Progress Report:

Effect of Helium and Deuterium Implantation on Tungsten Surfaces at T>1000 °C

Ben Cipiti

G.L. Kulcinski, J.F. Santarius, R.P. Ashley, G.R. Piefer, S.K. Murali, R.F. Radel, A. Wehmeyer, D. Boris, T. Uchytil

HAPL Workshop

September 24-25, 2003

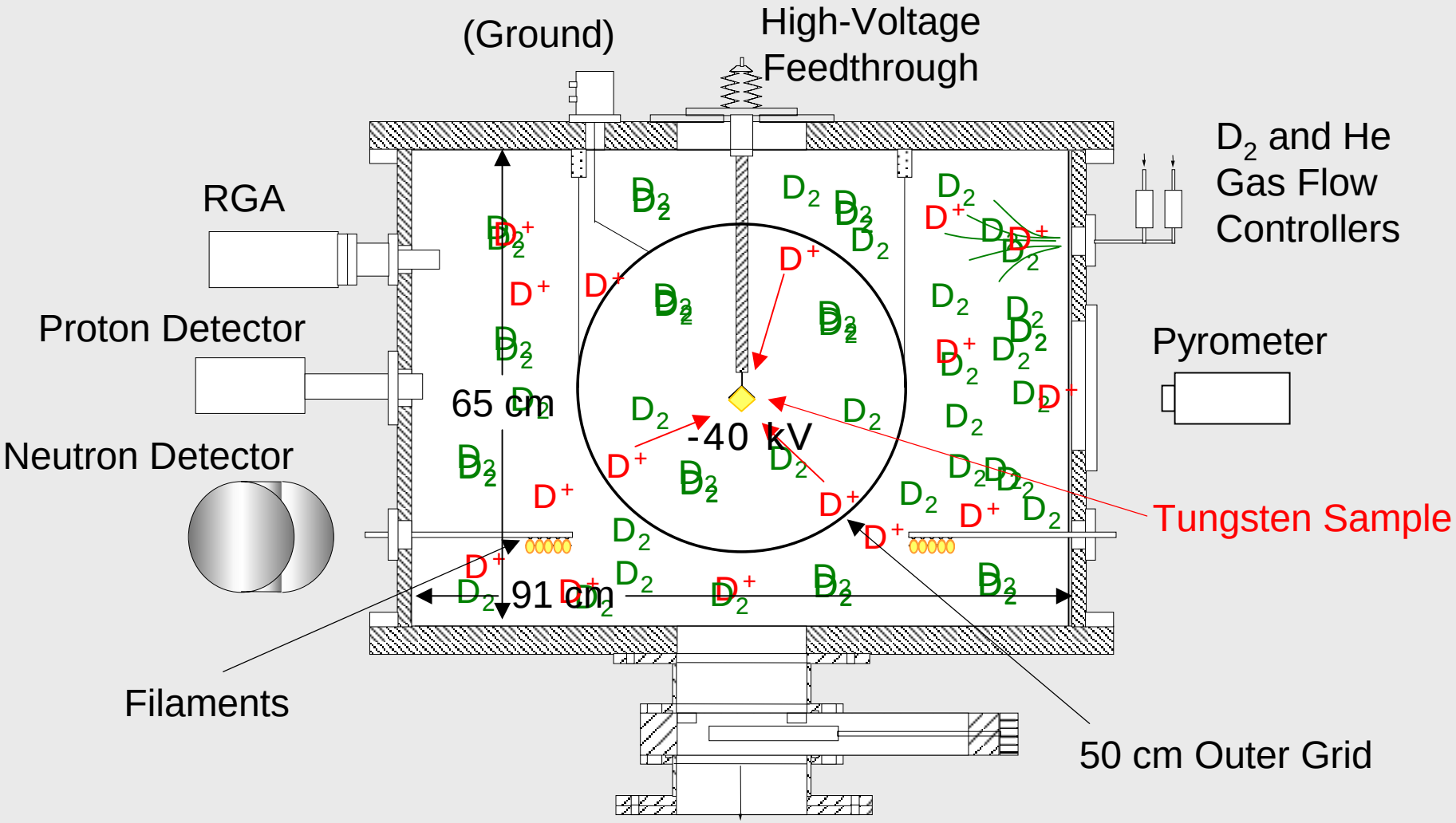
Overview

- Objective

  Determine the effects of high energy deuterium & helium implantation on tungsten surfaces at temperatures > 1000 °C

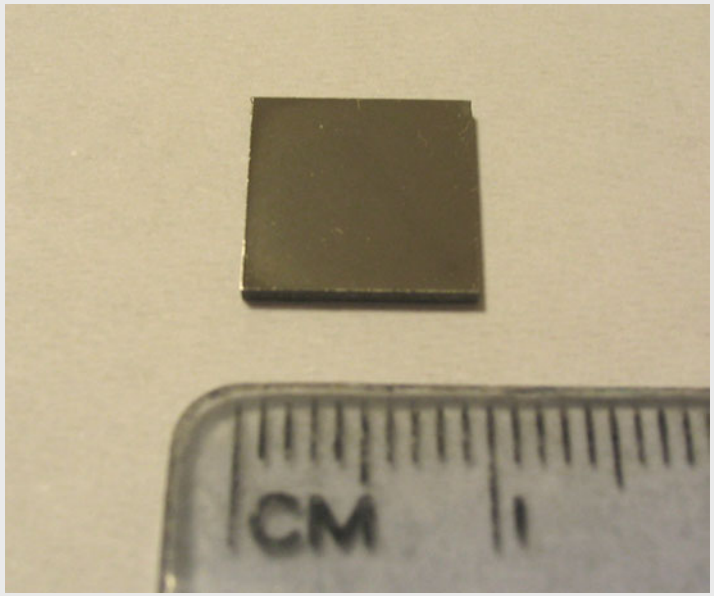
- Outline
  - Experimental Setup
  - Sample Characteristics
  - Deuterium and Helium Results
  - Discussion
  - Future Work

