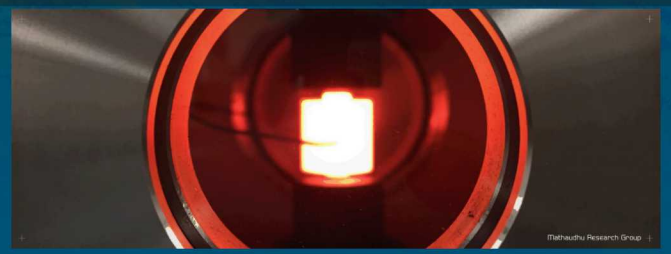
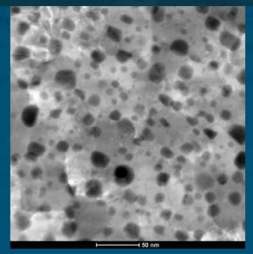
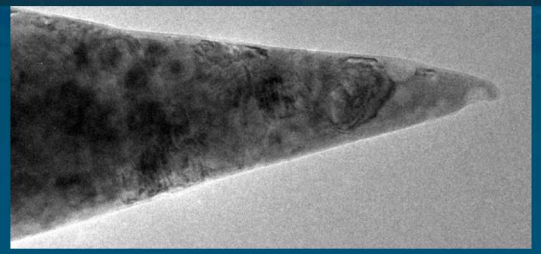
SAND2019-11785C

# Effect of Irradiation on Microstructure and Mechanical Properties of Metal Matrix Nanocomposite





PRESENTED BY

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Suveen Mathaudhu — University of California, Riverside
Khalid Hattar — Sandia National Laboratories NM

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# Radiation and thermal creep tolerant materials

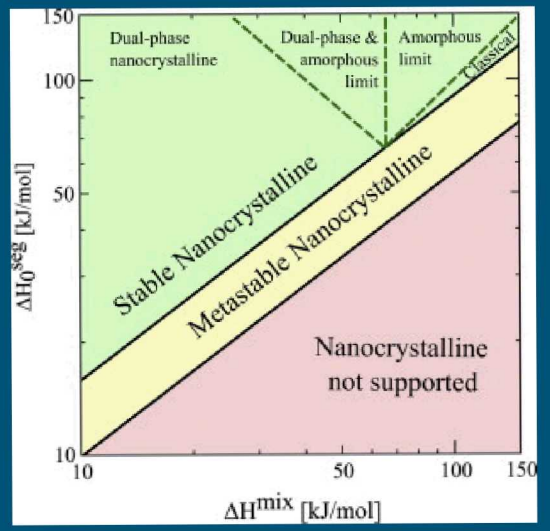
Stable microstructures with many nanoscale interfaces:

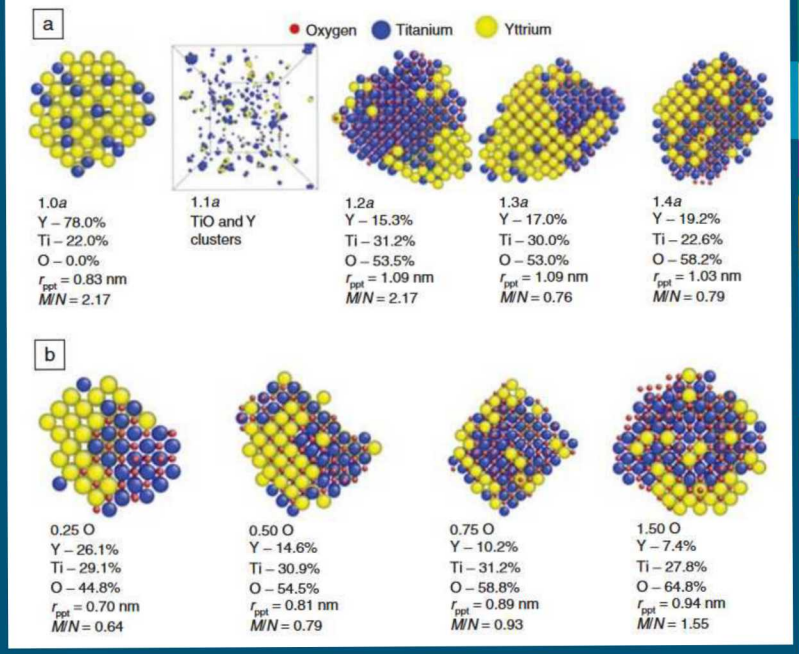
Oxide Dispersion Strengthened (ODS) Alloys

