Solid Collection Efforts: Ta Collimator Evaluation

J. M. Gostic

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Ta collimator sets that were part of the gated x-ray detector diagnostic (GXD) at NIF were analyzed for debris distribution and damage in 2011. These disks (ranging in thickness from 250 to 750 µm) were fielded approximately 10 cm from target chamber center (TCC) on various symcap, THD and re-emit shots. The nose cone holder and forward Ta collimator (facing target chamber center, TCC) from all shots show evidence of surface melt. Non-destructive analysis techniques such as optical microscopy, surface profilometry, scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), and x-ray fluorescence (XRF) were used to determine debris composition and degree of deformation associated with each Ta disk. Molten debris from the stainless steel nose cone contaminated the surface of the collimators along with other debris associated with the target assembly (Al, Si, Cu, Au and In).

Surface elemental analysis of the forward collimator Ta disks indicates that Au hohlraum debris is less concentrated on these samples versus those fielded 50 cm from TCC in the wedge range filter (WRF) assembly. It is possible that the Au is distributed below or within the stainless steel melt layer covering the disk, as most of the foreign debris is captured in the melted coating. The other disks (fielded directly behind the forward collimator in a sandwiched configuration) have visible forms of deformation and warping. The degree of warping increases as the shock wave penetrates the assembly with the most damage sustained on the back collimator. In terms of developing a solid collection capability, the collimator analyses suggests that close proximity may cause more interference with capsule debris collection and more damage to the surface of the collector diagnostic.

The analyses of the Ta collimators were presented to the Target and Laser Interaction Sphere (TaLIS) group; a representative presentation is attached to this document.
Ta Disk Analysis

10/1/2010
Shot Profile

• Date: 11/24/2009    Shot ID: N091120-002-999
• Laser Energy: 843.54 kJ

Disk Information

• Distance to TCC
  – 0-0, 100 mm
  – 0-315, 80 mm
Configuration

Ta Disks with 120–150 µm holes for collimator

Kapton Disks

Ta Disks with, 120 – 150 µm holes for collimator
0-0 Disk 1 (100mm)

Serial Side (facing TCC)

Back Side (away from TCC)

Stainless steel melt on surface

Glue residue from Carbon tape, from SEM analysis
0-315, Disk 1 (80 mm)

Serial Side (facing TCC)  Back Side (away from TCC)
0-0, Disk 2 (100 mm)

Serial Side (facing TCC)  Back Side (away from TCC)
0-315, Disk 2 (80 mm)

Serial Side (facing TCC)  Back Side (away from TCC)
0-0, Disk 3 (100mm)

Serial Side (facing TCC)

Back Side (away from TCC)
0-315, Disk 3 (80 mm)

Serial Side (facing TCC)  Back Side (away from TCC)
0-0, Kapton Disks

Between Ta Disks 1 and 2

Between Ta Disks 2 and 3
0-0, Kapton Disk 1
Surface Deformation

Surface penetration, back side crater formation
0-0, Kapton Disk 2
0-315, Kapton Disks

Disk 1, between Ta disks 1 and 2

Disk 2, between Ta disks 2 and 3
0-315, Kapton Disk 1
Surface Deformation

Collimator Holes, high degree of melt, front surface

Little surface penetration, back side
Microscope Images
Disk 1, 0-0 (100 mm)
• High degree of surface melt
• Holes were covered by the melt and irregular in shape
• Area of holes ranged from 700 to 14,000 µm²
SEM Image of Surface, Disk 1 0-0

Collimator Region

Edge Region

N = 65 holes remaining
Disk 1, 0-315 (80 mm)
- High degree of surface melt, covered entire disk
- Most of the holes are still visible, some irregular holes in edge region
- Area of holes ranged from 19,200 to 24,500 µm²
SEM Image of Surface, Disk 1 0-315

Collimator Region
N = 111 holes remaining

Edge Region, surface melt extends to outer boundary
EDS Analysis

Disk 1, 0-0 (100mm)
Debris

Disk 1, 0-0 (100mm)

Microscope Images
• Debris is scattered over the middle region of the disk (around collimator holes and melt)
• Diameter of splats ≤ 100 µm

SEM Imaging & EDS Analysis
• Disk is Ta but there is a stainless steel (Cr, Fe, Ni) layer on top

Disk 1, 0-315 (80mm)

Microscope Images
• Debris is scattered over the entire disk
• Diameter of splats ≤ 200 µm

SEM Imaging & EDS Analysis
• Disk is Ta but there is a stainless steel (Cr, Fe, Ni) layer on top
0-0 Disk 1 Serial Side - Debris
EDS Analysis

Surface Composition: Ta (62), Fe (26), Cr (7), Ni (3), Al (2)

1. Cu (64), Fe (21), Cr (6), Si (6), Ni (3)
2. Cu (84), Fe (7), Al, Si, In, Cr (2), Ni (1)
3. Fe (54), Cr (15), Al (12), Au (7), Ni (7), Ta (5)
4. Fe (33), Al (28), Ta (26), Cr (9), Ni (4)
5. Al (61), Fe (23), Cr (7), Ni, Ta, Au (3)
6. Fe (54), Cr (15), Al (13), Ta 11, Ni (6)
7. Al
8. Ta
9. Cu (62), Si (34)

Surface Composition: Ta (62), Fe (26), Cr (7), Ni (3), Al (2)
0-315 Disk 1 Serial Side - Debris

50 µm

20 µm
EDS Analysis

Disk 1, 0-315

Identified splats and particles similar to Disk 1 0-0
Common Features

Al particles

Ta particles
Ta Crystals
<table>
<thead>
<tr>
<th>Element</th>
<th>Aluminum</th>
<th>Ta</th>
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<tbody>
<tr>
<td>Al</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Si</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cu</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Au</td>
<td>X</td>
<td>X (very few)</td>
</tr>
<tr>
<td>In</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fe</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cr</td>
<td>X</td>
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<tr>
<td>Ni</td>
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<tr>
<td>Zn</td>
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</tr>
<tr>
<td>C</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Ti</td>
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<td>X</td>
</tr>
<tr>
<td>Mn</td>
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<tr>
<td>S</td>
<td>X</td>
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</tr>
<tr>
<td>Cl</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Ba</td>
<td>X</td>
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</table>
Summary

• Warping/Bowing - difficult to establish
  – Stainless steel melt across the surface of the disks,
  – Dimpling from collimator fabrication
  – Side angle measurements, minimal warping was observed on the second and third disks using pin mount angle measurements
    • Precision surface metrology required

• Hole Degradation
  – Only the primary (facing TCC) disks had hole degradation.
    • 0-0: n=65 holes remaining
    • 0-315: n=111 holes

• Debris Analysis
  – Mainly stainless steel (Fe, Cr, Ni)
  – In, Al, Au, Cu and Si
  – Ta particulates