 were made by bonding microscope slides together with a fast curing 2-part epoxy such as Devcon 5 Minute Epoxy.

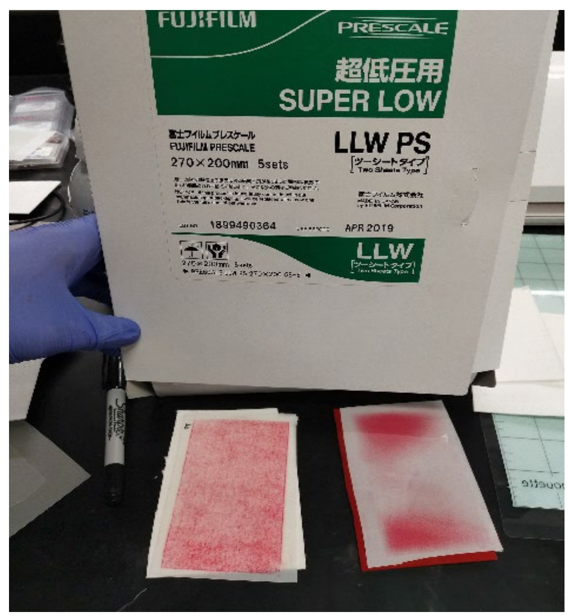


Figure 2. Pressure sensitive film showing the pressure differences between using a press pad (left) and silicone rubber (right)

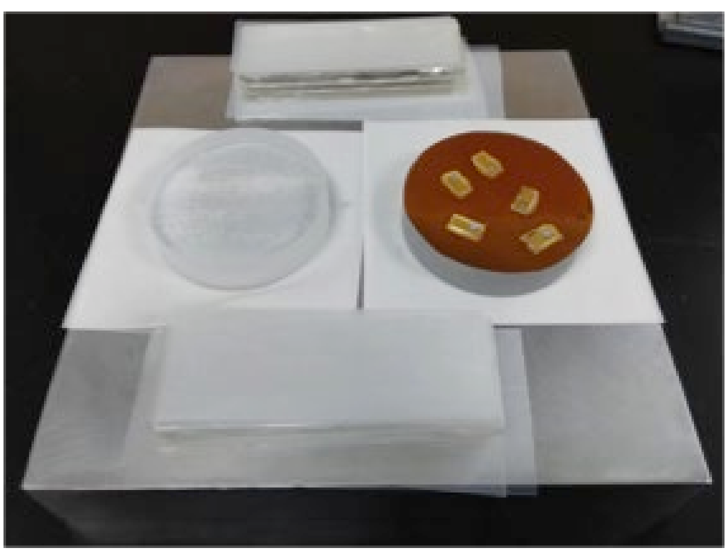


Figure 3. Press surface with spacers made from glass slides

Sample Overview

The sample consists of a 4x8 mm LiF window with a 2x2 mm 100nm thick Aluminum coating offset to the top and 1mm away from the three nearest edges of the LiF. This coating is used for alignment and interferometry. We encourage purchasing the Al coated LiF from Asphera Incorporated as a tested and reliable source. A thin layer/foil of the material to be studied is adhered between the Al coated side of the LiF and the non-coated side of the Kapton ablator. Selecting the foil thickness should be carefully considered to avoid overtake by the release wave from the Kapton before breakout.

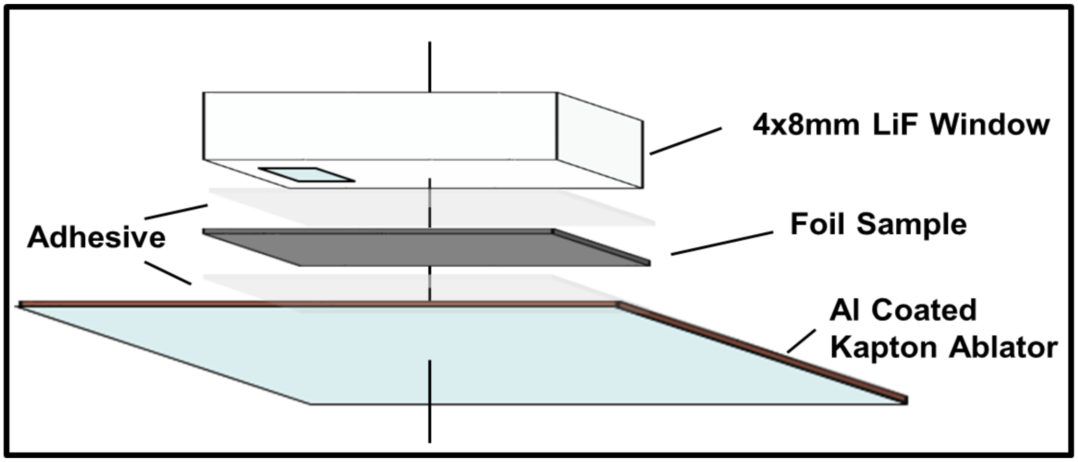


Figure 4. Assembly diagram of a laser-shock target.

The main limitation in the uniformity of the sample is the foil/material to be studied. A White Light Interferometry (WLI) image of the foil/material will provide a good estimate of the surface roughness/uniformity of the material. The thickness of the adhesive layer depends on many factors such as the viscosity of adhesive, amount of adhesive, temperature of curing, pressure, material being adhered, and cleanliness/dust. All parameters should be controlled and recorded as best as possible to ensure repeatable results.