Nano layered materials

Nanocrystalline Alloys

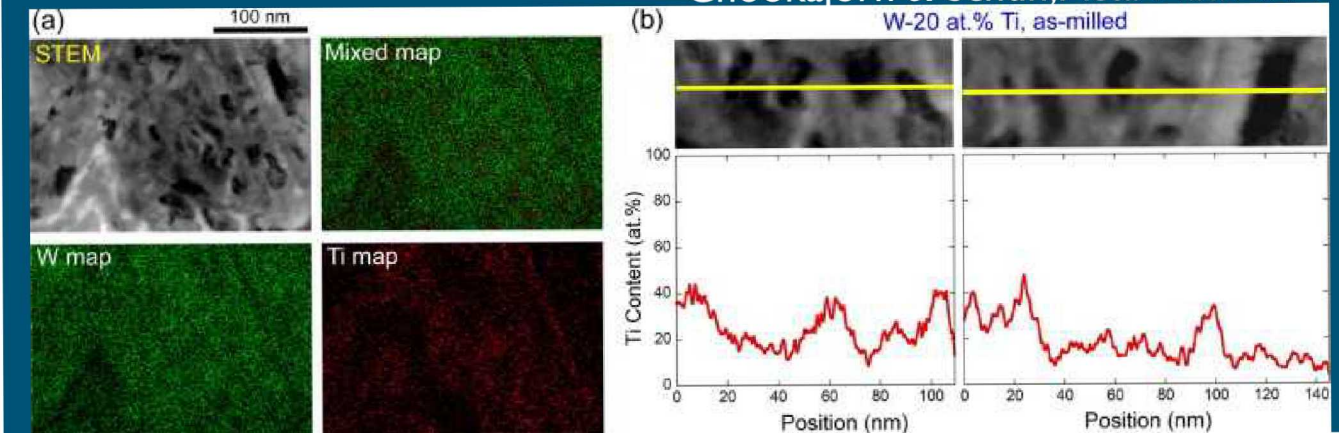
Murdoch and Schuh, Acta Mat. 2013

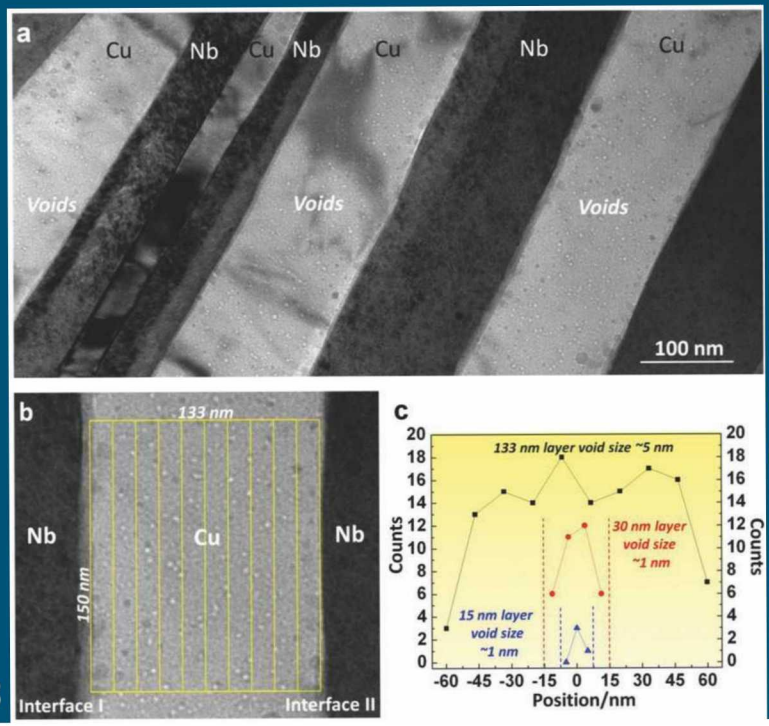



Demkowicz et al. MRS Bulletin 2011

Chookajorn & Schuh, Acta Mat. 2014

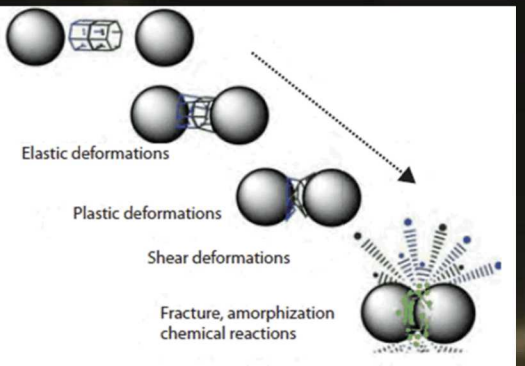



Han et al. Adv. Mat. 2013

