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Solid Collection Efforts: Ta Collimator Evaluation

J. M. Gostic

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Solid Collection Efforts: Ta Collimator Evaluation

J. M. Gostic

Chemical Sciences Division

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

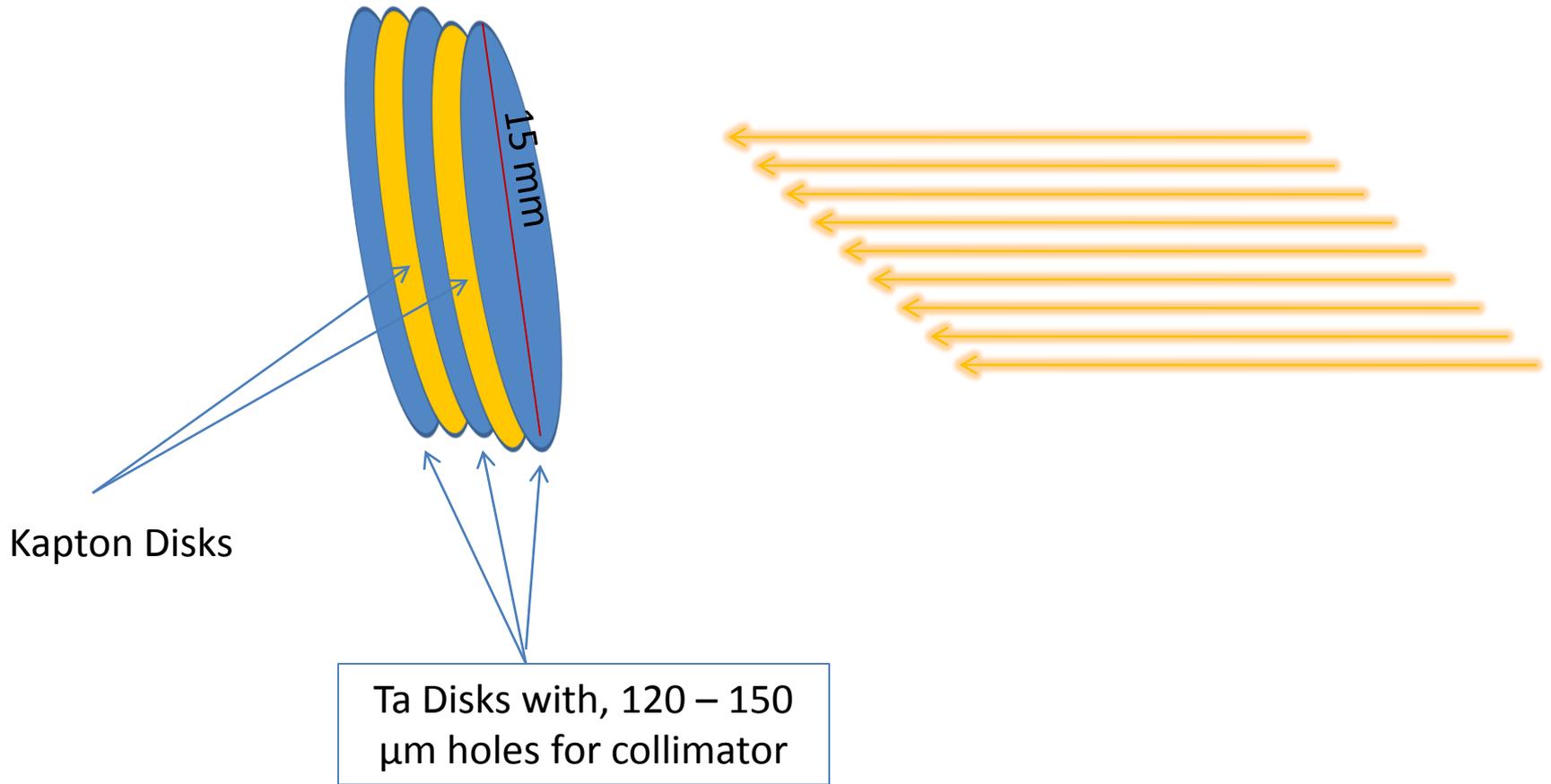
Shot Profile

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

Disk Information

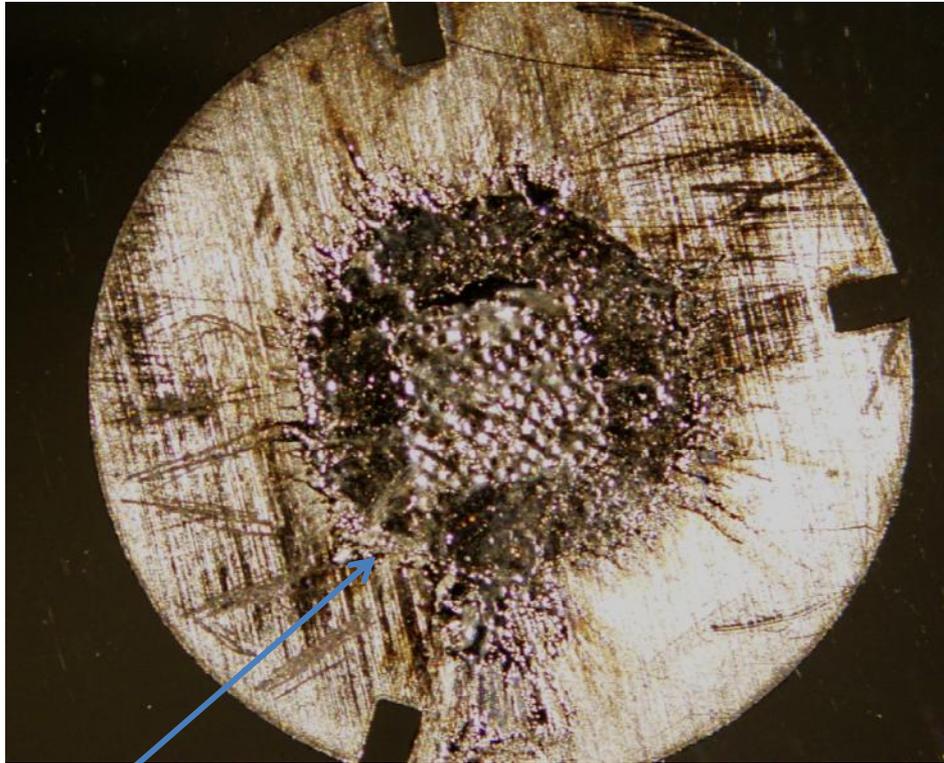
- Distance to TCC
 - 0-0, 100 mm
 - 0-315, 80 mm

Configuration



0-0 Disk 1 (100mm)

Serial Side (facing TCC)



Stainless steel melt on surface

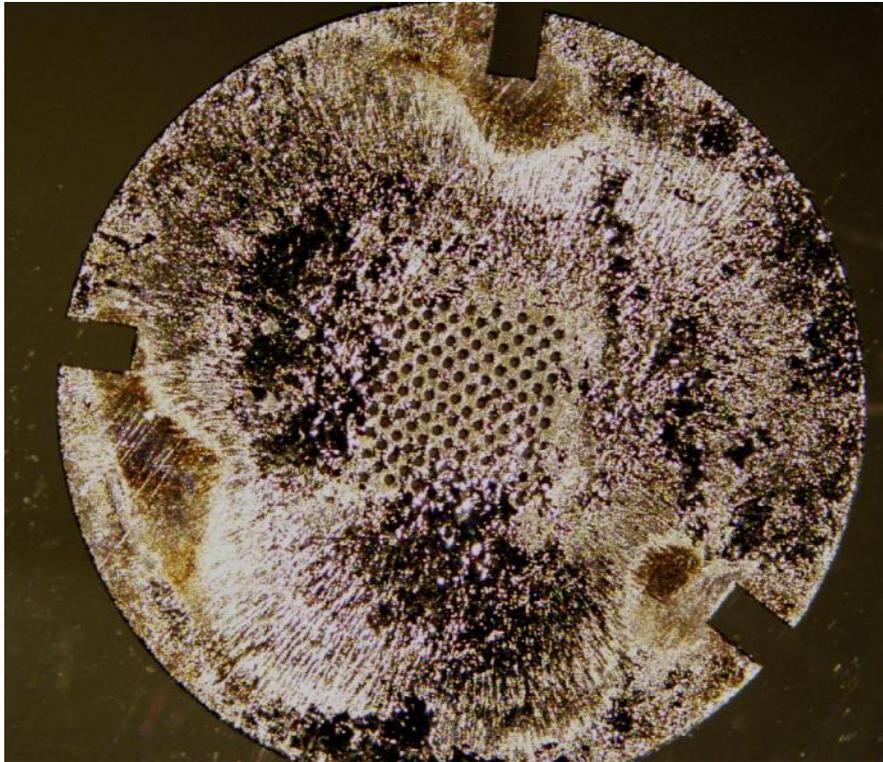
Back Side (away from TCC)



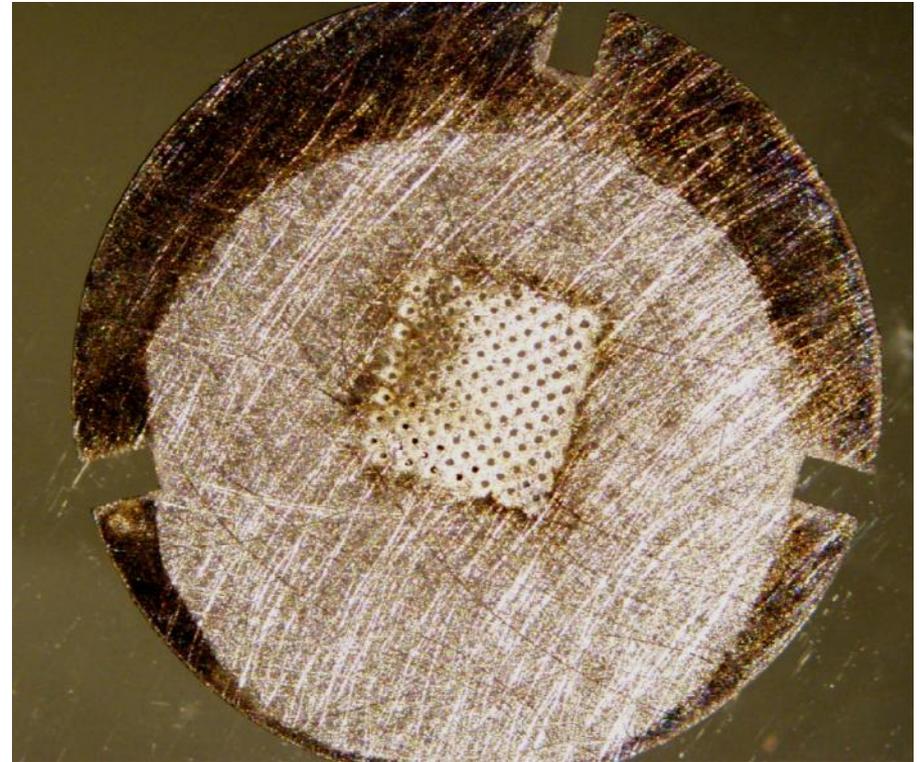
Glue residue from Carbon tape, from SEM analysis

0-315, Disk 1 (80 mm)

Serial Side (facing TCC)

