Stanford Linear Accelerator Center

Experimental Testing of NLC Structures and of X-Band Cavities

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Overview

- X-Band Accelerator Experiments:

  NLC Structures (Copper)

  CERN Fabricated Structure with Tungsten Iris Inserts

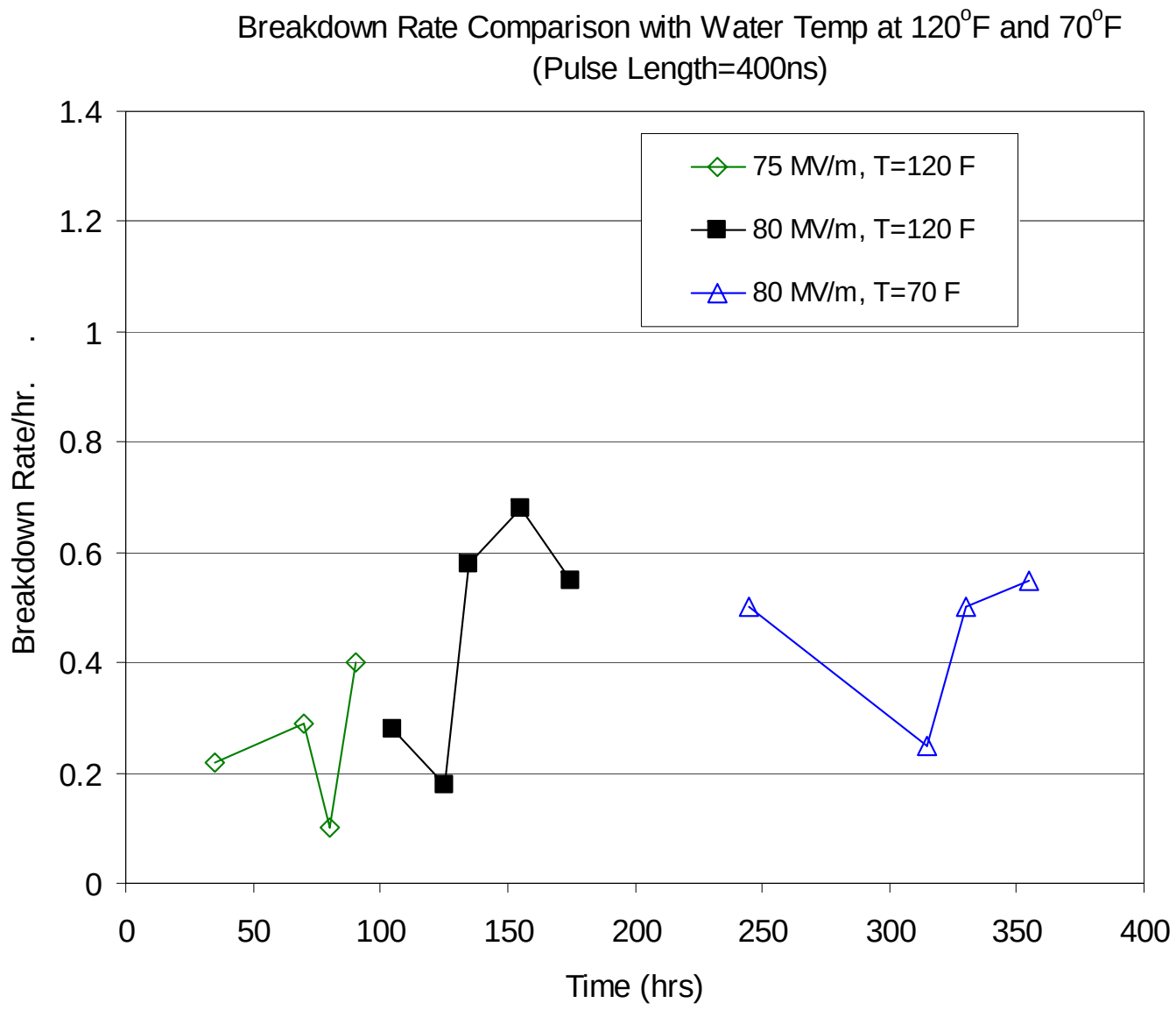
- Tungsten Material Study: Machining, Etching and Polishing Techniques

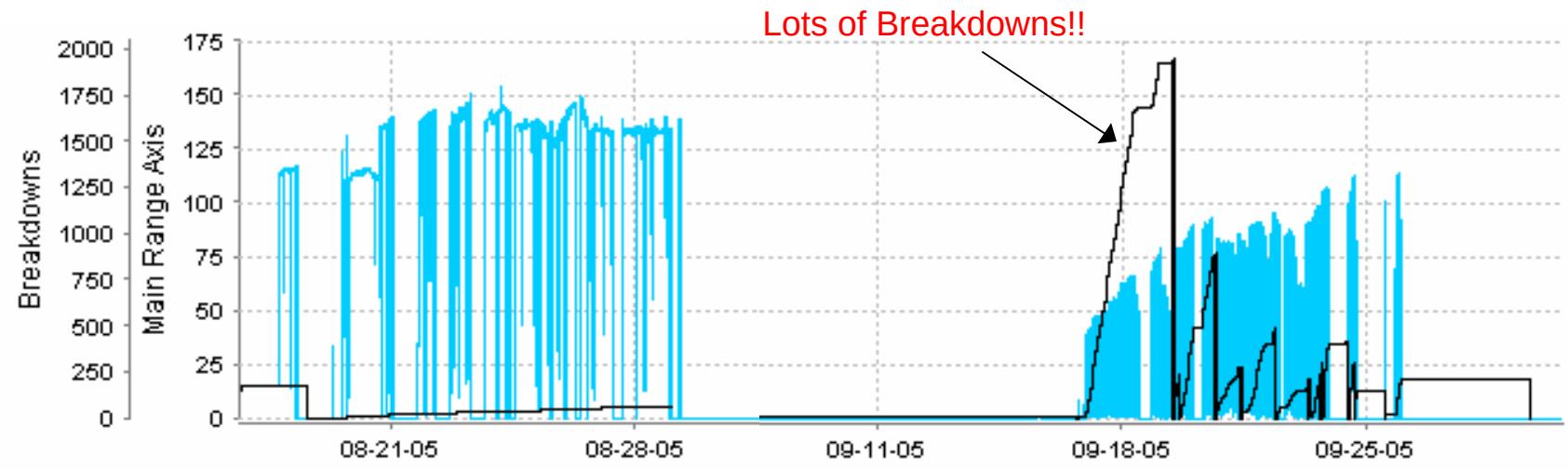
- X-Band Breakdown Cavity using Refractory Metals

NLC Copper Structures

Impact on Breakdown Rate due to:

- Lower Water Temperature
- Different Types of Venting Conditions


Breakdown Rate Comparison with Water Temp at 120°F and 70°F
(Pulse Length=400ns)
75 MV/m, T=120 F
80 MV/m, T=120 F
80 MV/m, T=70 F
Breakdown Rate/hr.
Time (hrs)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
50
100
150
200
250
300
350
400



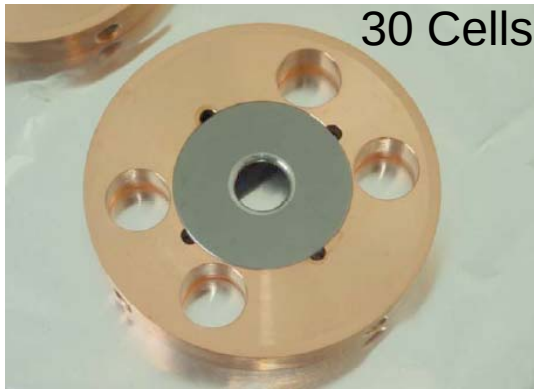
Heat Tape Bake

Venting to Filtered Atmosphere at Elevated Temperatures (~200°C)

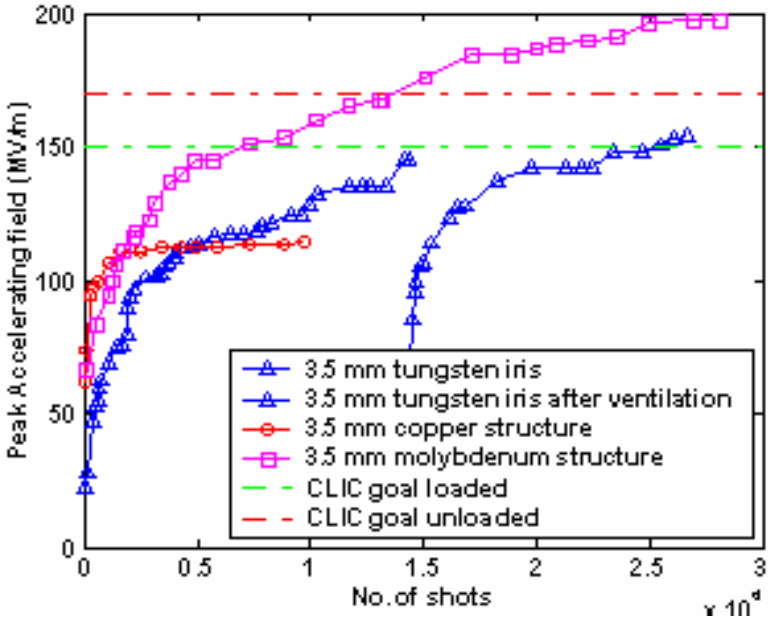
Power (MW) = Cyan

Breakdown # = Black

CLIC 30 GHz “30-Cell Clamped” Accelerator Structure using Tungsten/Moly Iris Inserts



Pulse Length=16ns



X-Band Accelerator Results with Tungsten Insert

RF Conditioning: No significant improvement with continued rf processing.

