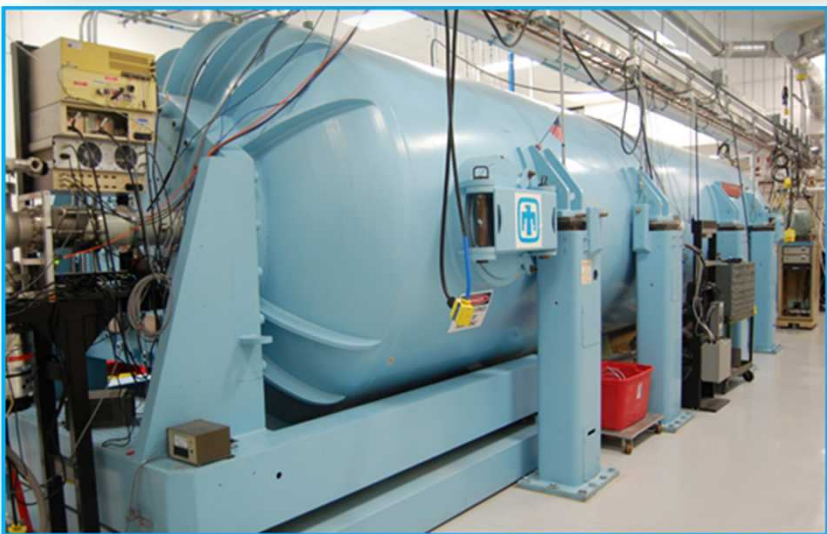
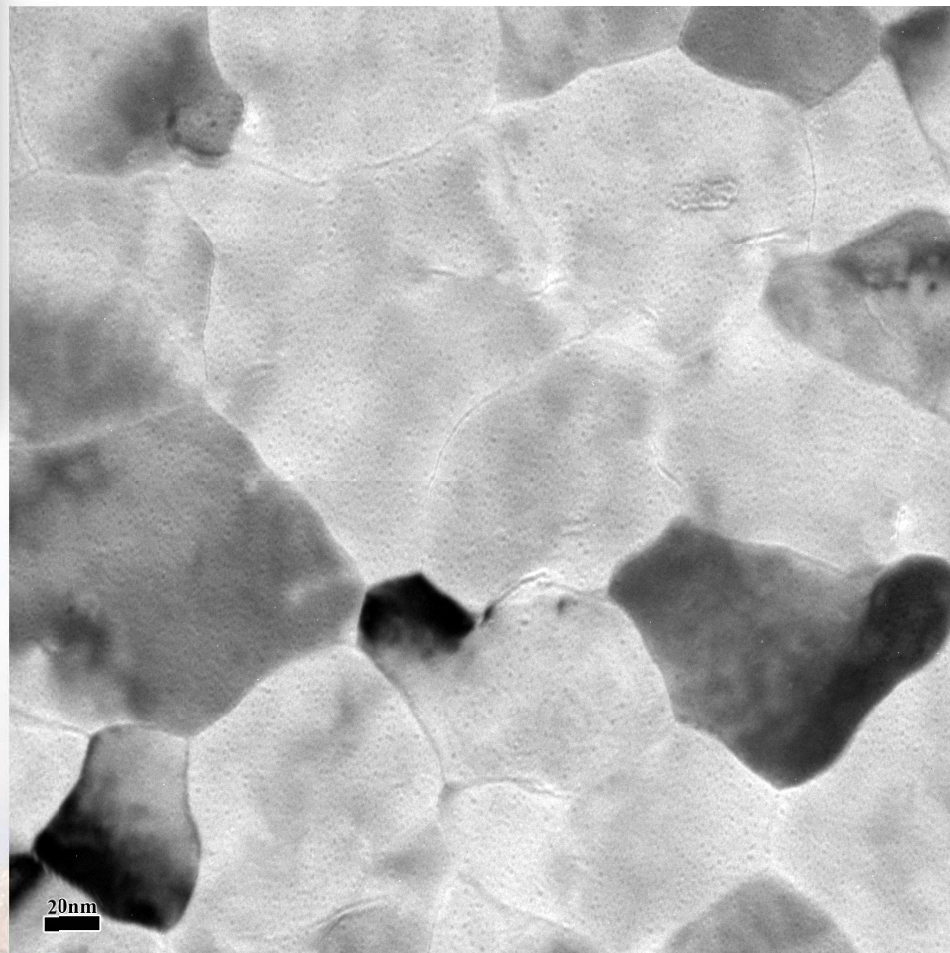