# High Energy Ball Milling

Slowed
360x



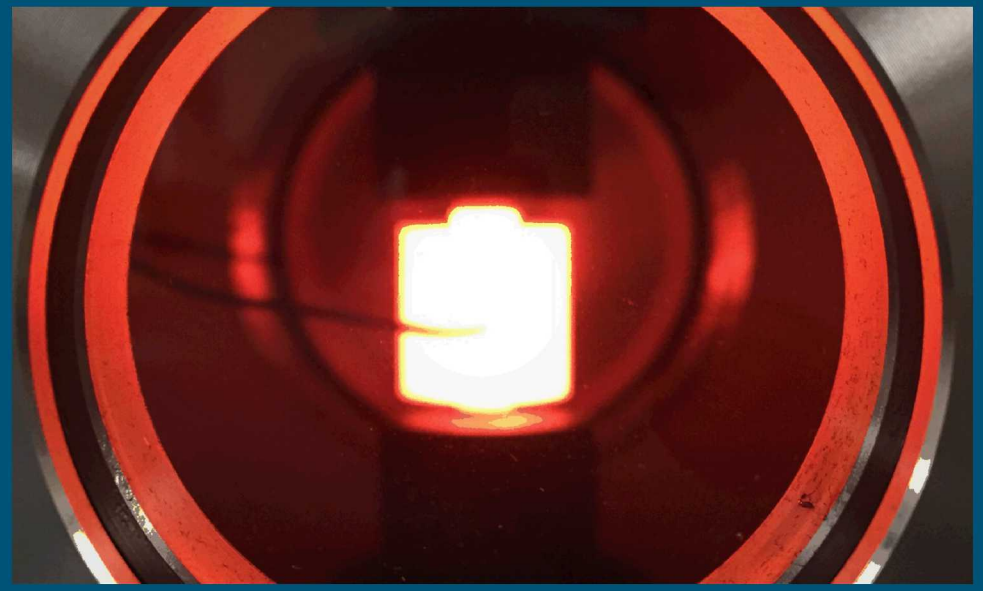

1 cm

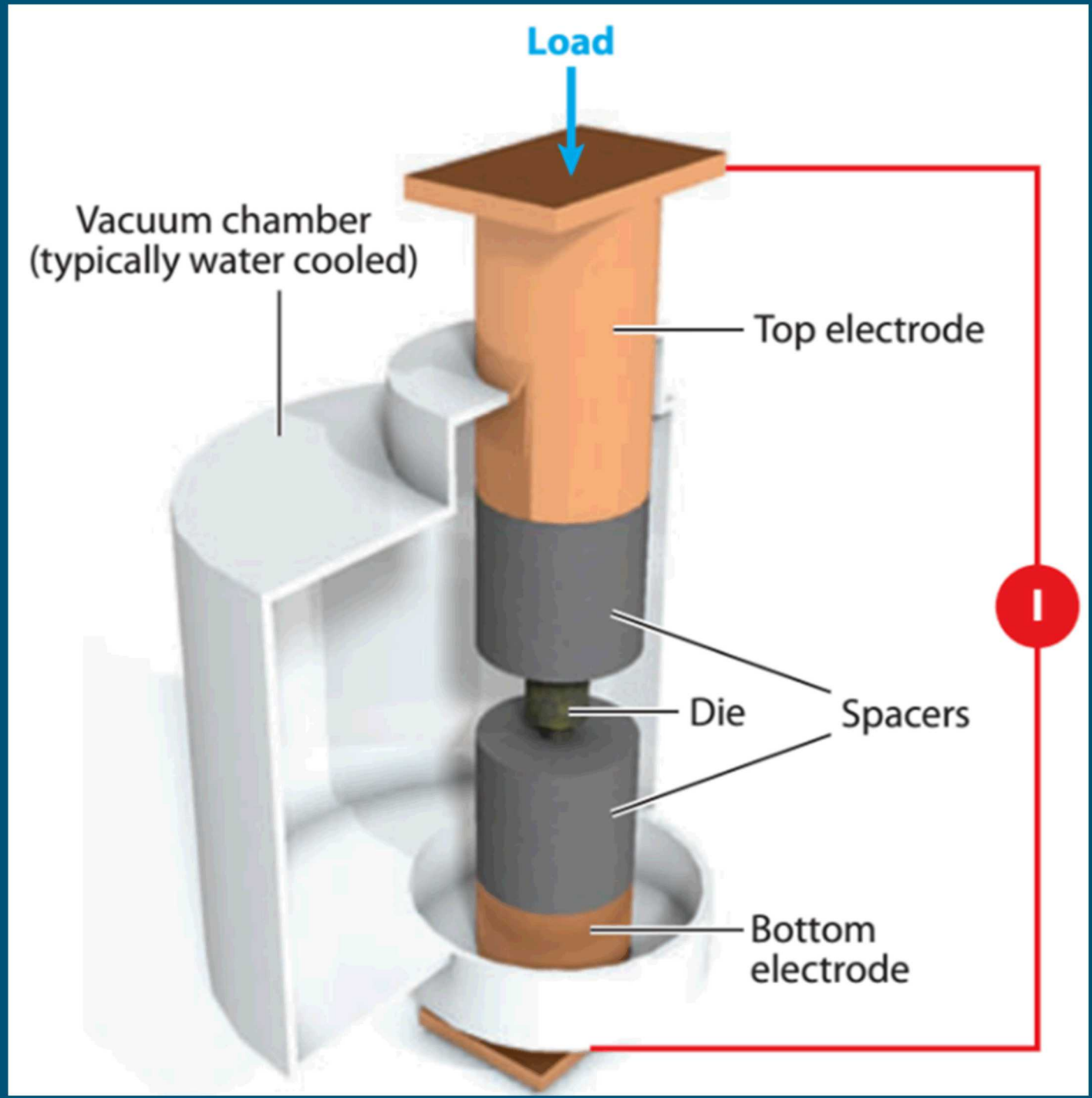
# Spark Plasma Sintering

800 - 1000 °C

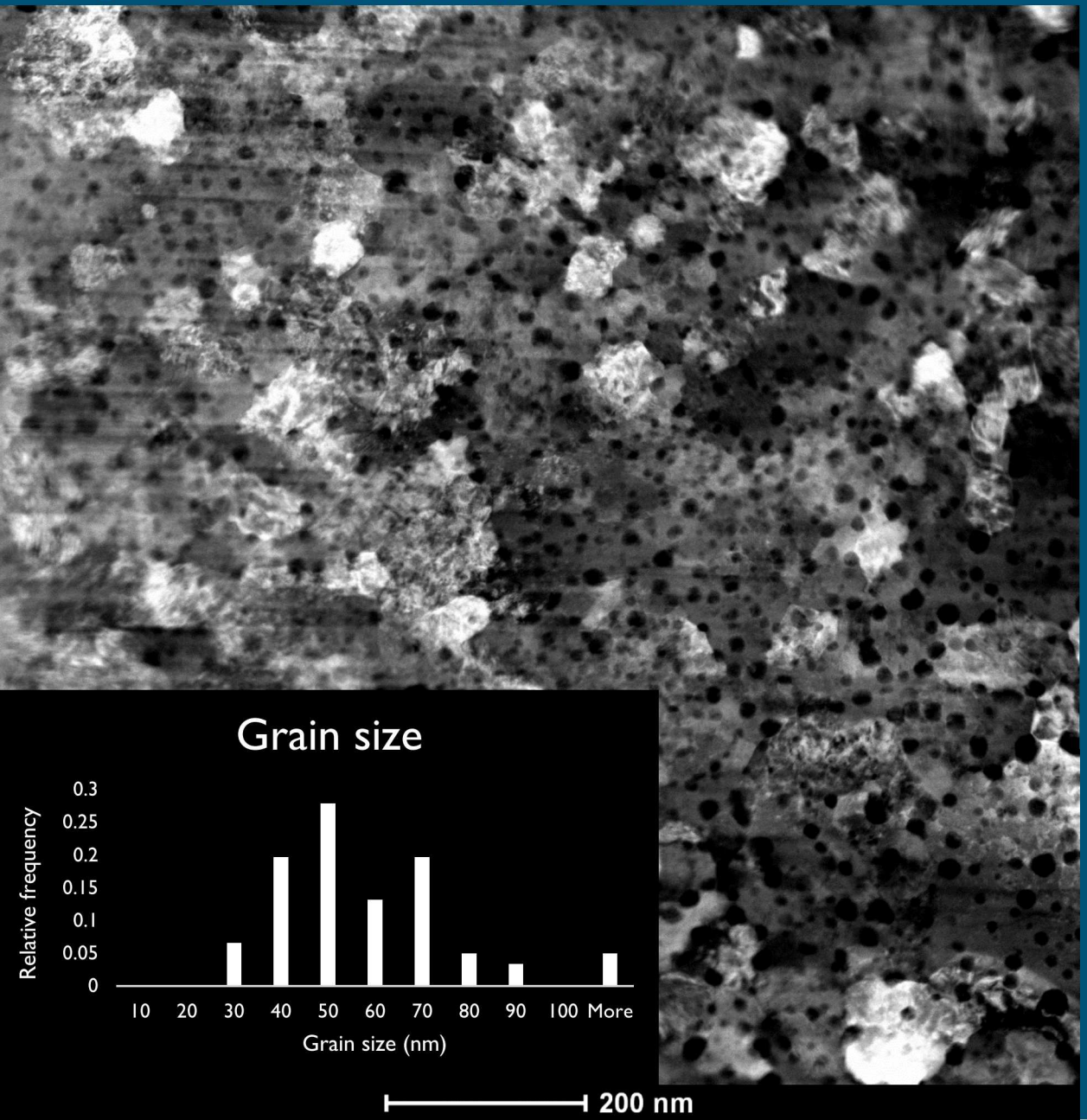
~5 minutes at temperature

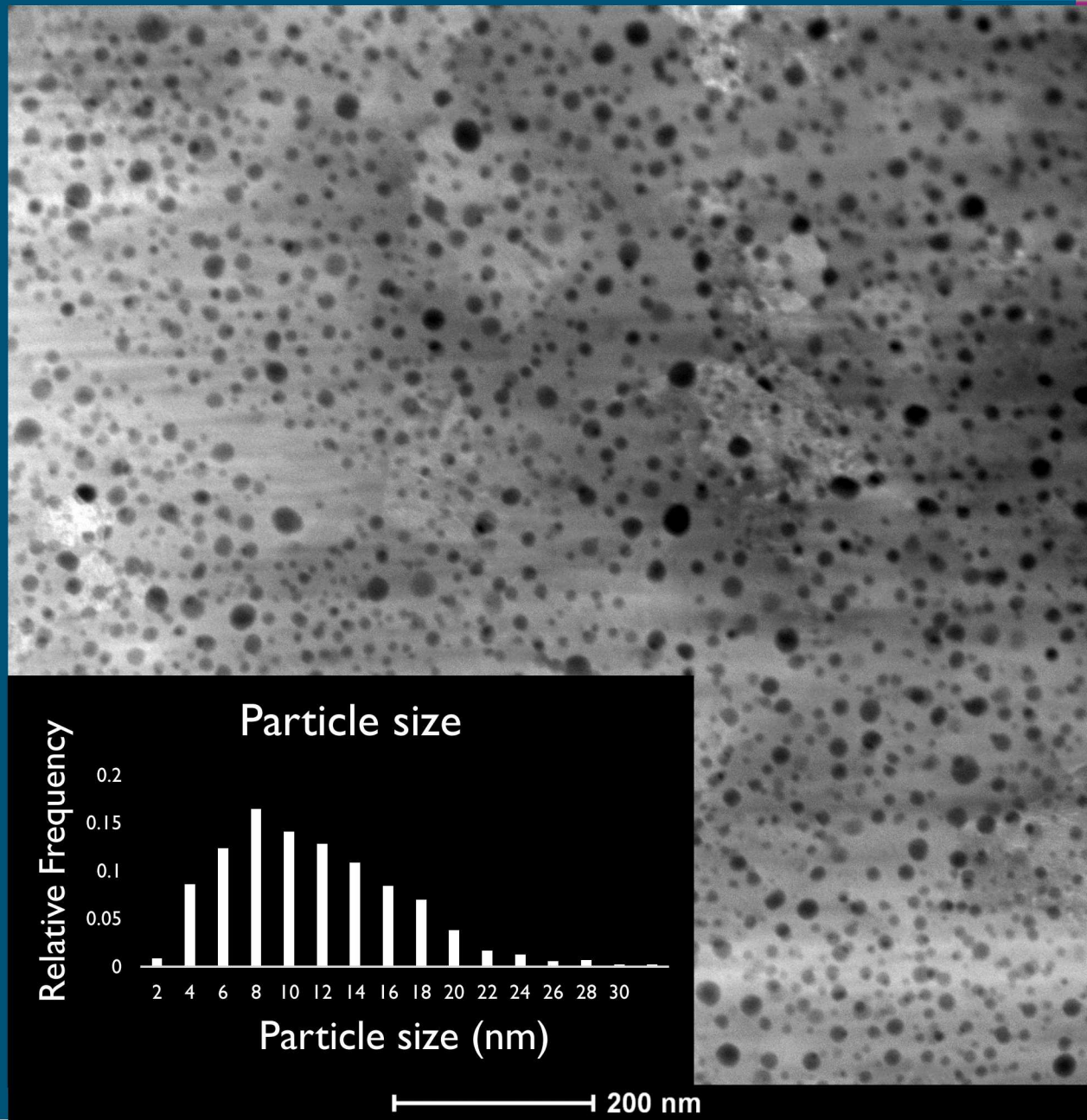
Nanofeature retention