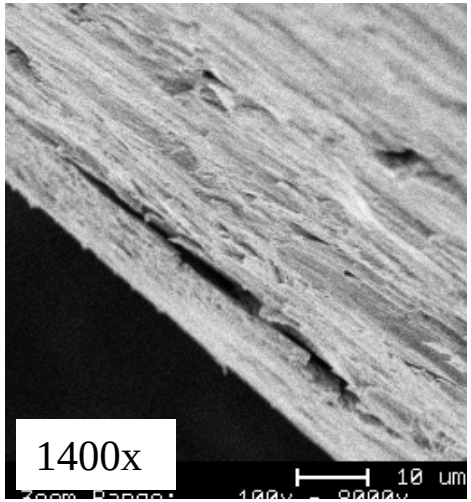
Reprocessing was necessary when returning to any given pulse length in order to reach previously achieved power levels.

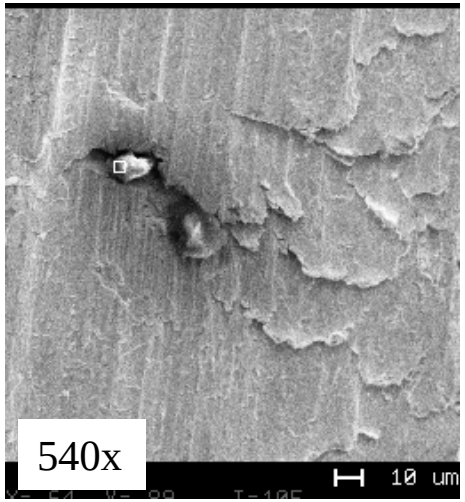
Tungsten performed much worse than the X-band copper structures:

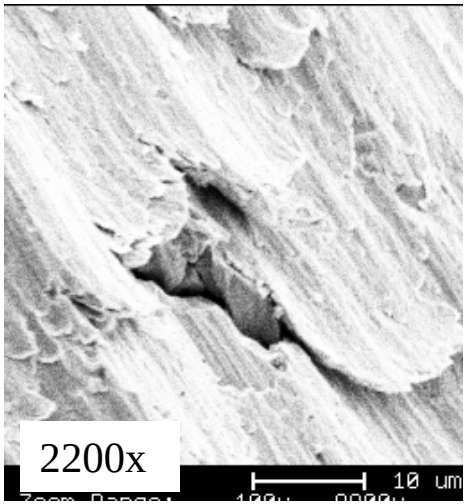
NLC goal:	400ns, 65 MV/m (<0.1 bds/hr)
W-structure:	200ns, 63 MV/m (10-20 bds/hr)
Cu-structure:	250ns, 100MV/m (<10 bds/hr)

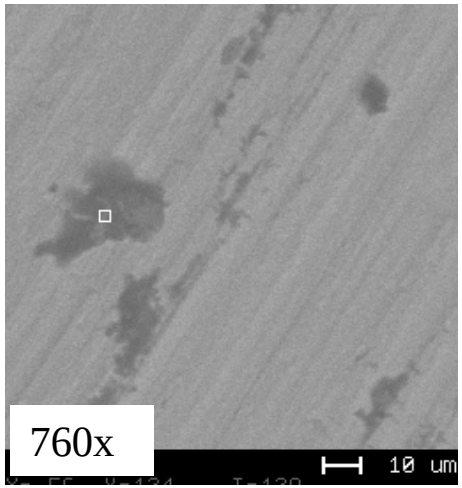
SEM analysis on sample tungsten inserts sent to us by CERN revealed numerous fractures and embedded carbon particles on the surface suggesting the need to find a better fabrication process.