Scott Coon  
Department 01111

# 2015 STAR Summer Internship

SAND2015-6234PE

## Sandia National Laboratories



# STAR Internship-Summer 2015

## ■ East Mountain High School

- Senior

## ■ Where I interned this summer

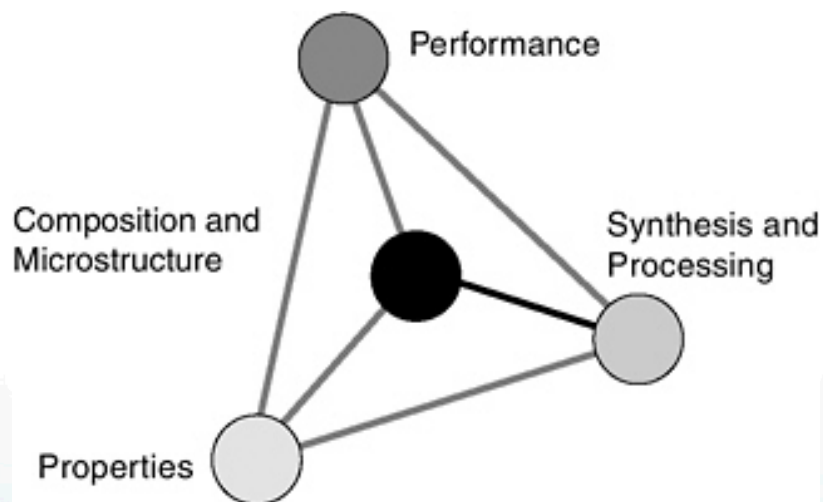
- Ion Beam Laboratory (IBL) Building 720
- Physics
- Materials Science/Engineering





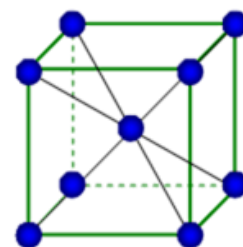
# What is Materials Science?

- “Investigating the relationships that exist between the structures and properties of materials.” (Callister)



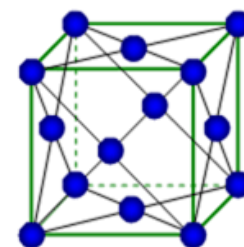
Via: [www.nap.edu](http://www.nap.edu)

Crystal lattice examples



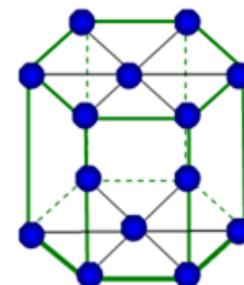
Cubic body centered (bcc)

Fe, V, Nb, Cr



Cubic face centered (fcc)