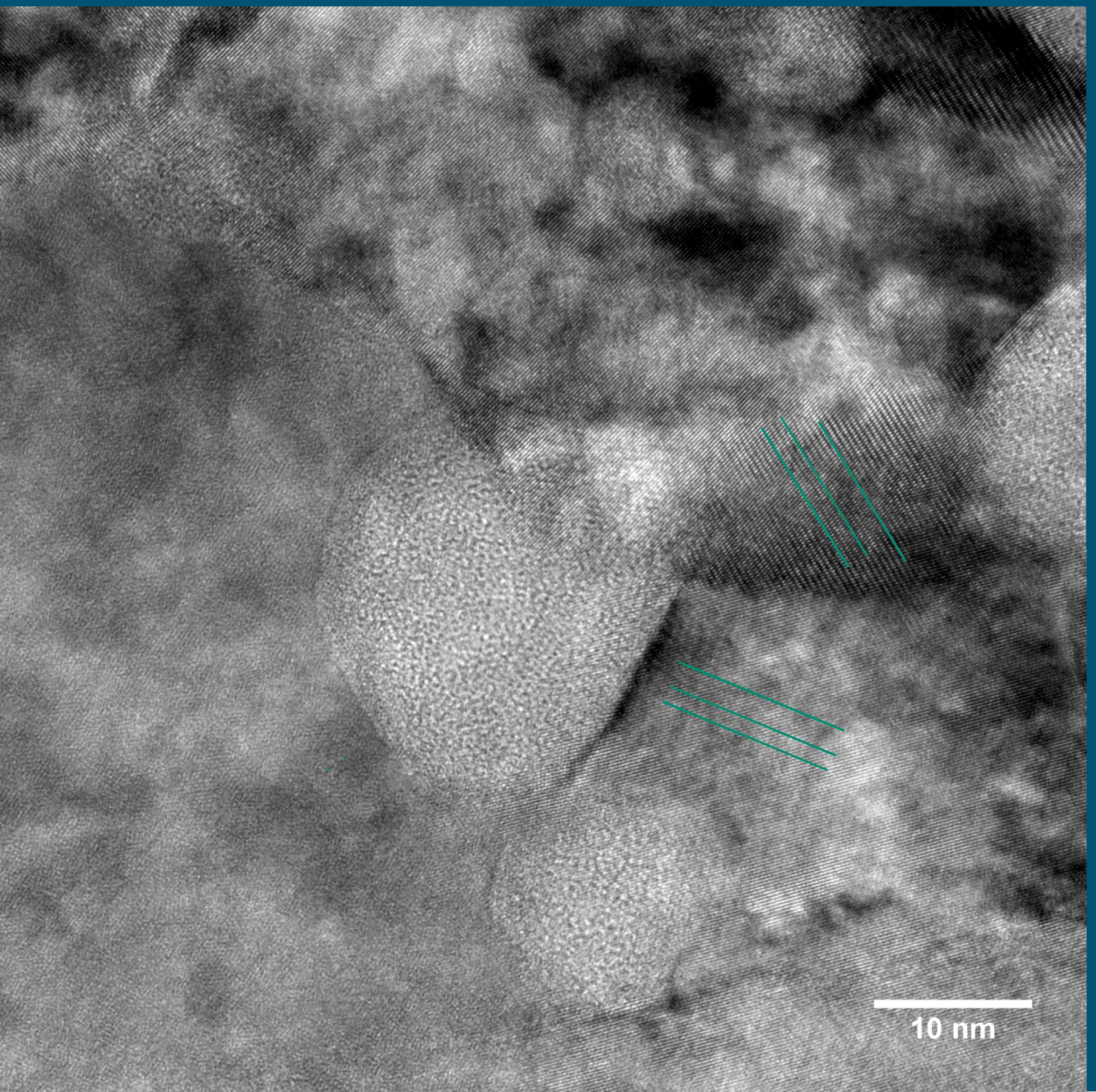


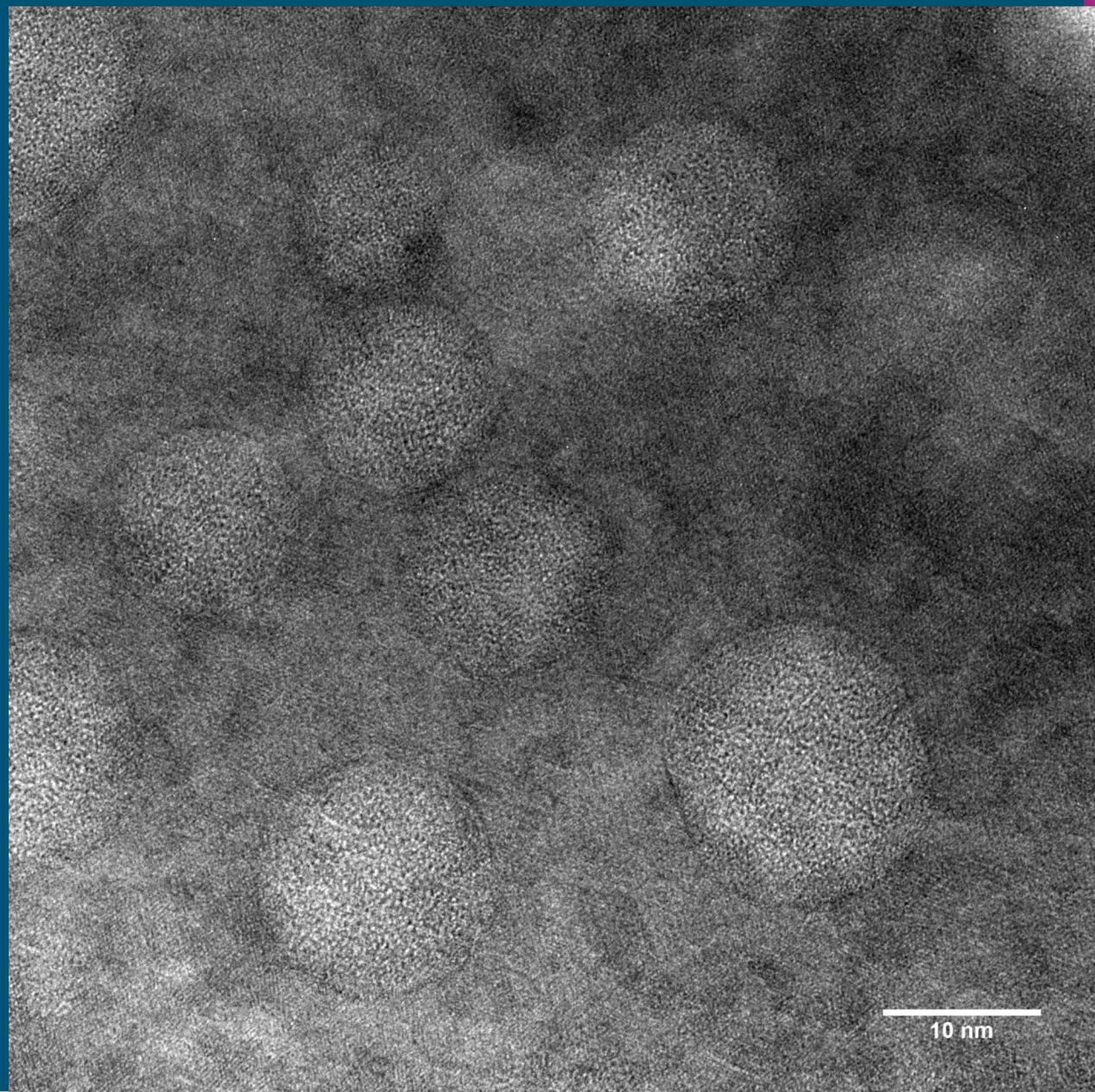
# Microstructure 800 °C



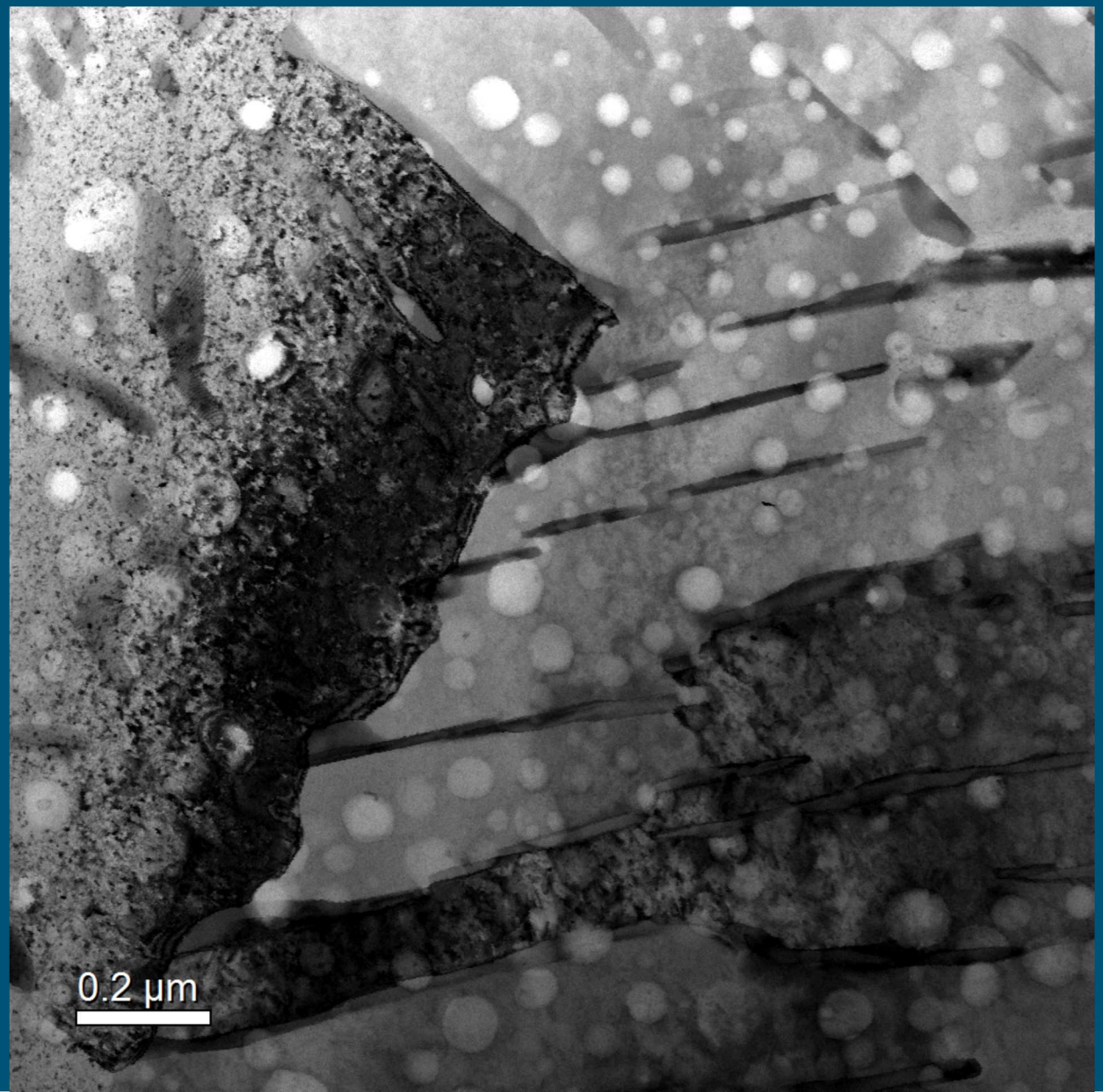
# HR TEM



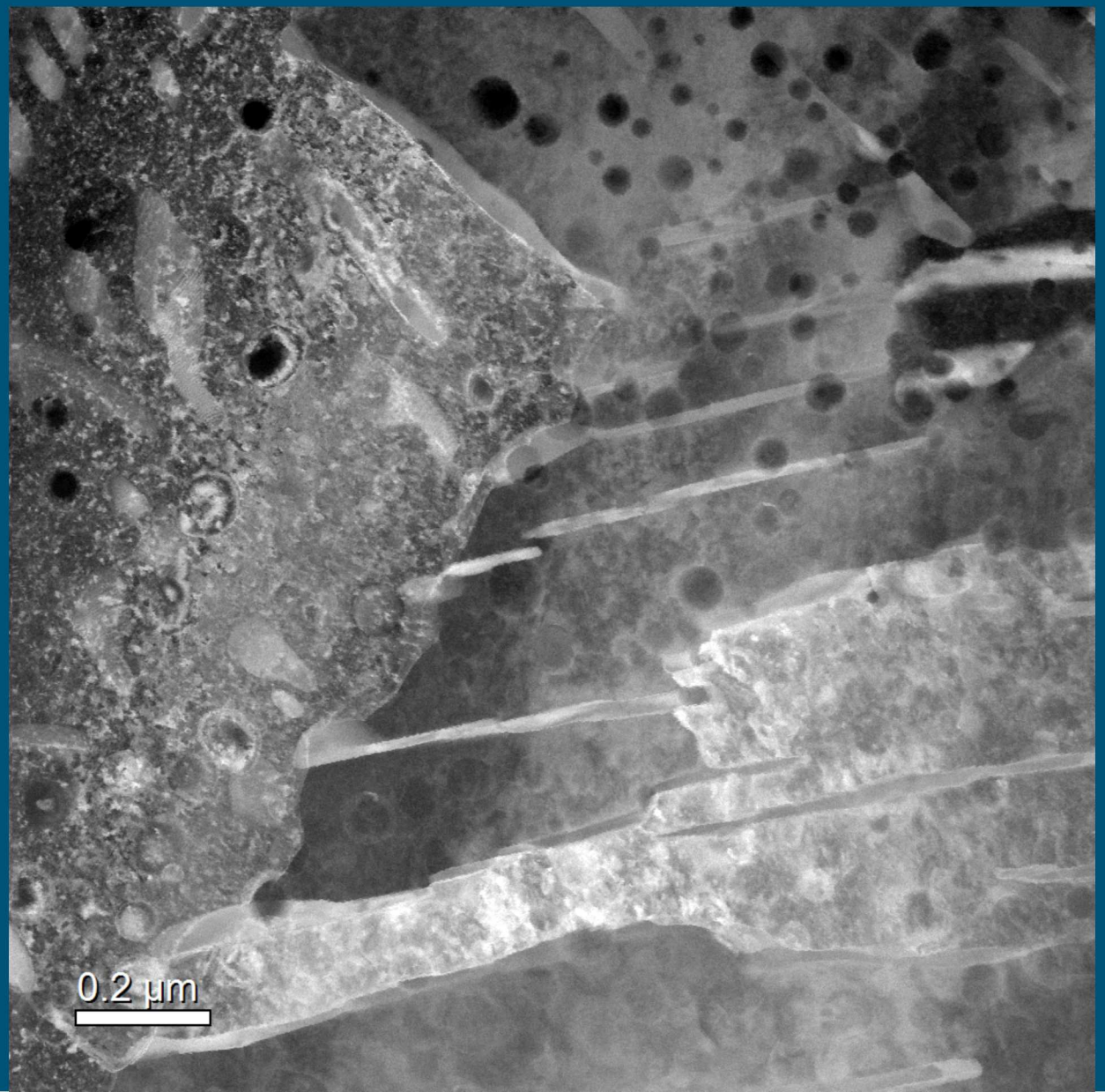



# Higher temperature 1000 °C

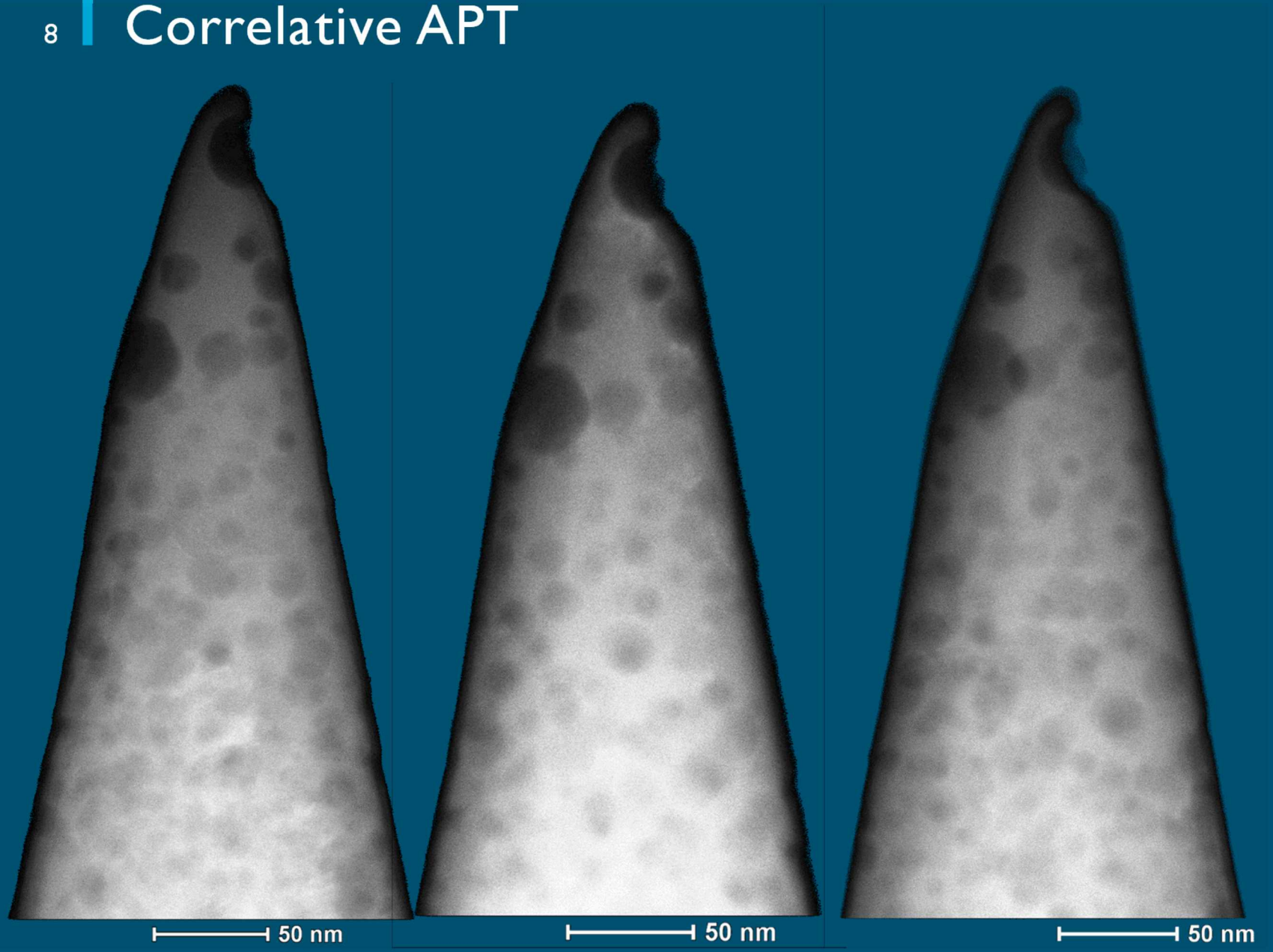
BF



