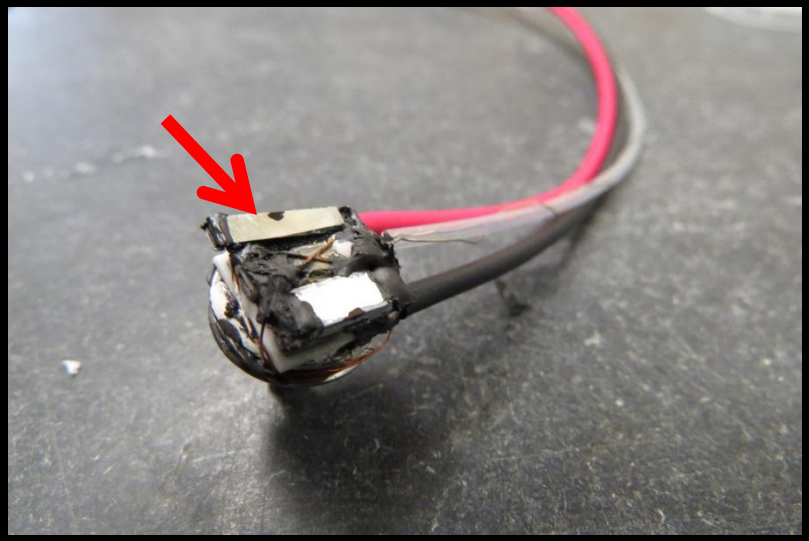
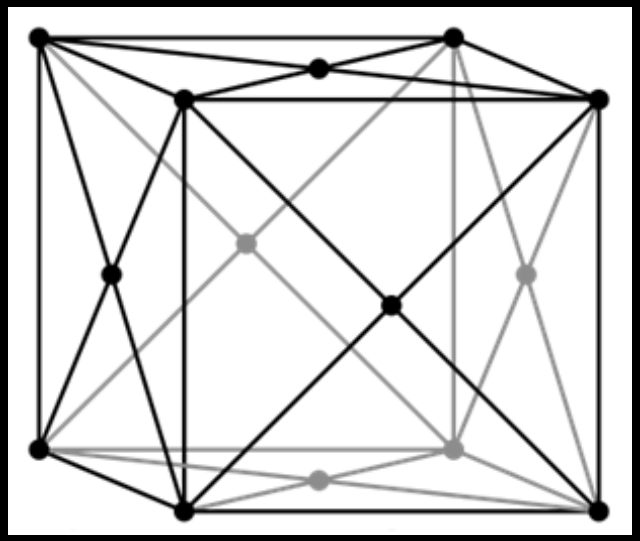
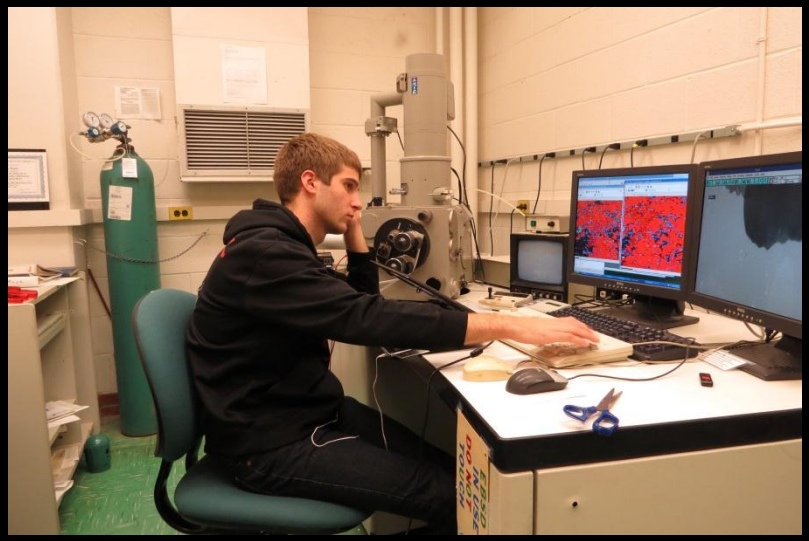
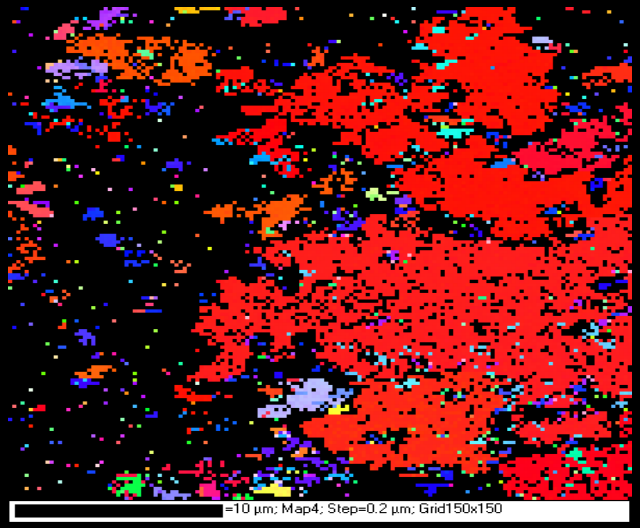
Ethan Ocock and Emily Morrow
Houghton College
Cornell University