Al, Ni, Ag, Cu, Au



Hexagonal

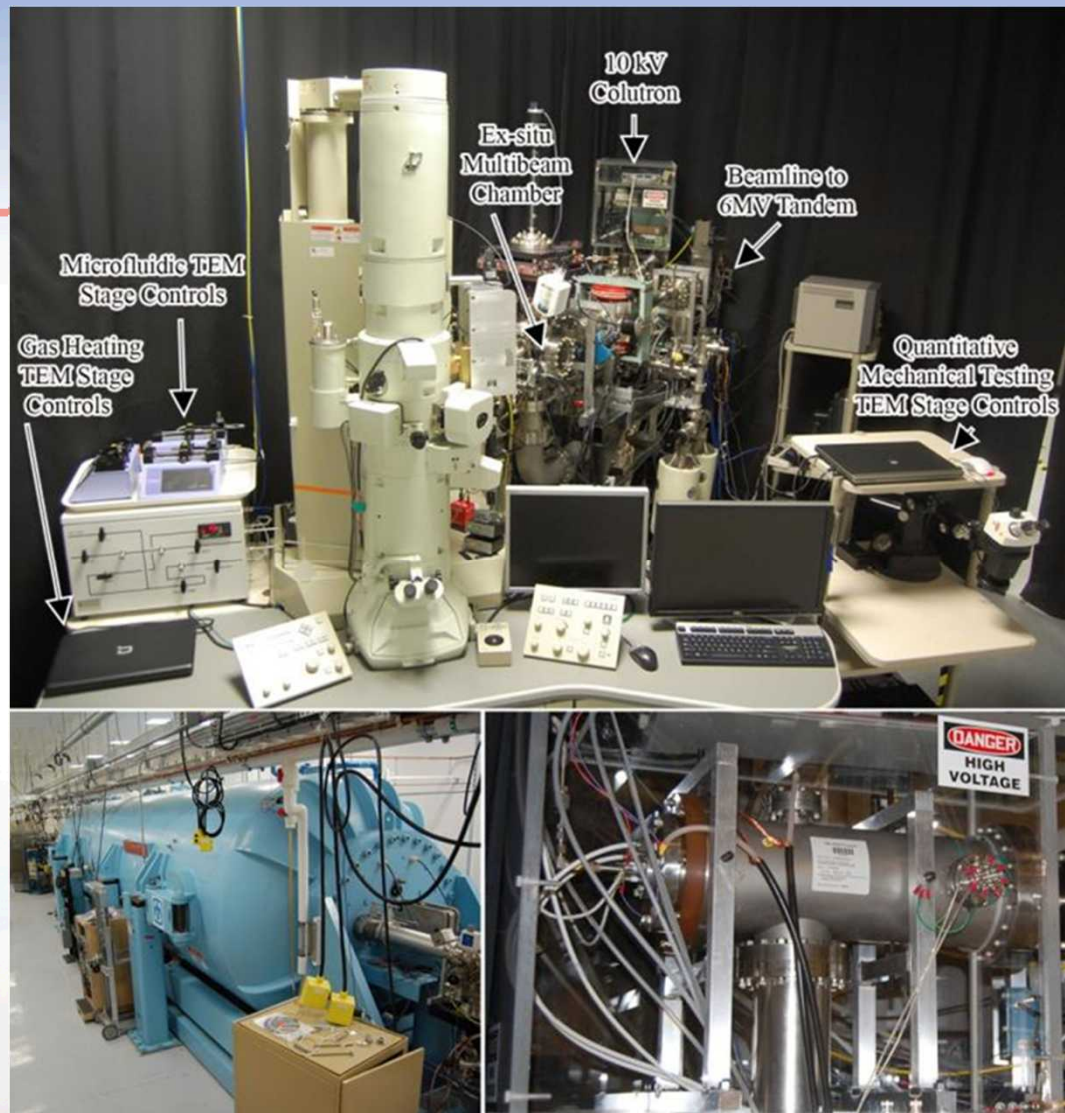
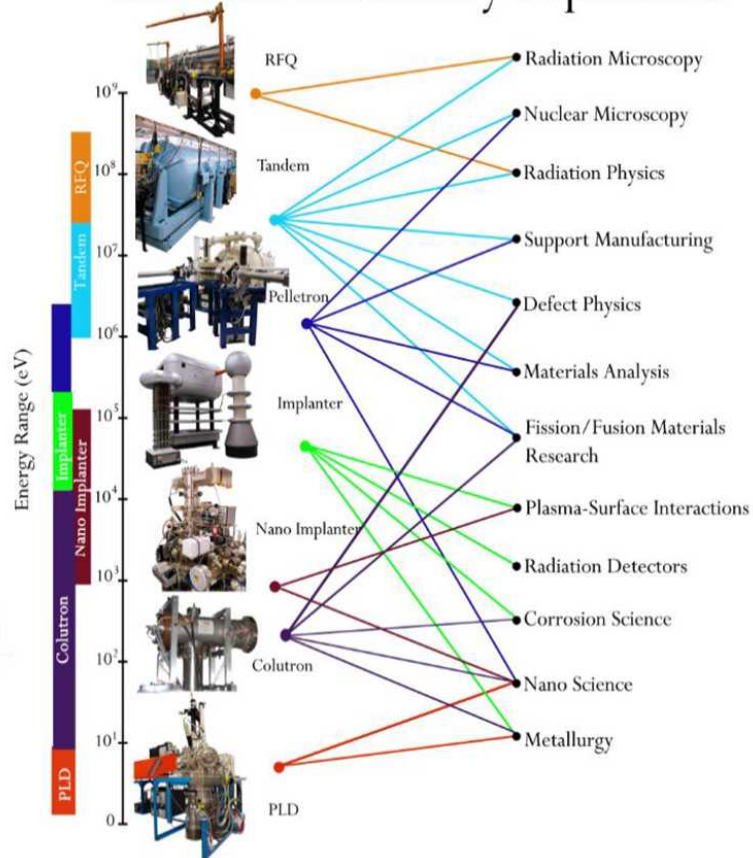
Ti, Zn, Mg, Cd

[www.substech.com](http://www.substech.com)

- Incorporates multiple scientific disciplines
- Crystal structures determine many material properties (strength, hardness, etc)
- Relationships between structure, processing, property, and performance
- Characterizing Materials

# Capabilities of the Ion Beam Laboratory

## Ion Beam Laboratory Capabilities



The IBL also contains an *in situ* ion irradiation transmission electron microscope ( $I^3$ TEM).

One of two in US, twelve in the world.

Top: The *in situ* TEM is able to view samples as they are influenced by radiation in real time.

Bottom Left: The 6 MV Tandem Accelerator.