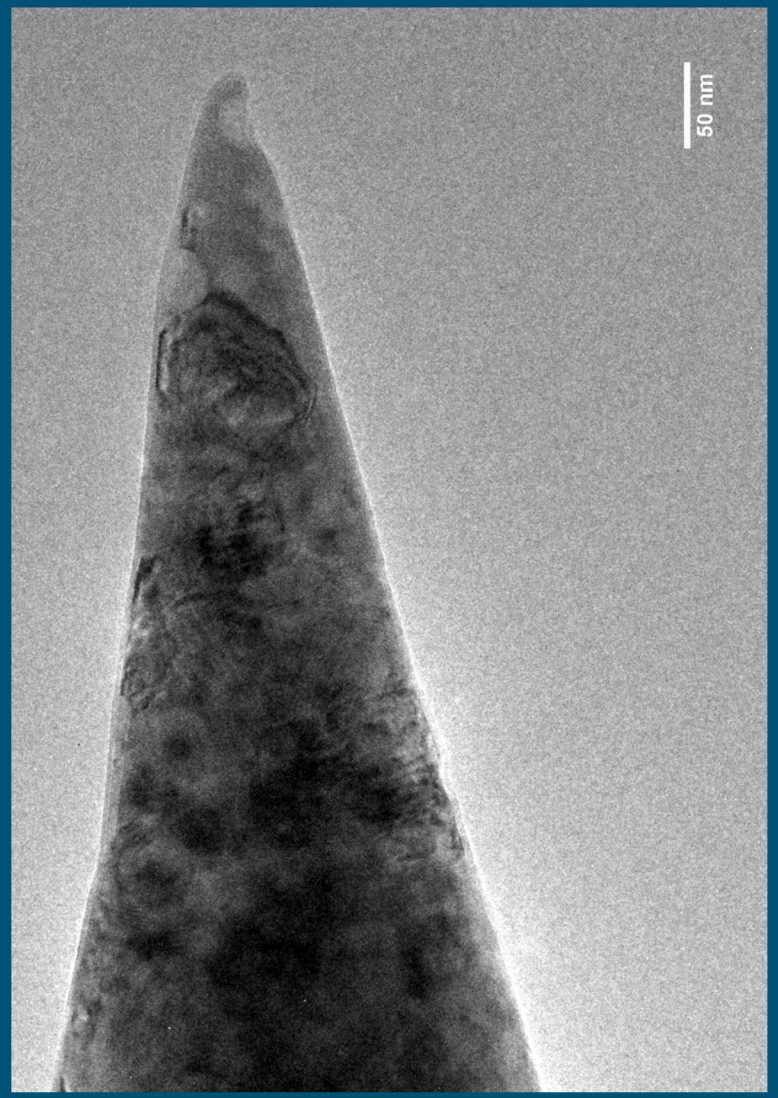

DF

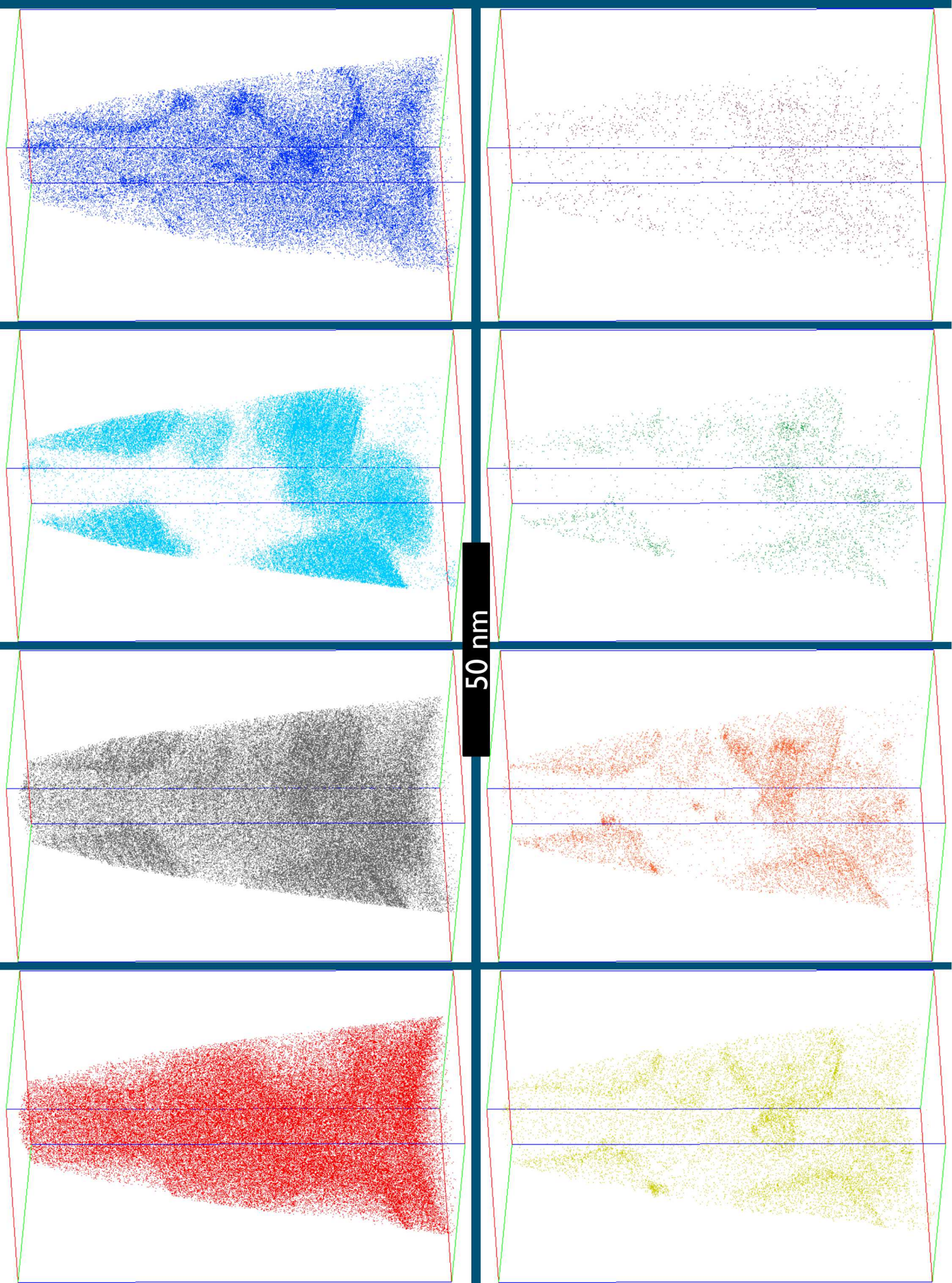


# Correlative APT

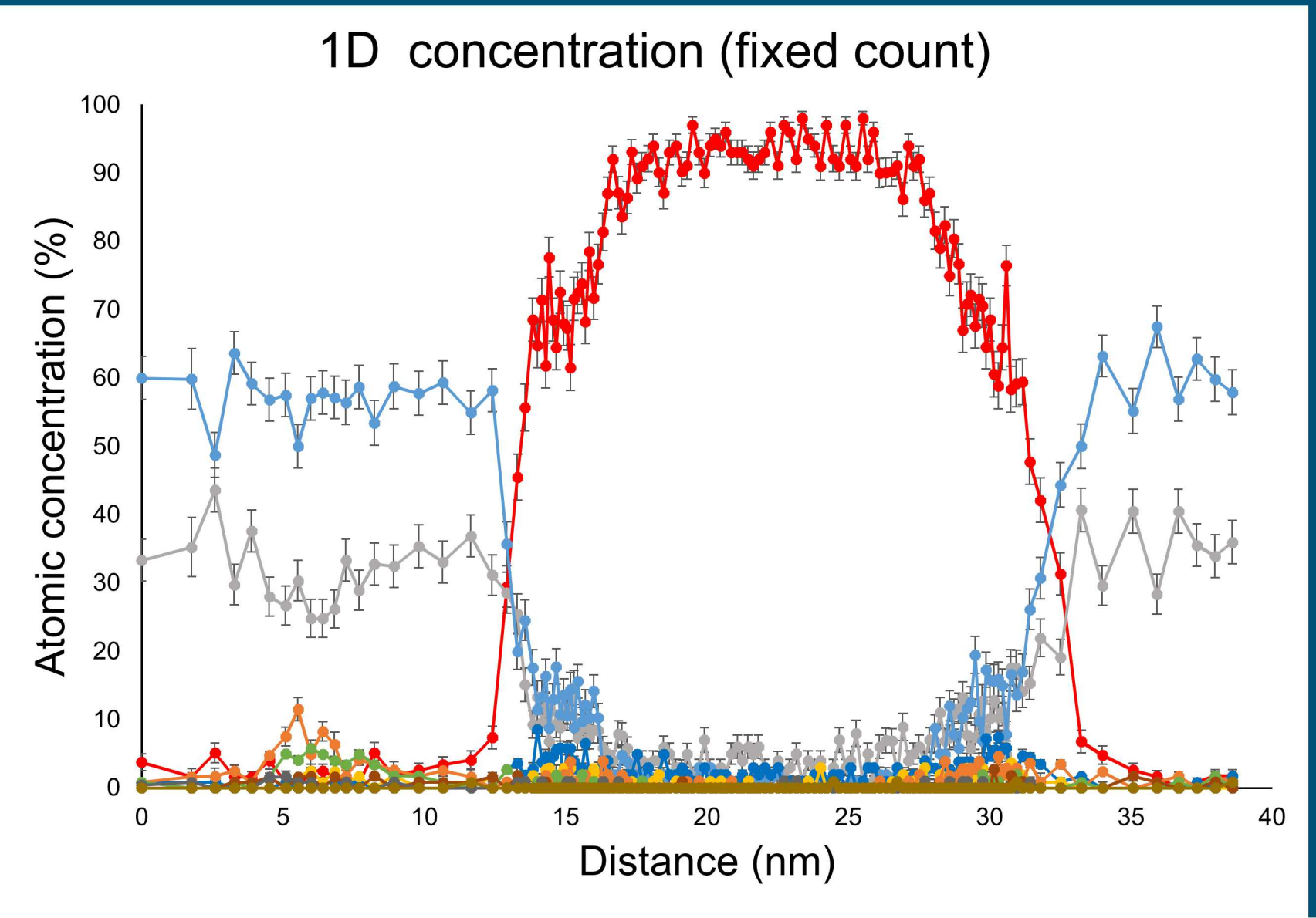


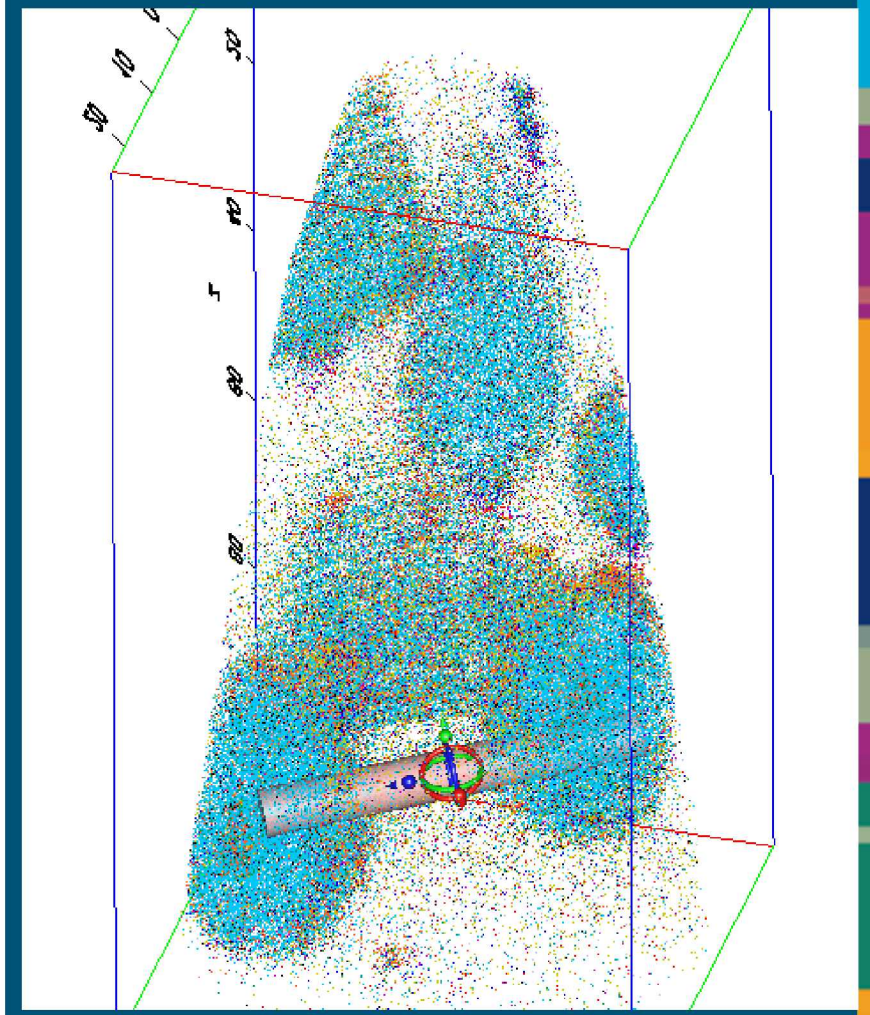

±10 deg tilt series



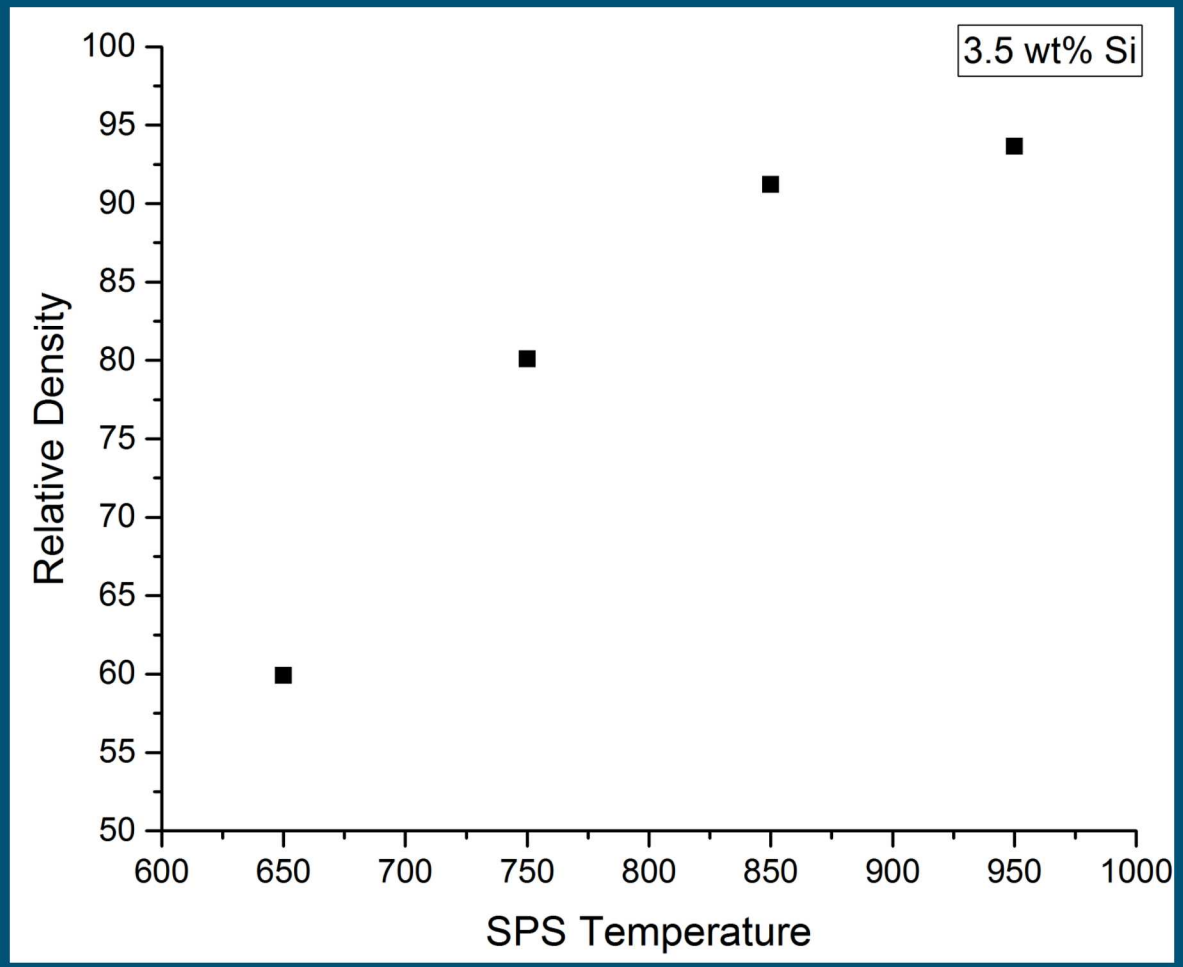

50 nm

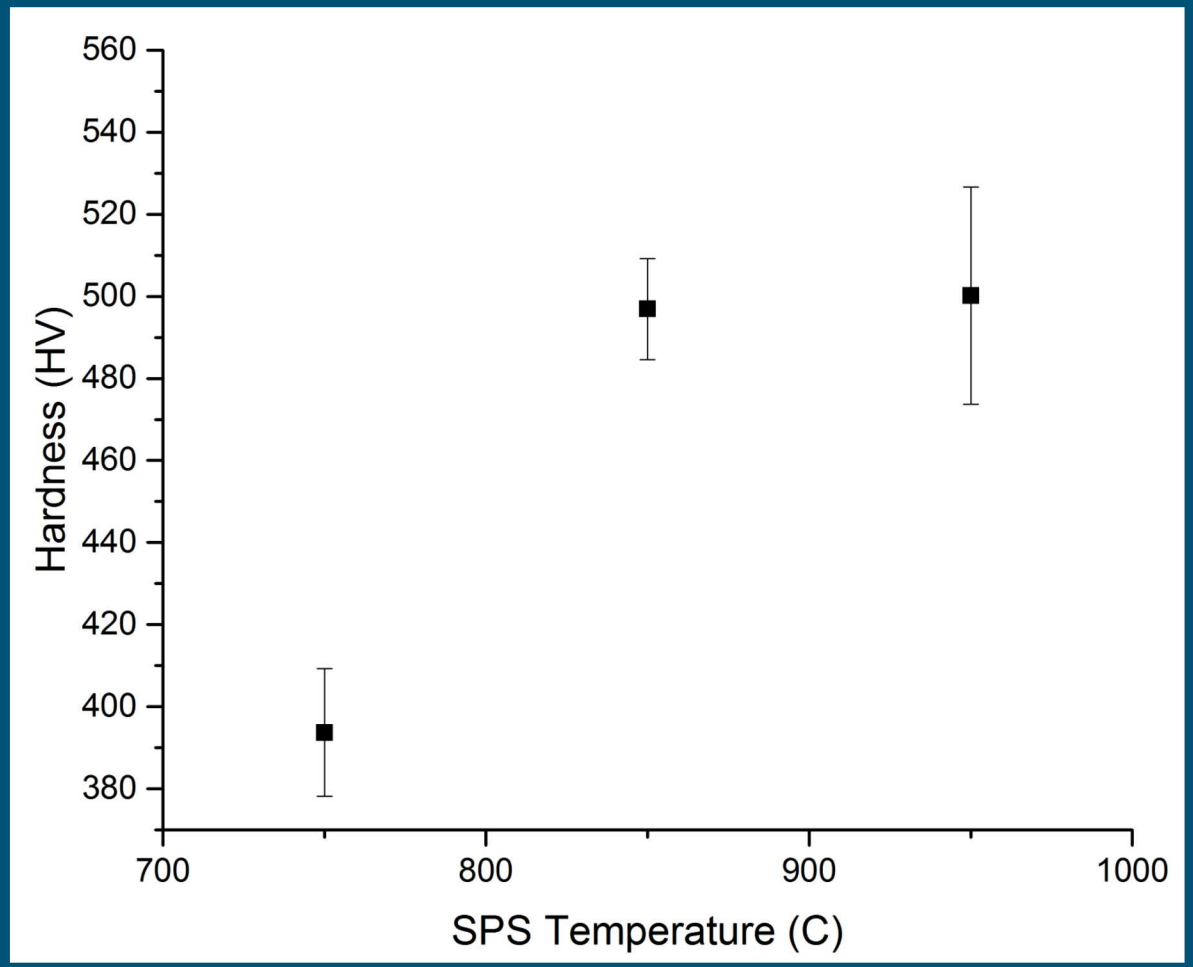