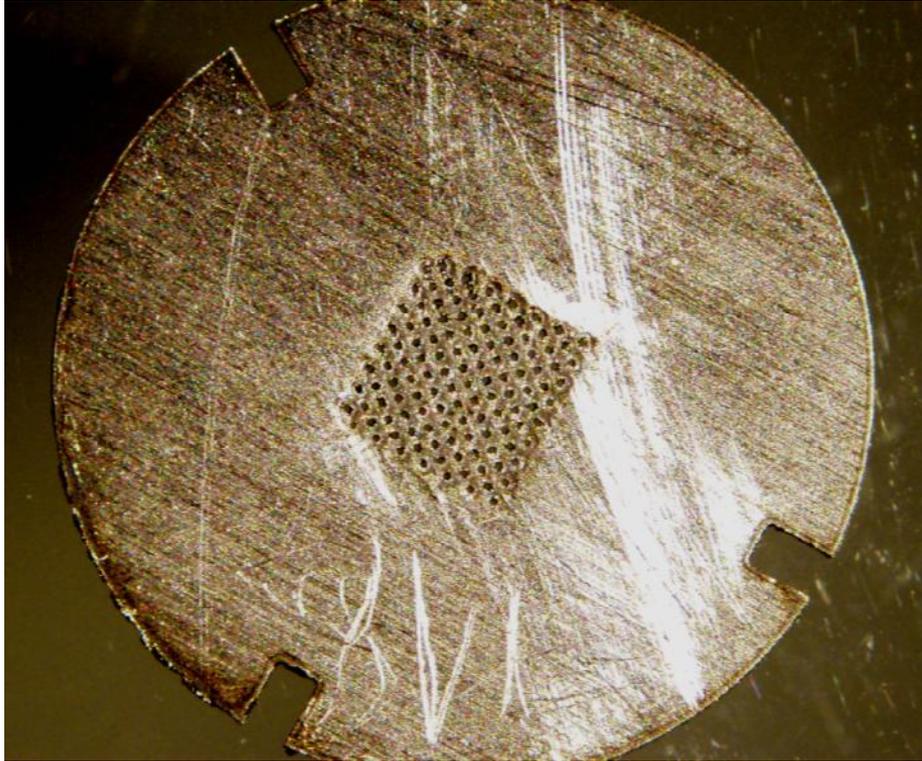


Back Side (away from TCC)

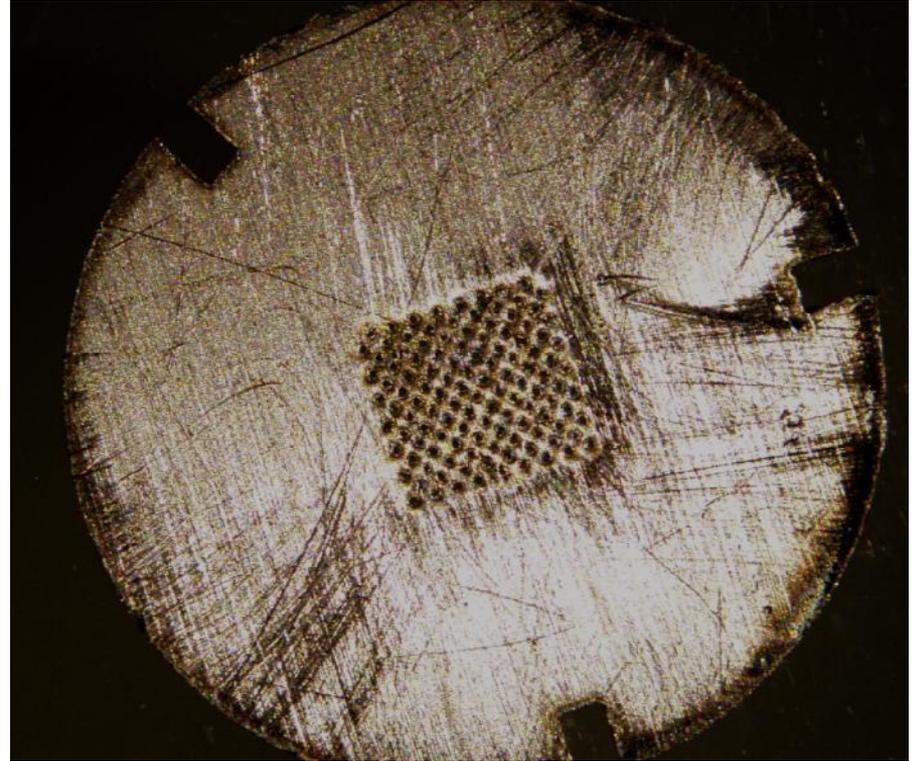


0-0, Disk 2 (100 mm)

Serial Side (facing TCC)

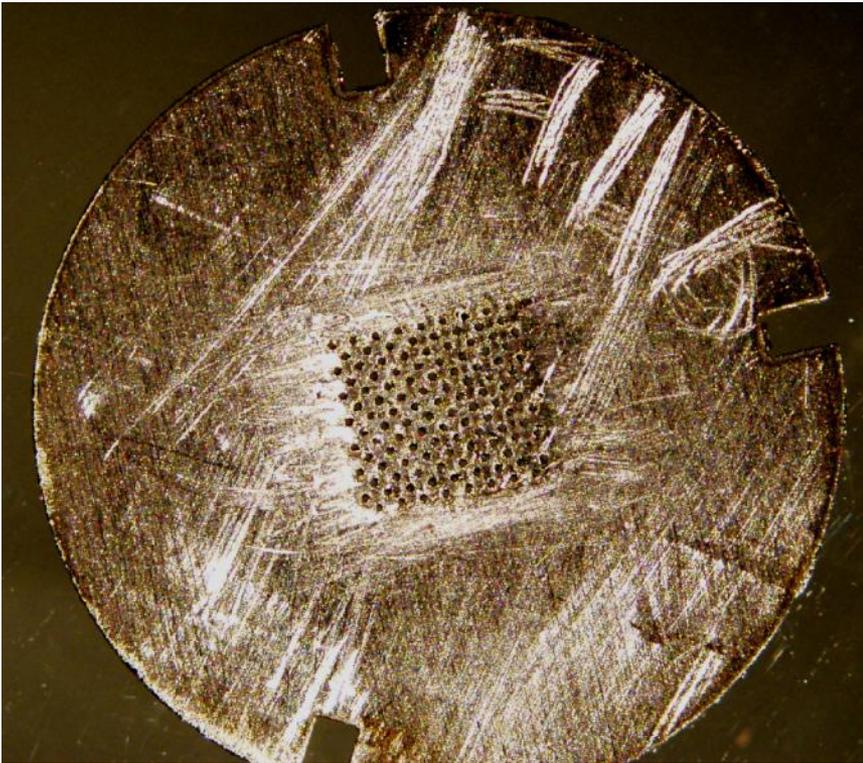


Back Side (away from TCC)

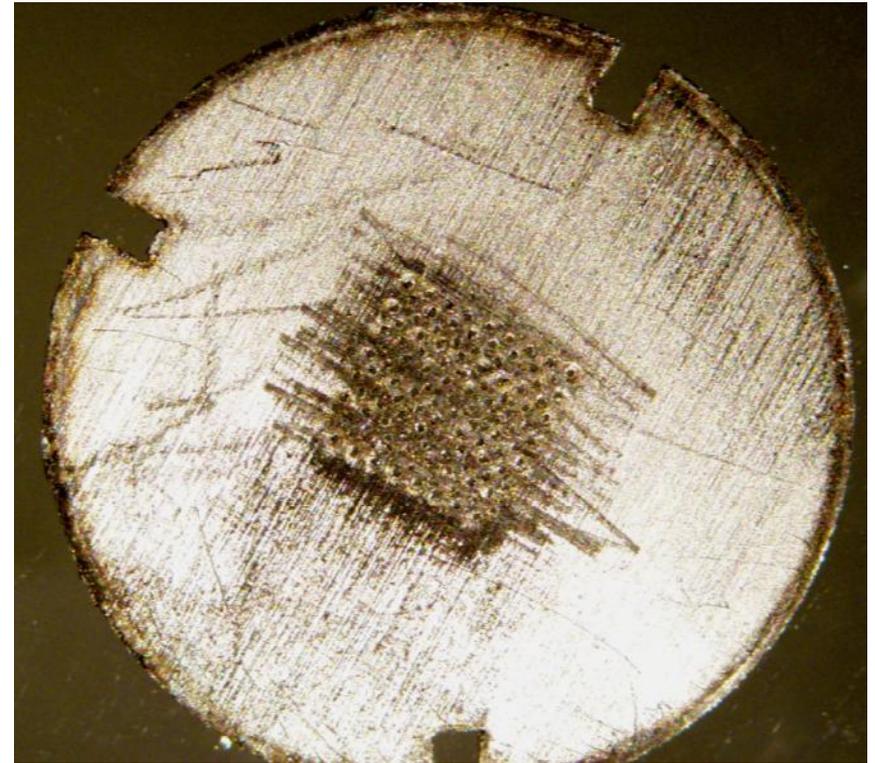


0-315, Disk 2 (80 mm)

Serial Side (facing TCC)

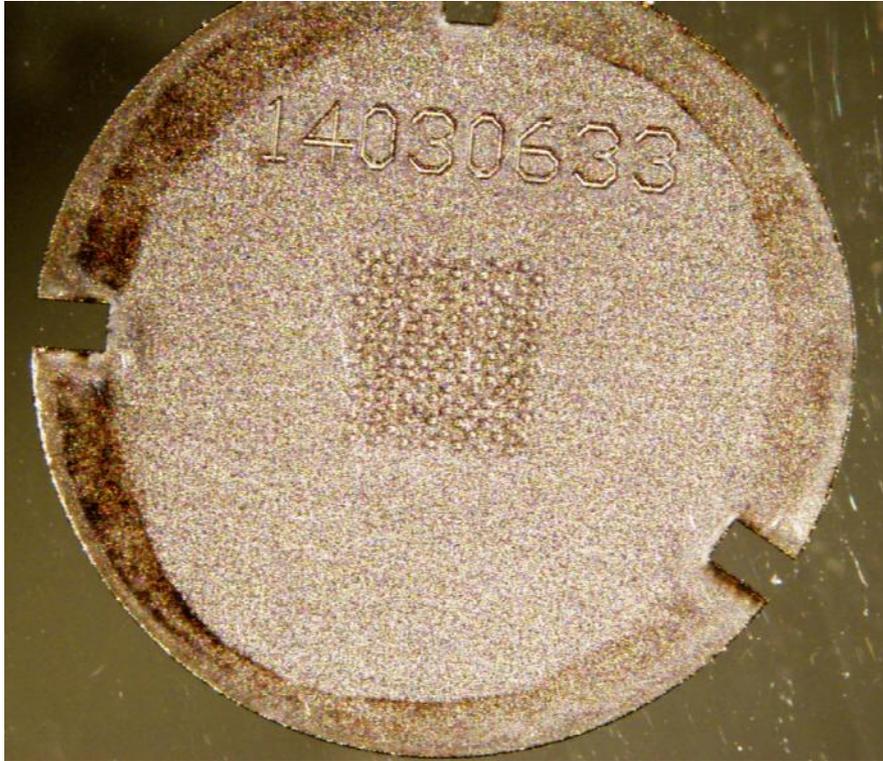


Back Side (away from TCC)

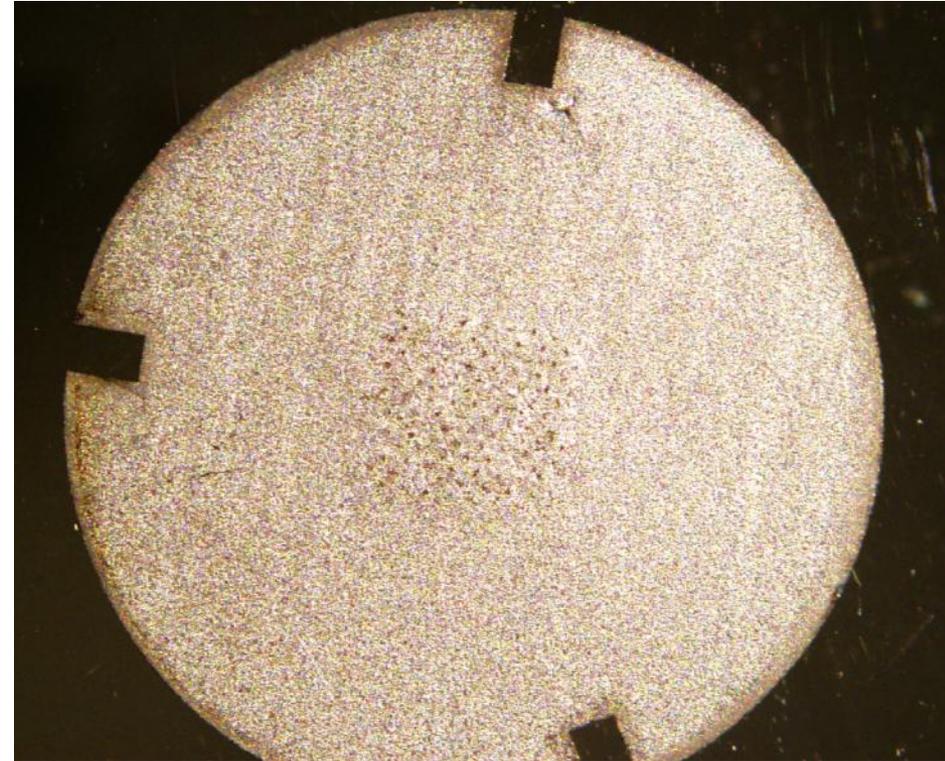


0-0, Disk 3 (100mm)