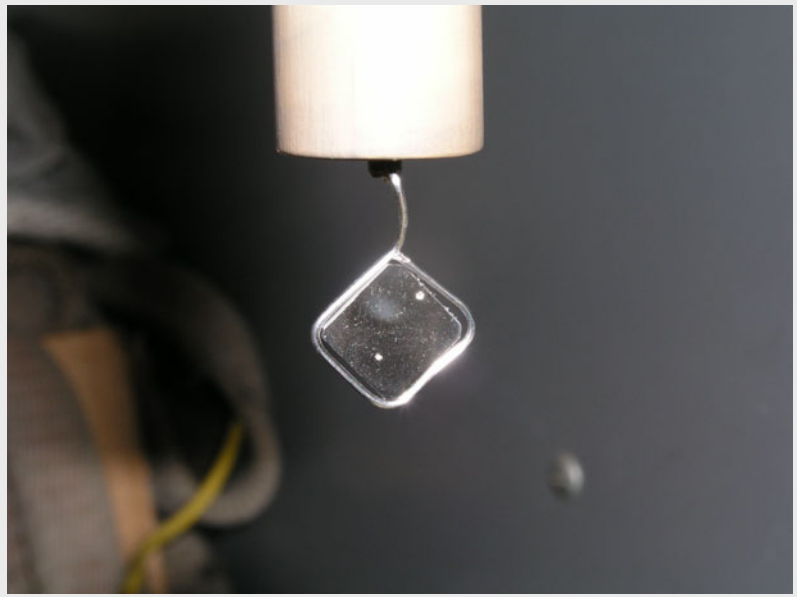
IEC Chamber Used for Ion Implantation



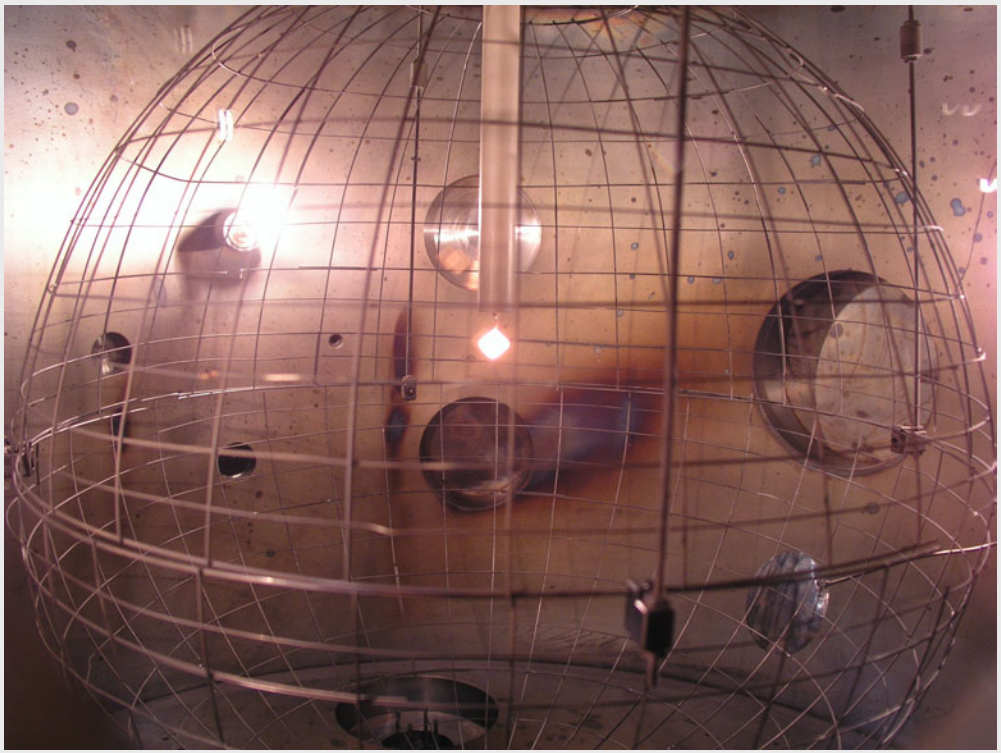
Tungsten Samples

- Powder metallurgy samples
- Obtained from Lance Snead, Oak Ridge
- Polished finish
- Lot #F05M12, stock #13981
- Spot-welded on to a W-Re wire loop