Bottom Right: The 10 KV Colutron Accelerator



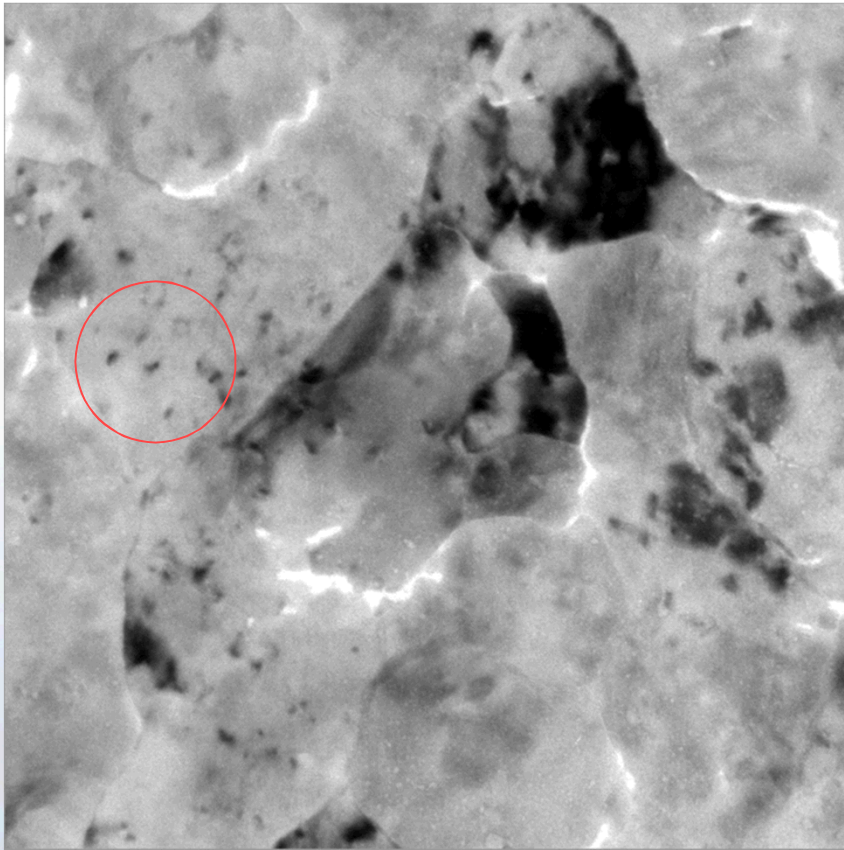
Sandia National Laboratories



# Radiation-Solid Interactions

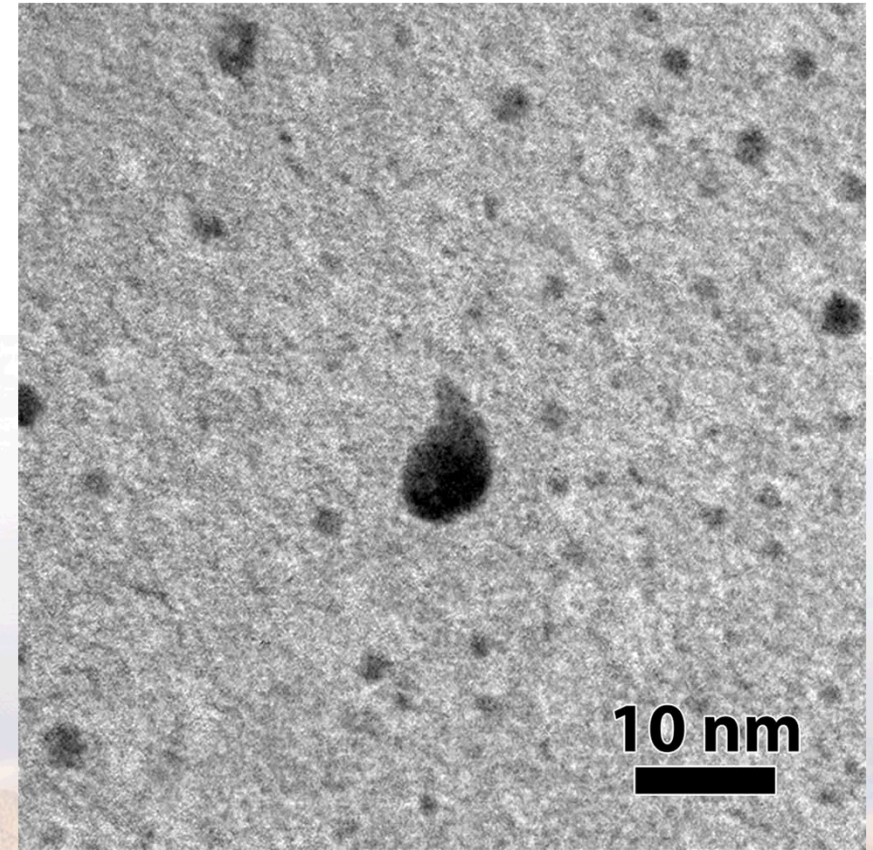
## Radiation interacting with tungsten forms defects in the tungsten

The void defects caused by radiation are clearly visible in this TEM image.



## Radiation-solid interactions at the IBL

Gold nanoparticle broken apart under single self-ion bombardment



Bufford, D. C. and K. Hattar (2014). "Physical response of gold nanoparticles to single self-ion bombardment." *Journal of Materials Research* **29**(20): 2387-2397.