=10 µm; Map4; Step=0.2 µm; Grid150x150

# Thin Films

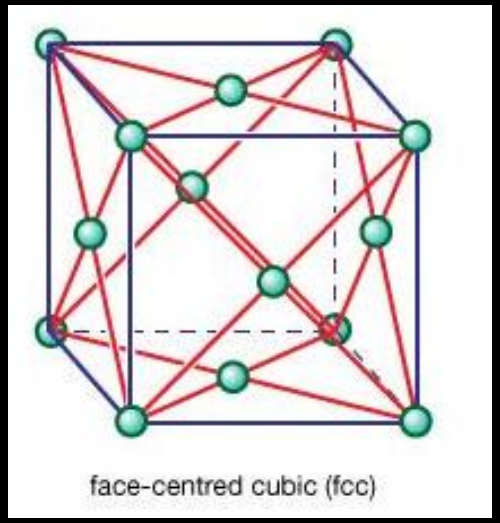
- Up to a few micrometers in thickness

- magnetic storage media (hard drives), circuit boards, and protective coatings

# Crystallography

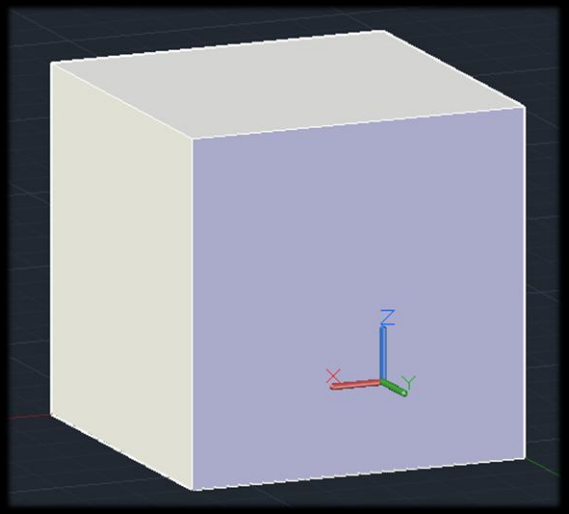
A crystal is a repeated structural pattern.

For silver, this is a face centered crystal (fcc).



face-centred cubic (fcc)

# Crystal Orientations

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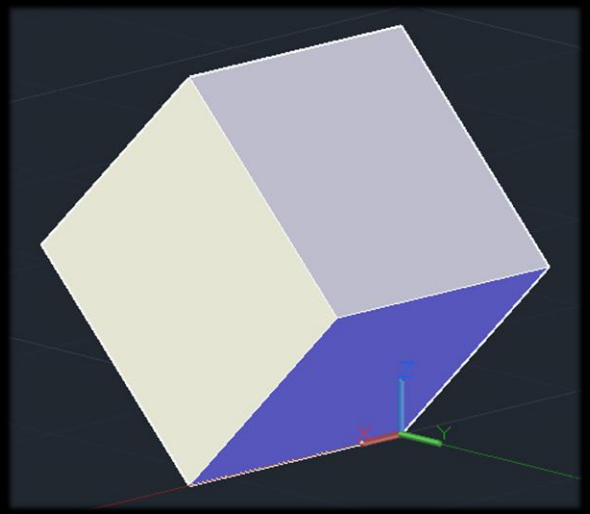