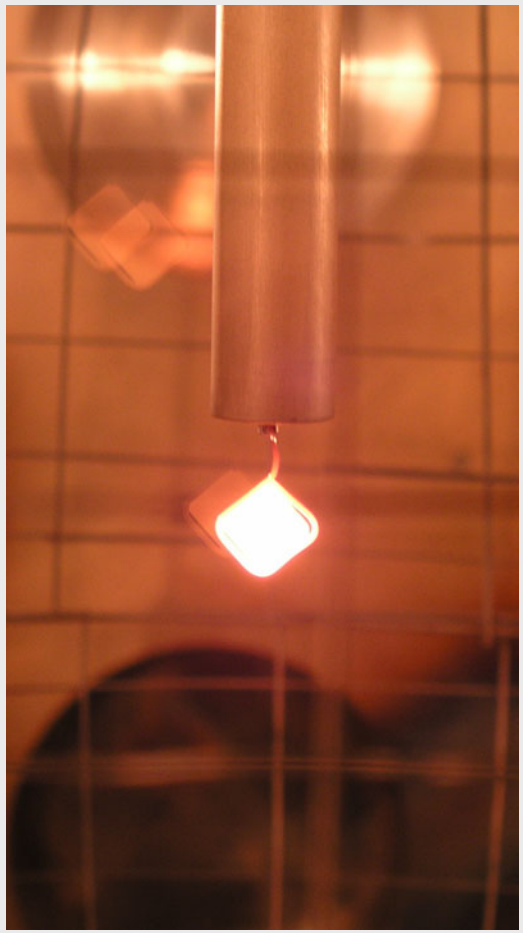




UW IEC Chamber has Capability of High-Temperature Implantation at 10-150 kV



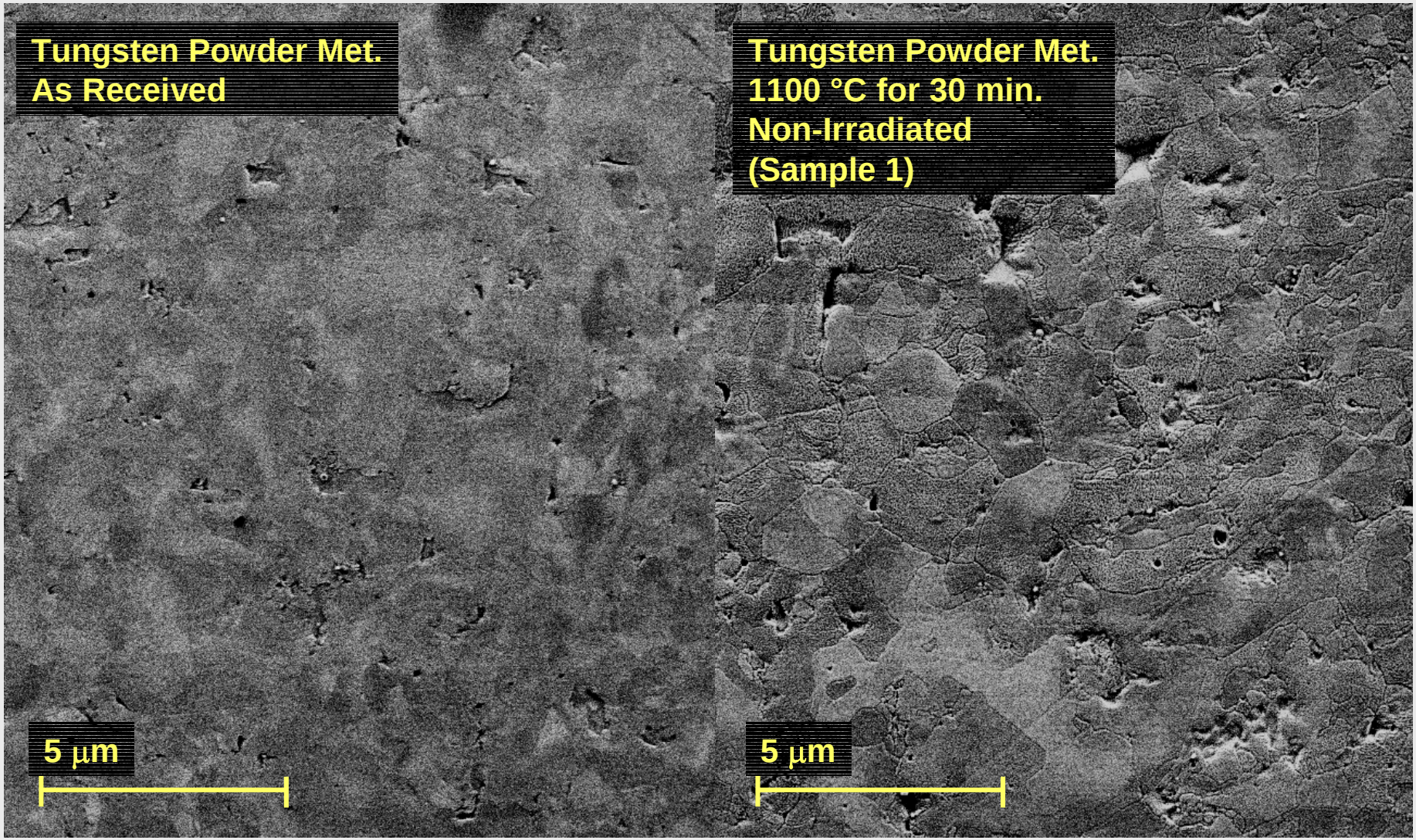
D^+, 20 kV, 5 mA
2 mtorr, 1100 °C



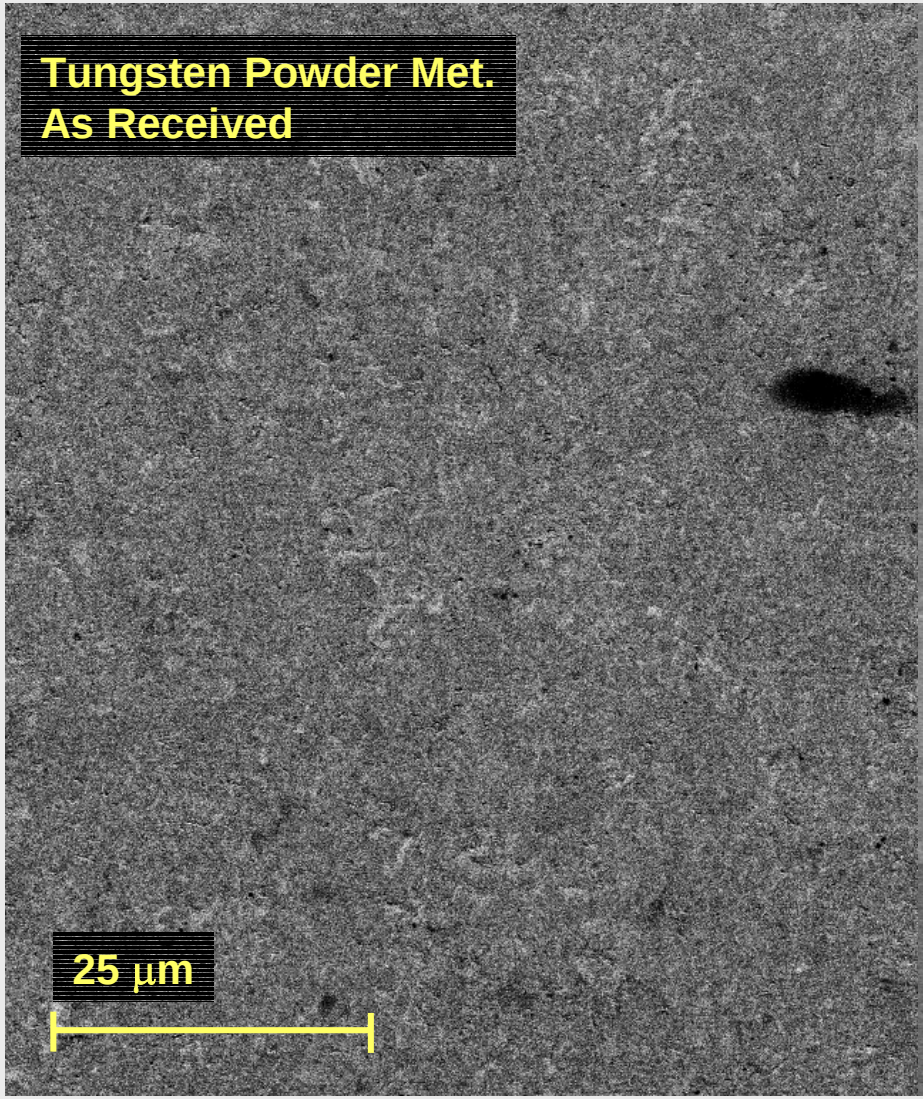
Conditions for Implantation of First Four Samples