Sandia National Laboratories

# Preliminary Projects

## ■ Strengthening Research Skills

- Literature Review

## ■ Learning Image Analysis & Editing

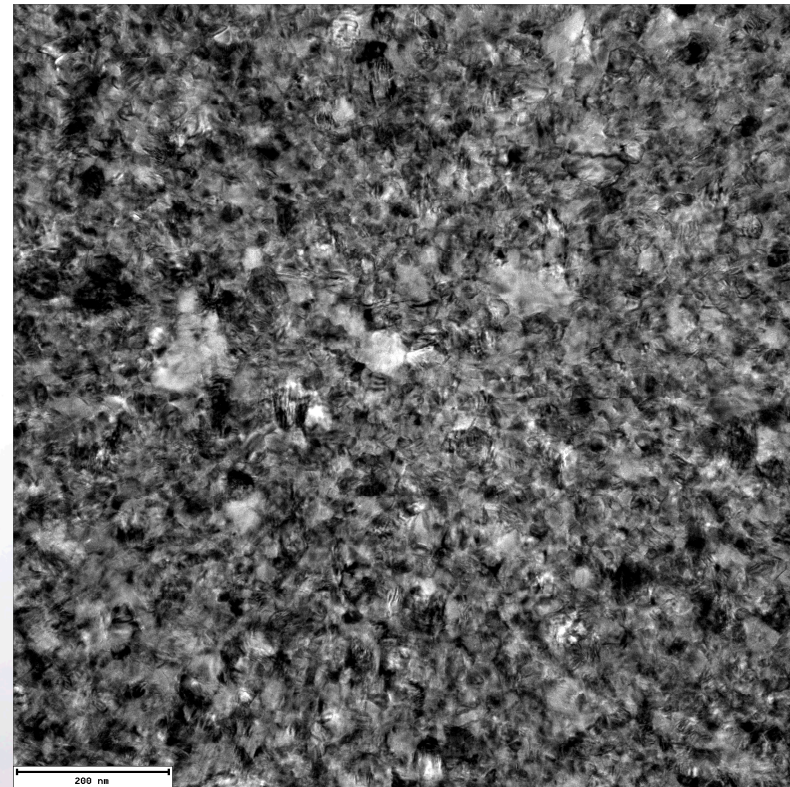
- Grain Size Analysis
- Defect Sizes and Densities in Materials

## ■ Learning to Code

- Python

## ■ Sample Preparation

- Palladium, Aluminum, Copper, Iron, Tungsten
- Thin Film samples (nanometer-sized)
- Prepared using “float off” technique
- Viewing samples in TEM