Serial Side (facing TCC)

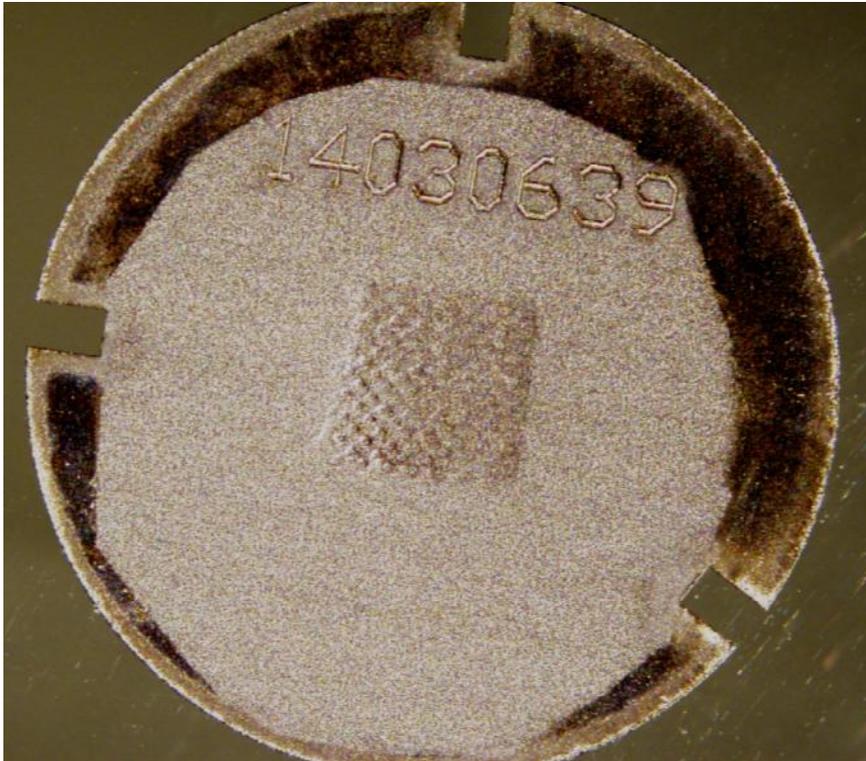


Back Side (away from TCC)

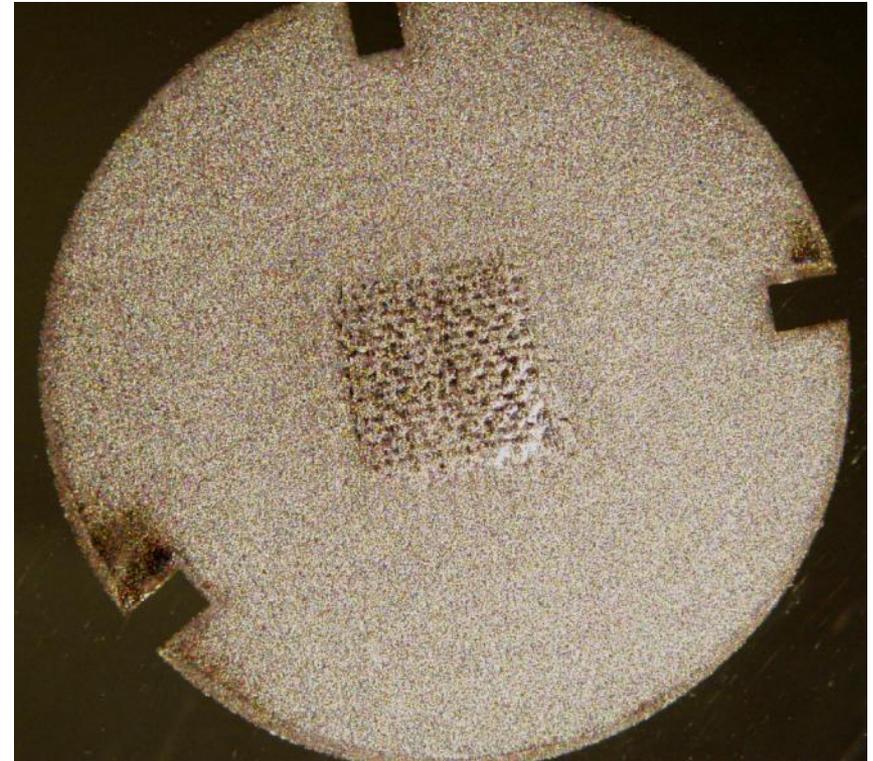


0-315, Disk 3 (80 mm)

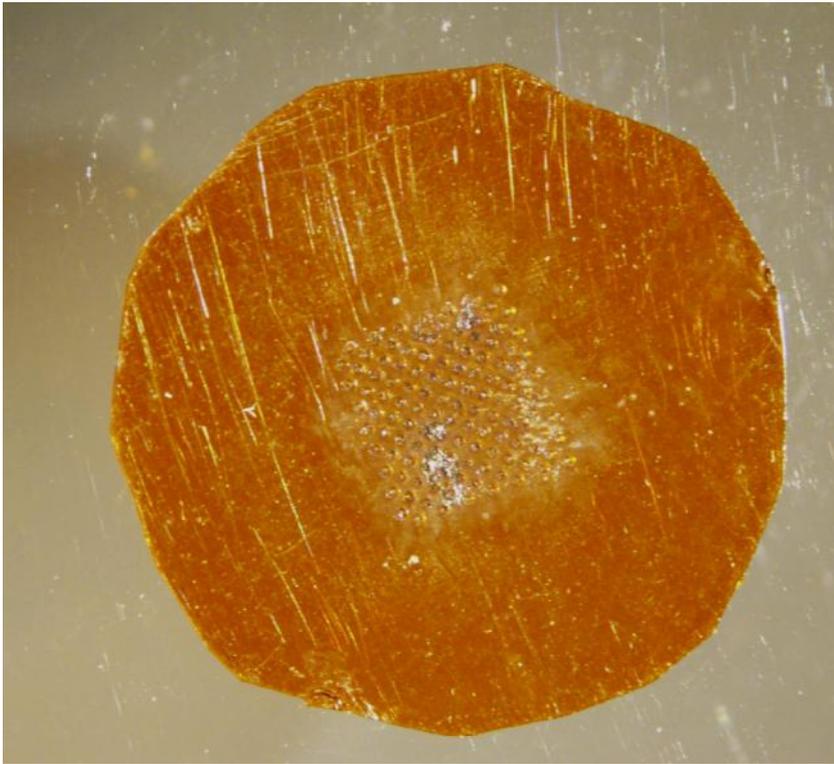
Serial Side (facing TCC)



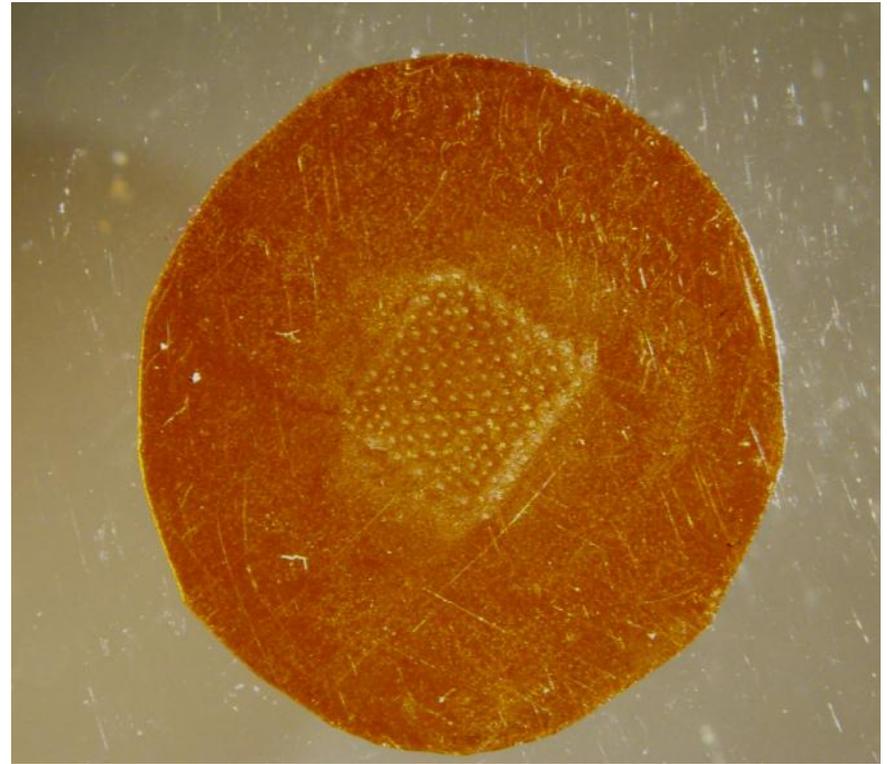
Back Side (away from TCC)