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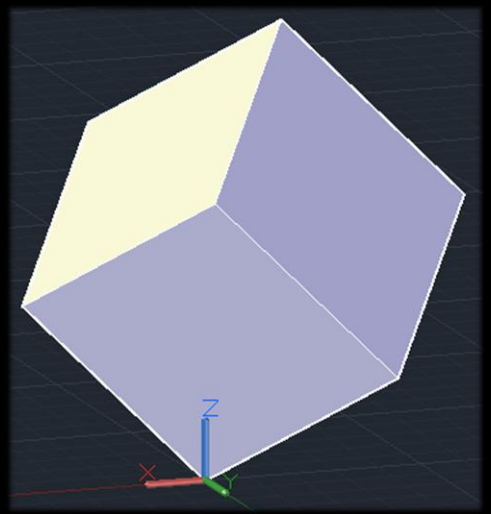
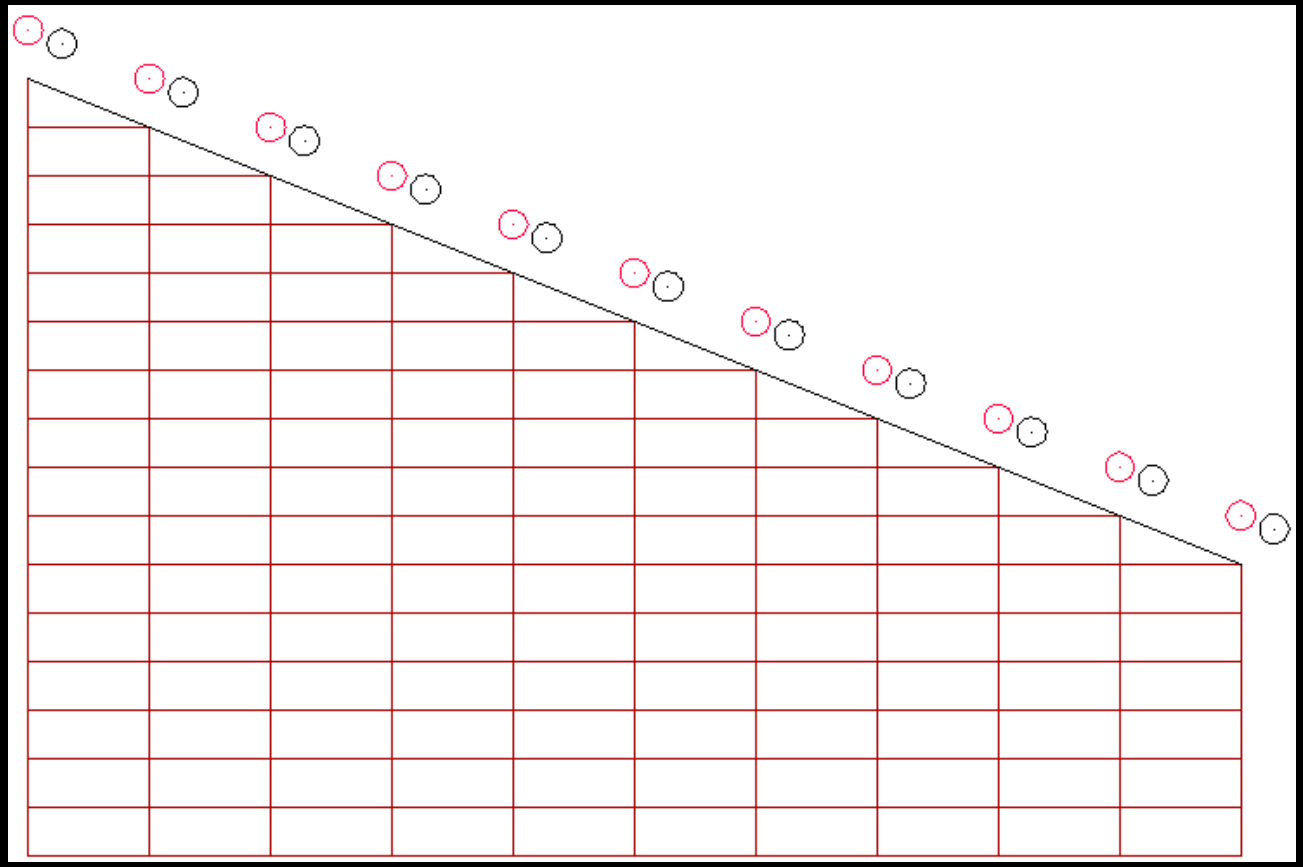
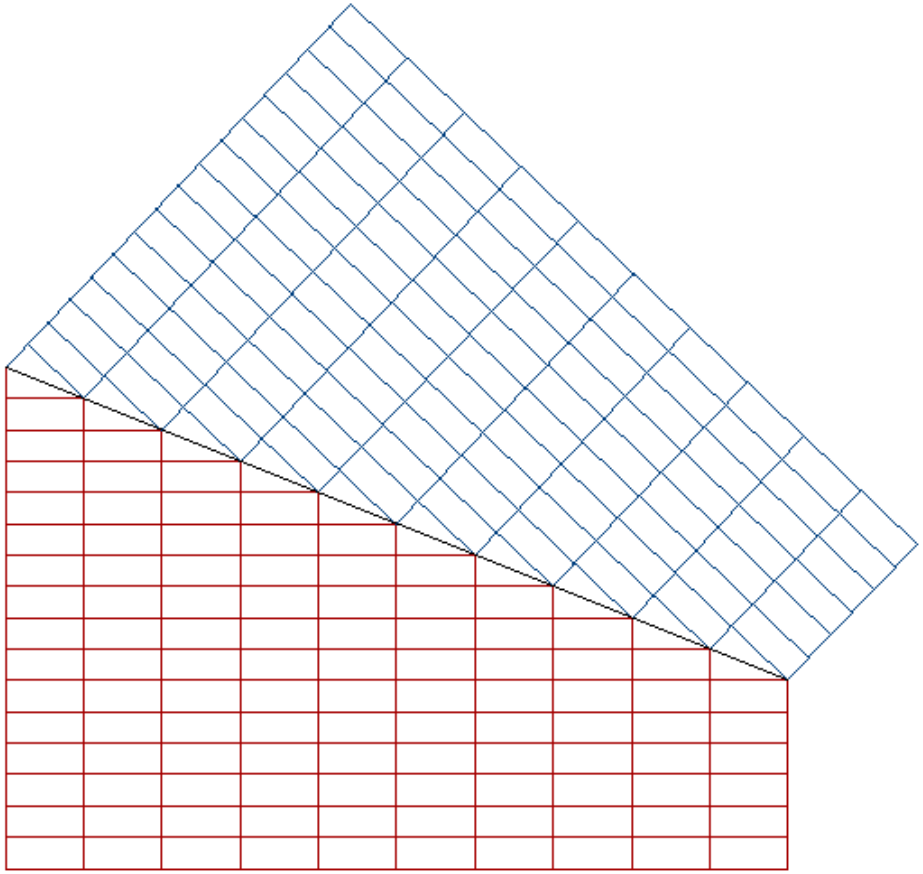


