Developments in HiZ Physics Package Fabrication

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Motivations

- High Energy Density (HED) Materials Physics program investigates the structure and strength of relevant materials at high pressure regimes.
- Develop methods to produce a series of targets for each HED Materials sub-campaign using plutonium (Pu) as the material of interest.
- Improvements include:
  - Coating to replace glued foils: better control of drive
  - Implanted helium into the Pu matrix for investigating the effects of aging
  - Adjustments to the typical fabrication and assembly process to accommodate safety requirements of working with Pu.

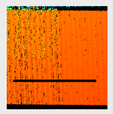
Physics Package Requirements

Plutonium Design Requirements and Verification

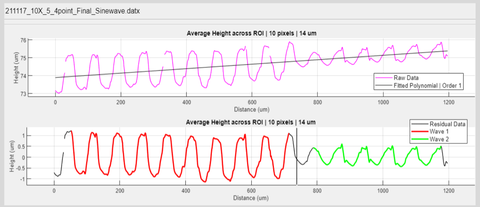
Sinewave surface of Pu

- High purity, full density 1.5x1.5 mm^2 Pu
- Ripple surface
  - nominal sinewave constraints: λ = 75 μm, A = 0.4-2 μm
  - <5% contribution from other harmonics
  - Confirmed with White Light Interferometry (WLI)
- Coat Pu surface with Copper (Cu) or Aluminum (Al), thicker than the sample
- Helium (He) implanted samples in future

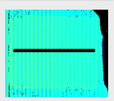
Standard WLI measurement with 10x objective



*Height image for reference



Improved 10x WLI measurement



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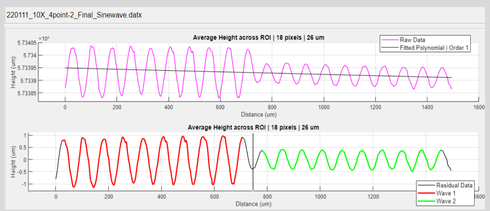
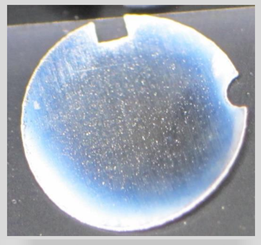


- High focal length required by containment vessel required for Pu safety
- WLI with a 10x objective gives distorted height without additional measures:
  - —Manual adjustment of glass compensated objective
  - —Very well leveled sample to avoid clipping low points
  - —High Dynamic Range: rescans at different light levels
  - —Signal Oversampling: increases measurement sensitivity

Coating and Cleaning Process Development

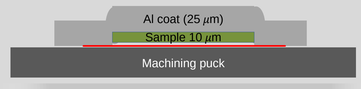
Free standing part
Bowing caused coating to deposit on bottom surface



25 μm Al coating onto 10 μm sample

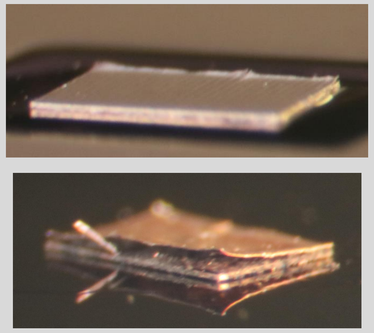
- Replacing a glued foil with a coating leads to large improvements in shot quality
- Pu activity denatures organic materials, creating air gaps
- Robustness needs to hold up to machining stress
  - —Flatten coating that is conformed to ripple surface
  - —Remove coating surface roughness

Gluing sample to substrate to avoid coating deposit back surface



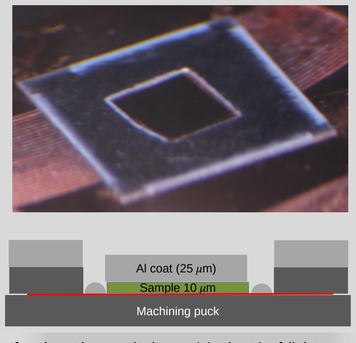
Sample edges, buried under thick coating, seal to mount surface

Standard sample cleaning practice wasn't enough to keep Cu or Al bonded to the Pu surface – more extensive cleaning was required



25 μm Al coating onto 10 μm sample

Sample prepped for coating:
Glued flat to substrate, mask fitted with <50 μm gap

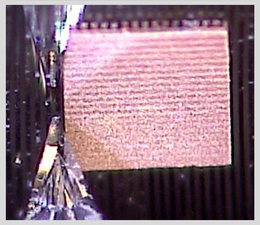


If mask matches sample shape, minimal coating falls between, allowing easy release