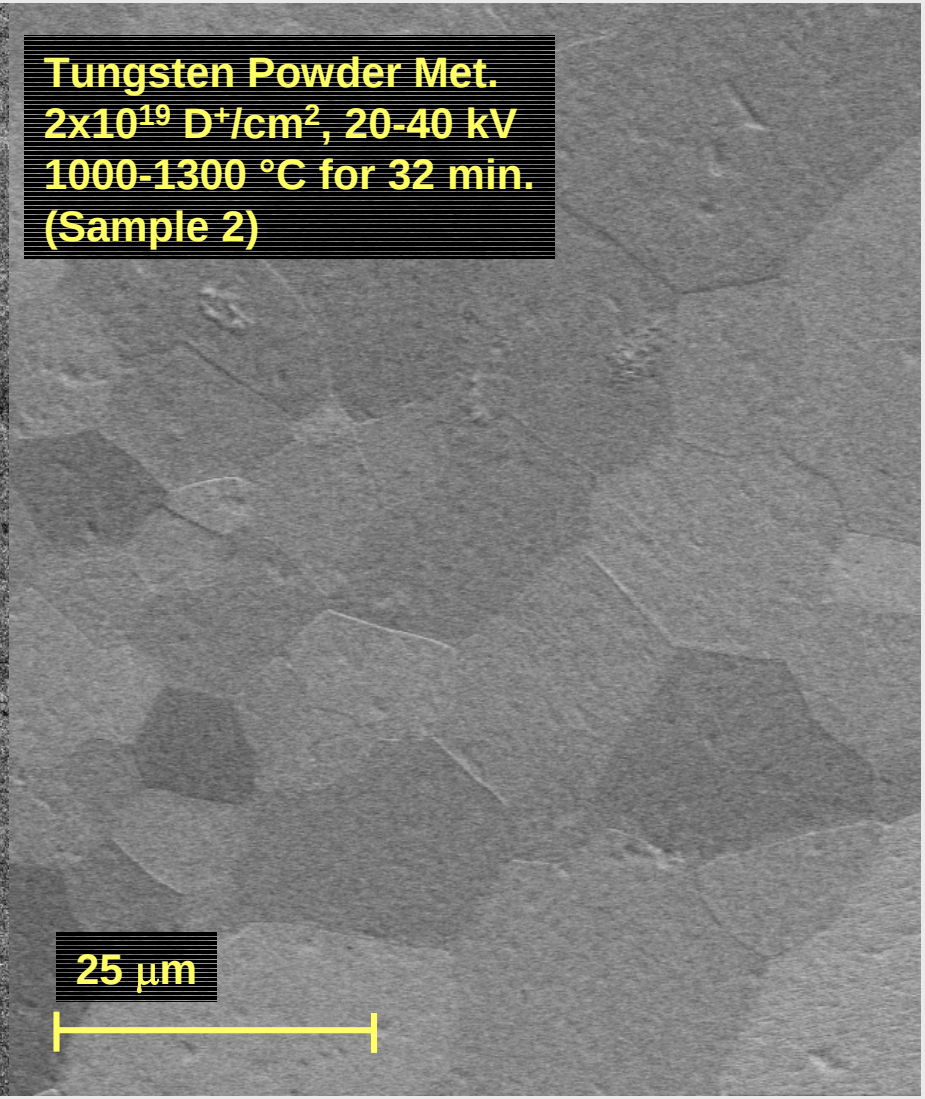
Sample	Temperature	Deuterium	Helium
1	1100 °C 30 min	-	-
2	1000-1300 °C 32 min	2×10^{19} cm^{-2} 20-40 kV	-
3	1100 °C 2 min	-	6×10^{17} cm^{-2} 40 kV
4	1200 °C 10 min	-	6×10^{18} cm^{-2} 40 kV