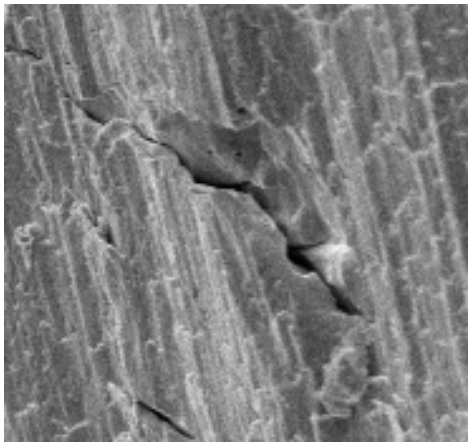
SEM Images of a Tungsten Iris Insert



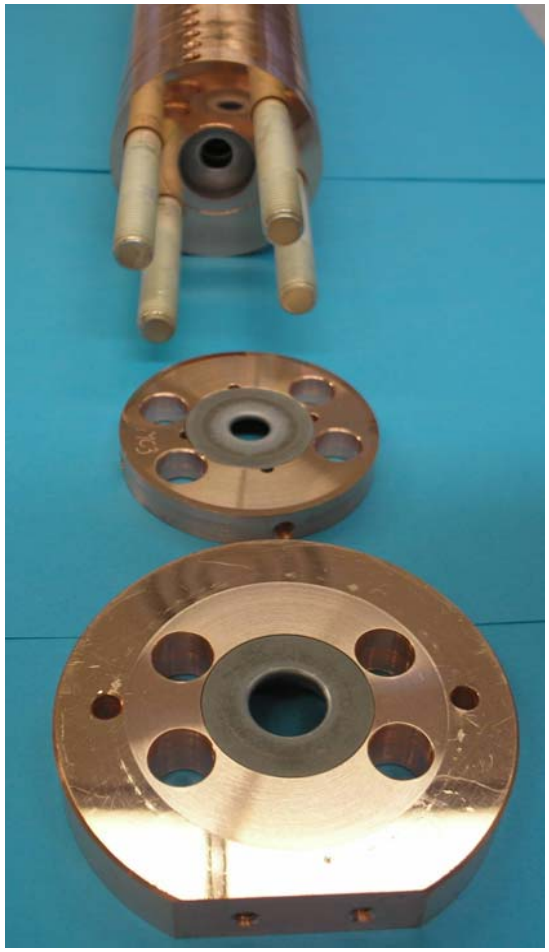








CERN Fabricated X-Band Accelerator with Tungsten Iris Inserts



Photographs of Four Tungsten Iris Inserts Taken After RF Processing

A-Side: Iris Facing Toward Input

Iris 1 Iris 2

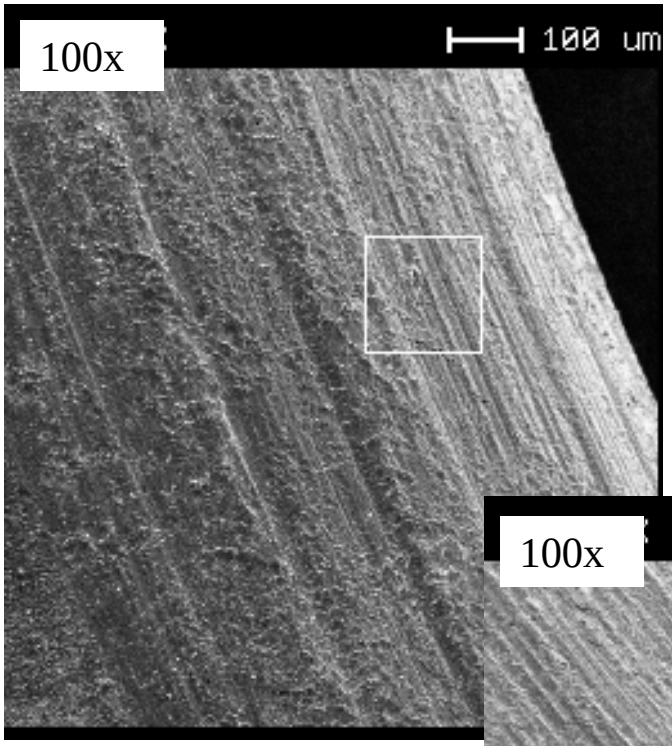
Iris 15 Iris 33

B-Side: Iris Facing Toward Output

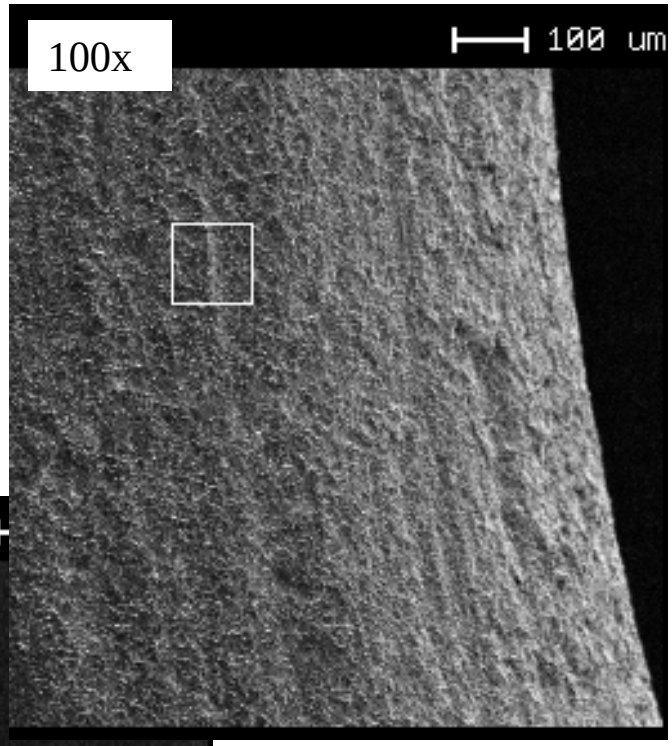
Iris 1 Iris 2

Iris 15 Iris 33

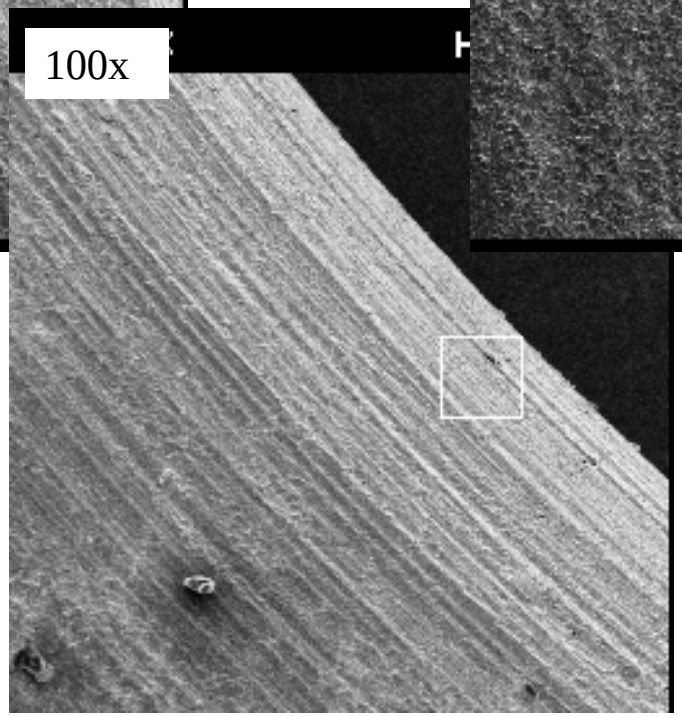
Iris 1



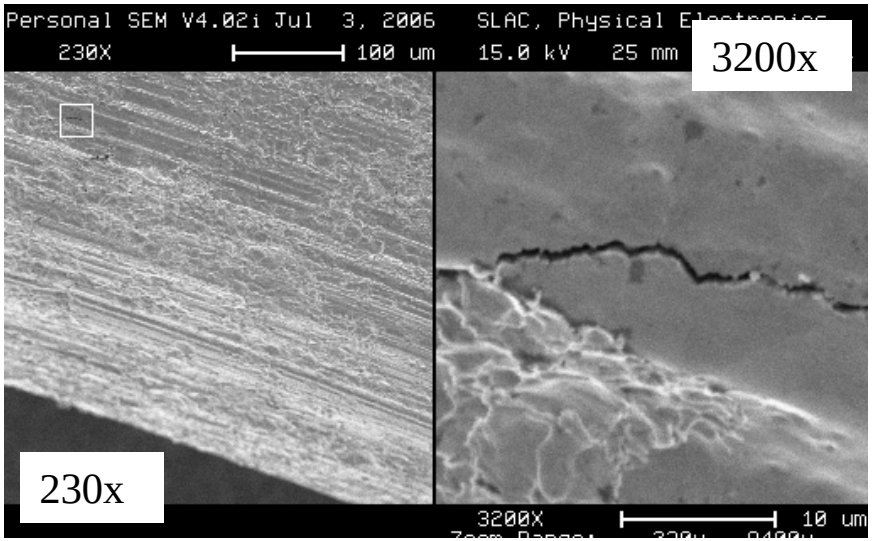
Iris 2

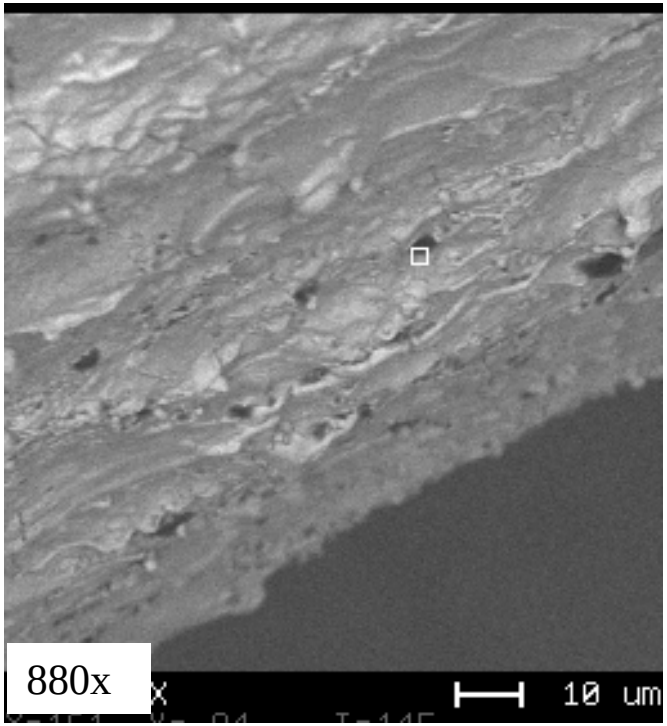


Iris 15

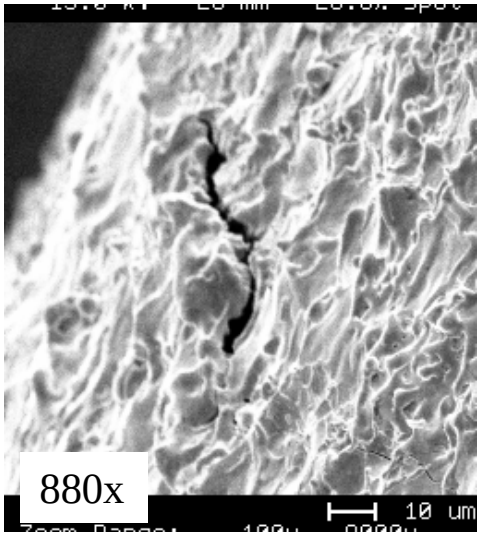


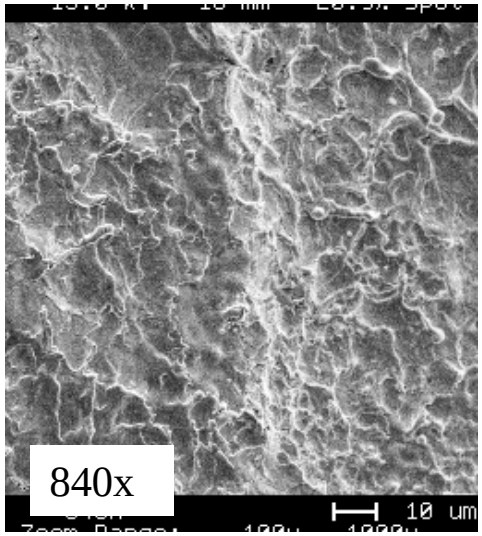
After RF Processing (Tungsten Iris 1)