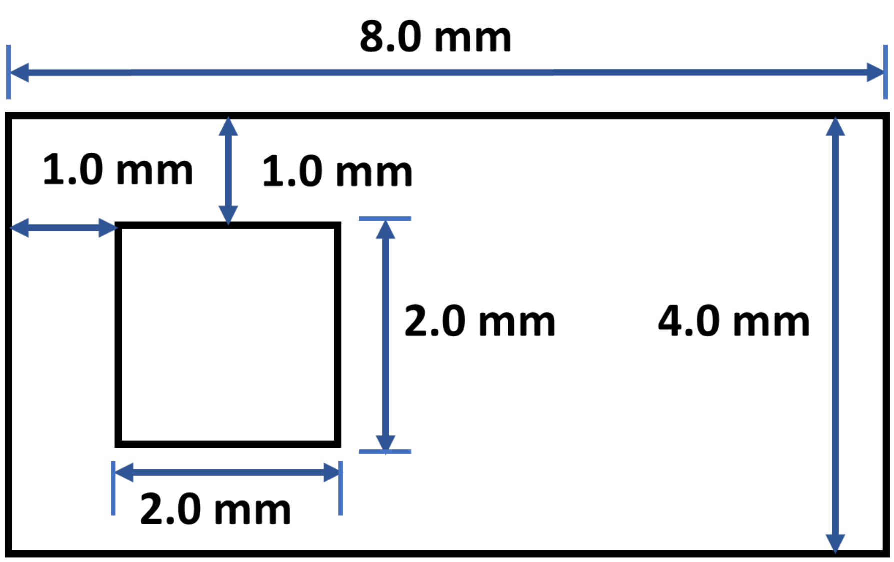


Figure 5. Dimensions of the LiF window and placement of the 100 nm thick Al coating.

Procedures

Pre-Assembly Procedure:

1.) Coat section of LiF with 100nm of Al according to the drawing above

2.) Cut Kapton, sample foils and press pad to appropriate sizes.

   a. Overcut the Kapton to the size of the optical flat as seen on the right in Fig. 3. This prevents glue from running to the front surface and adhering the sample to the optical flat.

   b. Overcut the sample foil to be greater than the LiF window dimensions (>1 mm each side) to ensure burrs and deformations from cutting do not interfere with the bond gap. This also provides adequate margin during bonding as layers may shift during the process.

   c. Overcut the press pad to ensure full coverage of the surfaces in contact with the press.

3.) Thickness measurements of LiF, Kapton, and the Sample Foil are taken using a soft-touch Heidenhain MT1281MW.

   a. Soft touch or optical measurements are necessary. The Heidenhain Certo 6001 leaves permanent deformations on LiF at all pressure levels. (See Figs. 9-11)

Assembly Procedure:

Samples need to be dust and contamination free to achieve repeatable thin (<1μm) glue bonds. Therefore, it is recommended that the following steps are done in a cleanroom environment. While a thin-set glue such as Angstrom Bond has many hours of working life, it is important that these steps be completed in an efficient manner to minimize exposure to dust/debris.

1.) Kapton is placed on optical flat Al-coated side down, after ensuring there is no dust

2.) Adhesive is applied to Kapton where the sample is to be placed

3.) Adhesive is applied to both sides of sample

4.) Adhesive covered sample is then placed onto adhesive covered area on the Kapton.

5.) LiF Window gets adhesive applied to Al-coated side.

6.) LiF window gets placed Al-coated side down onto the sample.

7.) Lightly press on the LiF window and check to make sure that there are no bubbles.

8.) Repeat for remaining samples

   a. Make sure samples are evenly distributed throughout the press to ensure uniformity of pressure and leave enough room to easily cut apart the samples later.

9.) Place PACOTHERM TRIPACK on top

10.) Set press to desired pressure and temperature (see Figure 6 for cure times)

   a. At DCS pressure is set at 160 PSI and temperatures up to ~95°F have been successfully used. Higher temperatures may result in bubble formation and is not recommended.

11.) Once curing is done, remove from press and cut samples apart

12.) Repeat the measurements with the fully assembled sample to determine sum of the two glue bond thicknesses.

13.) Inspect the target for the presence of bubbles or inclusions. Targets displaying visible defects or having bond thicknesses larger than 1 μm should not be used.