Copper and Aluminum coatings successfully adhere to the Plutonium samples

Multiple etch recipes used on sample

Ripple Pu post Cu coating

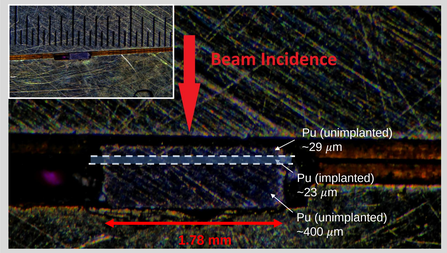


Cu coat surface matches sample sinewave
Prepped to machine flat

Helium implanted Samples

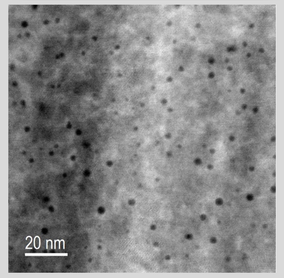
- Aging Pu evolves He gas
- Want to age material beyond what is currently available
- He may impact material performance
- He implantation at the Center for Accelerator Mass Spectrometry (CAMS).
- Post- implant, sent to PNNL for TEM analysis

As-prepared (cut and lapped) cross-section of the He implanted Pu sample.

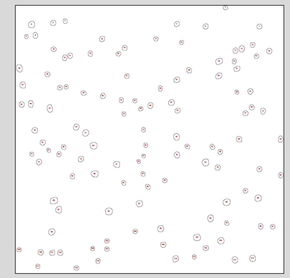


TEM images are analyzed to determine size and density

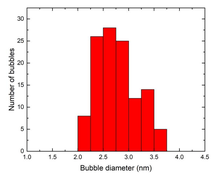
TEM image of He bubbles within Pu matrix



He bubble image analysis - Fitting



He bubble image analysis - Distribution

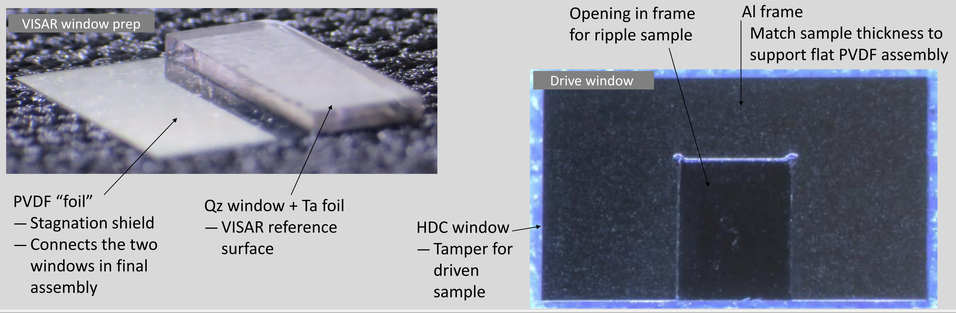


	Specification	Measured
Average Diameter	1-2 nm	2.5 nm
Standard Deviation	--	0.4 nm
Total Bubble Count	--	118
Approximate Bubble Density	1-3 x 10^{17}/cm^3	3-5 x 10^{17}/cm^3

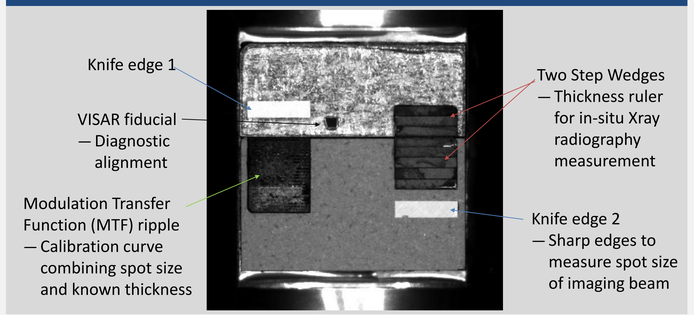
First successful helium implant completed

- Goals for the next run:
  - —improve bubble size and density
  - —update the vacuum system to simplify installation and retrieval
  - —improve thermal control during implantation
  - —increase turn around time and
  - —better control size and density

Low Z assembly in main machine shop



Final PP installed on target



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