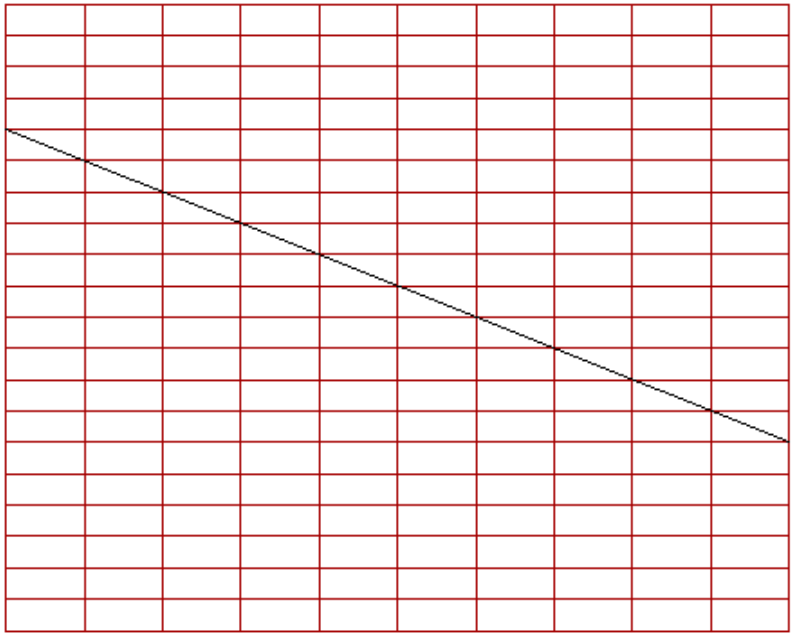

<111>

# Twinning

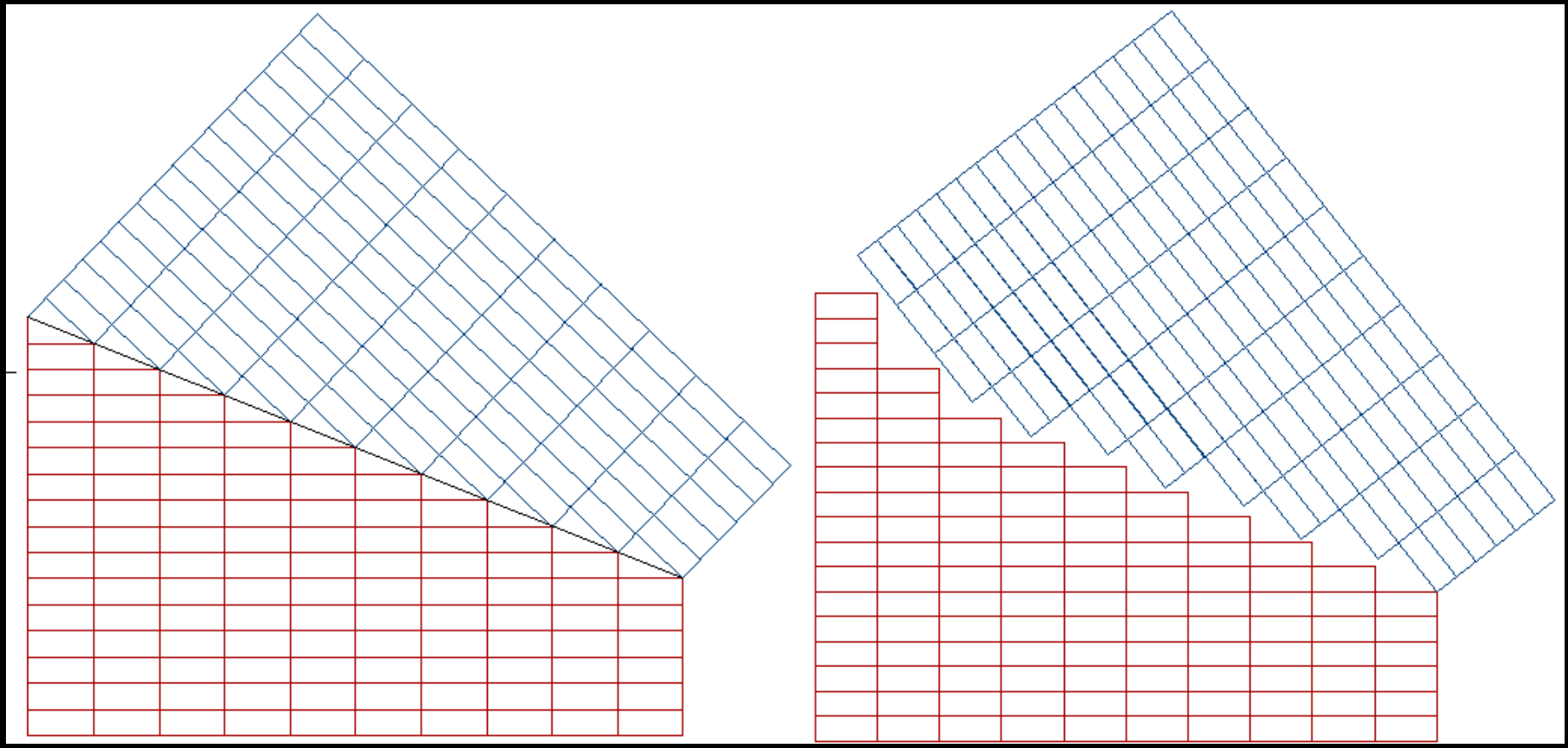


# Twinning



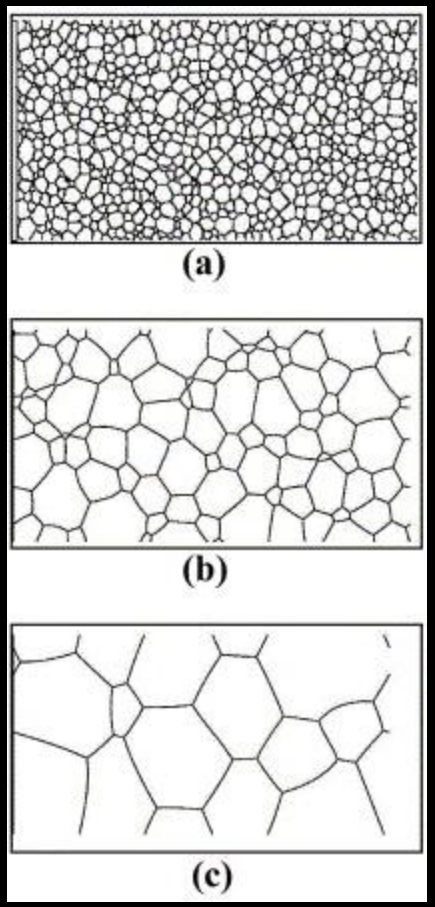


# Twinning



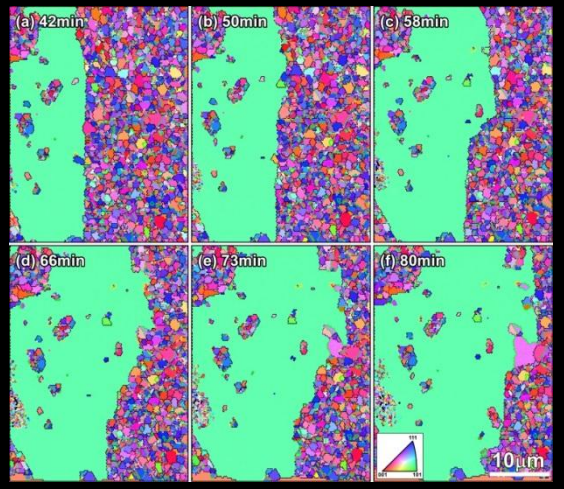
# Normal Grain Growth

- Big grains eat little grains
- Energy reduction
- Will eventually stop



# Abnormal Grain Growth

- Consumes grains that are much smaller
- Grows indefinitely
  - Other Abnormal growth
  - High density grains



# Motivation

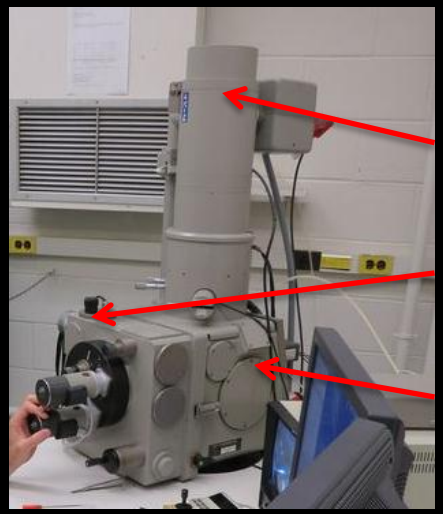
What are the driving forces which cause the transformations?