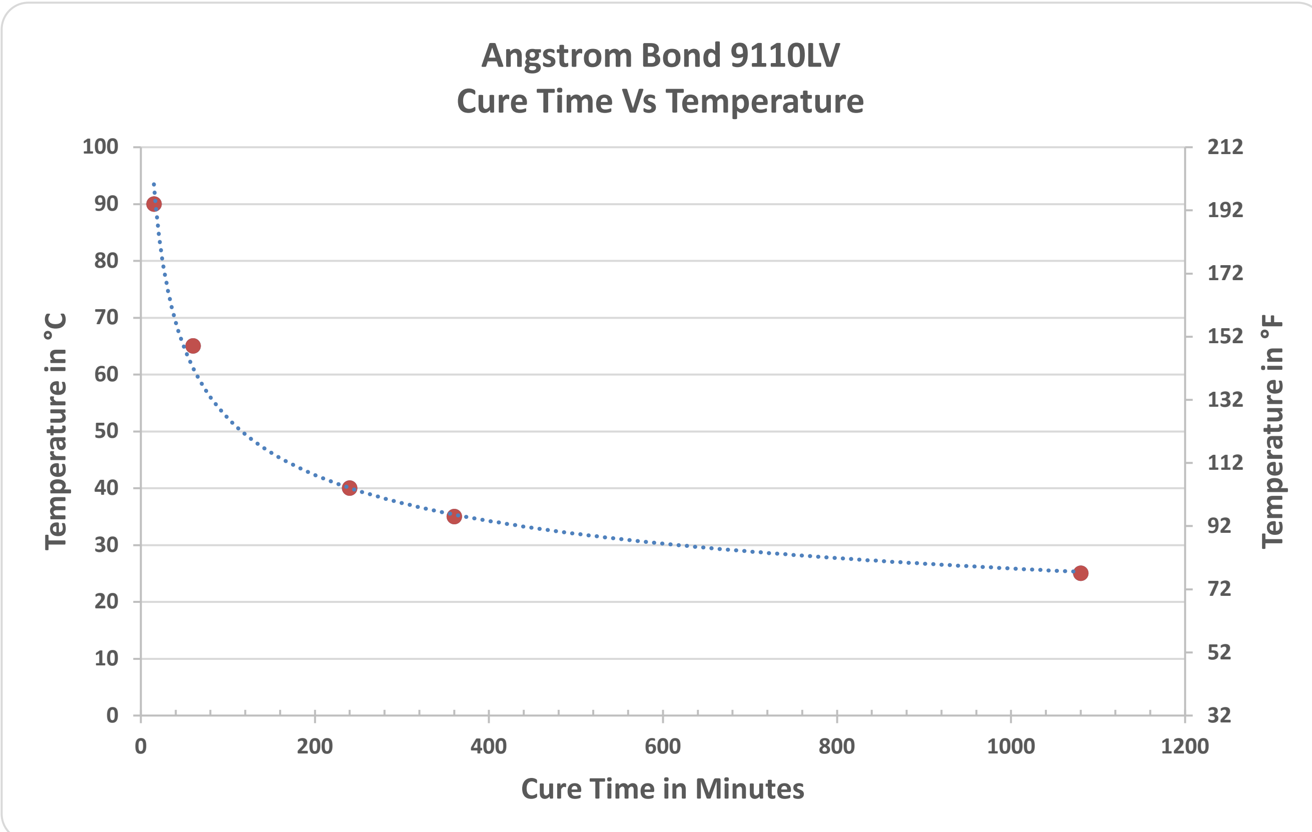


Figure 6. Cure Time Rates for Angstrom Bond

Mounting Assembled Samples:

Samples are adhered to aluminum bars using super glue and a 3d printed jig. Jigs are printed to match windows of specific dimensions. The assembled sample is placed into the jig with the window side down. A small amount of glue is placed near one end of the sample and then an aluminum bar is pressed onto the glue. This setup is shown in the Figure 7. This mounting procedure typically results in the sample tilting less than 1 mrad with respect to the bar. 3D printed versions of the aluminum bar (technical drawing at the end of this document) have proven to work as well. Be sure the location of interest, where the drive laser strikes, is positioned at least 0.5 mm above the top of the aluminum bar such that the drive laser has clearance to converge onto the sample without clipping the bar.

If the sample is a free surface target without a window or if the window is too small to mount to the bar as described above, an alternative bar can be used that has a through hole for the drive laser and x-rays (technical drawing at the end of this document). The tapered side of the through hole is for the incident side of the drive laser. The sample is tacked to the bar on the opposite side of the tapered hole.

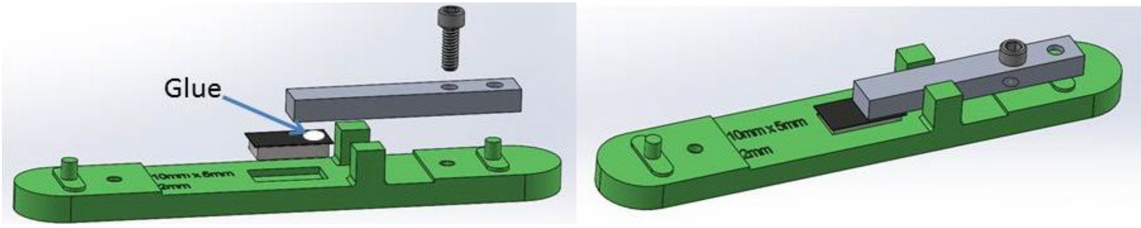


Figure 7. Adhering samples to bars

The aluminum bars are fastened with screws to an aluminum wheel (see Fig. 8). One of the bar locations is reserved for a scintillator used for alignment and another location is reserved for an x-ray standard, such as polycrystalline silicon (provided by the DCS, if desired – not shown). The other 22 locations are used for mounting samples.