Heating Tungsten Sample to 1100 °C Caused Grain Growth

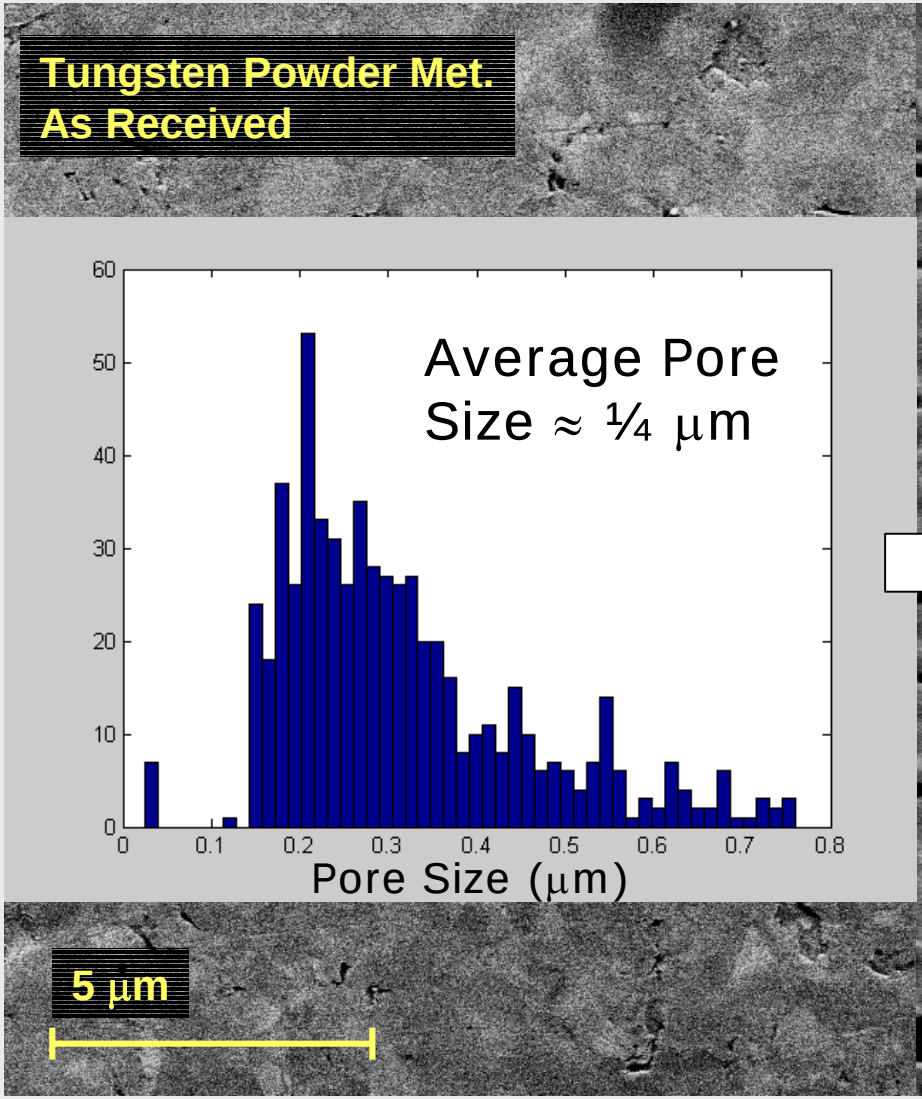


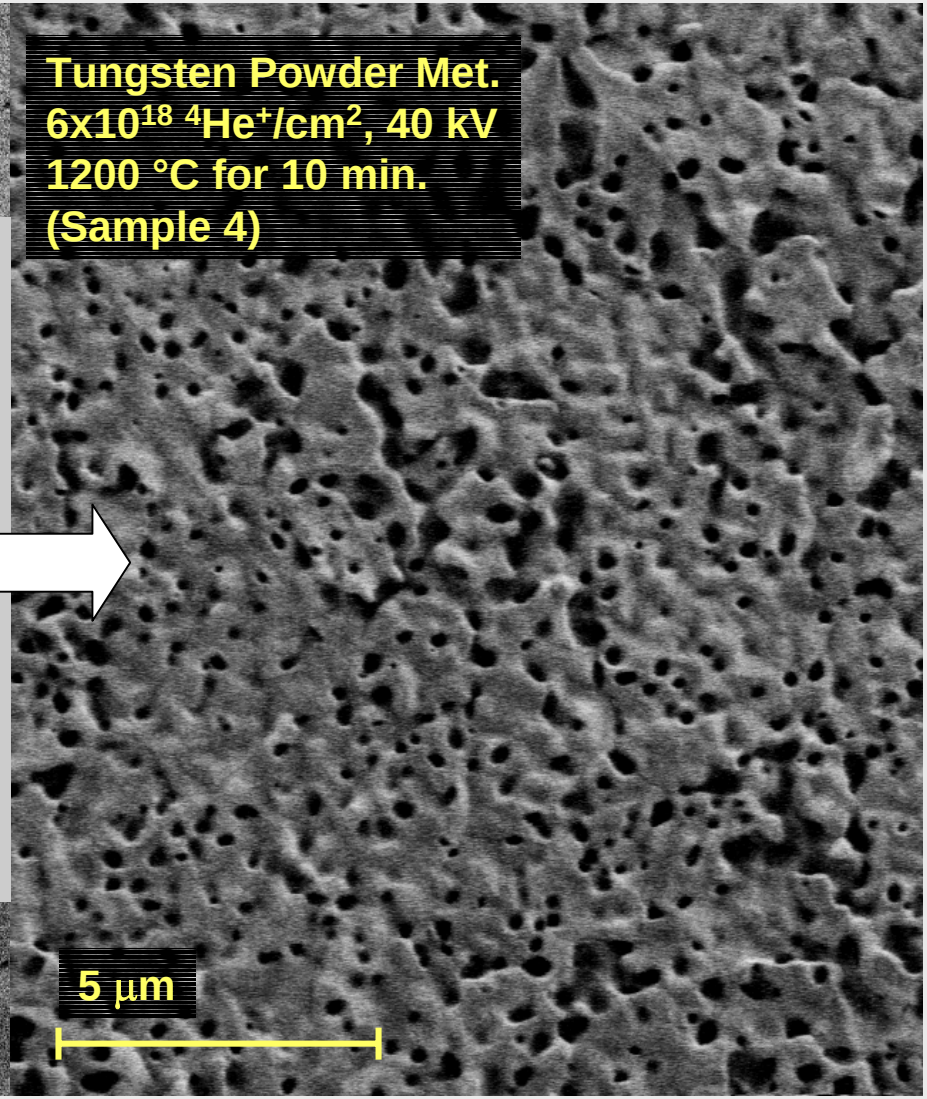
Deuterium Did Not Cause Blistering But Caused Substantial Grain Growth



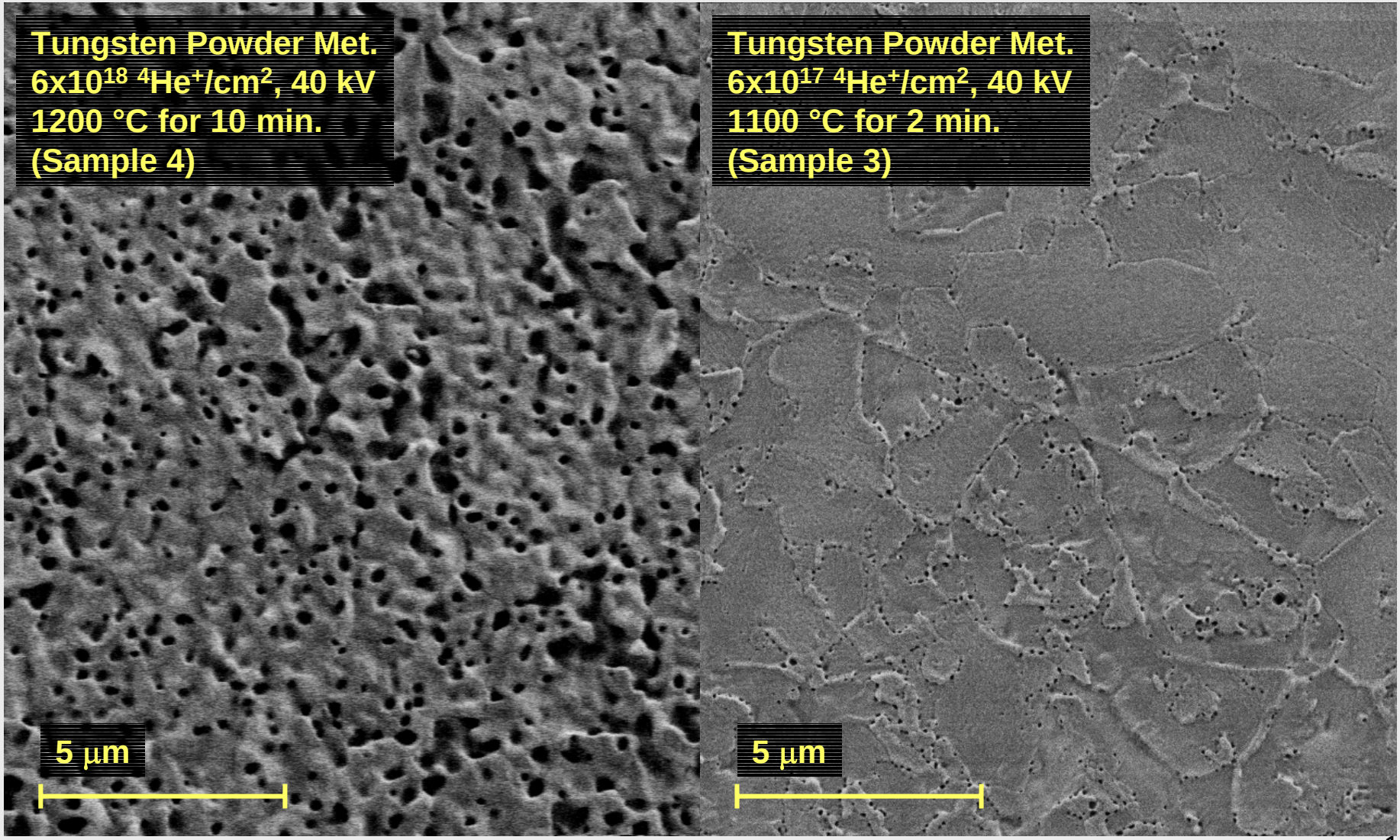


High Temp. Helium Implantation at $6x10^{18}$ $^4He^+/cm^2$ Created Porous Surface Structure