0-0, Kapton Disks

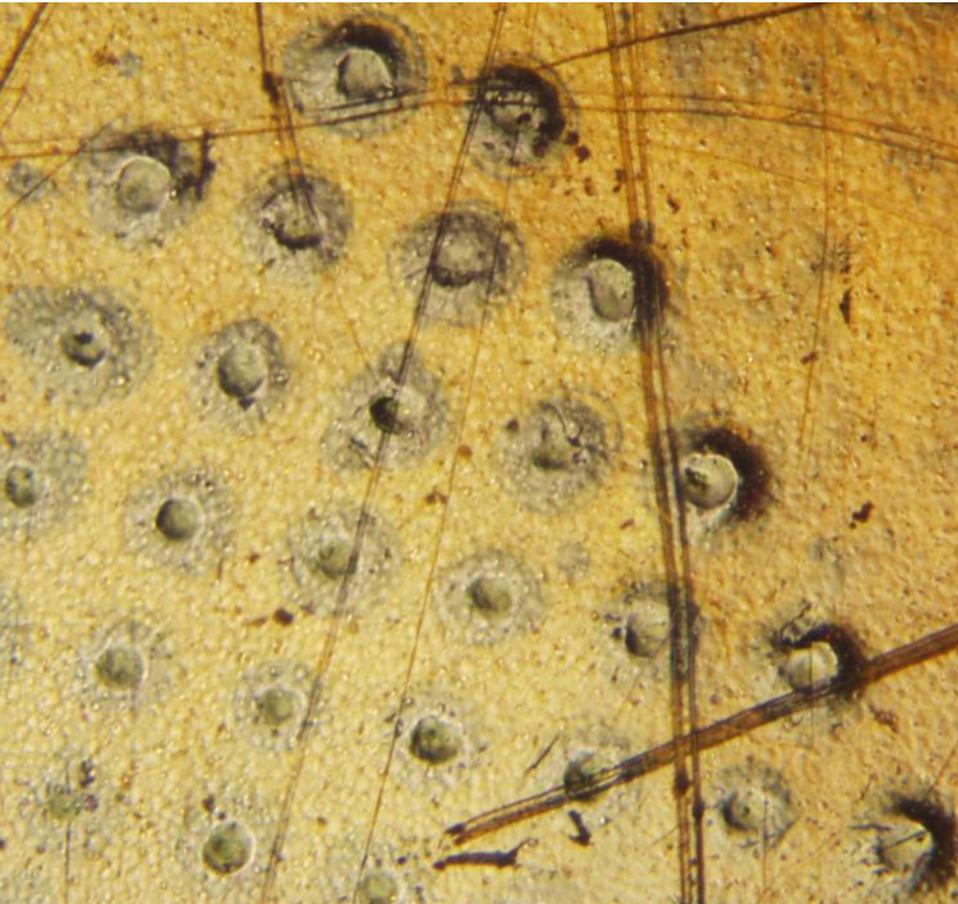


Between Ta Disks 1 and 2

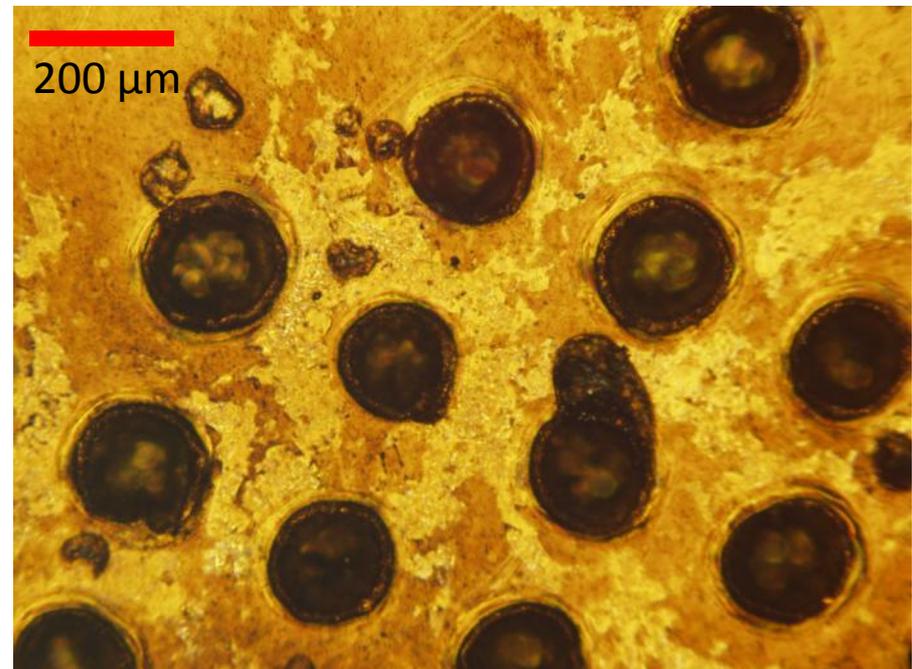


Between Ta Disks 2 and 3

0-0, Kapton Disk 1 Surface Deformation



Surface penetration, back side crater formation

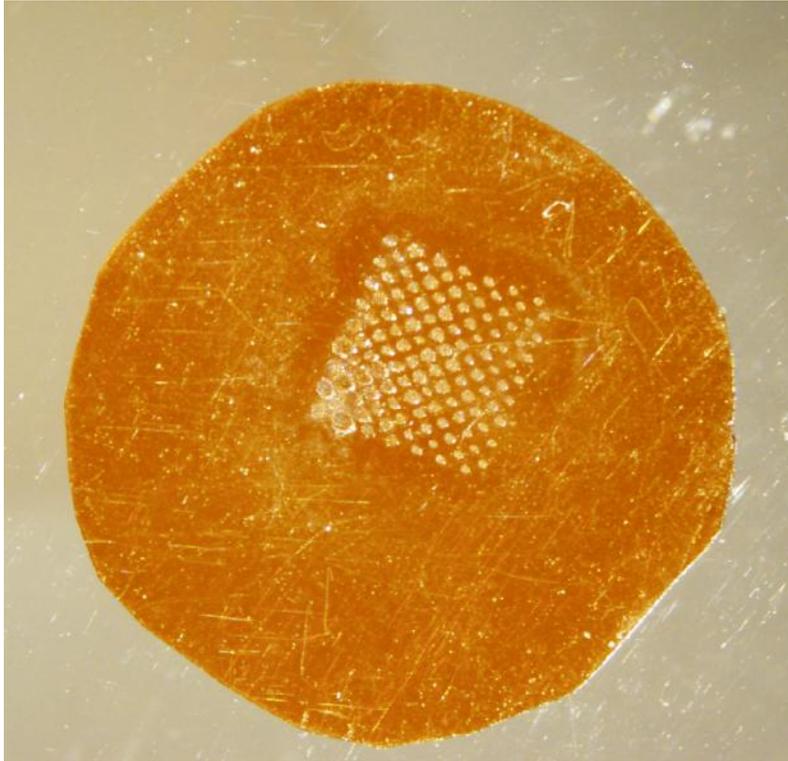


0-0, Kapton Disk 2

100 μm



0-315, Kapton Disks

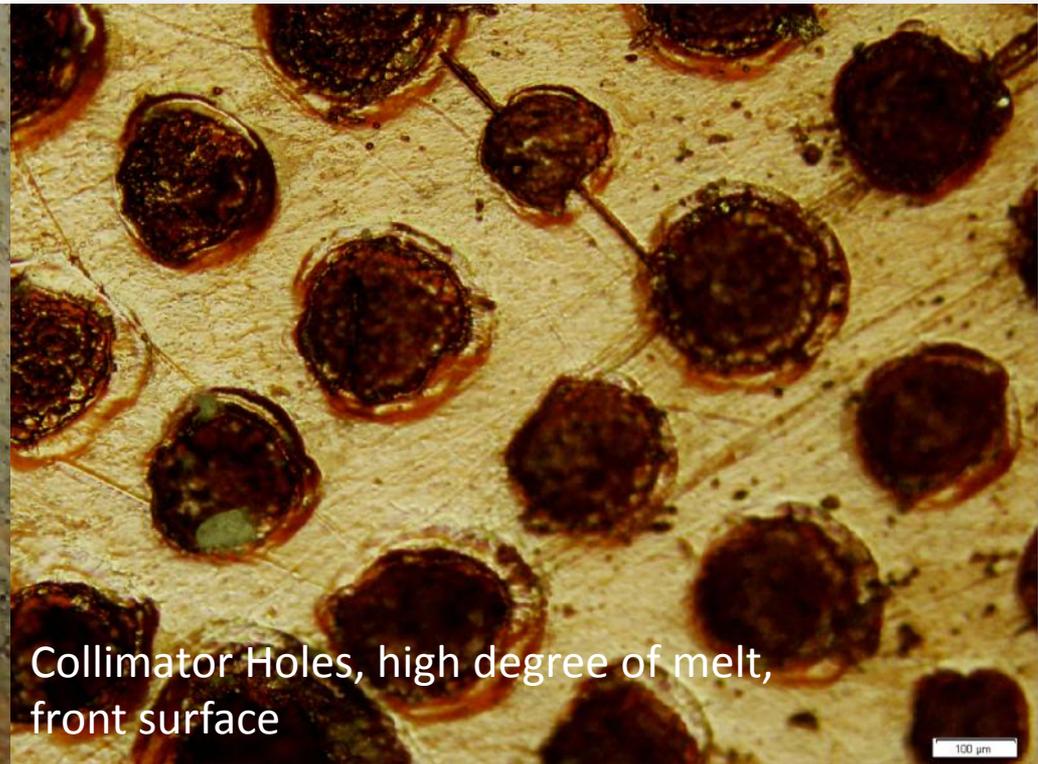


Disk 1, between Ta disks 1 and 2



Disk 2, between Ta disks 2 and 3

0-315, Kapton Disk 1 Surface Deformation

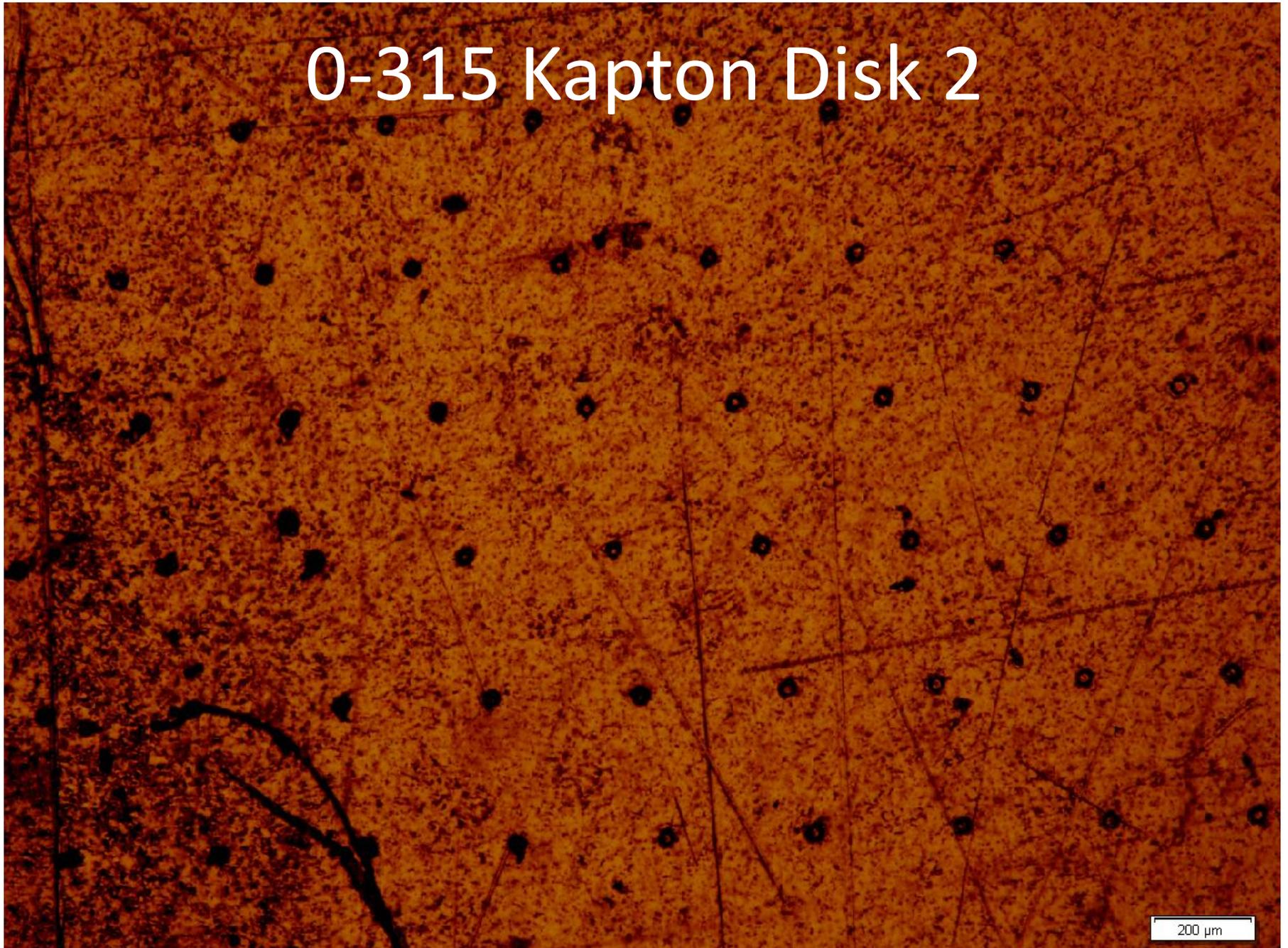


Little surface penetration, back side

200 μm

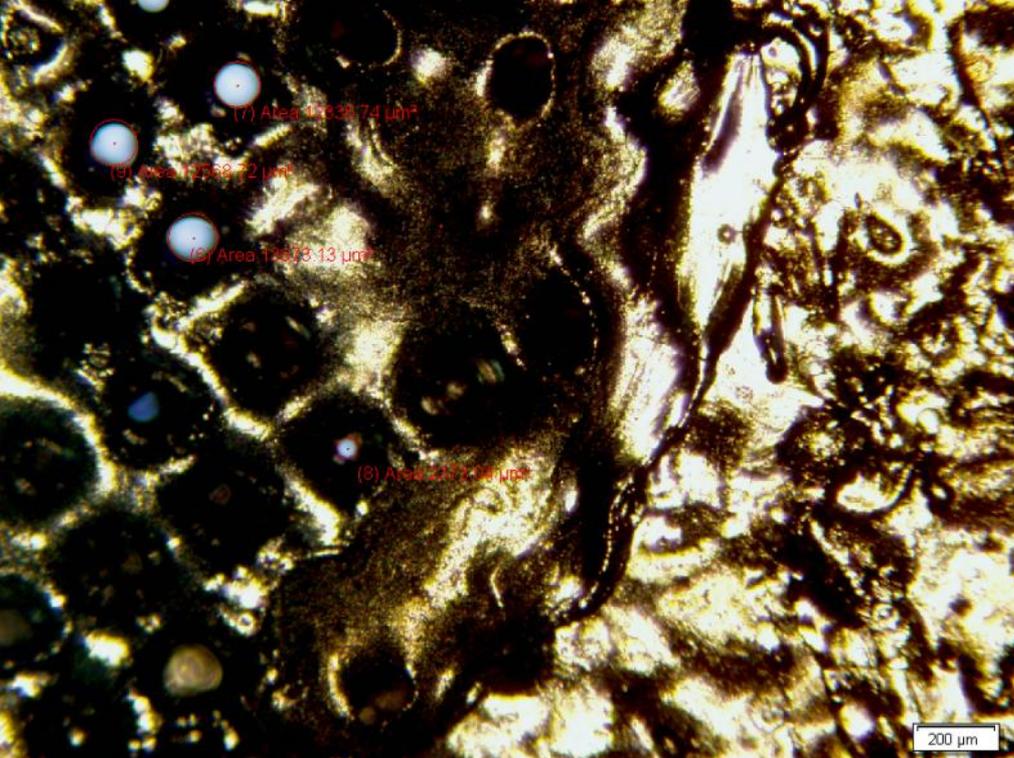
This image shows the back side of the Kapton disk. The surface is a mottled brown and grey color with a rough, textured appearance. There are several fine, dark scratches and fibers visible across the surface. A scale bar in the bottom right corner indicates 200 micrometers.