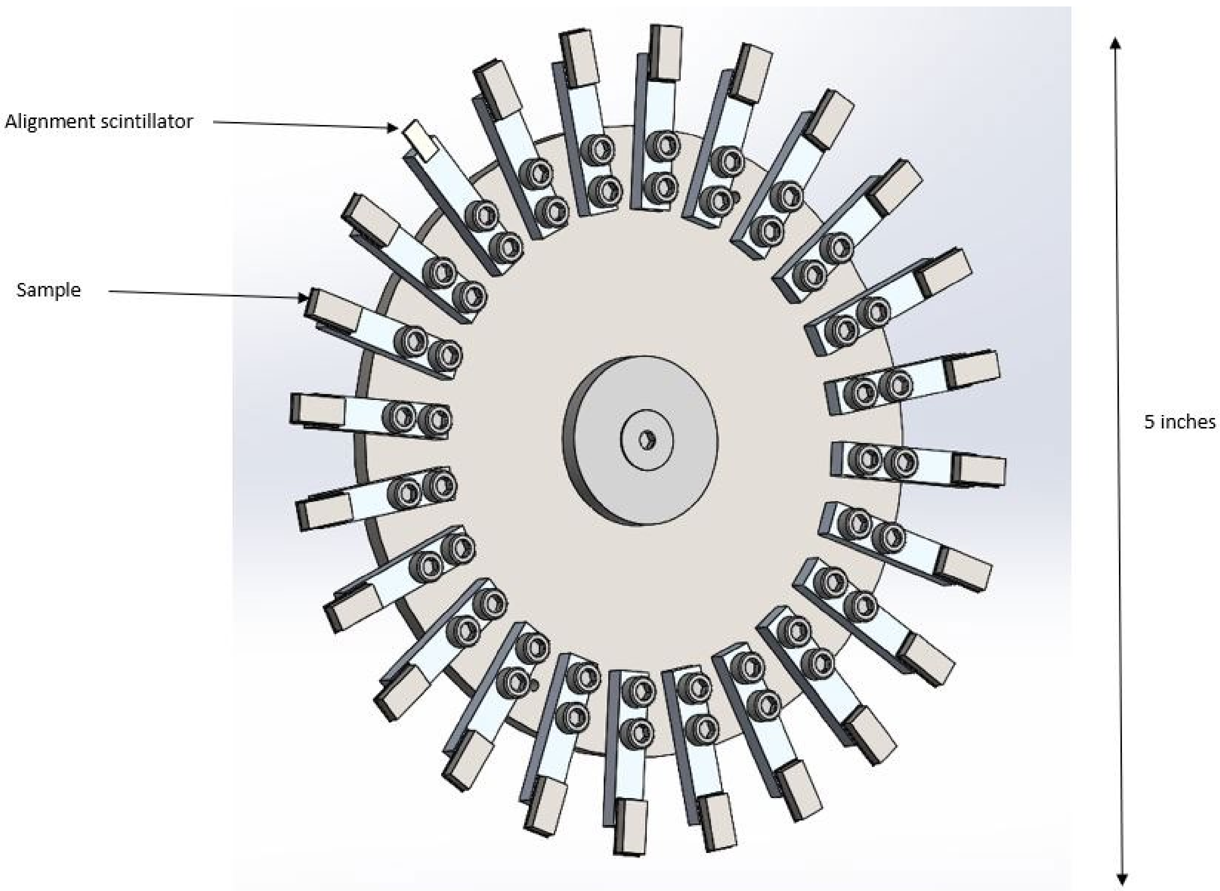


Figure 8. Sample wheel with samples and alignment scintillator.

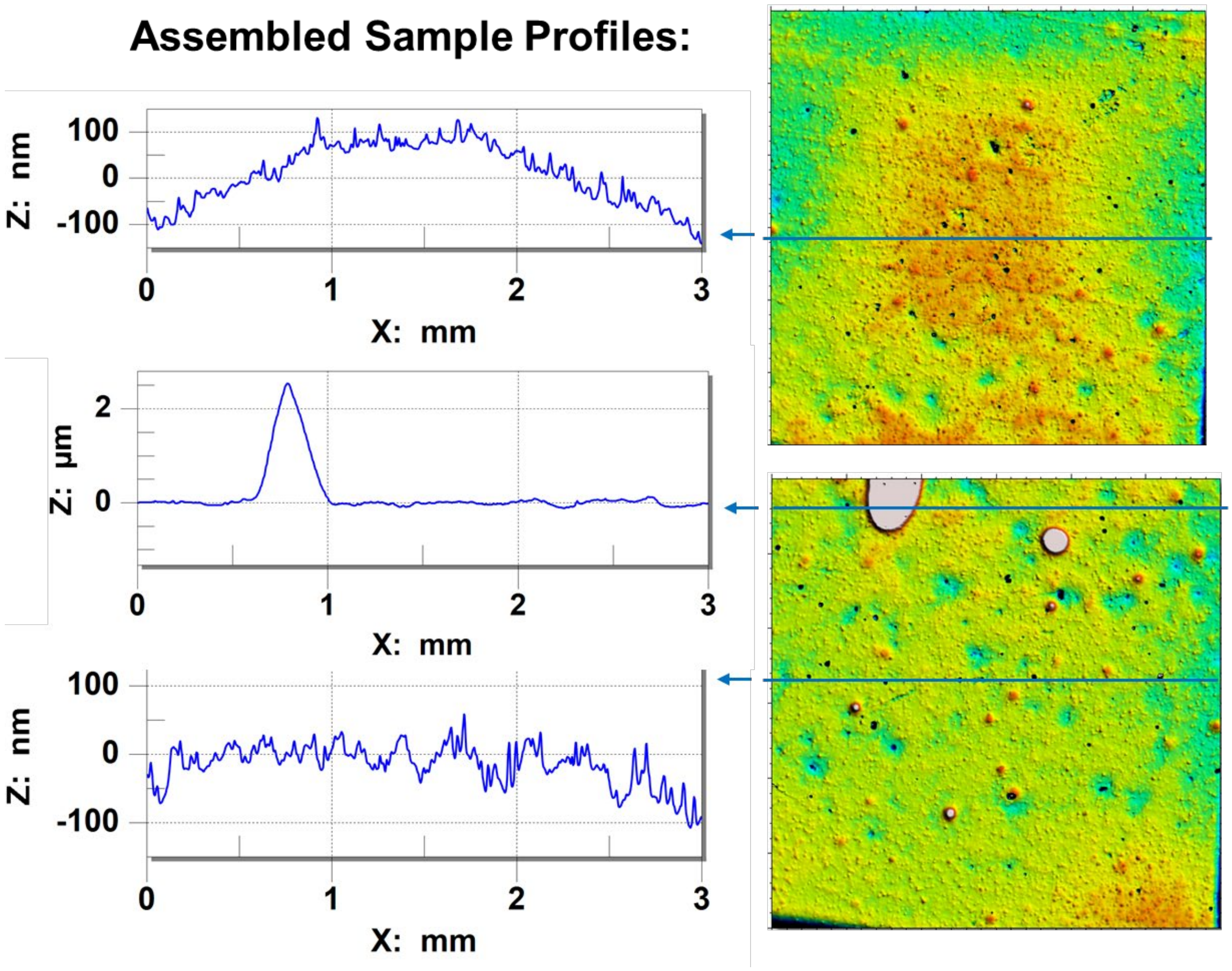


Figure 9. Shown are images taken by a White light interferometer of the ablator side of a plain Kapton LiF target. TOP: Shows uniformity and the protuberance caused from the Al coating below. MIDDLE: Shows the effect of dust/debris can have on sample/ablator uniformity. BOTTOM: Shows uniformity of the ablator.