# Particle Chemistry



# Hardness

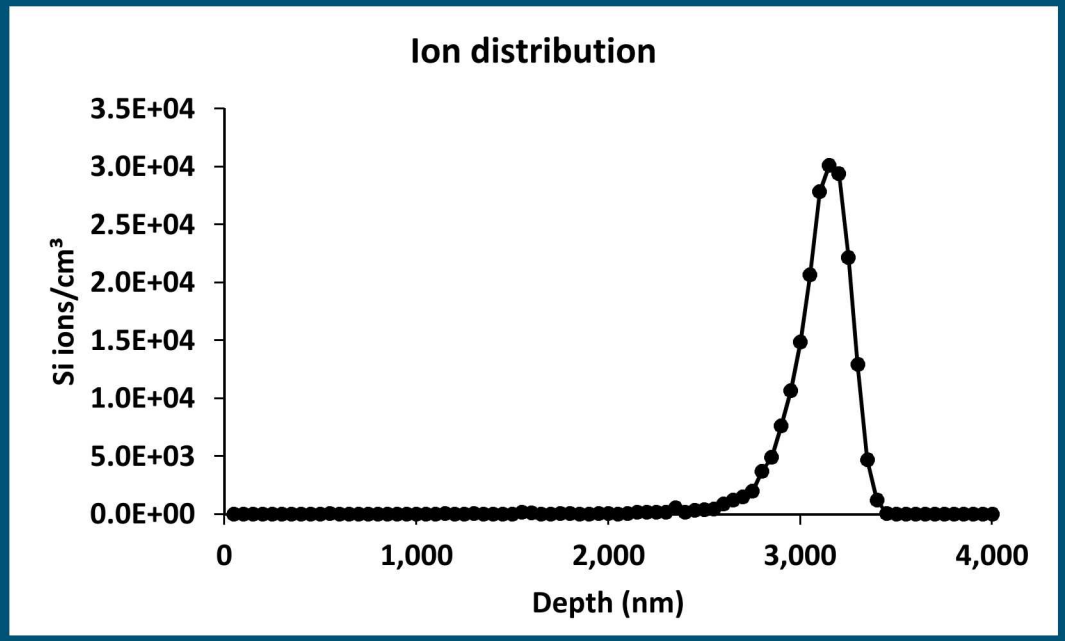

3.5 wt% Si
Relative Density
SPS Temperature
100
95
90
85
80
75
70
65
60
55
50
600
650
700
750
800
850
900
950
1000

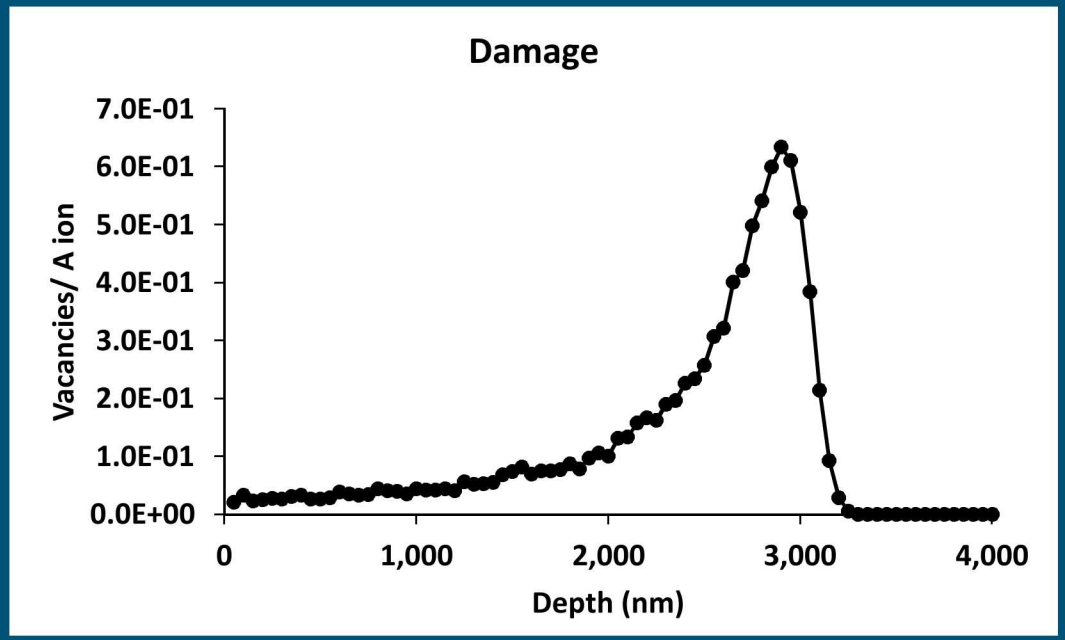

Hardness (HV)
SPS Temperature (C)
560
540
520
500
480
460
440
420
400
380
700
800
900
1000