0-315 Kapton Disk 2



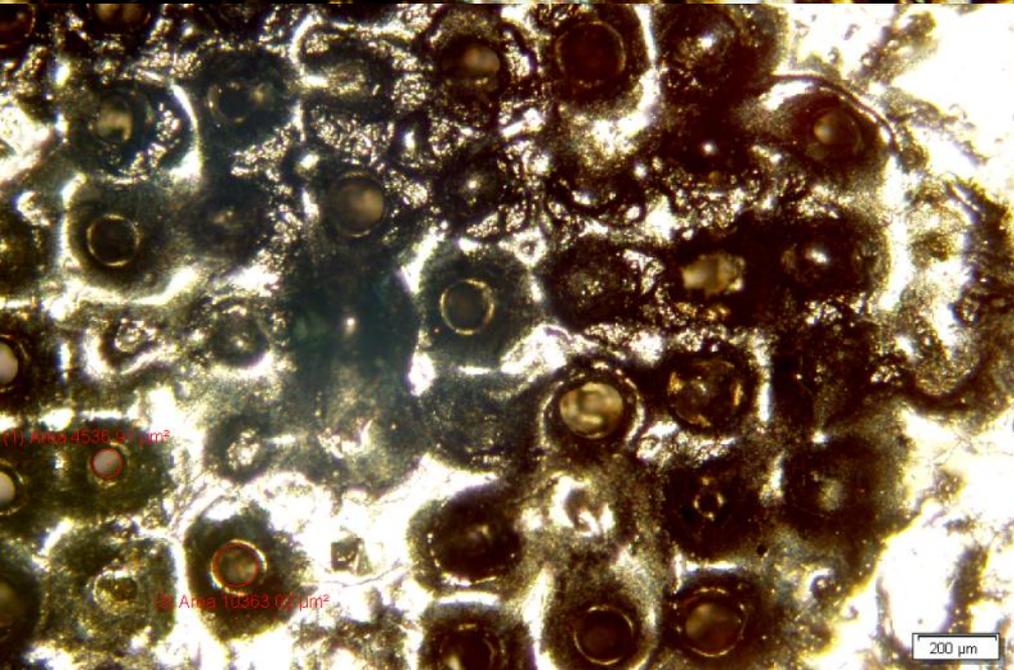
200 μm

Microscope Images

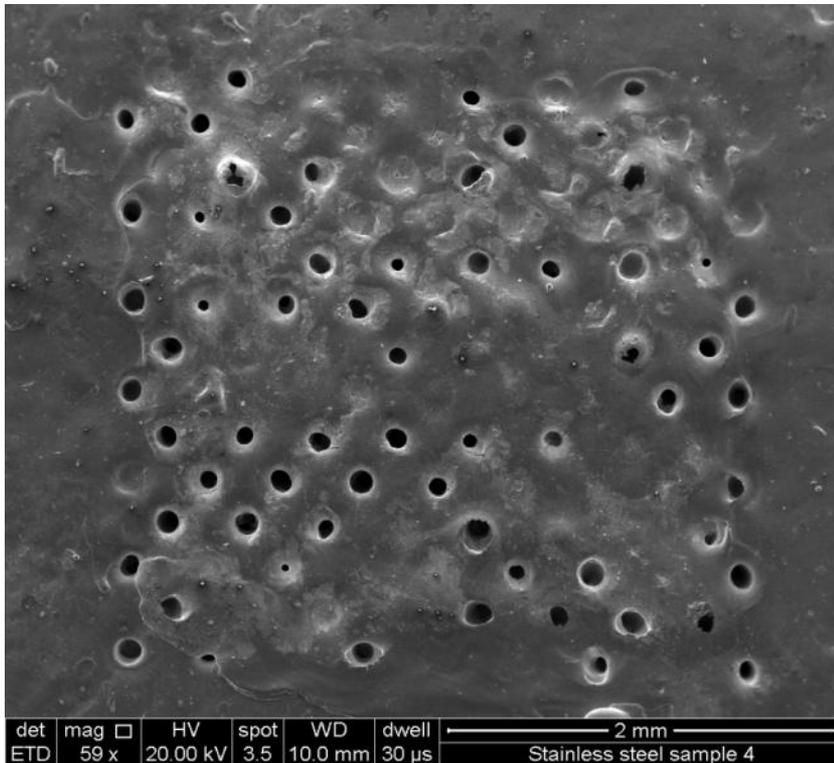


Disk 1, 0-0 (100 mm)

- High degree of surface melt
- Holes were covered by the melt and irregular in shape
- Area of holes ranged from 700 to 14,000 μm^2

