Overview of Coating Fabrication Capability Expansion at General Atomics

M. Weir[1], E. Marin[1], H. Xu[1], W. Sweet[1]
General Atomics, P.O.Box 85608, San Diego, CA 92121[1]

CUSTOM COMPOSITION AND THICKNESS ADDITIVELY MANUFACTURED FOILS

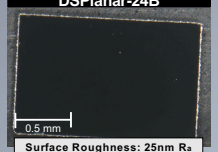
Molybdenum or Tungsten Alloyed with Boron: Comparison of Older and Newer Processes

DSPlanar-22B

Surface Roughness: 149nm Ra

- Historical production utilized a chemical etch release of the film.
- This technique required subjecting the part to strong acids, resulting in damage to the sputtered film alloy.

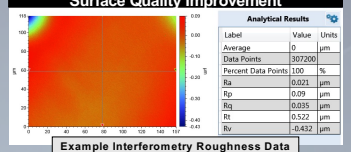
DSPlanar-24B



Surface Roughness: 25nm Ra

- New technique utilizes a mechanical release based on intentionally weak adhesion of the sputtered film to its substrate.

Surface Quality Improvement



Example Interferometry Roughness Data

- By eliminating the exposure to chemical solvents, the resulting film has both low defect density and reduces surface damage.
- This also manifests as a reduction in surface roughness, from ~150nm Ra in DSPlanar-22B to ~25nm Ra in DSPlanar-24B.

Compositional Metrology

- Dual Confocal Microscope measures average thickness.

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- Mass measurements with known dimensions produces average density.

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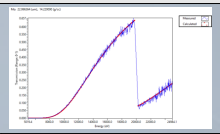
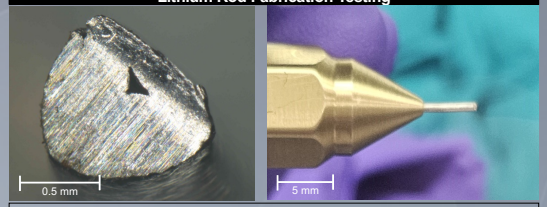


- X-ray transmission spectrum accurately measures W or Mo atomic density.

Combining the three measurements allows the calculation of boron density in an alloy with W or Mo.

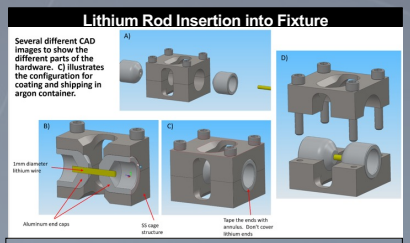
LITHIUM FABRICATION AND PASSIVATION

Lithium Rod Fabrication Testing



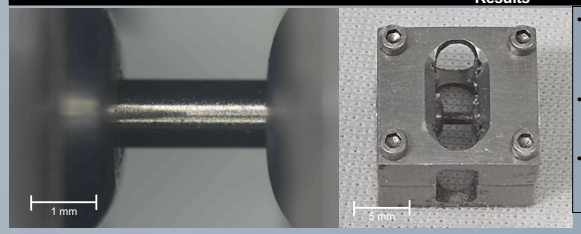
- Different techniques to make lithium rods were attempted.
- Rod rolling was attempted (left), but the malleability of the material resulted in a triangular cross section and a split in the middle.
- Extrusion was successful in making Li rods of desired thickness.

Lithium Rod Insertion into Fixture



- This new design calls for Lithium rods placed within a fixture then overcoated with parylene coatings to reduce the lithium oxidation rate.
- Ends of the lithium rod were peened to ensure contact and stability within the fixture.

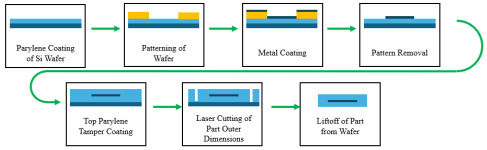
Results



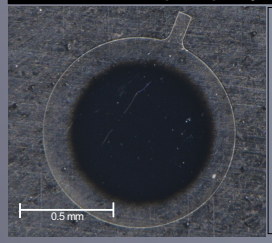
- High quality extruded lithium wires were fabricated, assembled into a fixture, and coated with a thick parylene layer without exposing the parts to an oxygen environment.
- The parylene coating was able to extend the lifespan of the parts in an oxygen environment from the scale of seconds to the scale of hours.
- This technique could be expanded to passivate other lithium parts.

URANIUM ALLOY COATINGS

Fabrication Process of Tamped Metals



Example: Opacity-24A



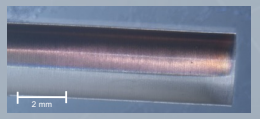
- Uranium and silicon were co-sputtered to produce the tamped microdots.
- A full batch of parts was manufactured in 2 days.

High Throughput

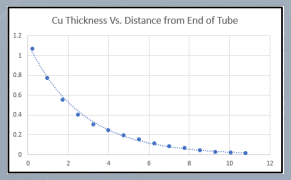
- Hundreds of parts can be manufactured in a single batch due to the use of semiconductor manufacturing techniques

COATING OF INTERNAL STRUCTURES

Tube Interior Coatings



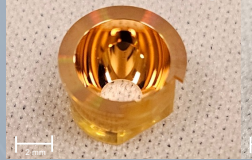
- Tube interiors were able to be Cu coated while masking half of the tube surface surface radially.



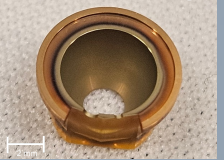
- Thickness gradients were able to be mapped by x-ray transmission, showing an exponential decay, which was predicted.

Hohlraum Liner Coatings

Hohlraum Before Coating

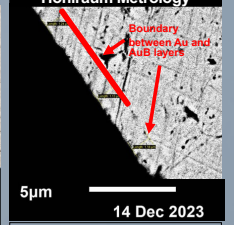


Hohlraum After Coating



- A gold/boron alloy was sputtered into a hohlraum after the hohlraum was machined and leached.
- This allows an expansion in hohlraum liner material capabilities, as the liner is not exposed to leaching chemistries. Therefore, liner design does not need to be considered for its resistivity to acids or bases.
- This technique also increases part throughputs and reduces production risks, as batch coating is no longer required, and failure analysis can be conducted each step of the process.

Hohlraum Metrology



- The boundary between the Au and AuB layers was subtle, but able to be measured with secondary electron imaging in SEM.
- Auger and XPS were used to evaluate the resulting coating composition.

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