Evaporation-deposited Palladium Sample as seen in the TEM

**Main Project:** *In Situ* Tungsten Experiments

**Question:** How does Tungsten react to extreme environments?



# Tungsten Project

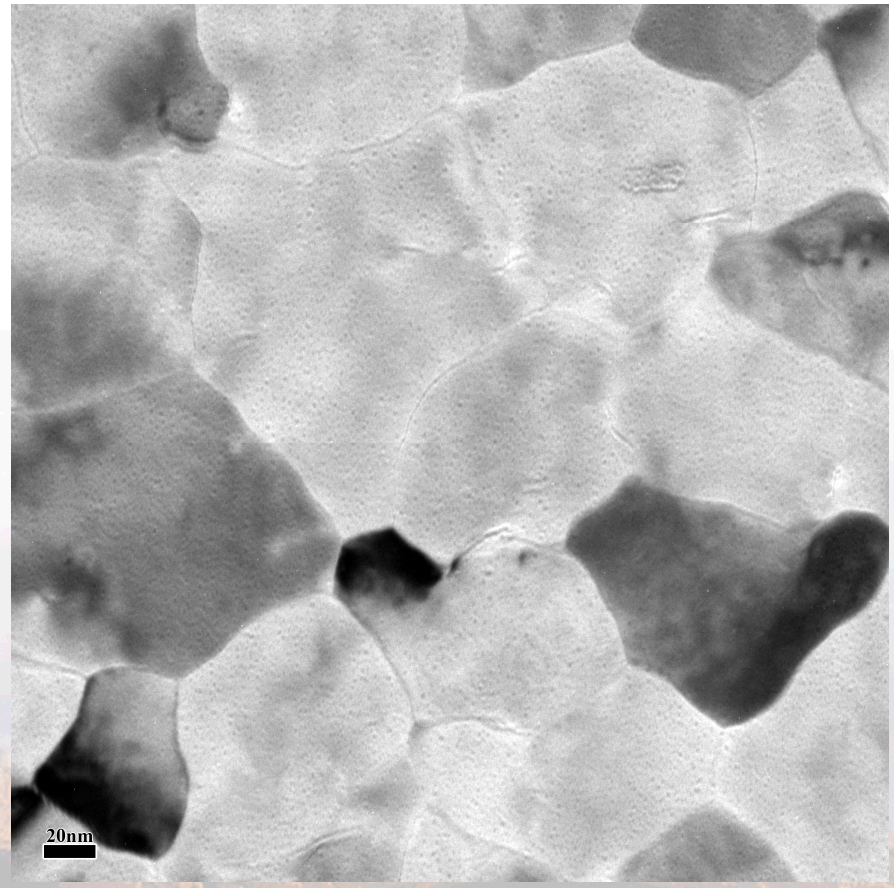
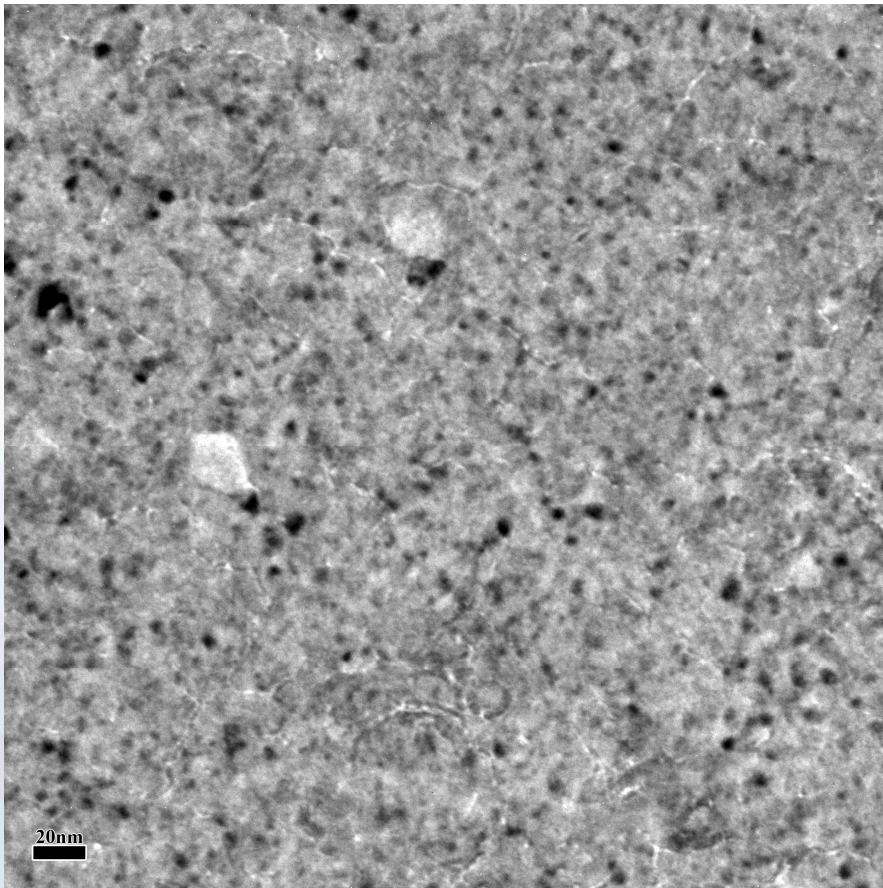
## Annealed (Heated) Samples