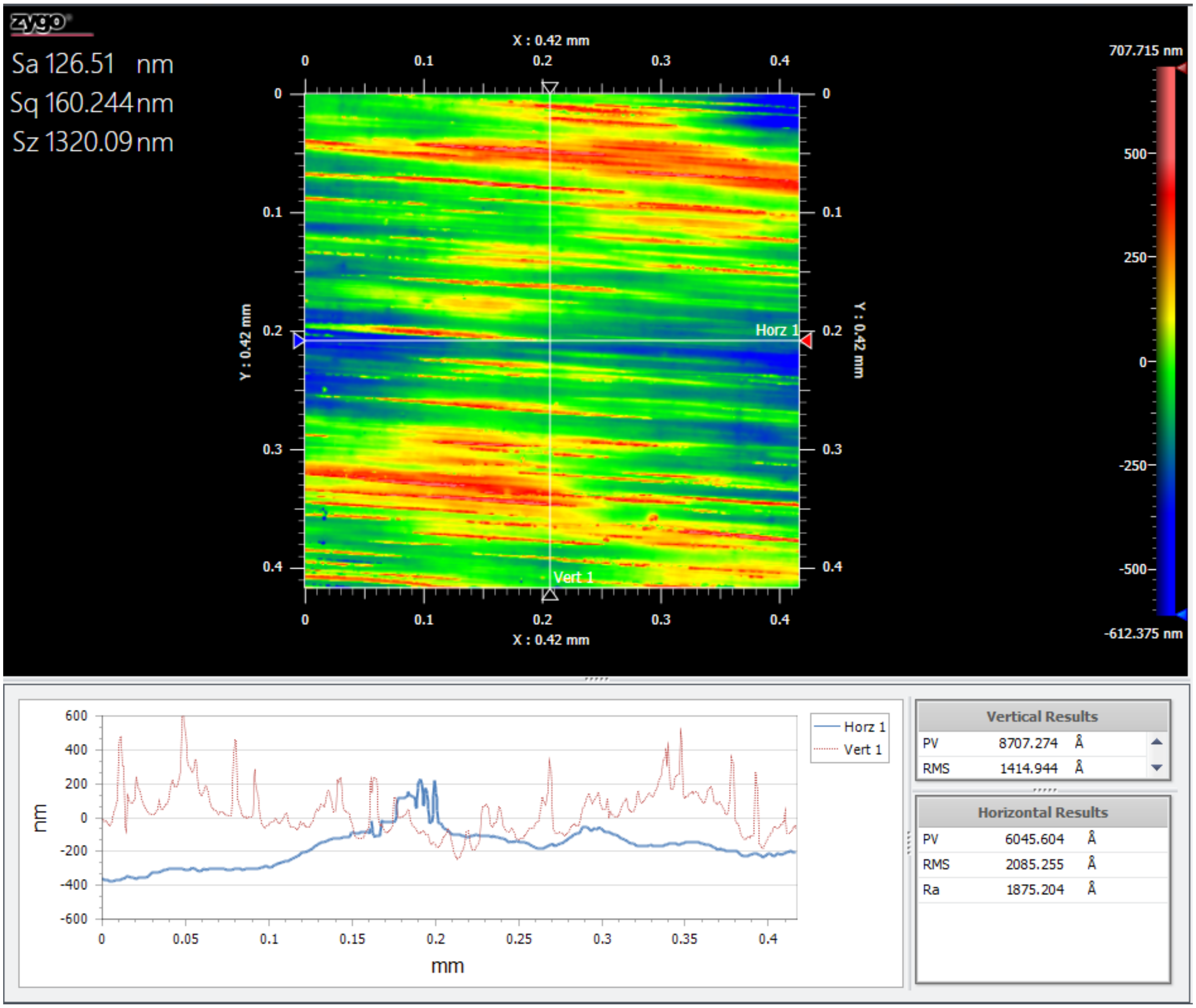


Figure 10. Zygo image above shows the non-uniformity of a plain Tantalum foil sample acquired from Goodfellow.