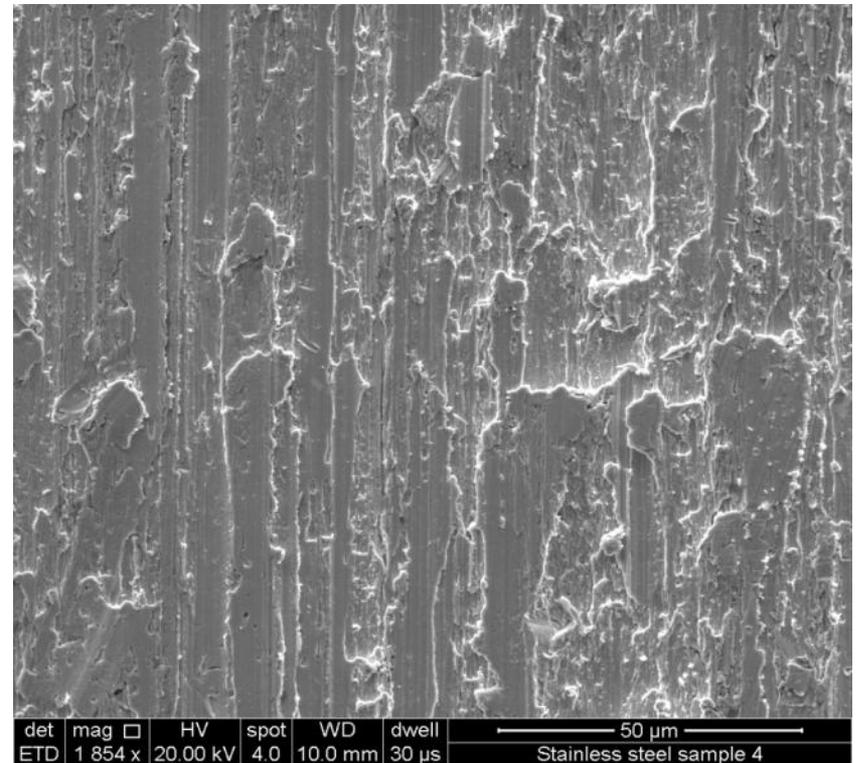


SEM Image of Surface, Disk 1 0-0

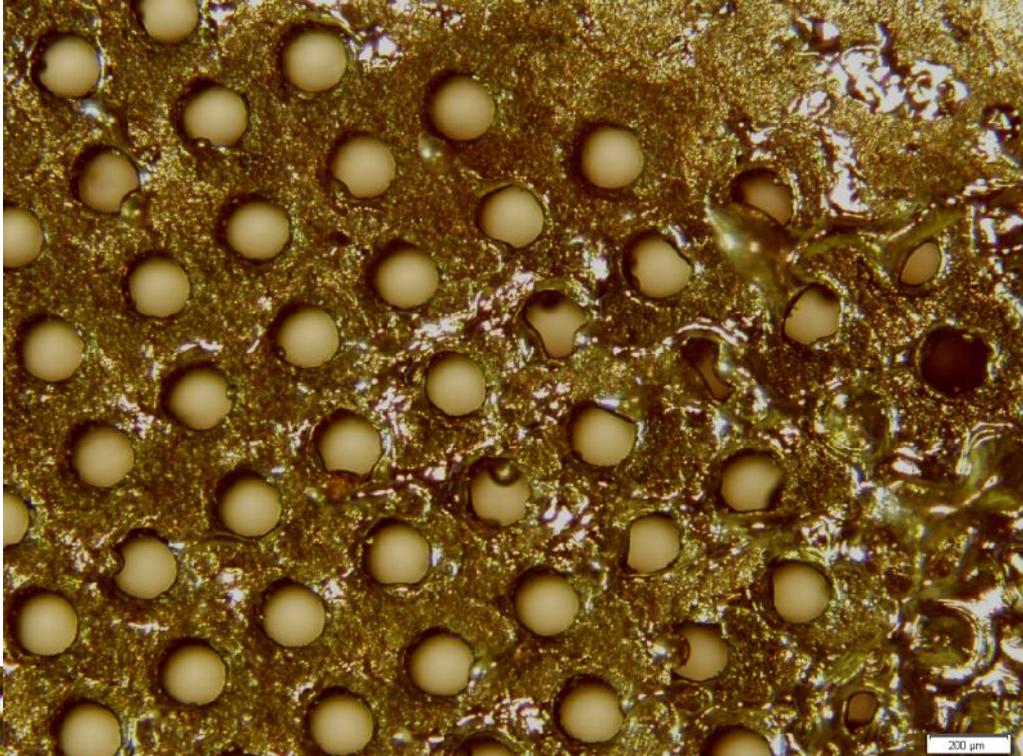


Collimator Region

N = 65 holes remaining

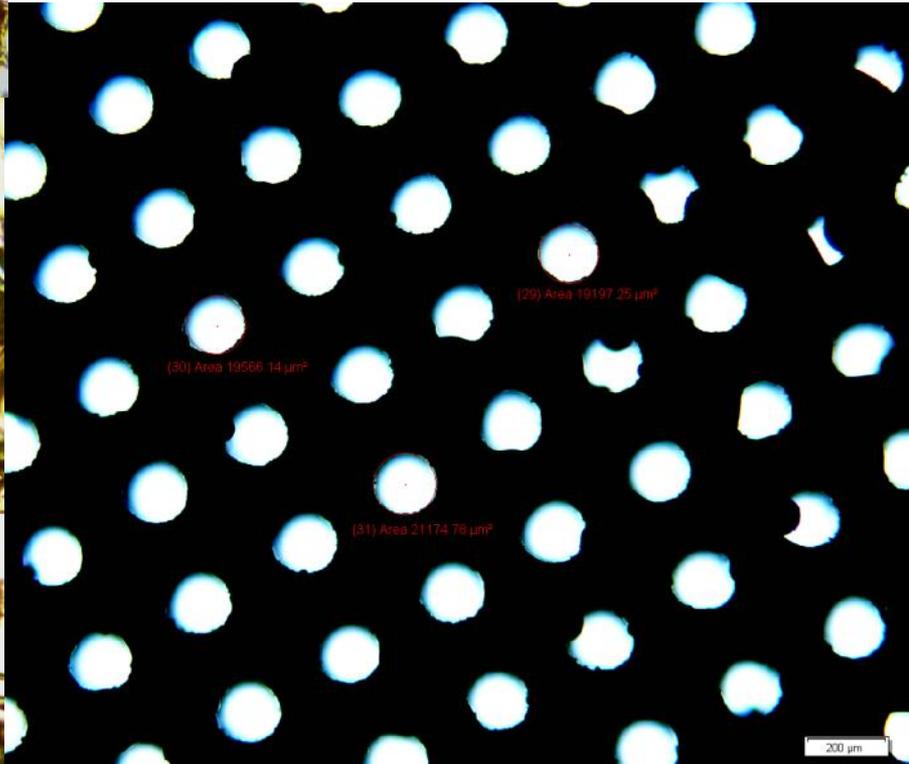
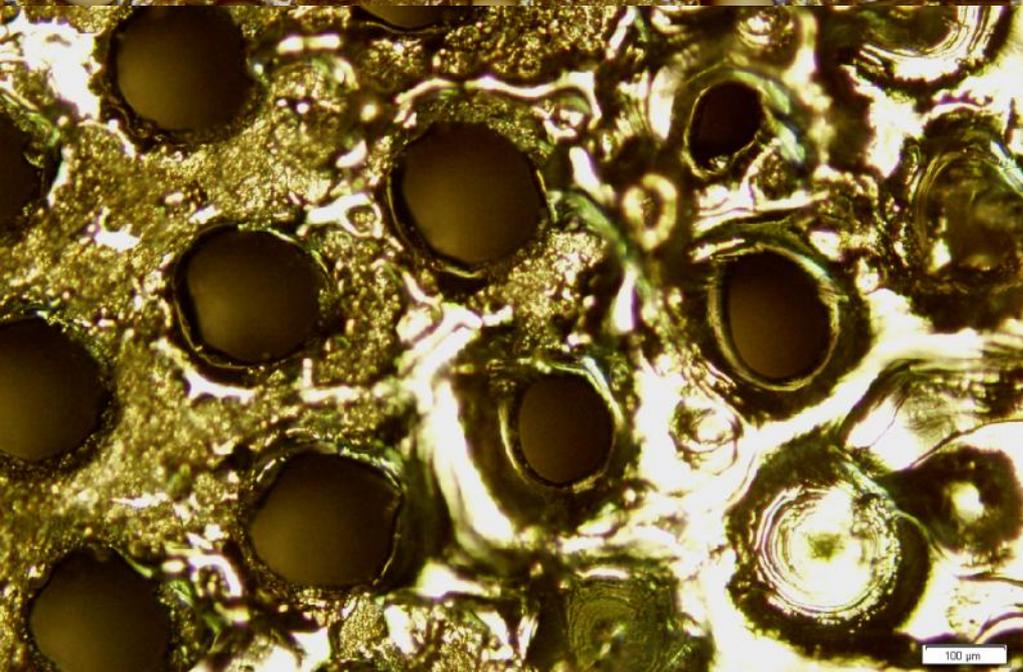


Edge Region

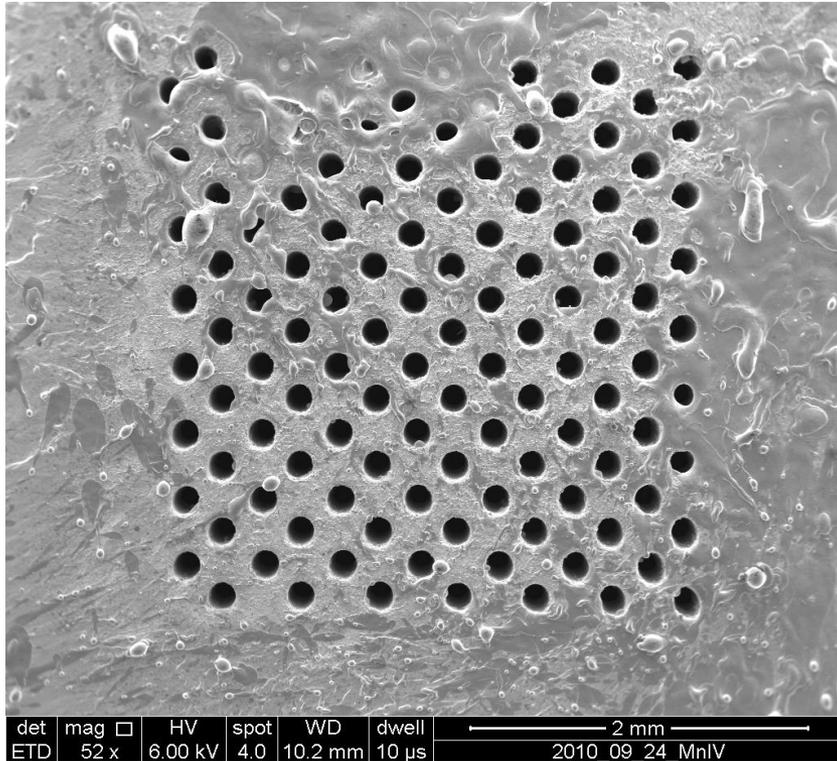


Disk 1, 0-315 (80 mm)

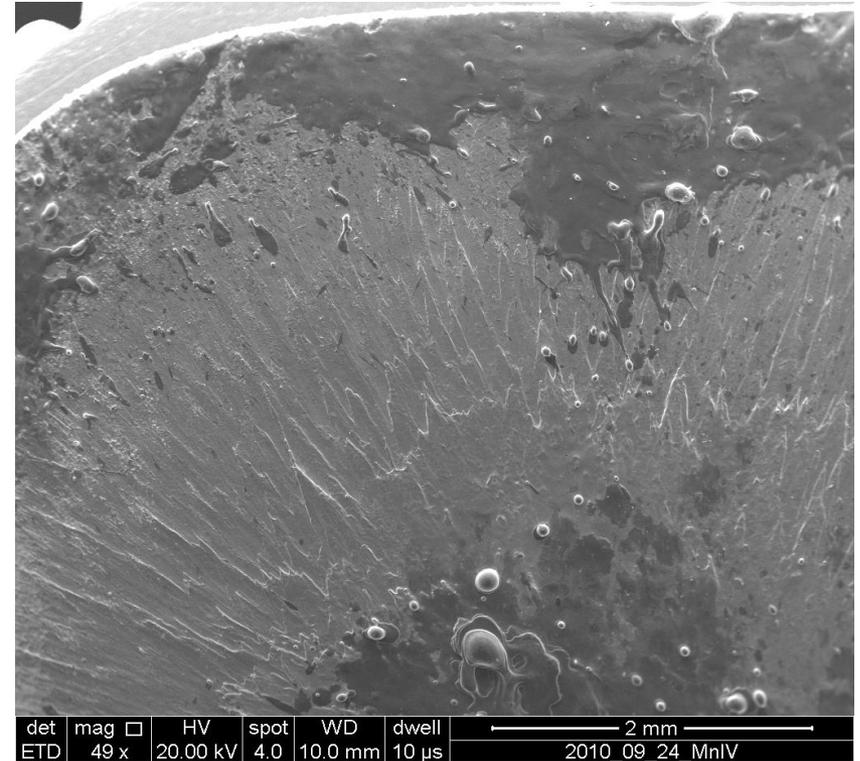
- High degree of surface melt, covered entire disk
- Most of the holes are still visible, some irregular holes in edge region
- Area of holes ranged from 19,200 to 24,500 μm^2



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 $\leq 100 \mu\text{m}$

SEM Imaging & EDS Analysis

- Disk is Ta but there is a stainless steel (Cr, Fe, Ni) layer on top

Disk 1, 0-315 (80mm)

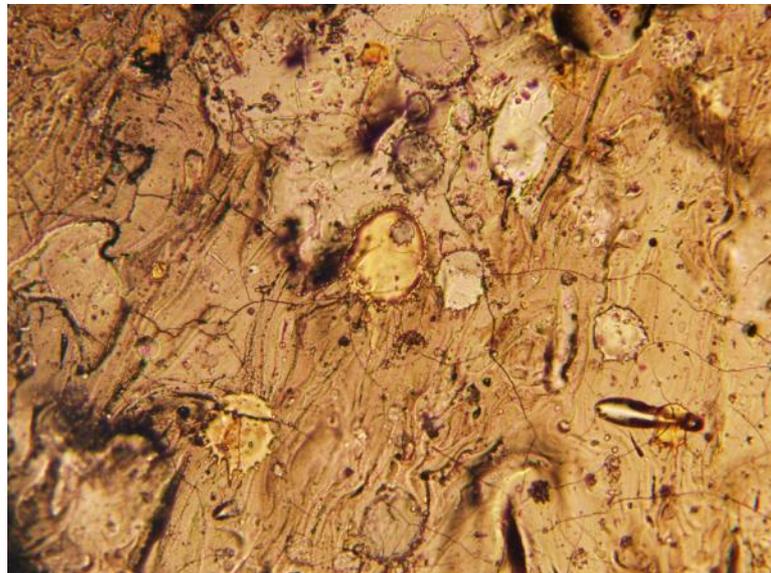
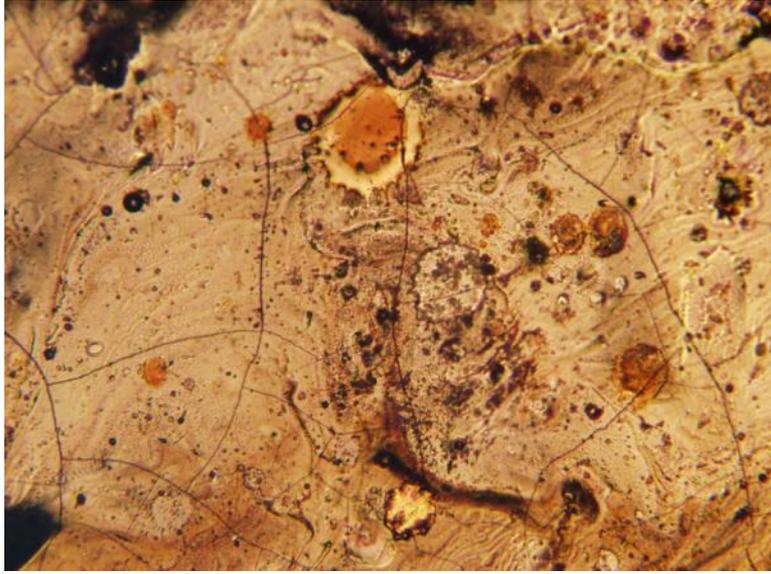
Microscope Images

- Debris is scattered over the entire disk
- Diameter of splats $\leq 200 \mu\text{m}$