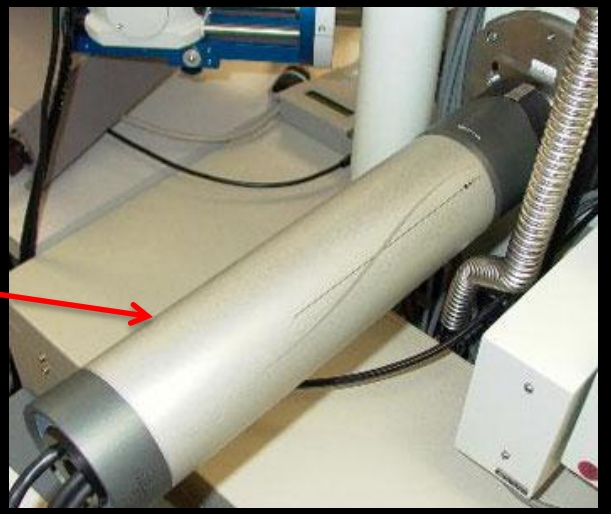
What kinds of grain growth occur?

How do grains grow?

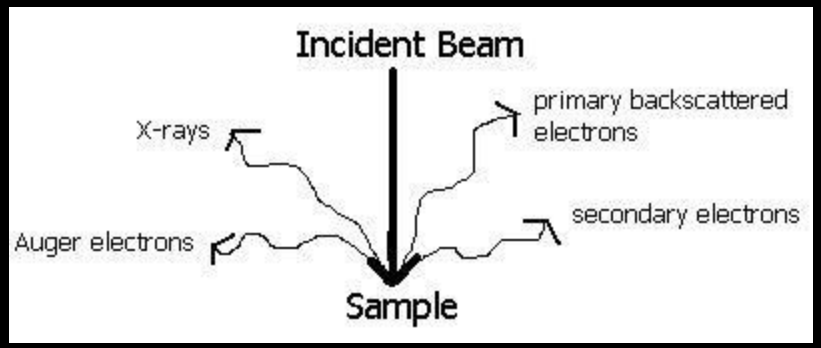
# Apparatus

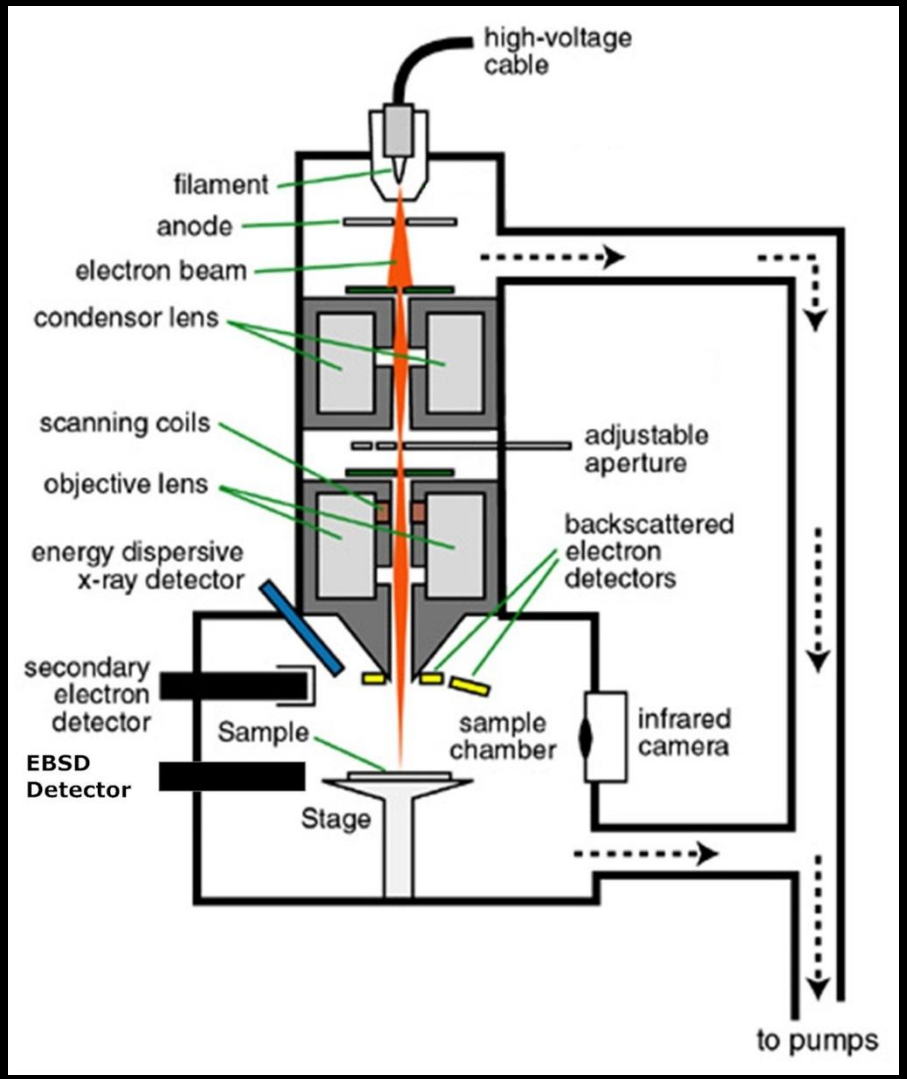
- Scanning electron microscope (SEM)
- Electron backscatter diffraction (EBSD)