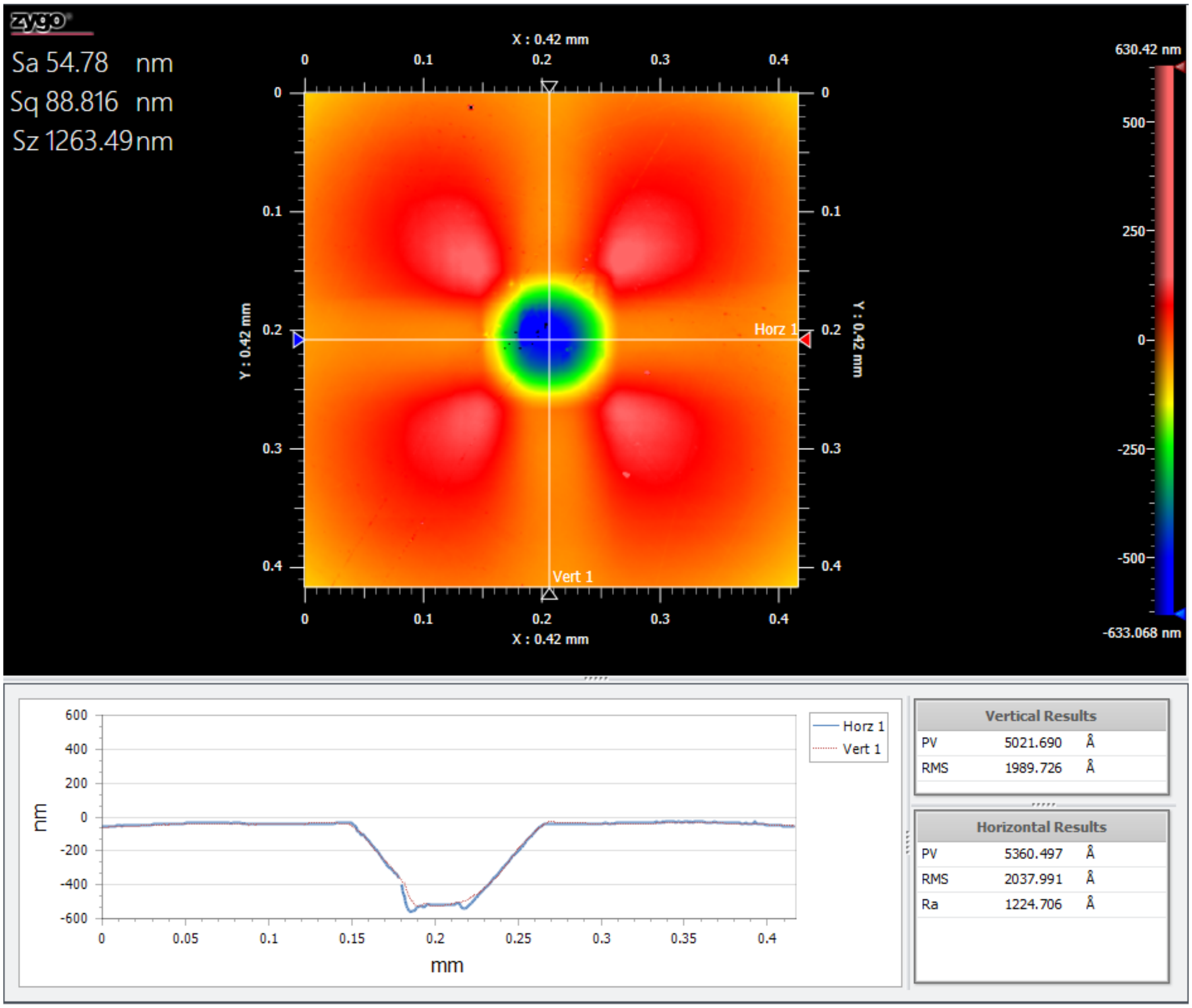


Figure 11. Shown is the indentation caused from a contact measurement from a Heidenhain Certo 6001 on the lowest force setting. It is recommended to use non-contact measurement techniques or a soft touch gauge such as the Heidenhain MT1281MW.

Additional Resources:

Randall, Greg C., et al. "An Evaporative Initiated Chemical Vapor Deposition Coater for Nanoglue Bonding." *Advanced Engineering Materials* 20.3 (2018): 1700839.

Paguio, R. R., et al. "Development of a Multi-Press Assembly Device for Planar Dynamic Material Property Targets." *Fusion Science and Technology* 73.3 (2018): 488-492.

Carlson, L. C., et al. "Automation of NIF Target Fabrication." *Fusion Science and Technology* 70.2 (2016): 274-287.

Seugling, R. M., et al. "Double Sided Interferometer, Profiling Measurement Simultaneously Yields Thickness and Form." *Proceedings of the American Society for Precision Engineering*. 2010.

Habenicht, Gerd. *Applied adhesive bonding: a practical guide for flawless results*. John Wiley & Sons, 2008.

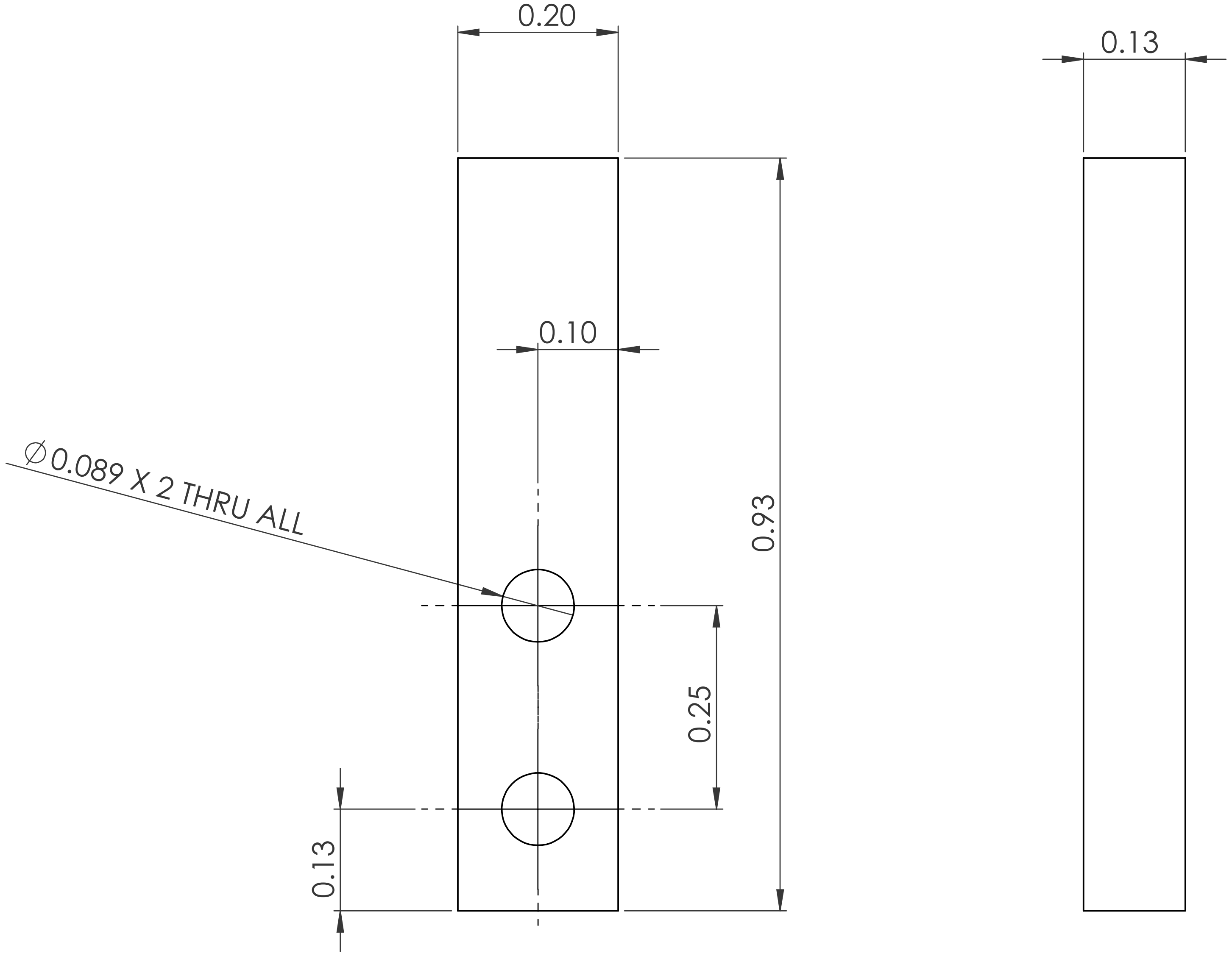
Seugling, R. M., et al. *Thickness and Stack Height Measurement Uncertainty of Experimental Packages for National Ignition Facility Targets*. No. LLNL-PROC-493011. Lawrence Livermore National Lab.(LLNL), Livermore, CA (United States), 2011.