# Irradiation Conditions

15 MeV $Si^{3+}$

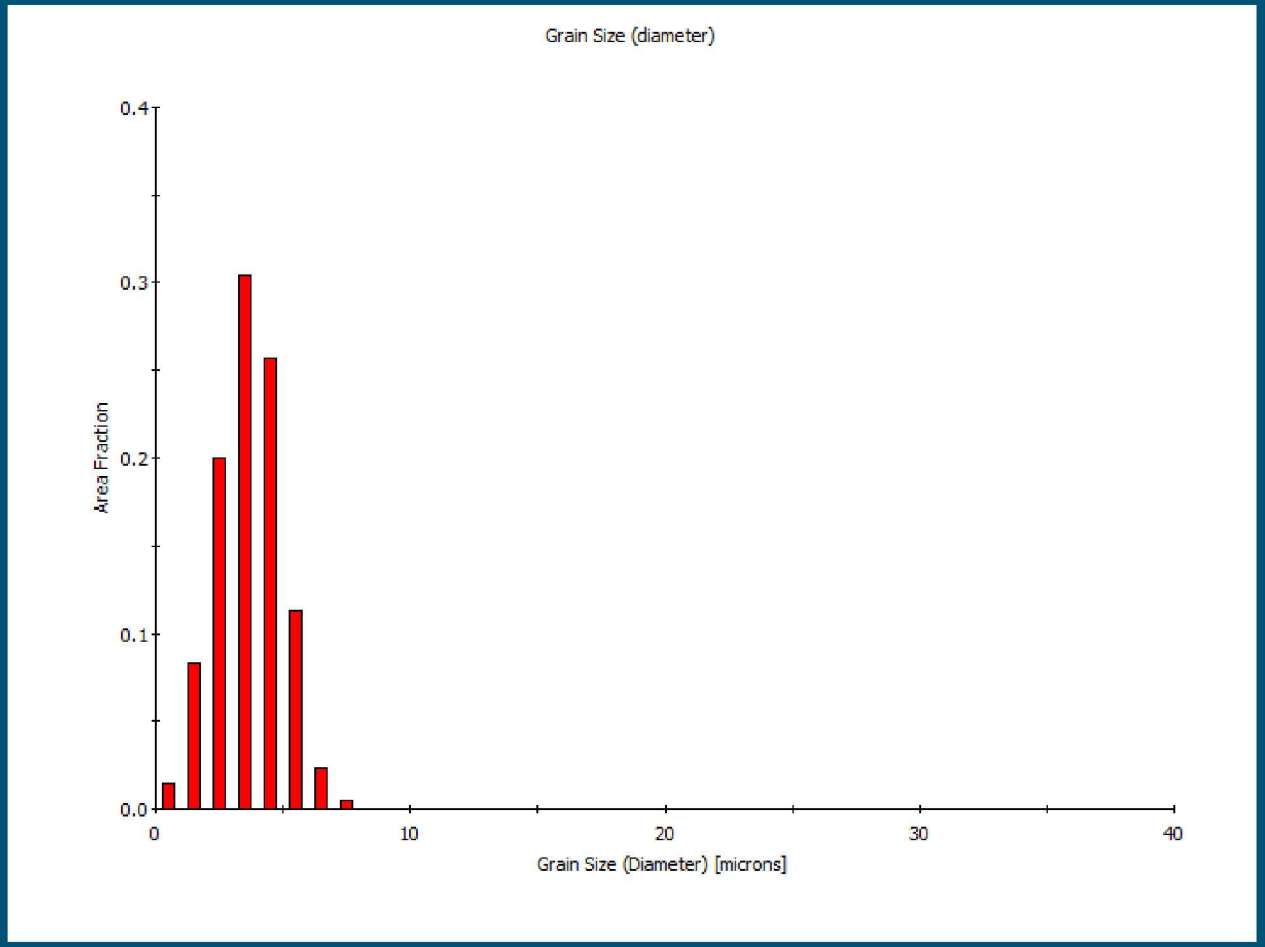
100 DPA at 2 micrometers depth



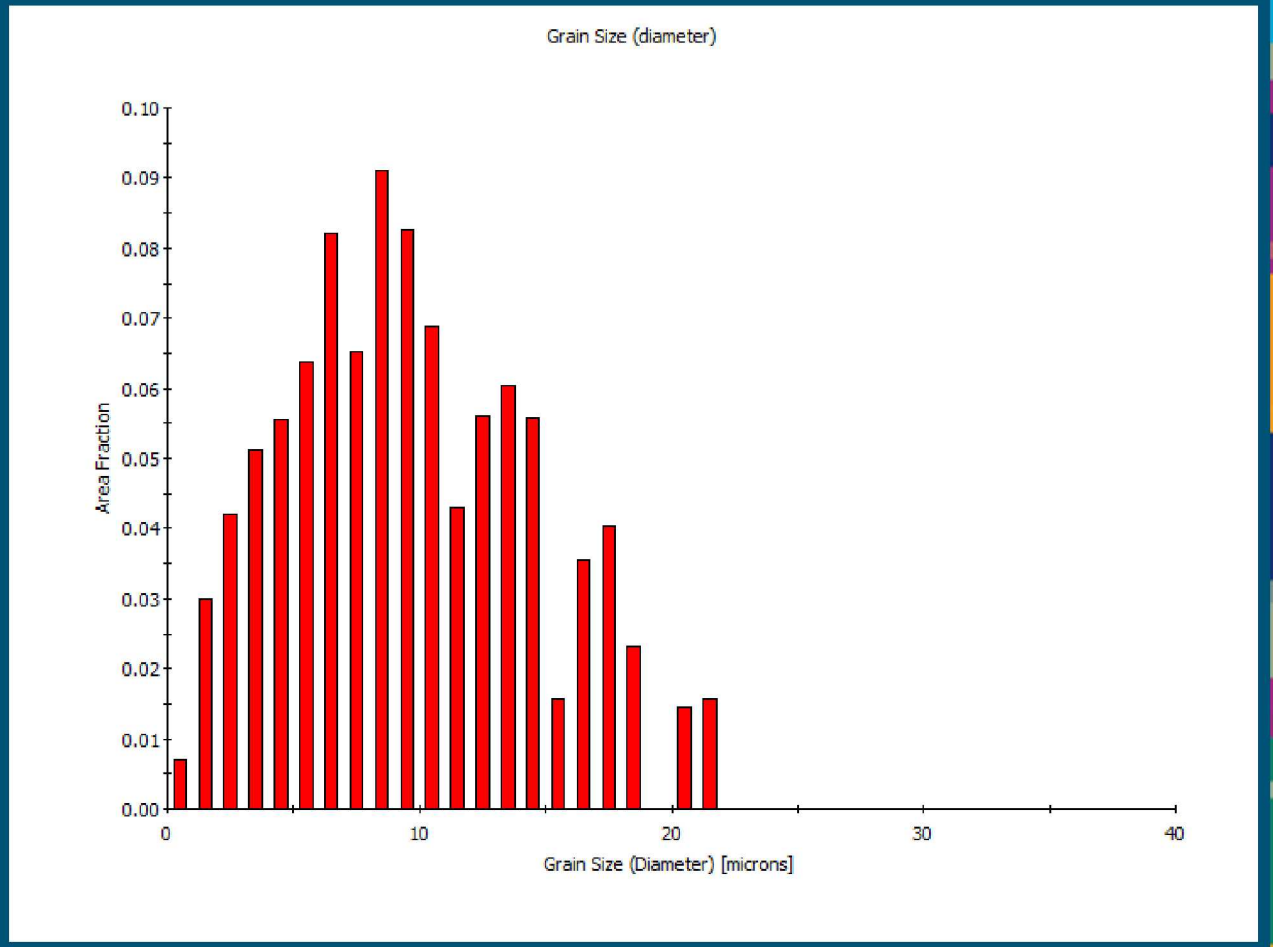



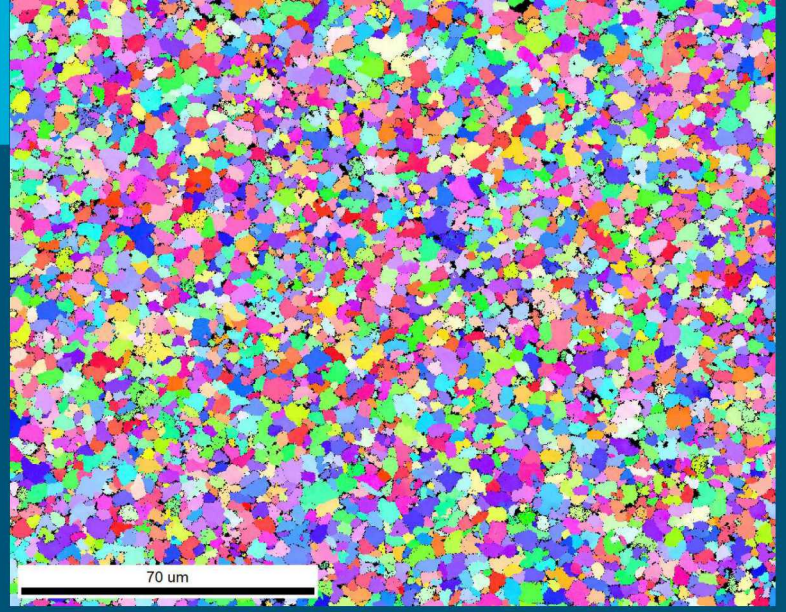
# Post Irradiation

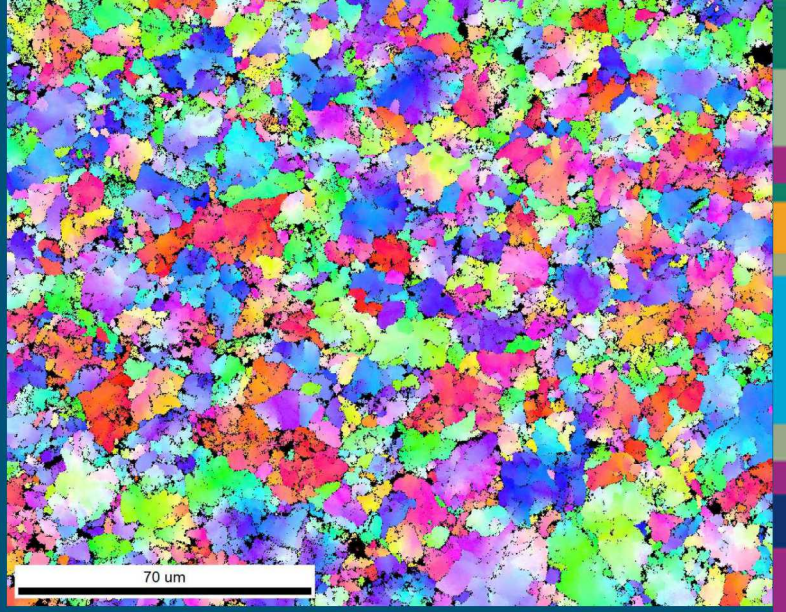
1 dpa




100 dpa




70 um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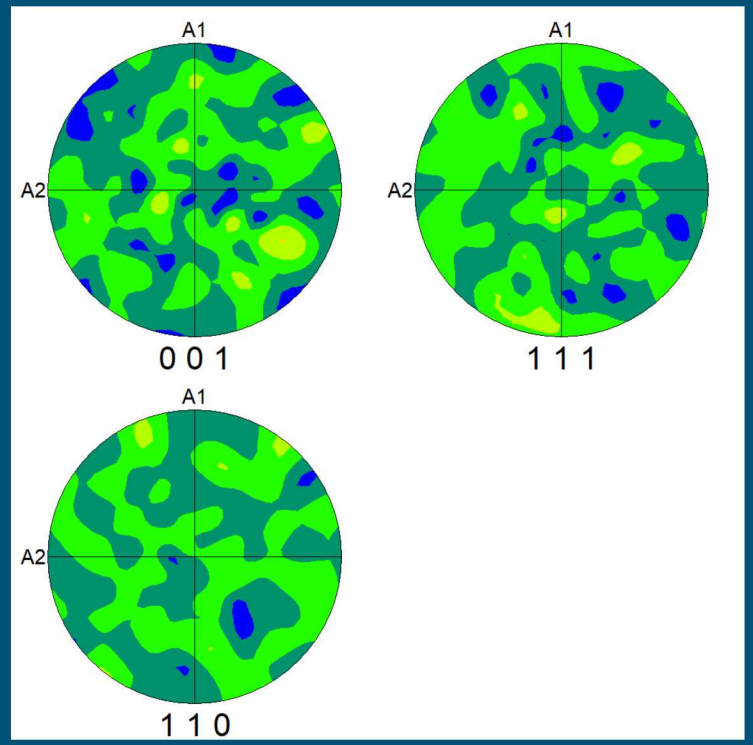
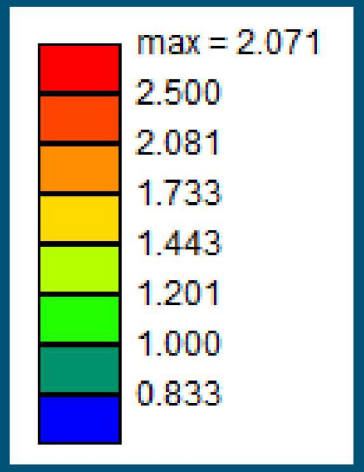
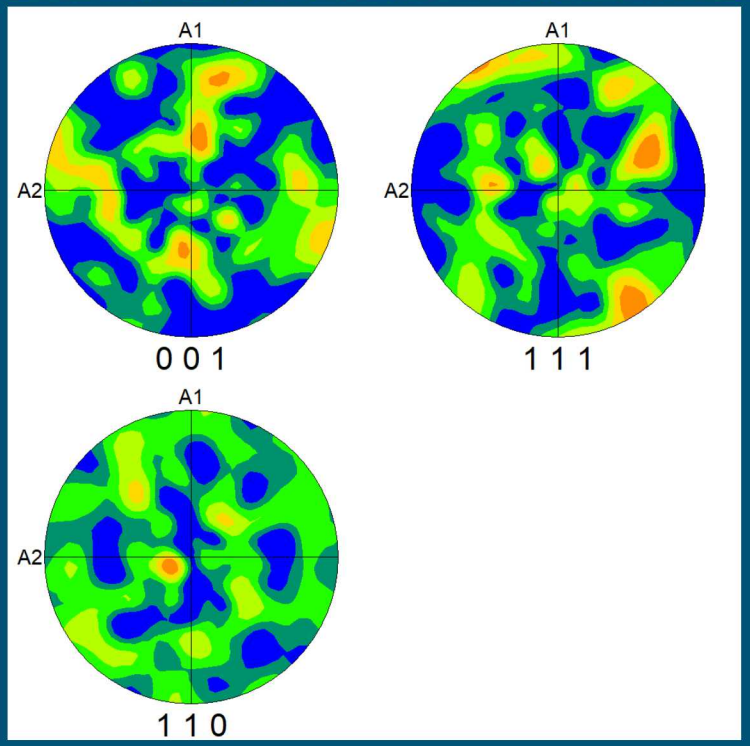

