Overview of the Requirements and Construction of Targets for Experiments on OMEGA and OMEGA EP

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Complex targets have been developed for three experimental campaigns

- **Cryogenic Compton radiography campaign**
  - 60-beam OMEGA laser implodes a cryogenic capsule with 100-\(\mu\)m-thick DT ice
    - Issue: tolerances on backlighter position relative to the capsule source

- **Two-plamon-decay experiments**
  - a 200-\(\mu\)m-diam molybdenum (Mo)-coated capsule co-centered with a GDP capsule
    - Issue: centering the two capsules to \(\pm 50 \, \mu\)m (radius) and reducing the seam size

- **Polar-drive shimmed (PDS) target**
  - the PDS capsule has a constant inner radius and a varying wall thickness
    - Issue: wall-thickness variation and mounting strategy
Compton radiography cryogenic target assembly requires strict tolerances

- The capsule implosion is backlit with x rays (60 to 200 keV) to image the core

Point-projection gold microwire positioning tolerances

- ±2° (pixel resolution)
- ±25 μm (OMEGA EP pointing, image displacement)
- ±50 μm (OMEGA EP pointing)

Au microwire backlighter

\[(\theta, \phi)_{\text{normal}} = (90°, 72°)\]
Constructing the target assembly is a multi-step process

1. 250-μm-diam Be wire is formed at 400°C in a geometry avoiding beam interferences
2. 10-μm-diam gold wire array is assembled and characterized
3. Be wire, backlighter subassembly, and target holder are assembled on a fixture
4. 14-μm-diam PBO fibers (Zylon) are constructed in a tripod arrangement
The capsule is positioned and joined to the target mount

- The completed assembly is measured using the Nikon software package
Cooling the Compton radiography target to 15 K induced dimensional changes (<100 μm) that are manageable. This suggests a 200-μm-diam core can be imaged.
Integrated two-plasmon-decay experiments on OMEGA will address electron coupling for direct-drive implosions

Symmetric or polar drive

- "Preheat" is from laser/plasma interaction-generated electrons (50 to 150 keV) that can reduce compressibility
- The amount of preheat is measured by the Kα yield of a molybdenum capsule inside a 20-μm-thick GDP capsule
- Requirements
  - ≥30 μm molybdenum on inner capsule
  - seam must be gap-free
  - concentricity to ±50-μm radius

860-μm-diam CH capsule

200-μm-diam Mo-layered capsule

XRS absolutely calibrated Mo Kα yield
Using a halfraum assembly approach, a molybdenum-coated capsule* is centered inside two hemispheres

1. Machine-matched sets of hemispheres (same wall thickness, measurement error $\pm 0.3 \, \mu m$; outer diameter, $\pm 5 \, \mu m$); to be completed at GA

2. Insert molybdenum-coated capsule using (a) formvar or (b) spider silk; add viscous glue to the seam to prevent laser light going into the center; to be completed at LLE

*J. Jaquez, General Atomics.
A prototype target was made using formvar to center the inner capsule.

218-\(\mu\text{m}\)-diam glass capsule co-centered to 8 \(\mu\text{m}\) of the GDP capsule outer diameter.

Seam is in view, glass capsule is centered to 9 \(\mu\text{m}\) of the outer diameter; seam width \(\sim 90 \mu\text{m}\).
Mounting the inner sphere using spider silk is another viable approach to achieve ±50-μm concentricity requirement.

Challenges:
- reduction of adhesive at seam
- handling molybdenum coating on 140-μm-diam glass

Top view

Glass capsule is within 20 μm of center of the GDP capsule

Side view

Glass capsule is within 14 μm of center of the GDP capsule
Results

The fraction of hot electrons reaching the cold shell is measured using Mo-coated capsules.

These experiments currently provide an upper bound on the fraction of hot electrons that reach the cold shell (preheat).
Polar-drive shimmed (PDS) targets have been fielded on OMEGA

• 40-beam OMEGA shots
• Asymmetric intensity
• Displaced pointing

A shimmed capsule will implode uniformly, compensating for the asymmetric illumination.
A polar-drive shimmed target uses a capsule with variable wall thickness.

\[ \theta = 0^\circ \]

\[ \theta = 90^\circ \]

Capsule thickness to compensate for 10% prolate intensity.

Shell thickness (\(\mu m\)) vs. \(\theta\) (°)
Polar-drive shimmed targets are machining intensive

(1) Water-soluble epoxy

(2) Dissolve adhesive, rotate 180°

(3) Turn pattern on other side

(4) Add fiducial, dissolve adhesive
Transferring the capsule requires precision fixturing
Machined capsules are coated, characterized for gas retention, and fielded from a planar moving cryostat.

Capsule sent from General Atomics, then Al sputter coated for gas retention.

Room-temperature moving cryostat with a spherical target (positioning accuracy <10 μm, 1-h shot cycle).

Advantages:
• Orientation
• Symmetry

Challenges: machining and accounting for orientation and gas retention.
Results

Framed radiographs of polar-driven target implosions on OMEGA show improved implosion symmetry with target shimming

10 atm, D₂-filled, 27-μm-thick CH capsules, imploded with triple-picket pulses from 40 OMEGA beams, 14 kJ on target, backlit with Ti x-ray emission at 4.7 keV

The shimmed capsule implodes more uniformly with this beam pointing (120-, 140-μm offsets for Rings 2 and 3).
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