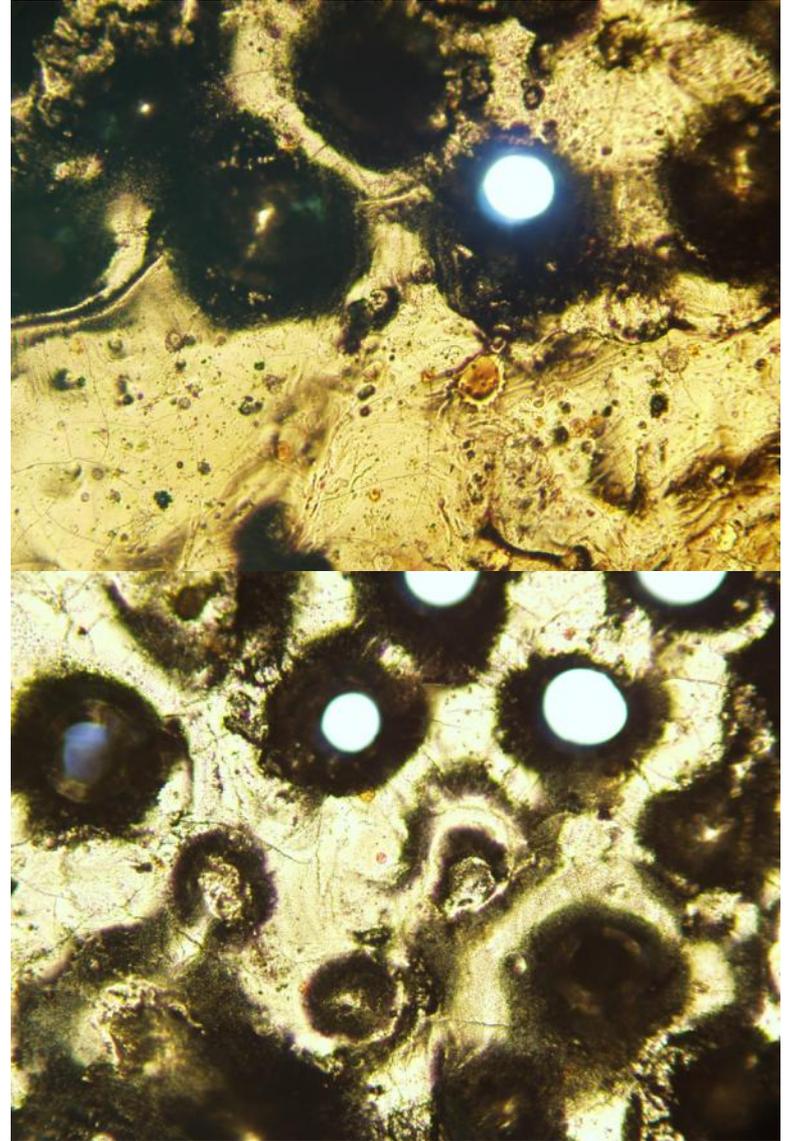
SEM Imaging & EDS Analysis

- Disk is Ta but there is a stainless steel (Cr, Fe, Ni) layer on top

0-0 Disk 1 Serial Side -Debris



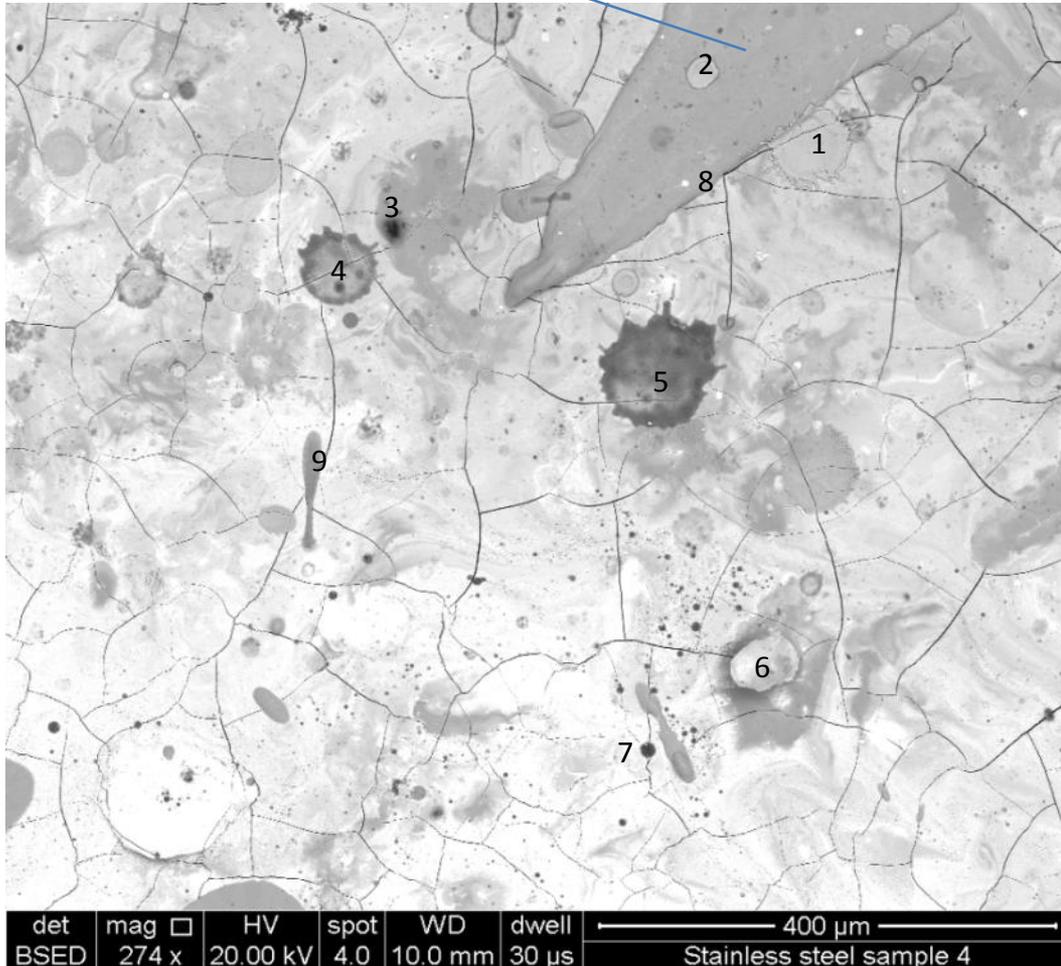
← 50 μm
100 μm →



Stainless Steel

EDS Analysis

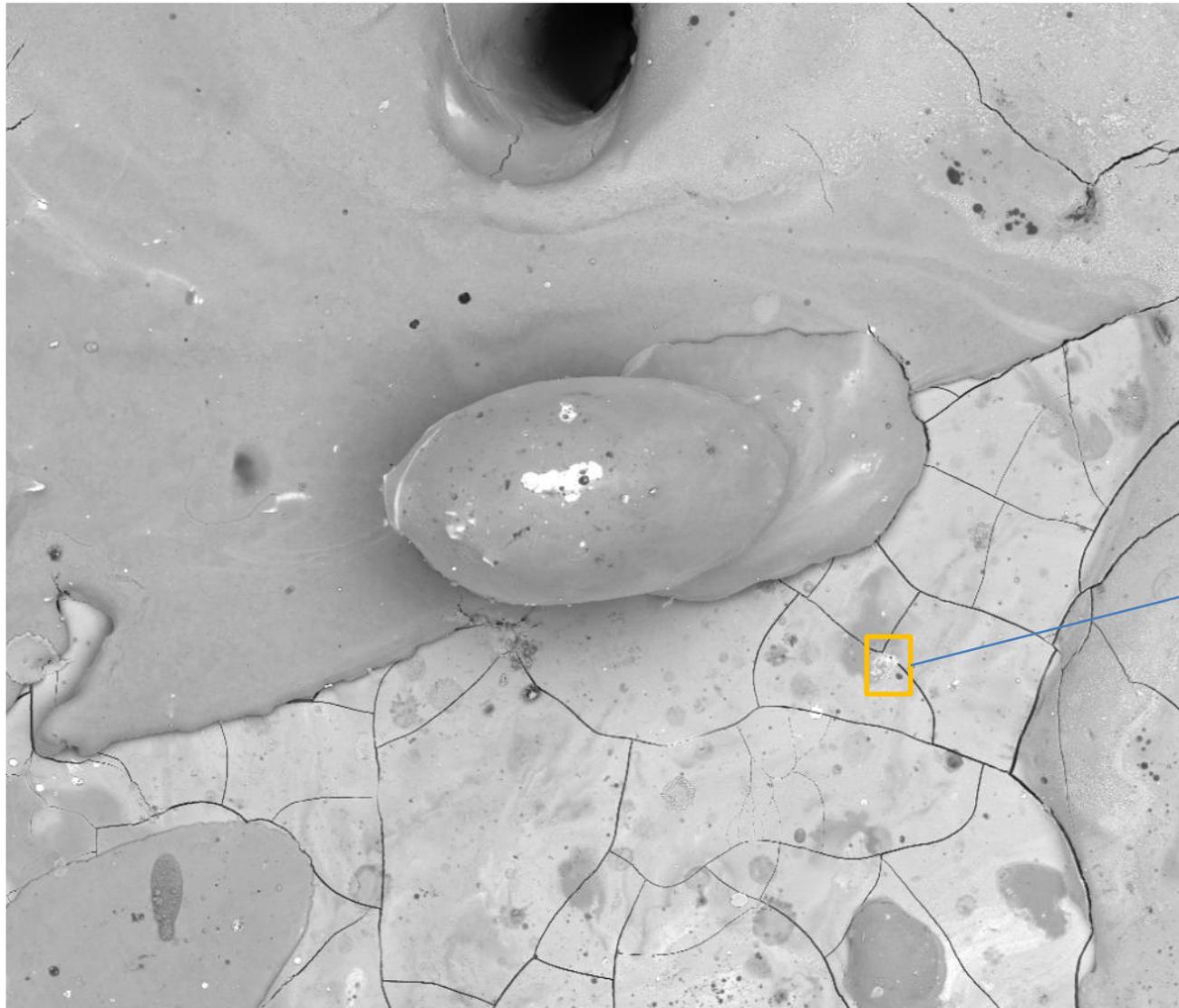
Disk 1, 0-0



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)

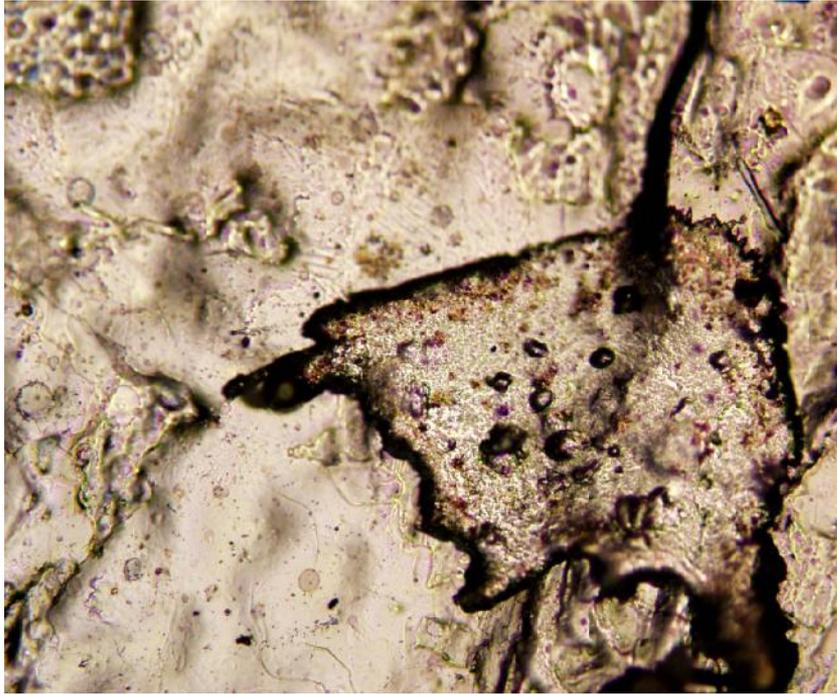
Disk 1, 0-0



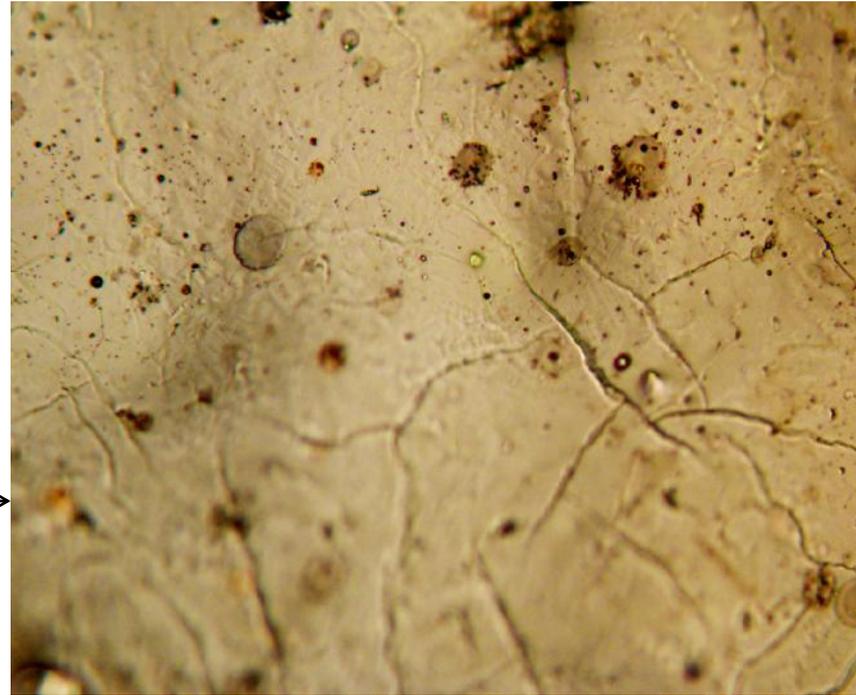
Au splat

det	mag	HV	spot	WD	dwell	300 μ m
BSED	354 x	20.00 kV	4.0	10.0 mm	30 μ s	Stainless steel sample 4