Pure tungsten before and after heating to 1000° C

Grain Size: 14 nm

➡ Grain Growth ➡

Grain size: 67 nm





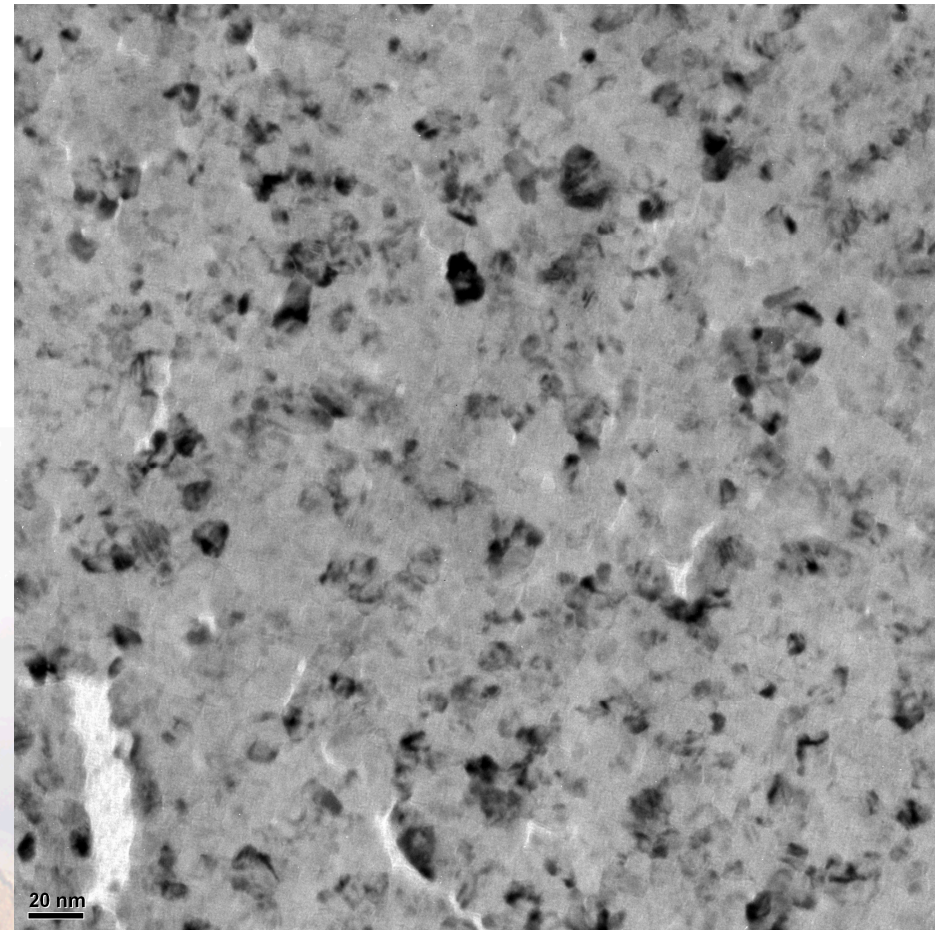
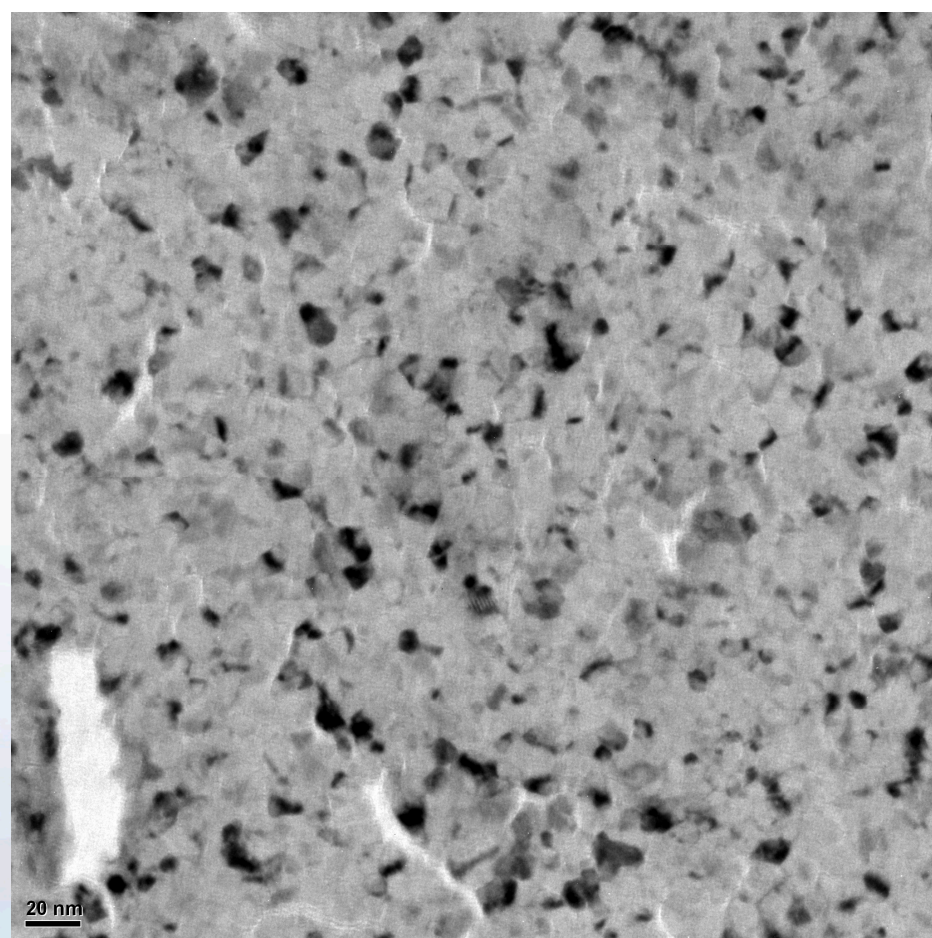
# Alloyed Tungsten