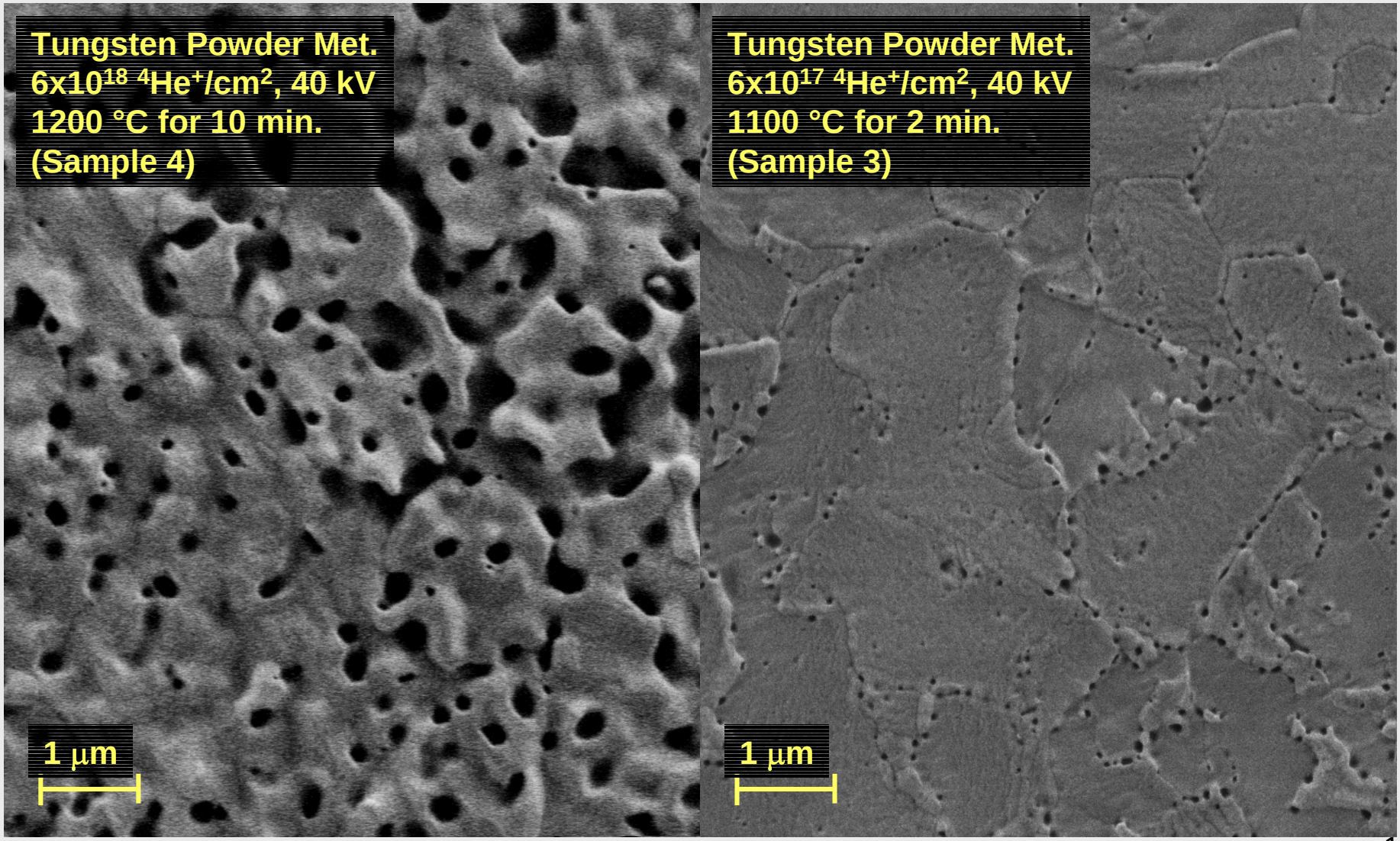




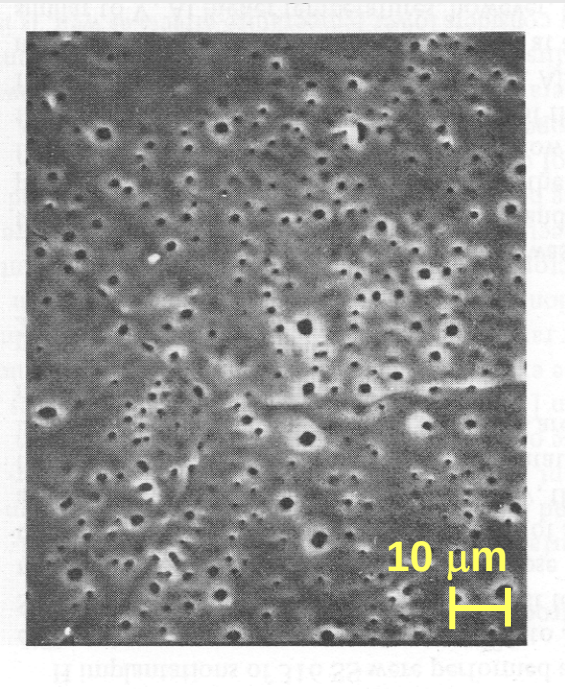
Pores Decorate Grain Boundaries at Lower Ion Fluence ($6x10^{17}$ $^4He^+/cm^2$)



Pores Decorate Grain Boundaries at Lower Ion Fluence ($6x10^{17}$ $^4He^+/cm^2$)