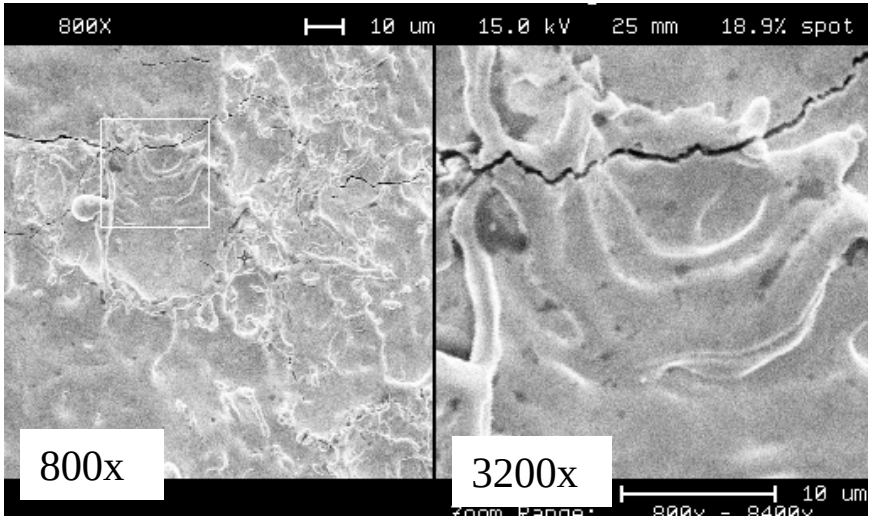




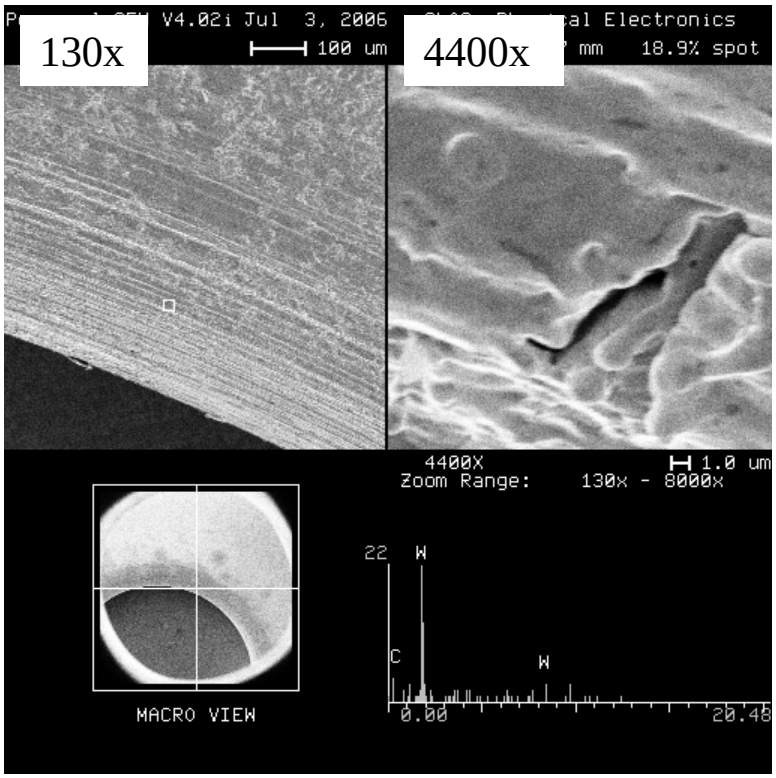
After RF Processing (Tungsten Iris 2)

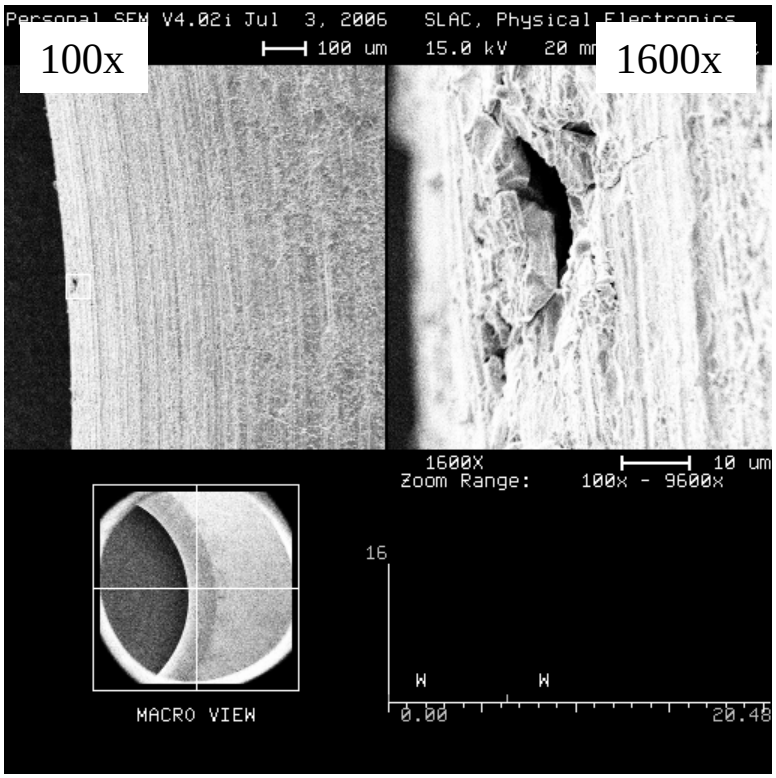






After RF Processing (Tungsten Iris 15)

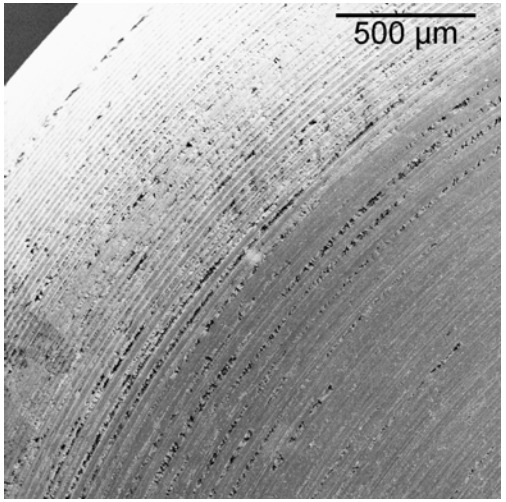


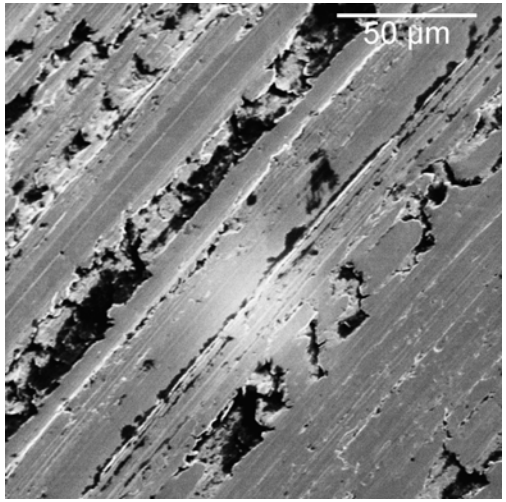


MS

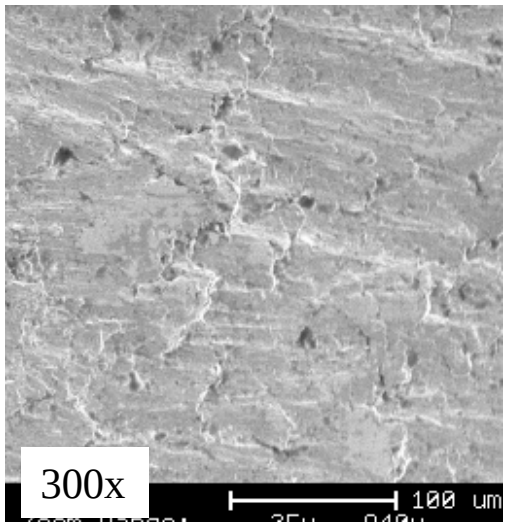
Tungsten Material Study

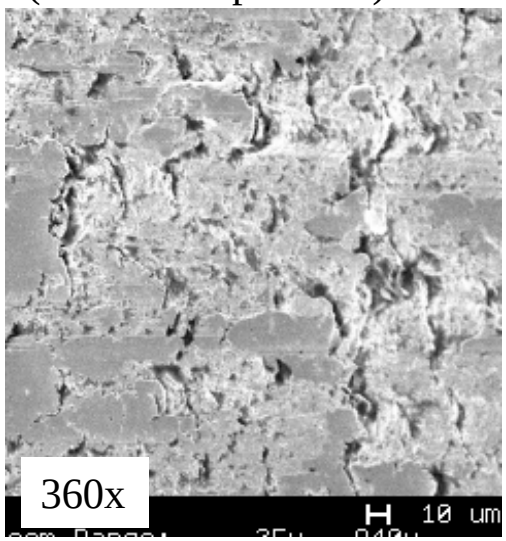
Tungsten Rod Machined at SLAC (Room Temperature)