Double-Sided Interferometer for Profiling Measurements Simultaneously Determining Thickness and Form. Micheal J. Wilson,
http://www.lanl.gov/conferences/tfm/presentations/08-23-12-AM1-2-Wilson.pdf

Benchtop nanoglue bonding of target materials. G. Randall, L. Gonzalez, R. Petzoldt, F. Elsner. General Atomics
https://lasers.llnl.gov/content/assets/docs/nif-workshops/tfm-2017/presentations/4-thursday/426_RANDALL.pdf

Sub-Micron Glue Bond, Carol Davis
https://lasers.llnl.gov/content/assets/docs/nif-workshops/tfm-2017/posters/tuesday/20_Davis.pdf

LiF Fabrication and Physics Package Assembly for NIF EOS Targets, Matt Bauer
https://lasers.llnl.gov/content/assets/docs/nif-workshops/tfm-2017/posters/monday/02_Bauer.pdf



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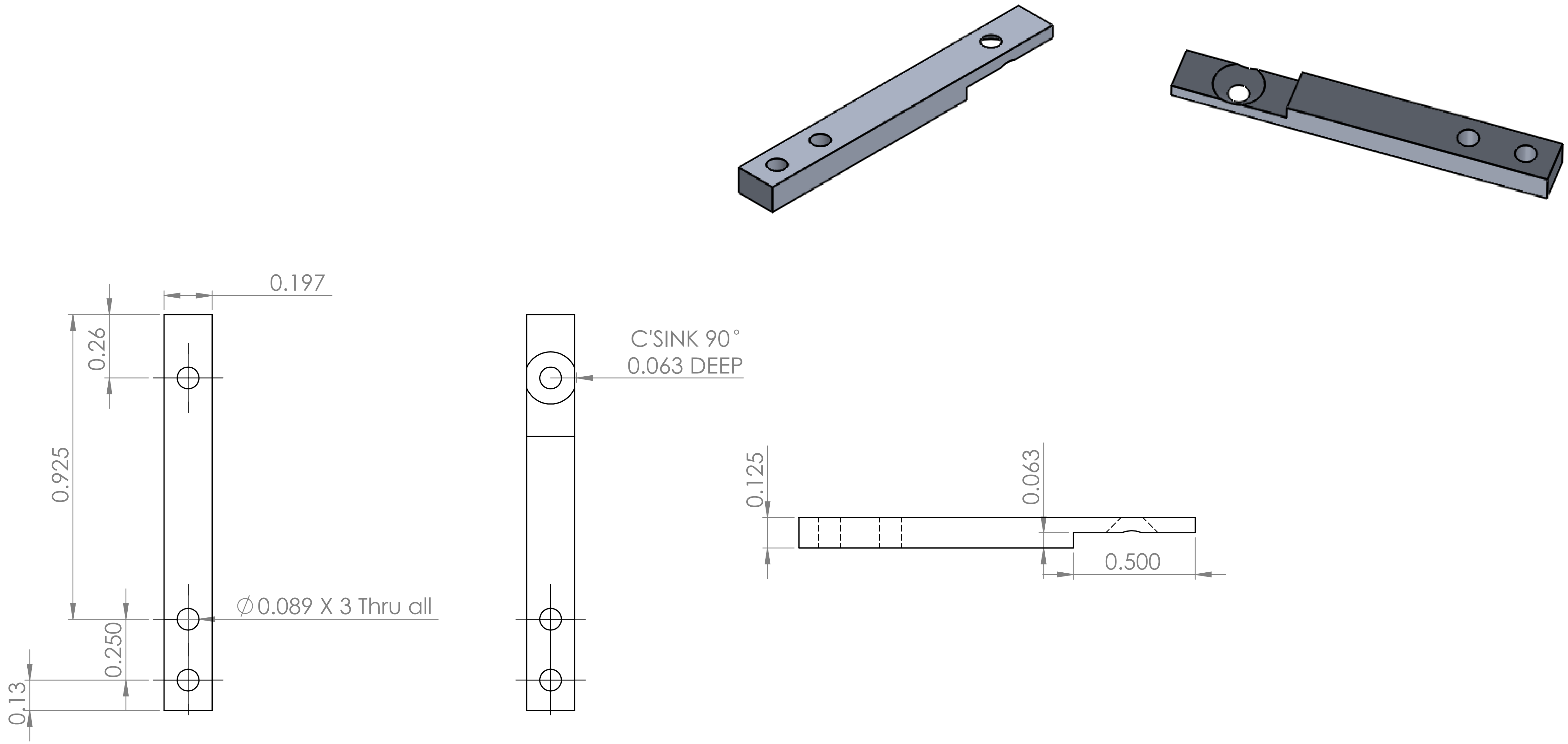