A1
A2
0 0 1
A1
A2
1 1 1
A1
A2
1 1 0


max = 2.071
2.500
2.081
1.733
1.443
1.201
1.000
0.833


A1
A2
0 0 1
A1
A2
1 1 1
A1
A2
1 1 0

# Future Work

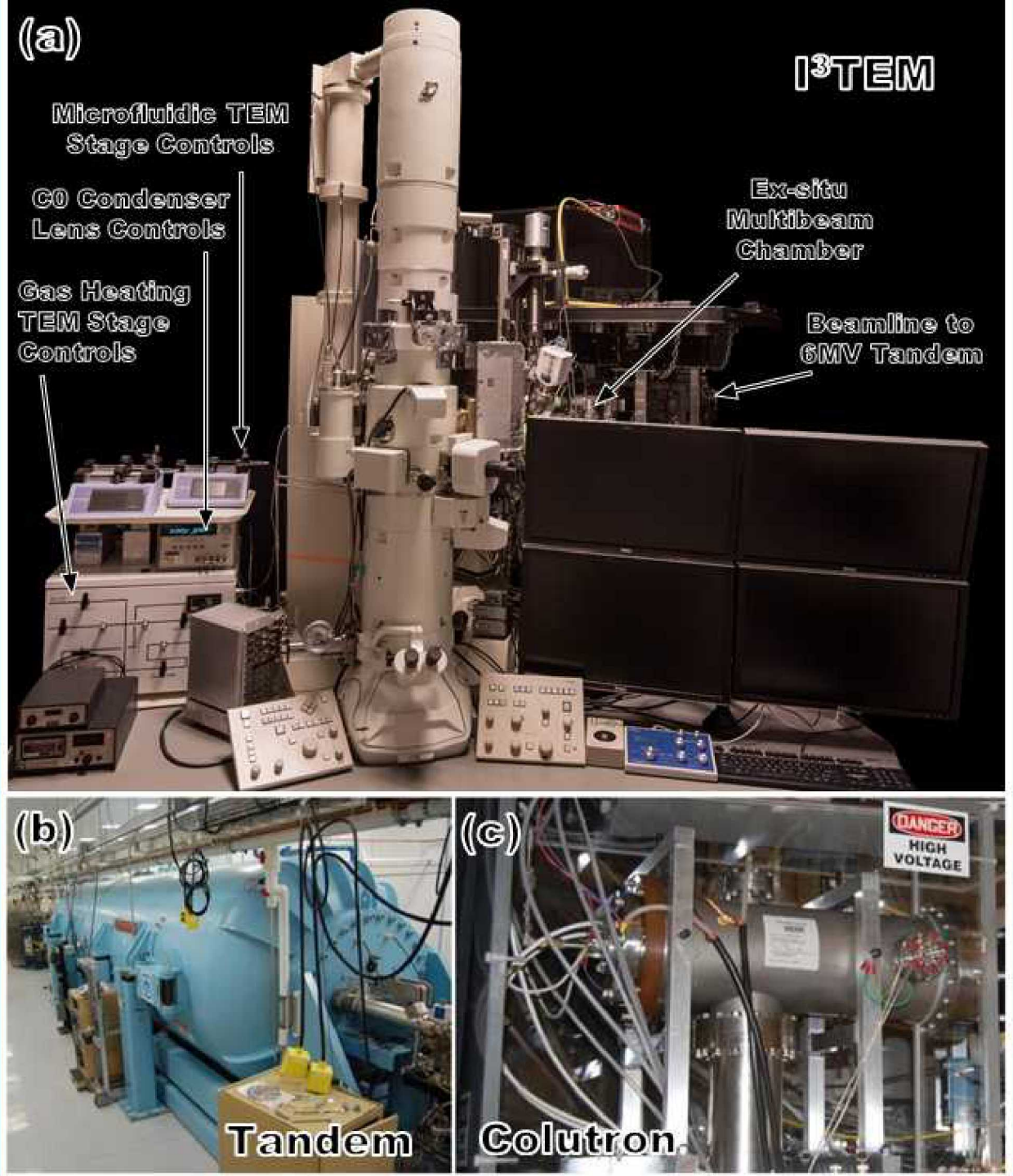
Post irradiation:

Boundaries

Particle interface

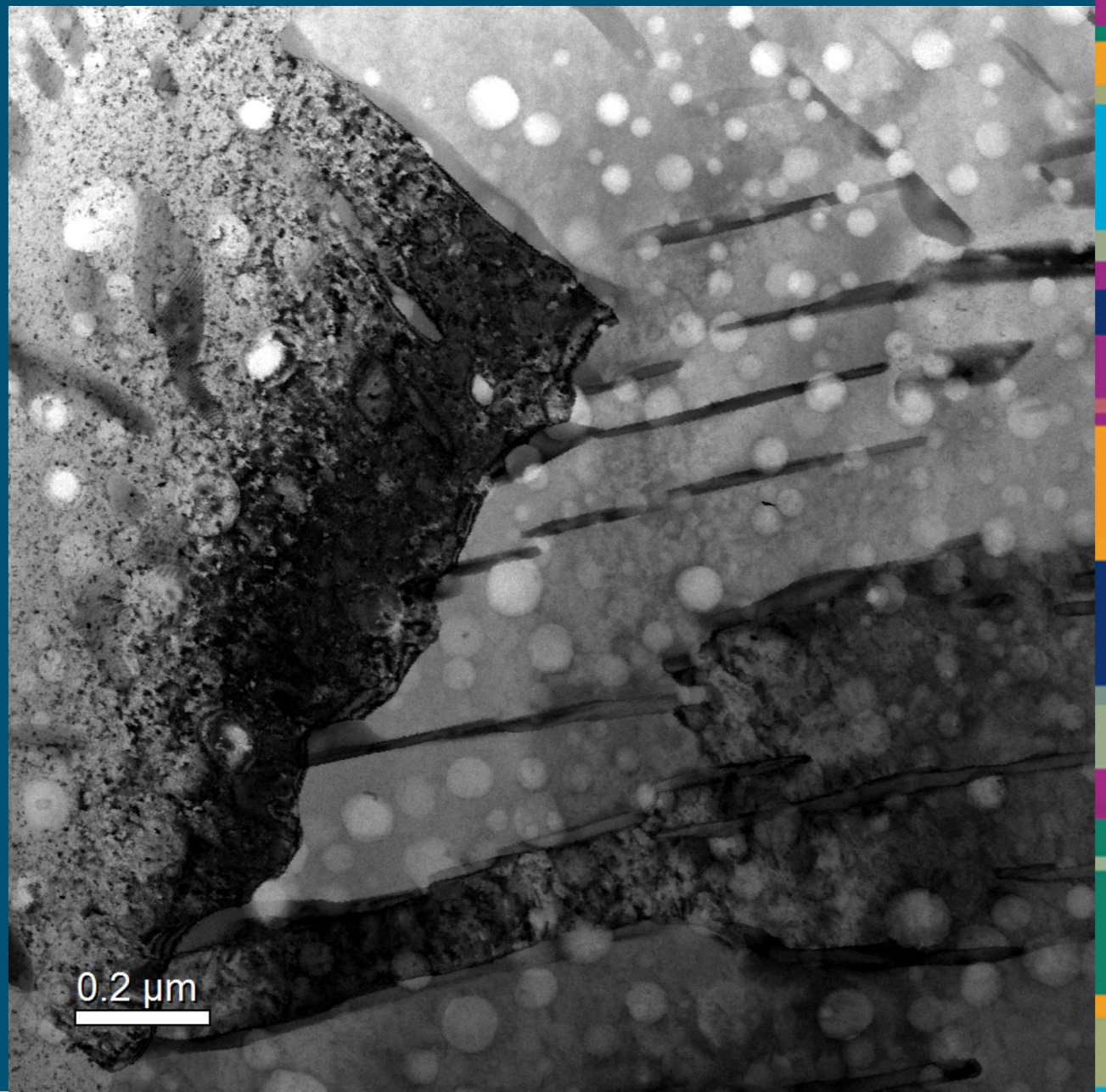
Phases

In situ irradiation and heating



# Summary

- Amorphous nanoparticles
- Ultrafine grained and nanocrystalline metal matrix
- Significant growth in grains, particle size, and a phase evolution with elevated temperature (>0.7 $T/T_m$)
- Retention of amorphous nanoparticle
- Ion irradiation induced changes



# Acknowledgements

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Chris Barr

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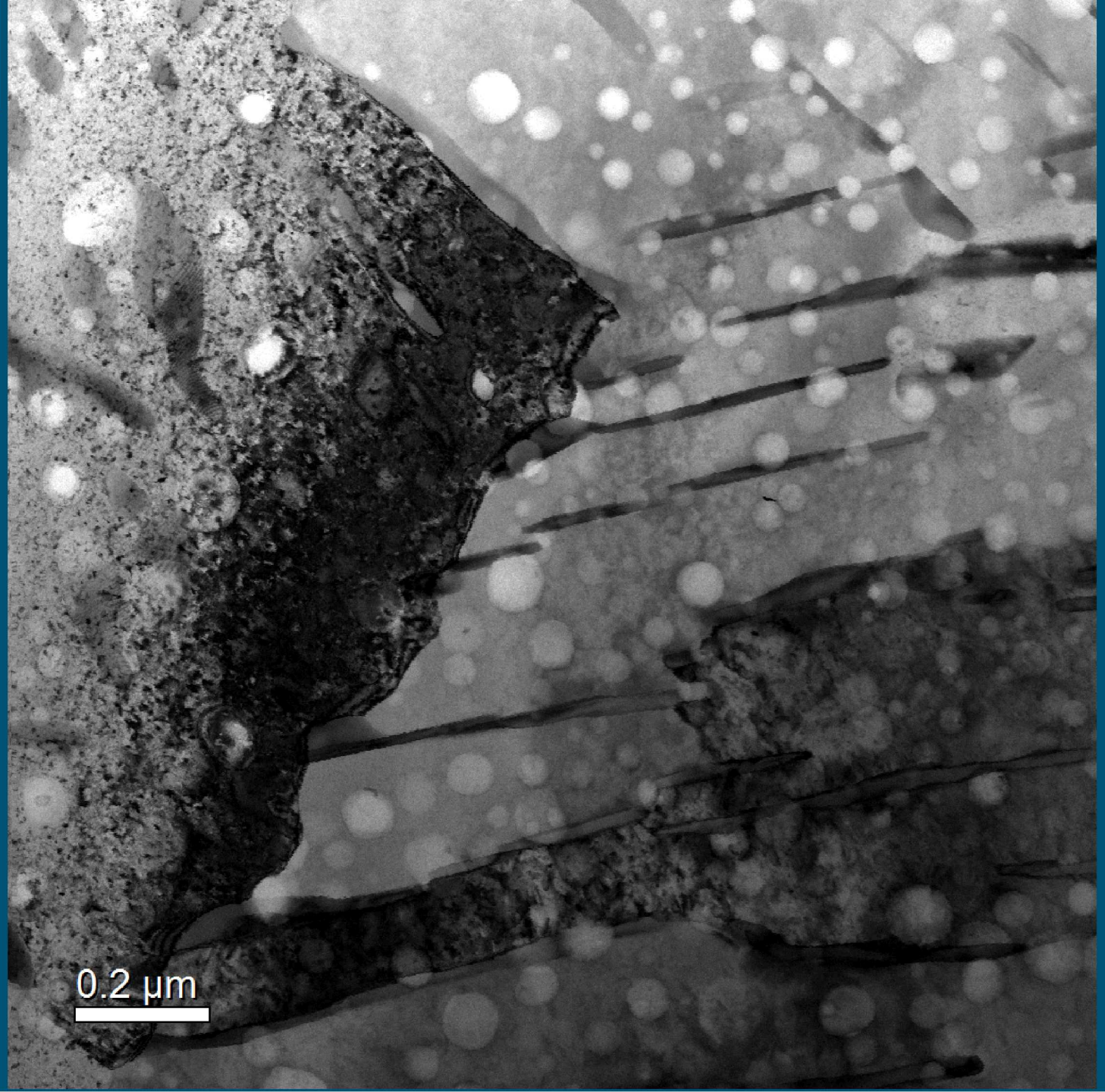


# Questions