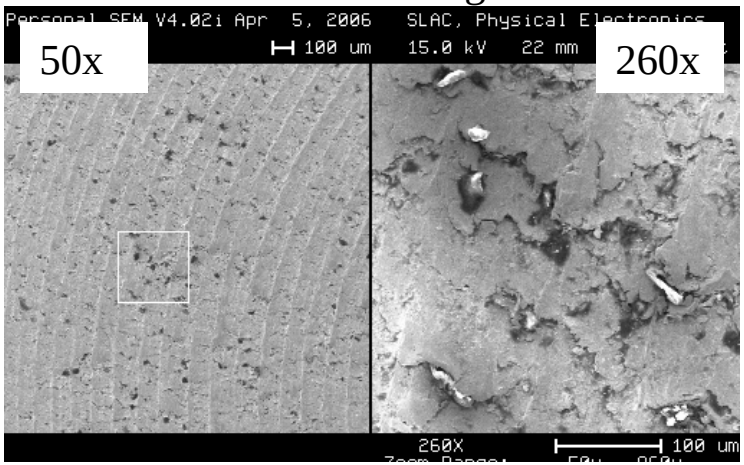
Tungsten Rod Machined at SLAC (400ºF Temperature)



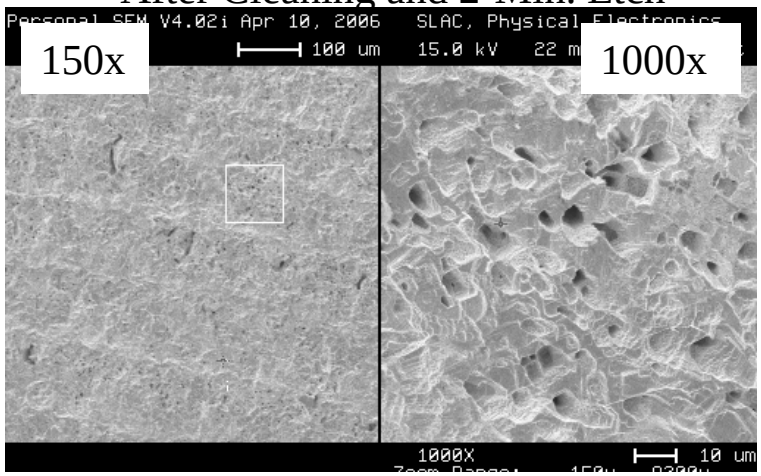


Tungsten Rod Machined at SLAC
(Experimented with different carbide tools)

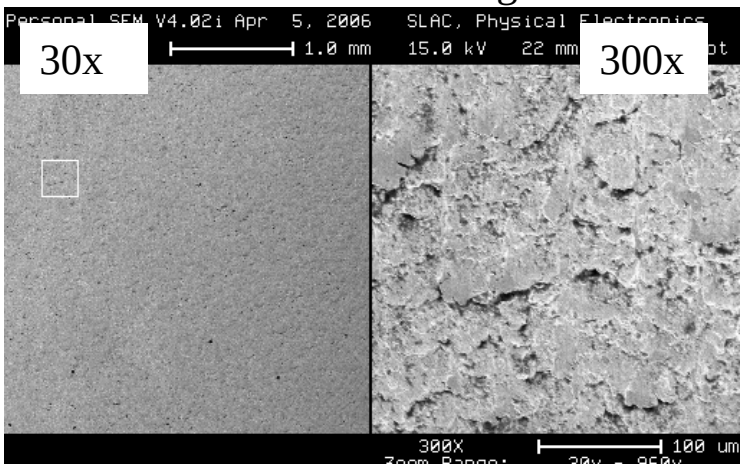
After Machining



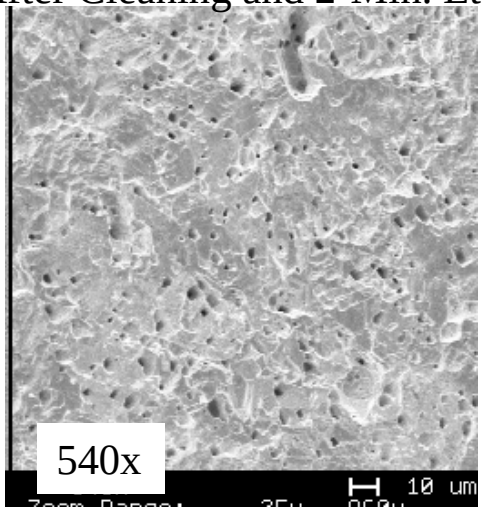
After Cleaning and 2-Min. Etch



After Machining



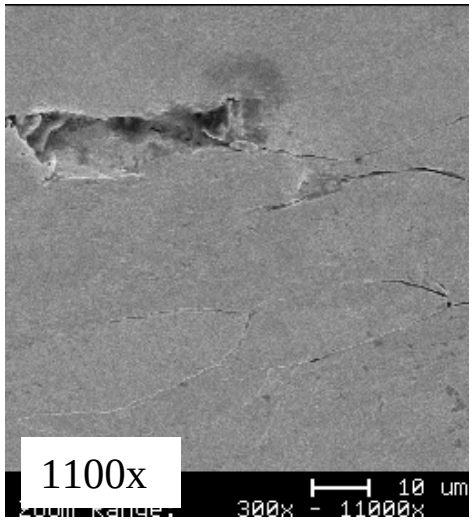
After Cleaning and 2-Min. Etch

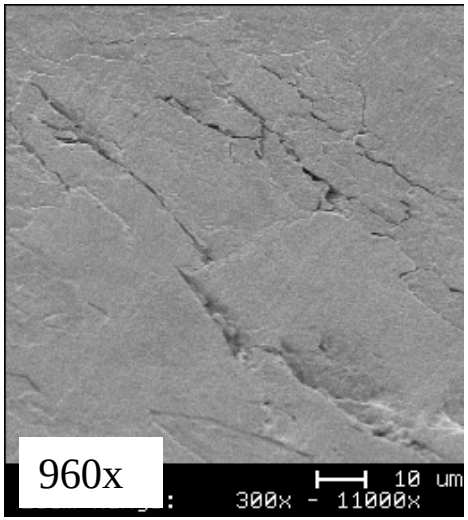


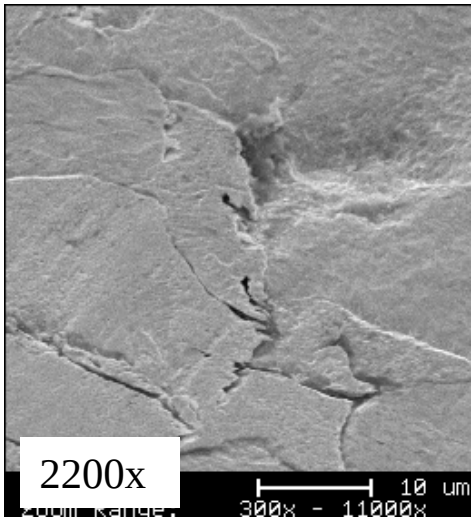
HF

Tungsten Rod Before and After Wet Hydrogen Firing (~1000°C)