Tungsten-Titanium before and after annealing

Grain Size: 10 nm

➡ Grain Growth ➡

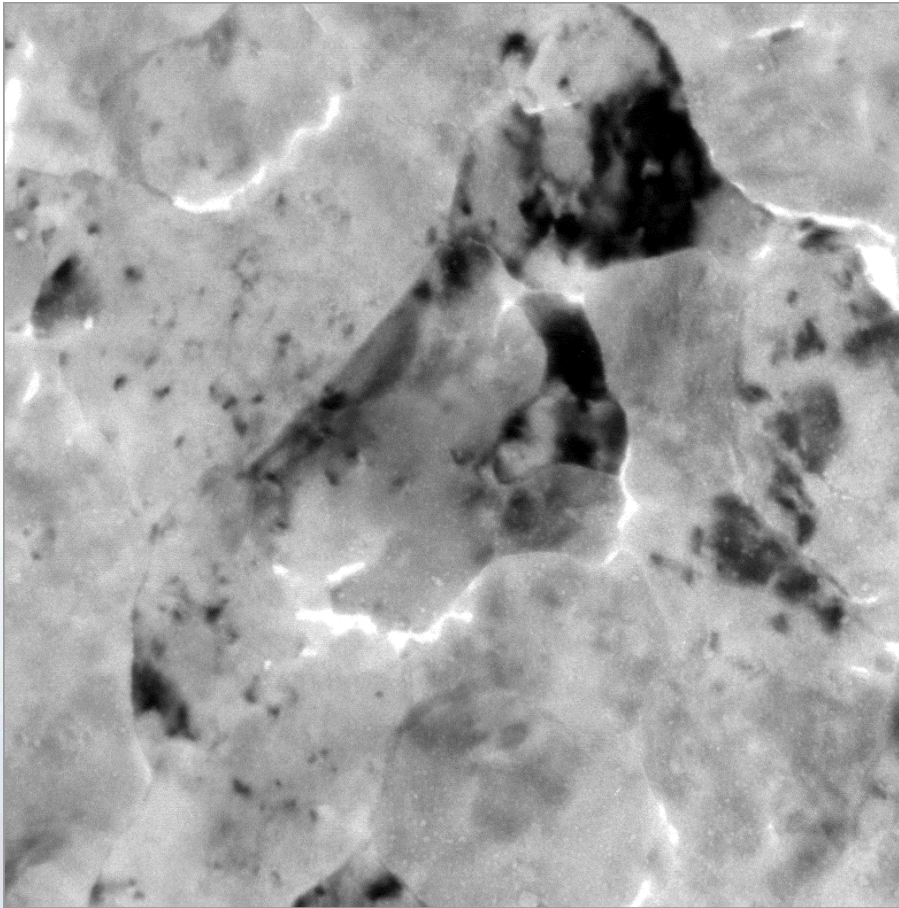
Grain Size: 12 nm





# Irradiation and Results

## Pure, irradiated tungsten



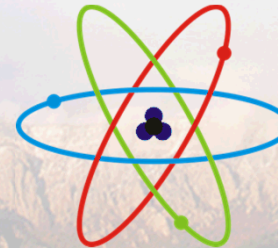
- After annealing the samples were irradiated with 3 MeV  $W^{4+}$  (self-ion irradiated)

## Results

- Pure tungsten has high tolerance for heat
- Alloying tungsten with titanium provides an increase in tolerance for heat
- Good heat tolerance means more uses in extreme environments

## Future Work

- Radiation experiments
- Testing in advanced, next-generation nuclear reactors



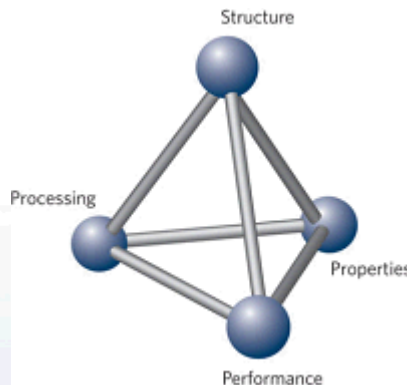
Sandia National Laboratories

# Conclusion

## Future

What this internship provided me:

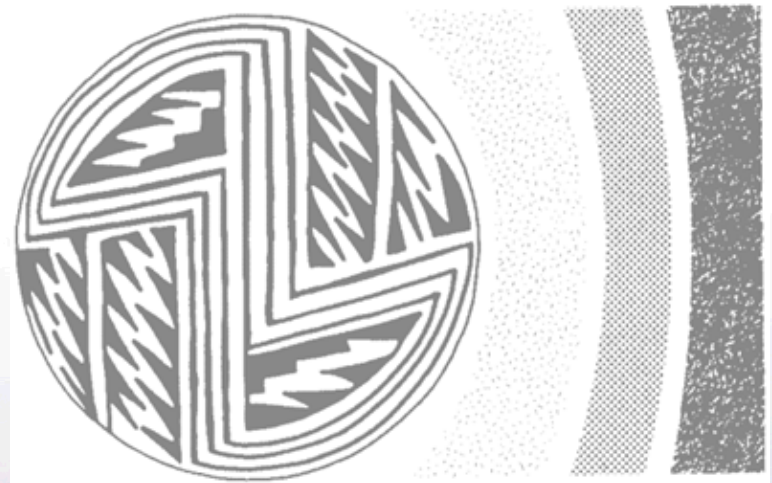
- Extended scientific knowledge
- Increased technological skills
- Real-world research experience
- Preparation for college



What this internship did not provide me:

- The words that make up the acronym “STAR”

- Attending 27<sup>th</sup> Annual Rio Grande Symposium on Advanced Materials (RGSAM)
  - Presenting poster on Tungsten project



Acknowledgements: Khalid Hattar, Jon Custer, Daniel Bufford, Brittany Muntifering, Olivia Donaldson, Mackenzie Steckbeck, Cajer Gong, Sarah Blair, Justin Davis, J. Trelewicz, Tyler Kaub, Greg Thompson