0-315 Disk 1 Serial Side -Debris



← 50 μm
— 20 μm →



EDS Analysis

Disk 1, 0-315



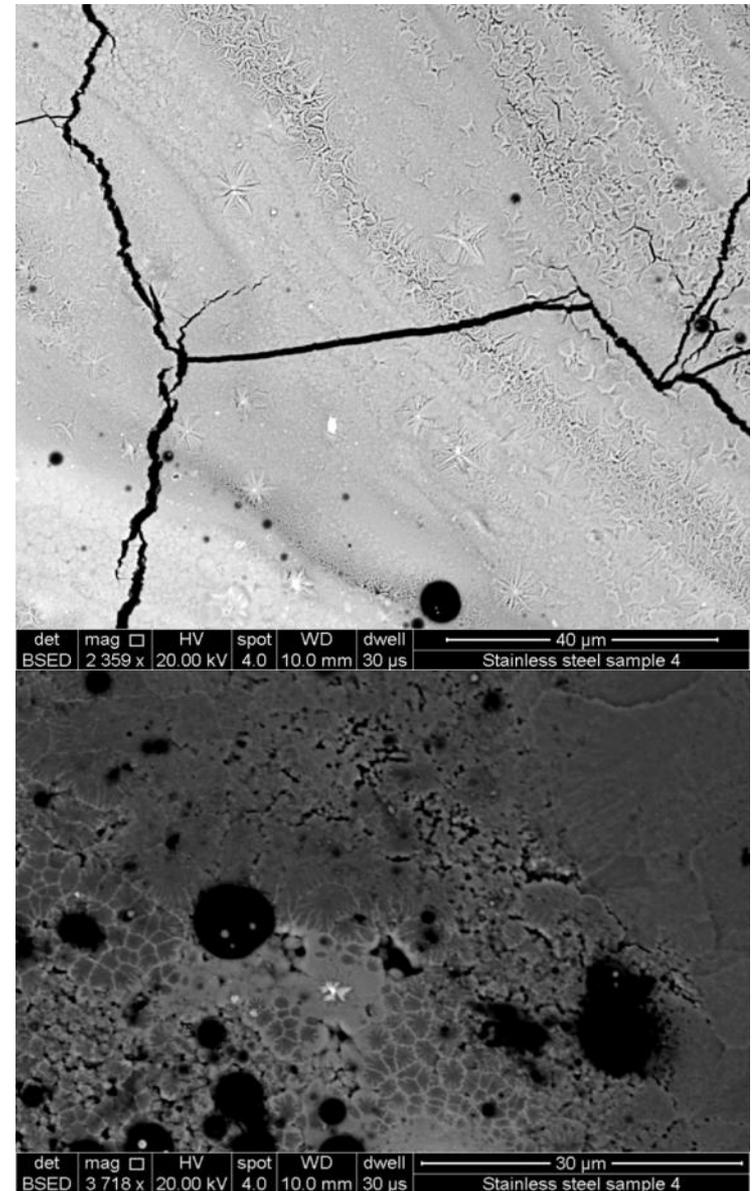
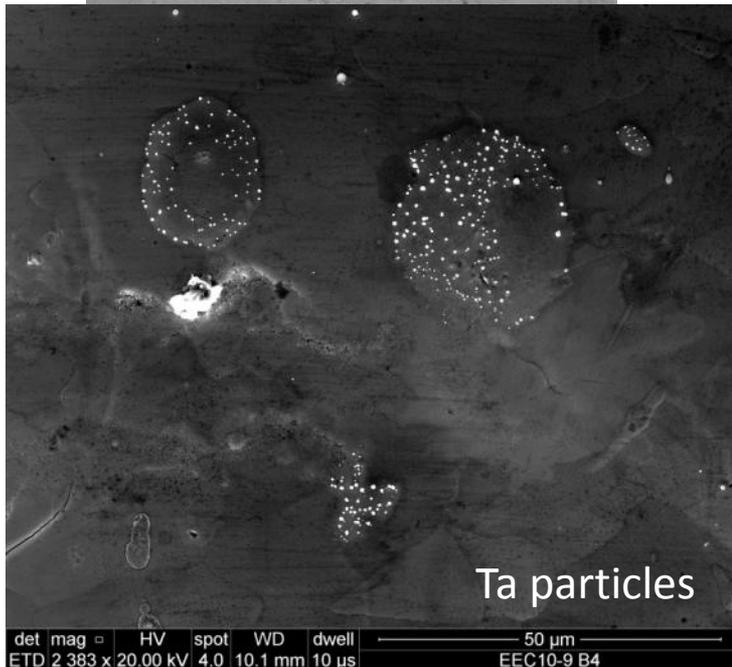
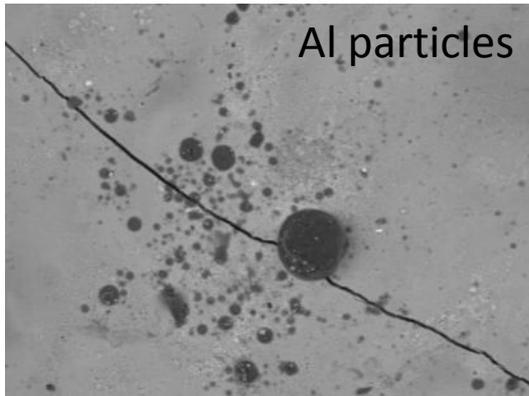
det	mag	HV	spot	WD	dwell	100 μm
BSED	899 x	20.00 kV	4.0	9.9 mm	10 μs	2010_09_24 MnIV



det	mag	HV	spot	WD	dwell	100 μm
ETD	899 x	20.00 kV	4.0	9.9 mm	10 μs	2010_09_24 MnIV

Identified splats and particles similar to Disk 1 0-0

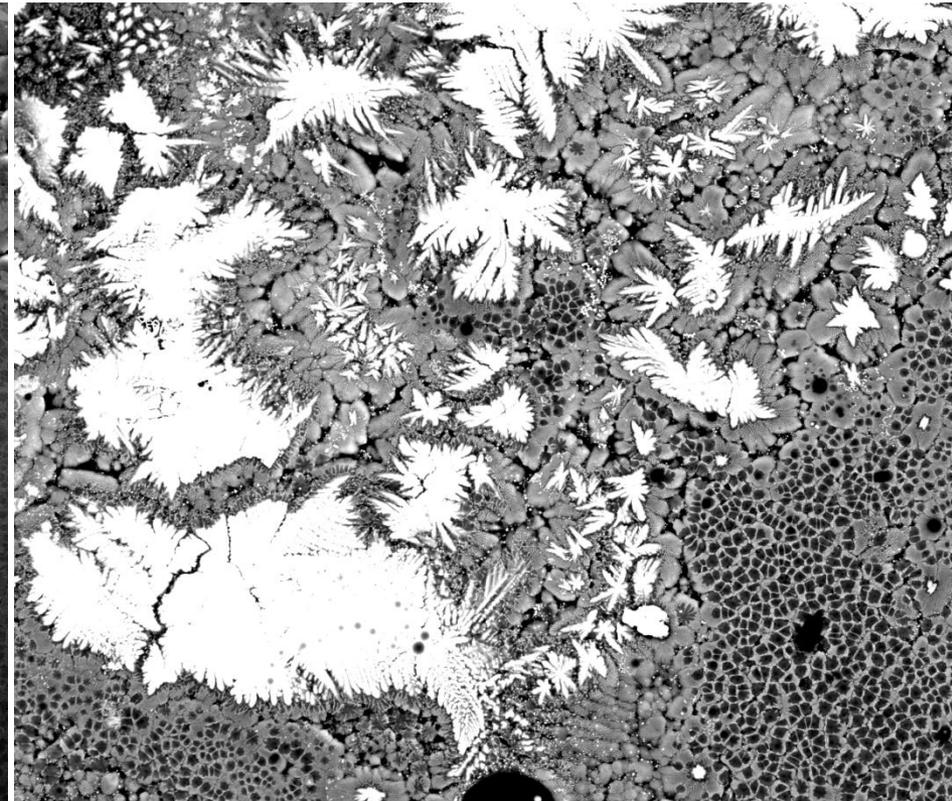
Common Features



Ta Crystals



det	mag	HV	spot	WD	dwell	Scale
ETD	3 234 x	20.00 kV	5.0	10.0 mm	10 μ s	40 μ m
Shot 8AX						

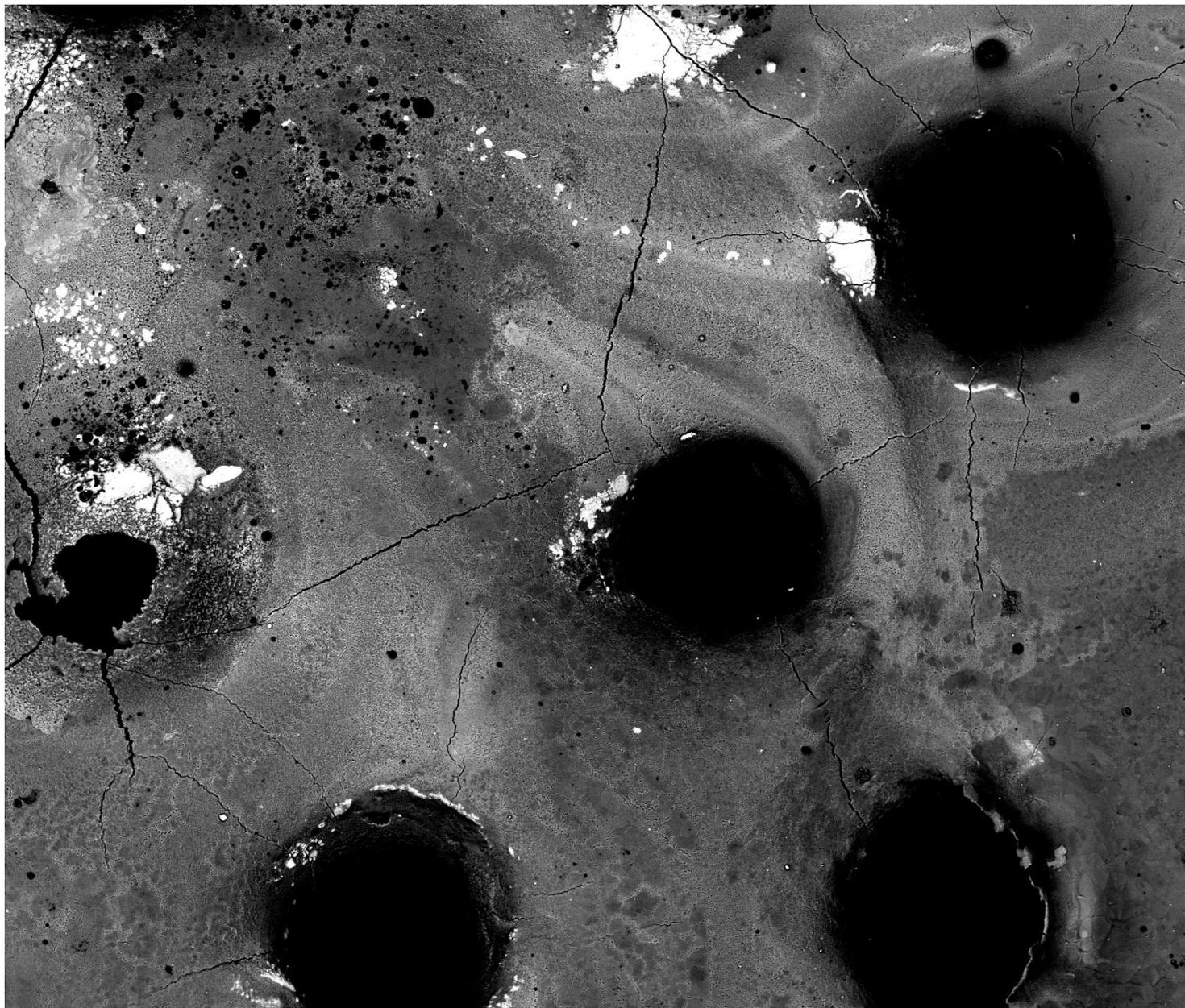


det	mag	HV	spot	WD	dwell	Scale
BSED	3 234 x	20.00 kV	5.0	10.0 mm	10 μ s	30 μ m
Shot 8AX						

Element	Aluminum	Ta
Al	X	X
Si	X	X
Cu	X	X
Au	X	X (very few)
In	X	X
Fe	X	X
Cr	X	X
Ni	X	X
Zn		
C	X	X
Ti	X	
Mn	X	
Ca	X	
S	X	
Cl	X	
Ba	X	

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



det	mag □	HV	spot	WD	dwell
BSED	324 x	20.00 kV	4.0	10.1 mm	10 μs

300 μm
EEC10-9 B4