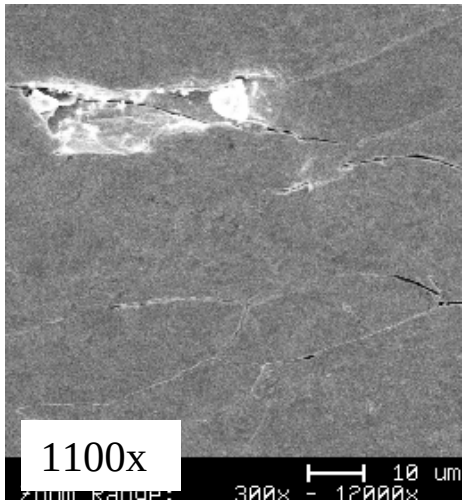
Before →

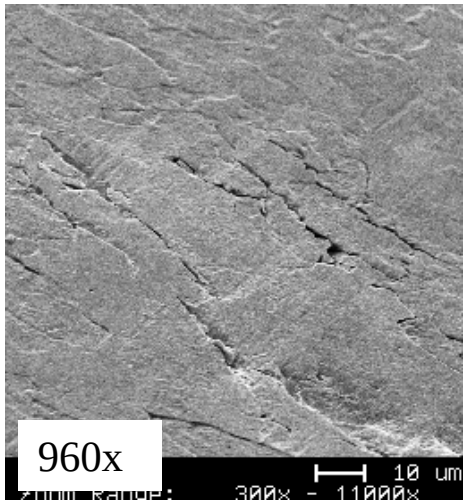


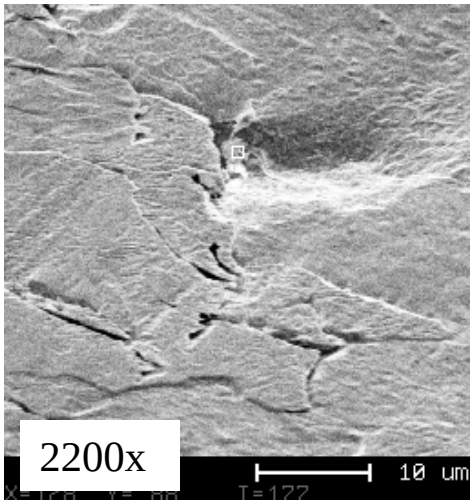




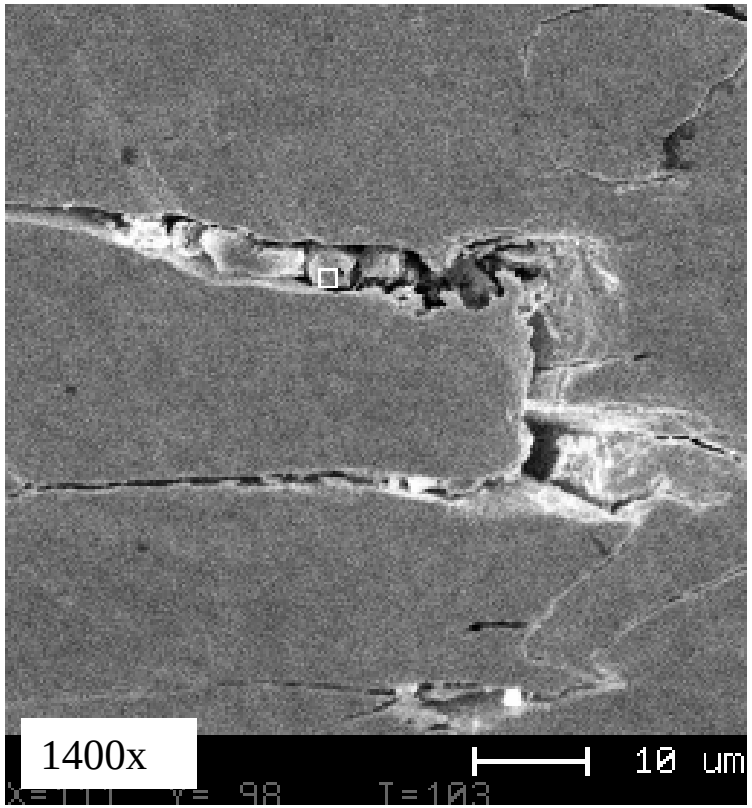
After →

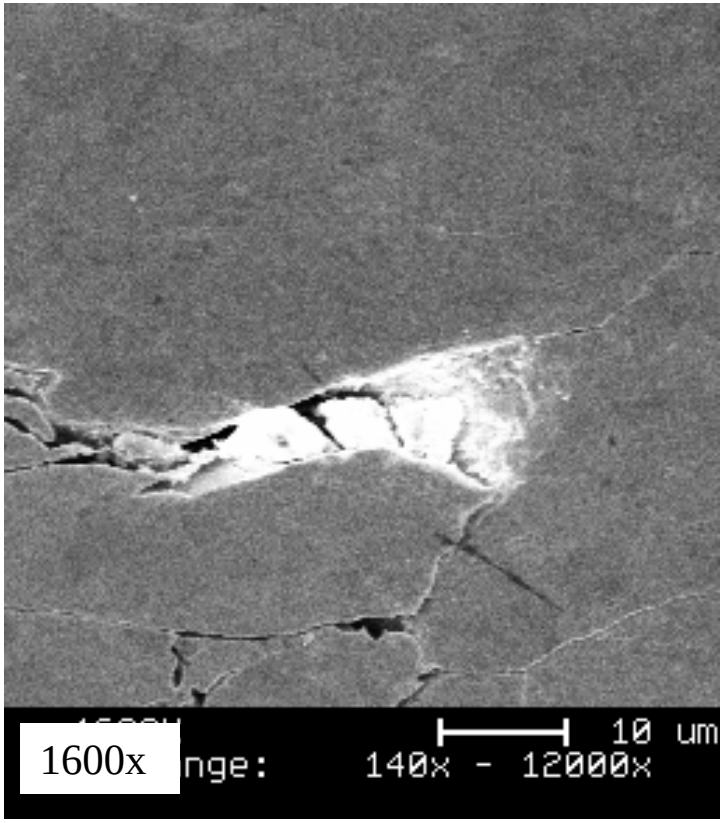




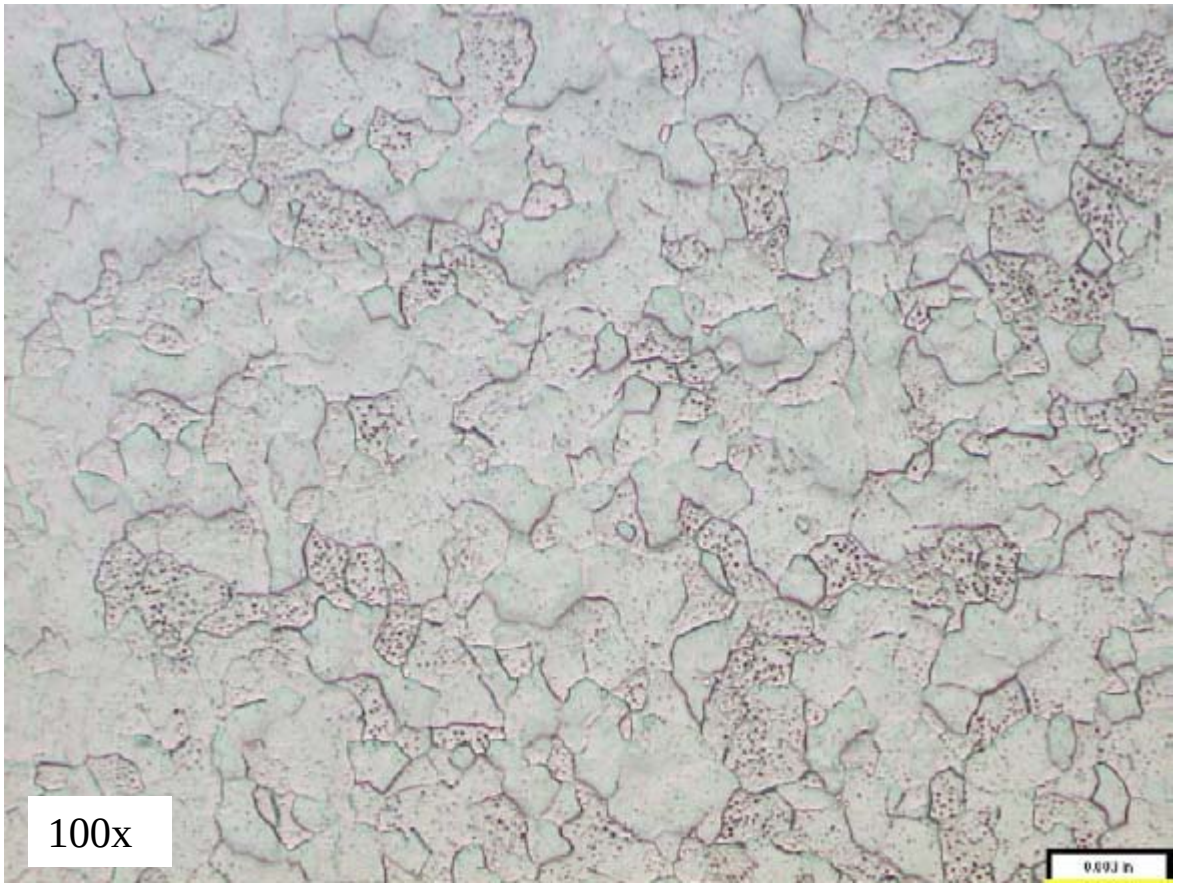


Tungsten Rod After Wet Hydrogen Firing at ~1000°C for Two Hours



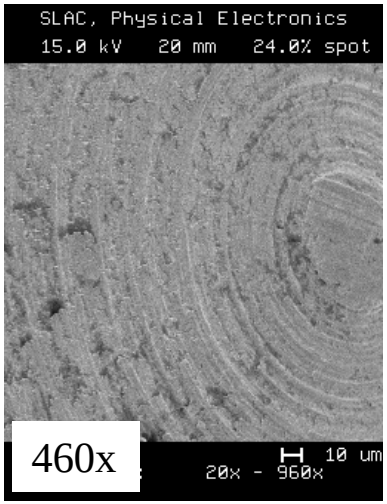


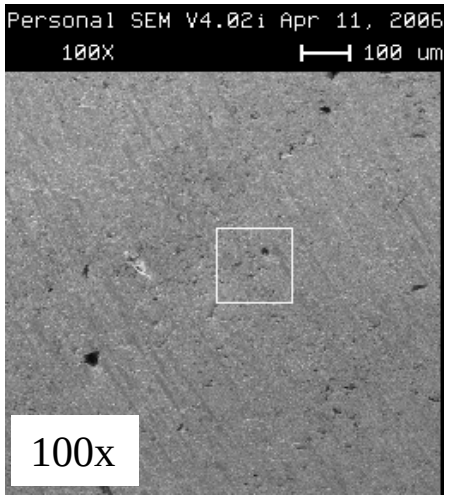
Tungsten Metallography



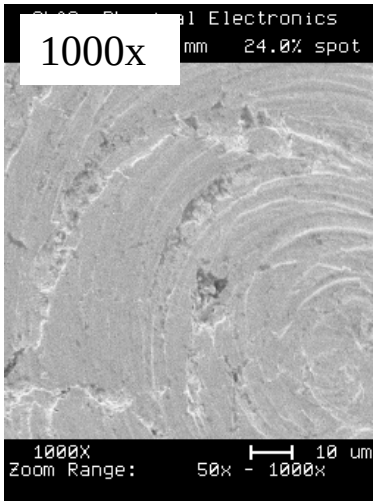
Etch pits on etched samples have density dependent on crystal lattice orientation (similar to other pure metals).