Pinhole Structure Seen 30 Years Ago



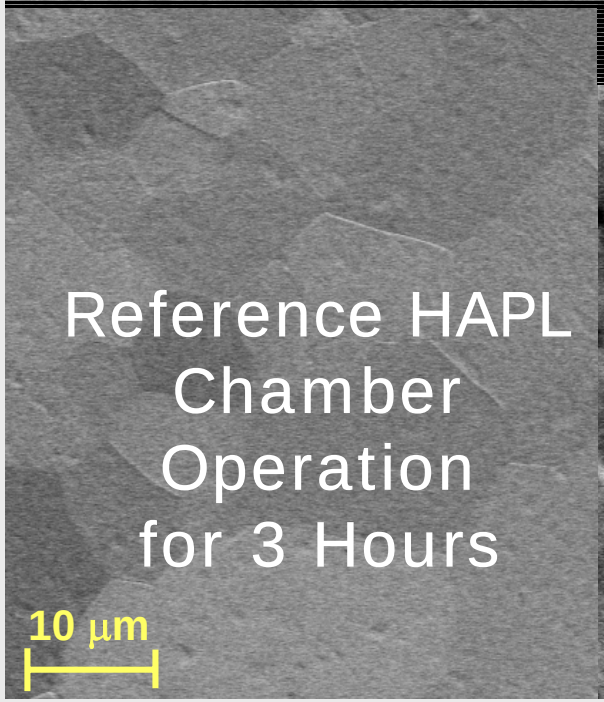
Vanadium @ 1200 °C
300 keV He^+ $2x10^{18}$ ions/cm^2

- "Pinhole" structure shown by the work of Thomas and Bauer on Vanadium (1974)
- Authors' Conclusions:
  - At high temperatures, bubbles intersect the surface to form the porous structure
  - This porous structure is stable and results in 100% helium re-emission

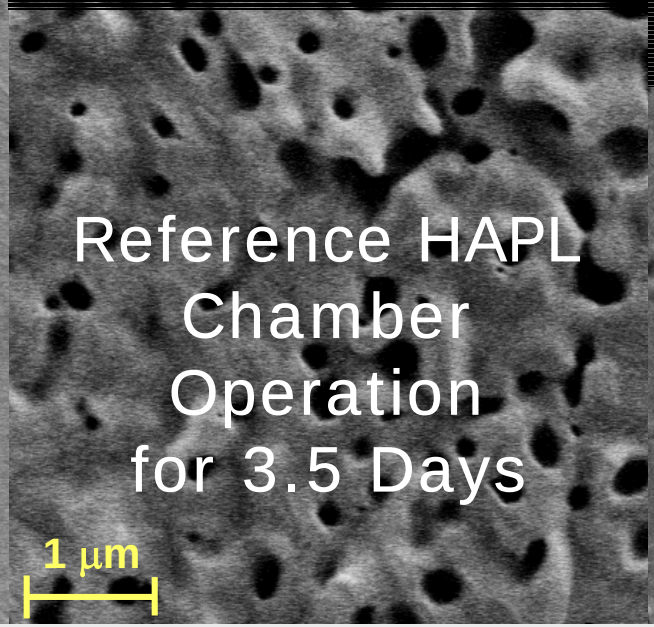
G.J. Thomas & W. Bauer, *J. Nucl. Mater.* (1974) **53**, 134.

Preliminary Conclusions

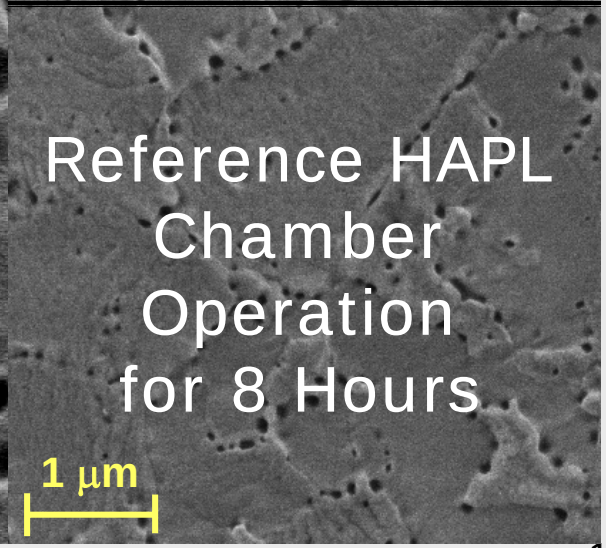
At 1100-1300 °C, $2x10^{19}$ D^+/cm^2 implantation produced no blistering



At 1200 °C, $6x10^{18}$ He^+/cm^2 implantation produced "pinhole" porous surface structure



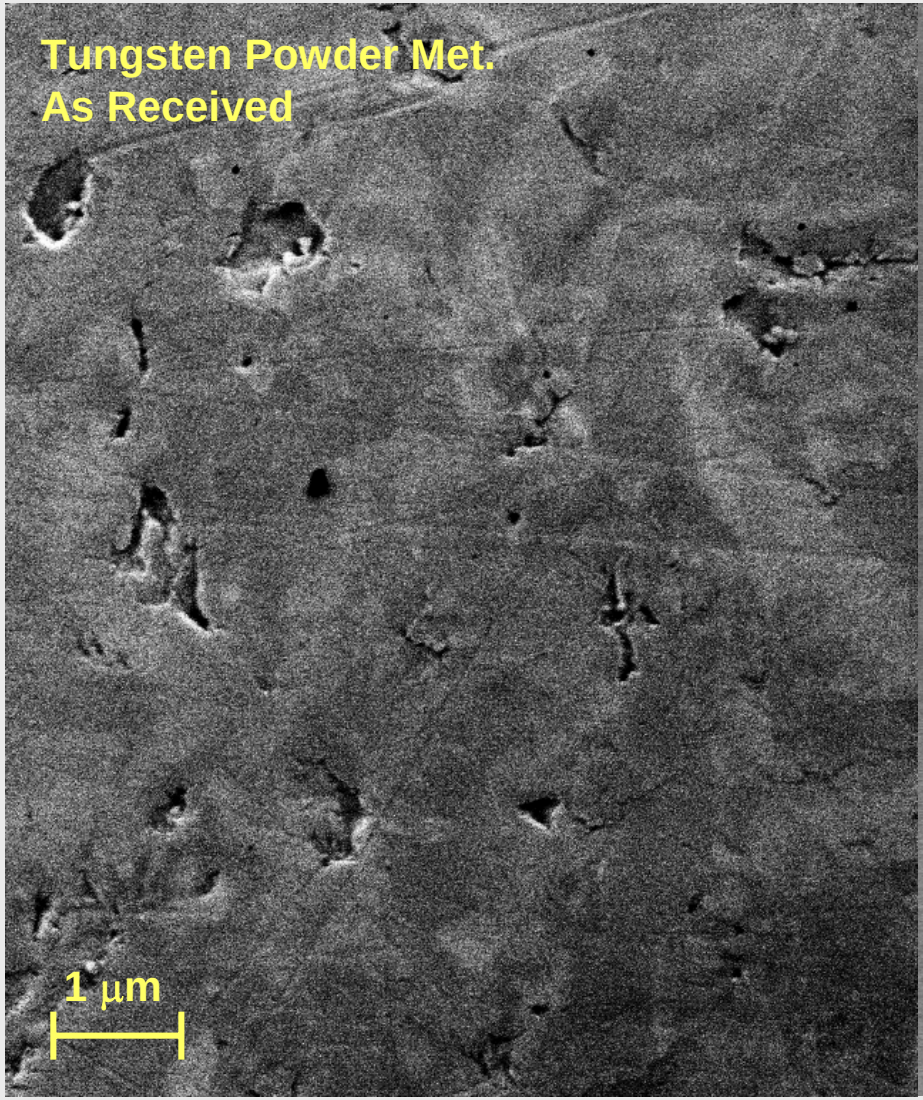
At 1100 °C, $6x10^{17}$ He^+/cm^2 implantation produced helium bubbles that decorate the grain boundaries