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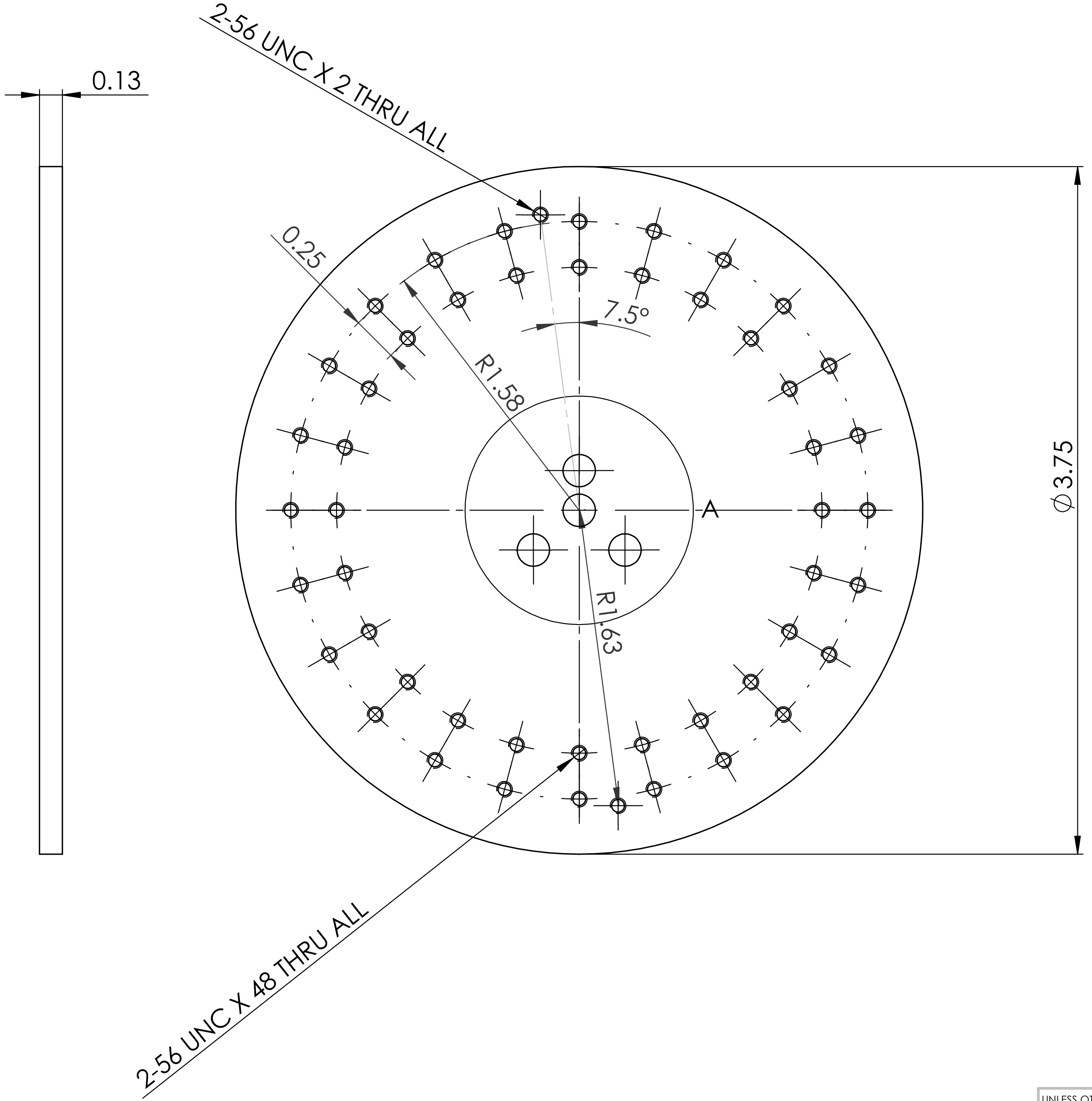

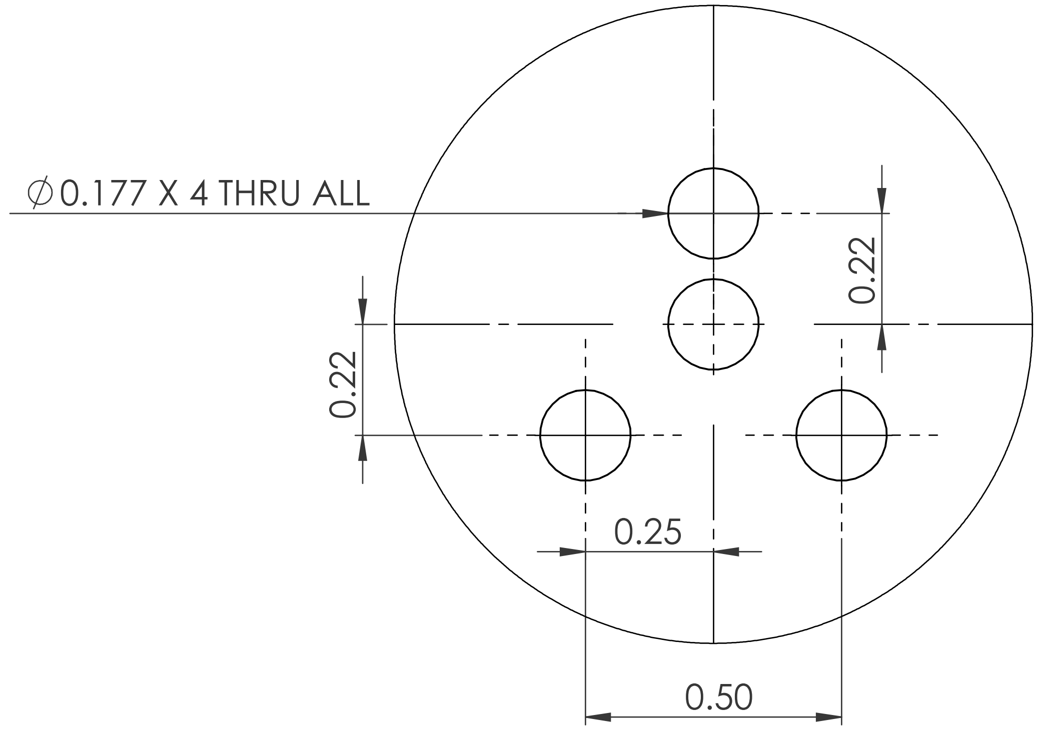

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