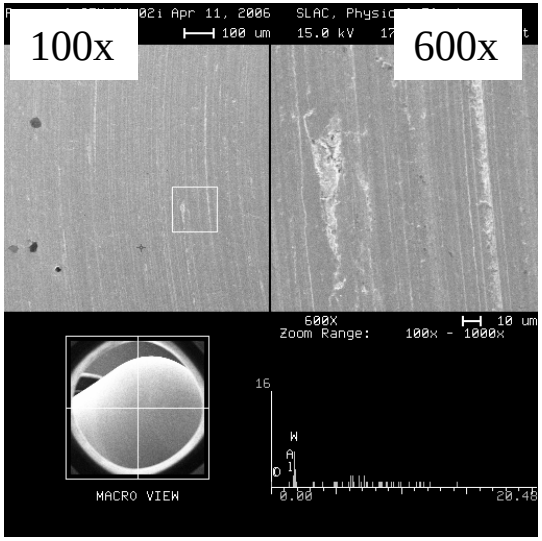
Machined by Philip-Elmet



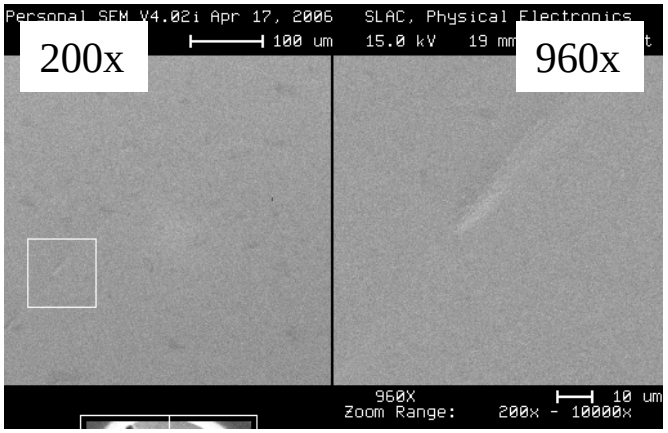


Turned and Polished by Philip-Elmet





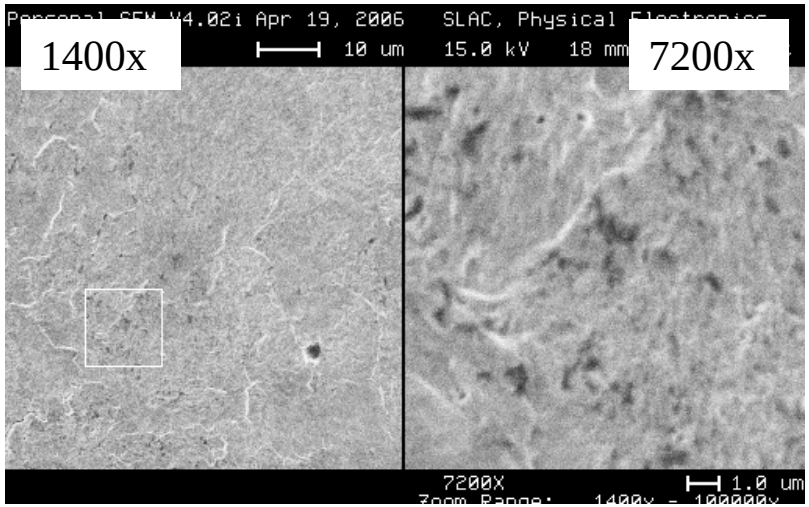
Tungsten Rod Machined at Philip-Elmet and Hand Polished using a Lathe at SLAC



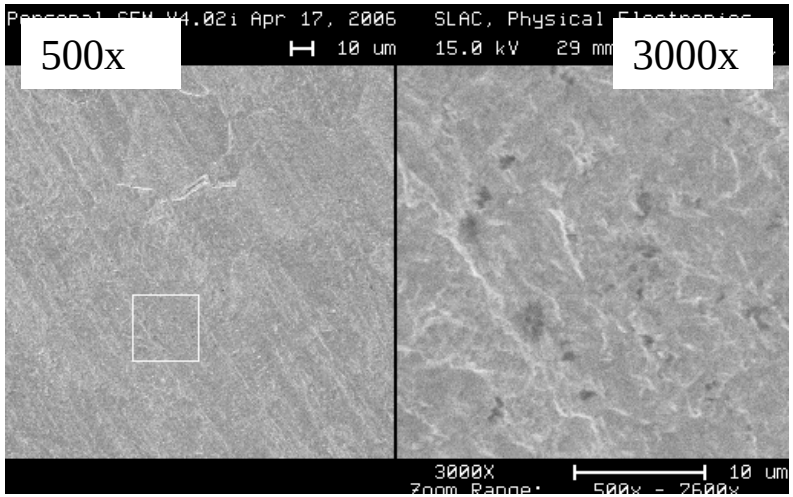
Tungsten Rod Machined at Philip-Elmet and Hand Polished using a Lathe at SLAC

Before Etching

After 5 Second Chemical Etch

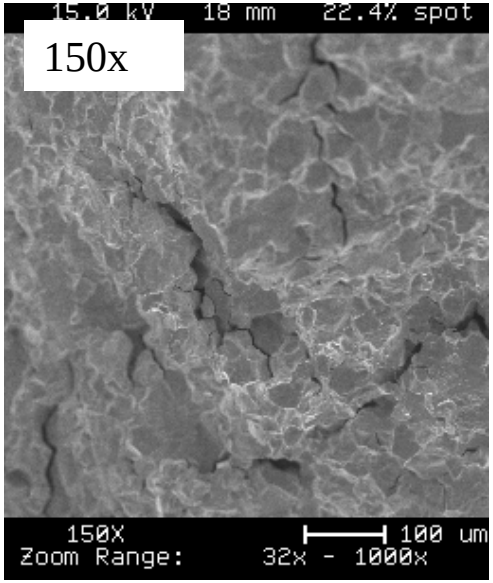


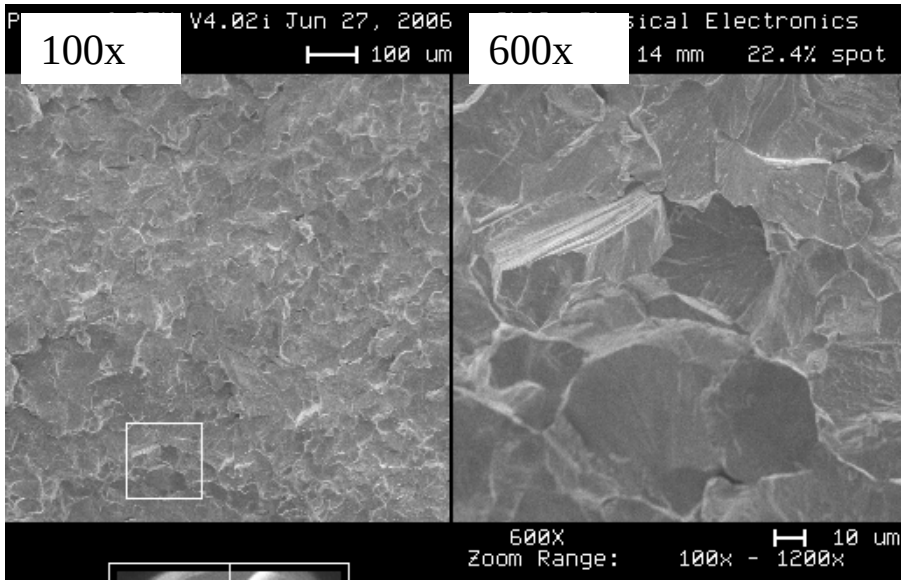
Philip-Elmet Polished Tungsten Rod After 30 Second Chemical Etch