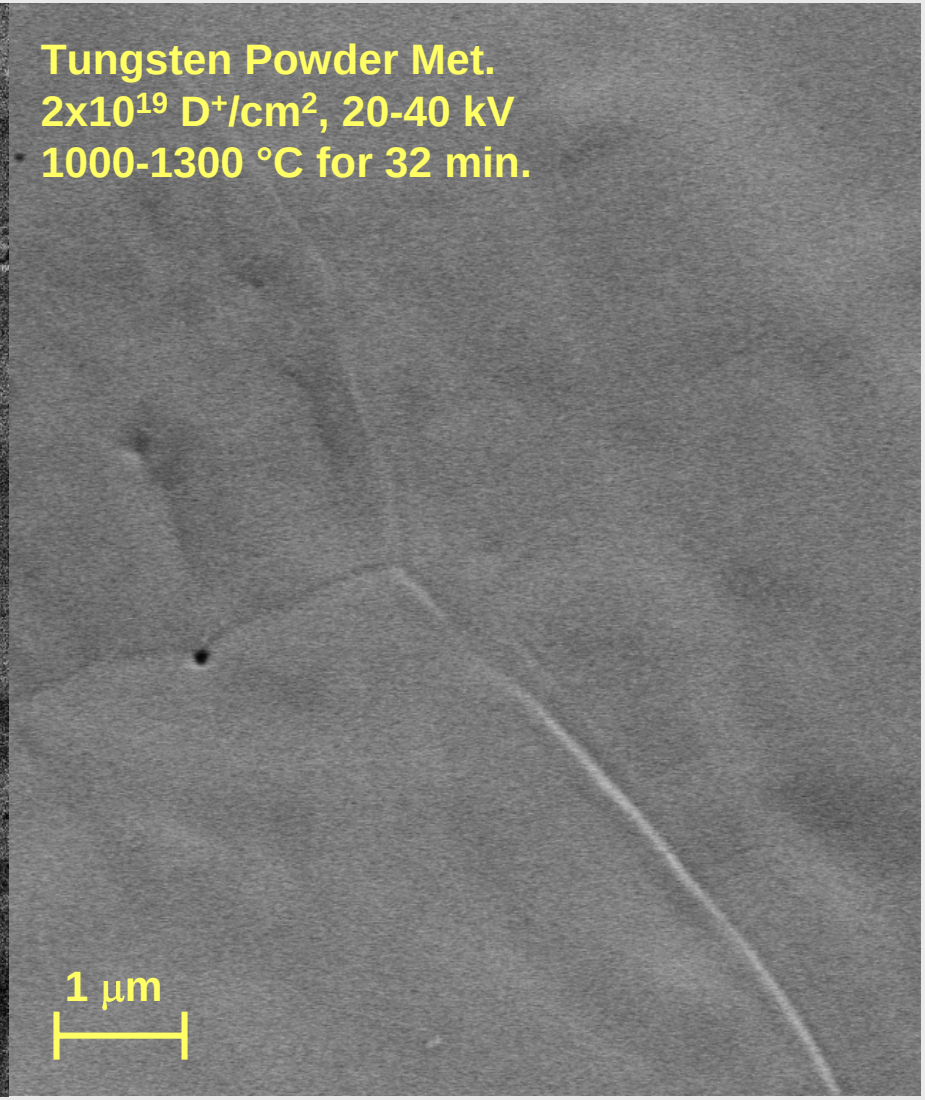


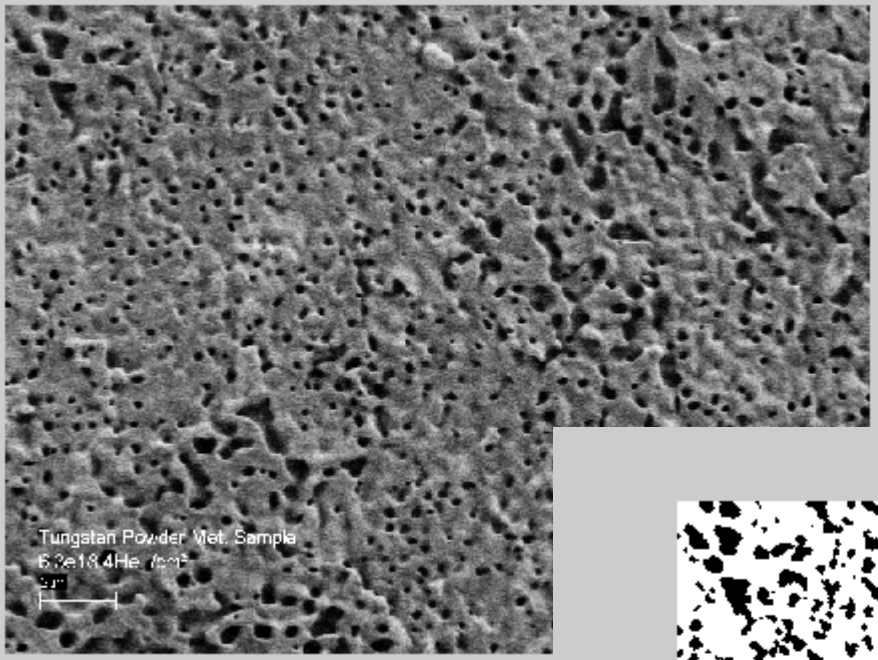
Future Work

- Higher Energy Implantation (40-100 kV)
- Implantation at Different Flux Levels
- Implantation at Different Temperatures
- Simultaneous D and ^{4}He Implantation
- Ion Density Depth Distribution

Deuterium Did Not Cause Blistering But Caused Substantial Grain Growth






Tungstan Powder Met. Sample