Improving Reproducibility in Sputtered Beryllium and Graded Copper Doped Beryllium Capsules

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Improving Reproducibility in Sputtered Beryllium and Graded Copper Doped Beryllium Capsules

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One of the designs for the NIF ignition targets is a Graded Copper Doped Beryllium Capsule

- Several magnetron sputtering systems are dedicated to producing these capsules
  - These systems are located at General Atomics in San Diego and at Lawrence Livermore National Laboratory in Livermore
  - The systems were all assembled at different times with varied gun components, chambers, and configurations

- We needed to minimize the natural variations in coating properties from system to system
The argon variation within and between the systems needed to be reduced

- The atomic percent of argon varied from run to run and from coater to coater
- The radial argon profile also varied
The coating system with the highest yield of target quality capsules was evaluated

- We wanted to improve the reproducibility of the S2 system and duplicate those results in the other coaters
  - Careful measurements of the system were taken
  - Hard stops and other positioners were designed and installed to decrease run-to-run variability
Even after engineering, argon results were still varied and did not correlate with changes

- **We designed a simple experimental matrix**
  - Changed one parameter slightly (ie, gun to pan distance)
  - Results were not reproducible
  - Trends were not evident

We did not see identical argon results when run conditions were duplicated

Stepped variations did not indicate any trends
A run with more than one sized mandrel was completed

- Different profiles were observed and were related to mandrel size
  - This holds true in all 3 coater systems

The smaller the mandrel, the higher the initial Argon; but the steady state Ar value stayed the same.
The smallest darkshield-to-target gap results in the lowest initial argon.
Final Ar values are not affected by the darkshield position.
**Gun-to-pan distance optimization**

- Steady state argon increased as the distance from the gun to the pan decreased.

**Graph:**

- S2NIF493-04: 2071um Man OD
- S2NIF491 2071
- S2NIF494-06: 2080 mand OD

**Text:**

493 compare ~2000 mandrel
493; gun 0.125" closer to pan
Increased mandrel quantity increases the Ar concentration
After careful alignment, argon profiles were reproducible and consistent.
An additional change may result in lower argon concentration. Lower argon concentration will increase the likelihood of ignition.
The copper coating rate fluctuated

- The point design requirements could not be met without recalibration for every run

- We needed to optimize our process to improve reproducibility
We optimized the position of the copper gun

- The copper gun was repositioned to minimize any shadowing
Copper deposition rates stabilized

- Rates were consistent within each coater, but not from coater to coater
  - We were not able to standardize gun position due to chamber configuration restraints
Coaters all demonstrate nonlinearity between copper wattage and deposition rate

- Expect to see linearity between watts and at % Cu
  - Three times the power should equal three times the concentration
- All coaters show the same deviation
  - To increase from 0.5 to 1.5 atomic % Cu, it is necessary to apply 3.6 times more power

<table>
<thead>
<tr>
<th>Cu Goal</th>
<th>0.5 at %</th>
<th>1.5 at %</th>
<th>W2/W1</th>
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<tr>
<td></td>
<td>Watts 1</td>
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<tr>
<td>GA Coater</td>
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<td>S6 Coater</td>
<td>3.4</td>
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Summary of Argon optimization

- We were able to reduce the run to run and system to system variability of the argon profile with careful calibration of the coating systems.

**Argon Results before Calibration**

**Atomic % Argon vs. Thickness (um)**

**Argon Results after Calibration**

**Atomic % Argon vs. Thickness (um)**
Summary of Copper optimization

- Two of the coaters have been tested and routinely meet specifications

<table>
<thead>
<tr>
<th>Date</th>
<th>Run Number</th>
<th>Cu Goal</th>
<th>Cu Actual</th>
<th>In Spec?</th>
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Further Production Goals

- We plan to modify the coater configuration to reduce the argon concentration
- We will re-optimize the copper for all systems as we finish the argon modifications