FT

Bulk Material Purity Test: Cracked Tungsten Rod



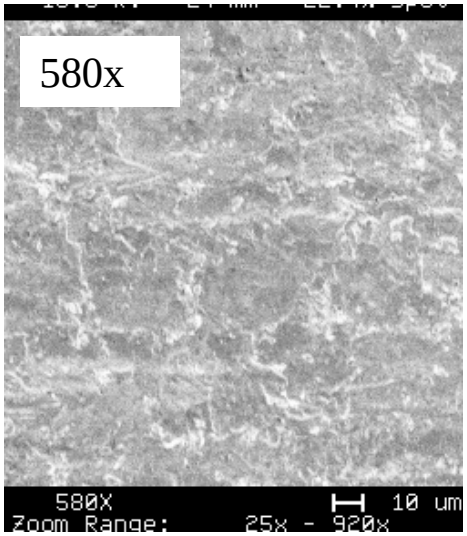


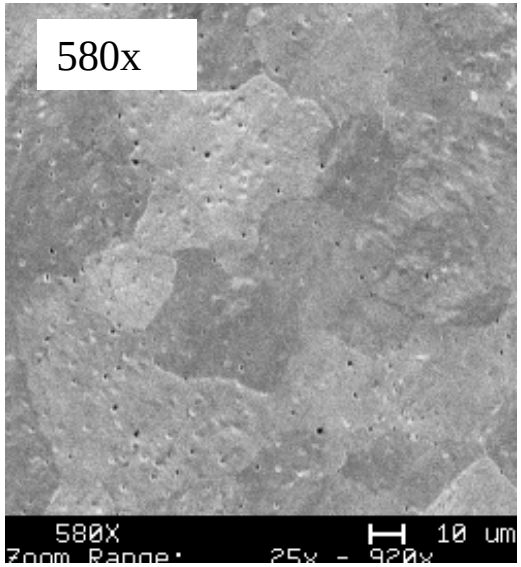
2 Volts, Time=2 min.

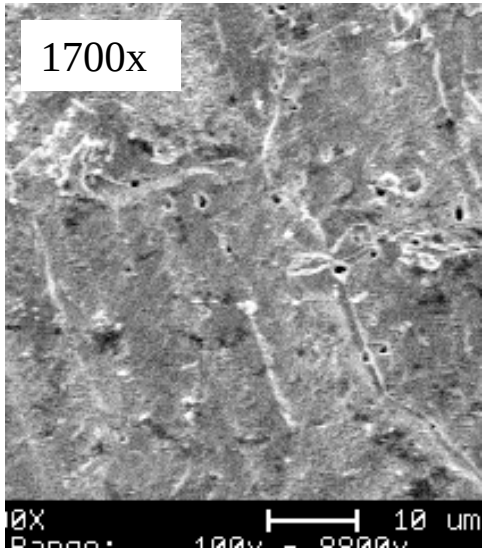
4 Volts, Time=2 min.

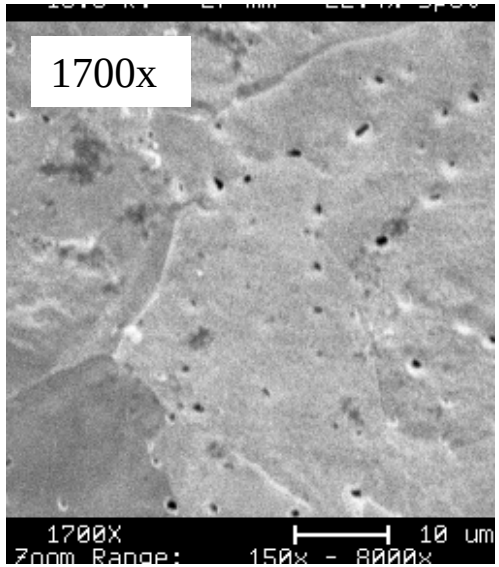
Electropolished

Tungsten

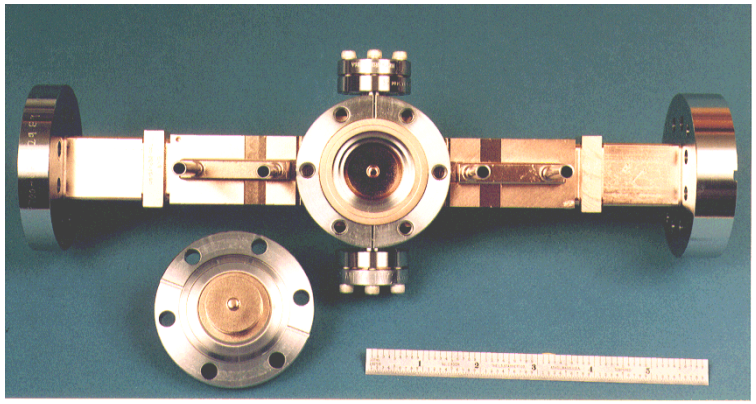








X-Band Cavity Material Breakdown Study



Program History

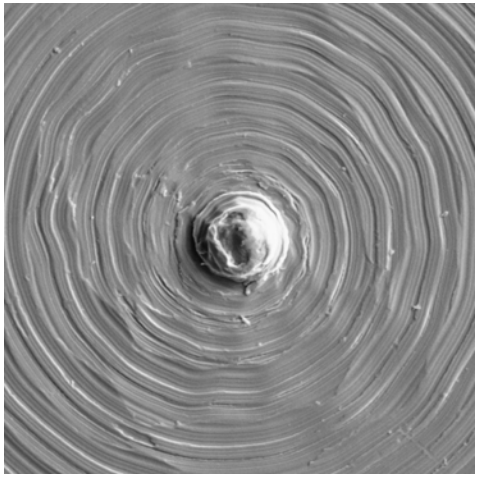
1996 Development of a TM_{010} Cavity
1997 Testing of Coatings and Surface Finish
Development of a TM_{020} Cavity
1998 Micro-particle Contamination
Grain Boundaries
1999 Pulse Length Studies
Various Vacuum Conditions
2000 Hi Q and Lo Q Cavity Experiments
2001 Materials Study
Short Pulse Processing

2006 Goal:

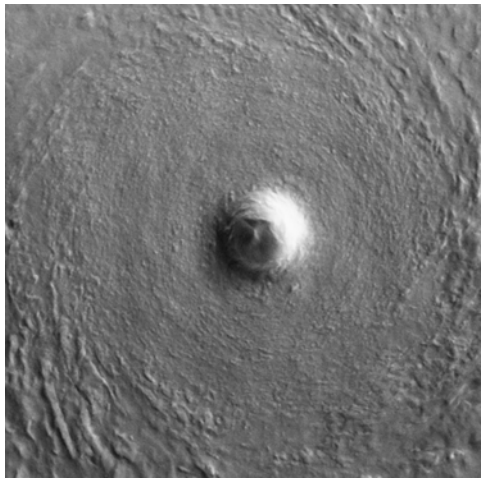
To RF Test Two Tungsten and One Moly Cavity Before The High Gradient Workshop Held at CERN this September.

Surface Topography of Copper Cavity Noses (Magnification: 1000x)

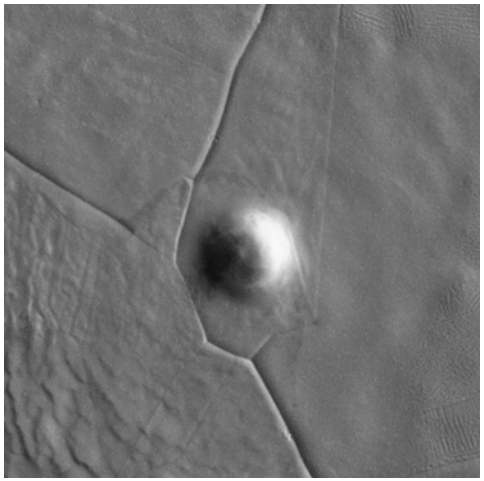
Before Etch



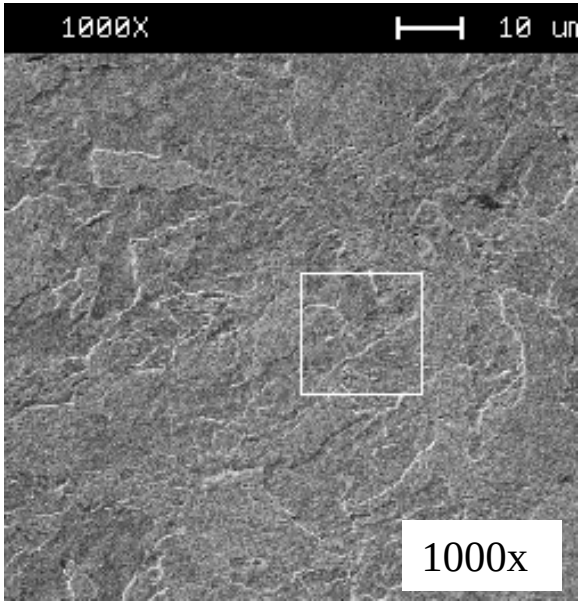
After Chemical Etch



After Heat Cycle



Hand Polished Tungsten Rod after Chemical Etch. →



Conclusions

- Working with Tungsten is very challenging!!
- I remain optimistic that we will be able to fabricate tungsten cavity noses with a suitable surface topography for rf testing.
- The Tungsten cavity experimental results will (hopefully) be ready to present at CERN this September at the High Gradient Workshop.