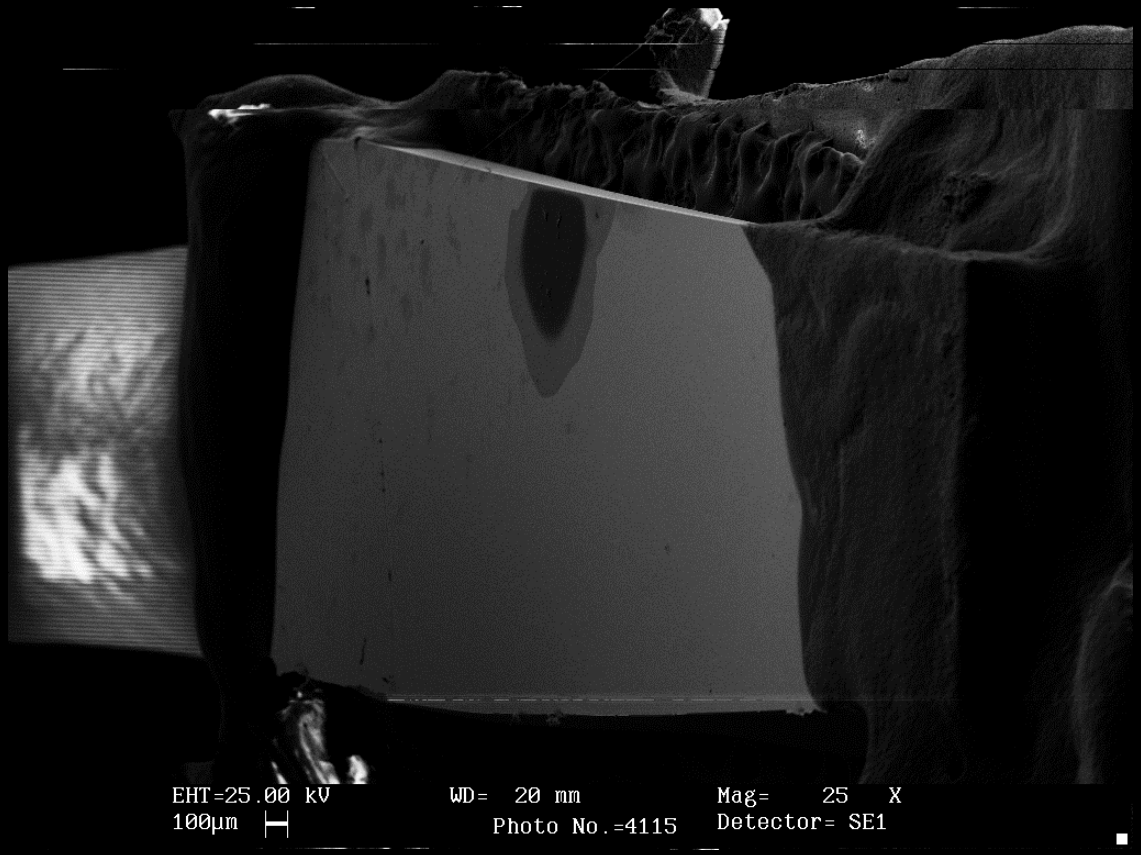



# SEM

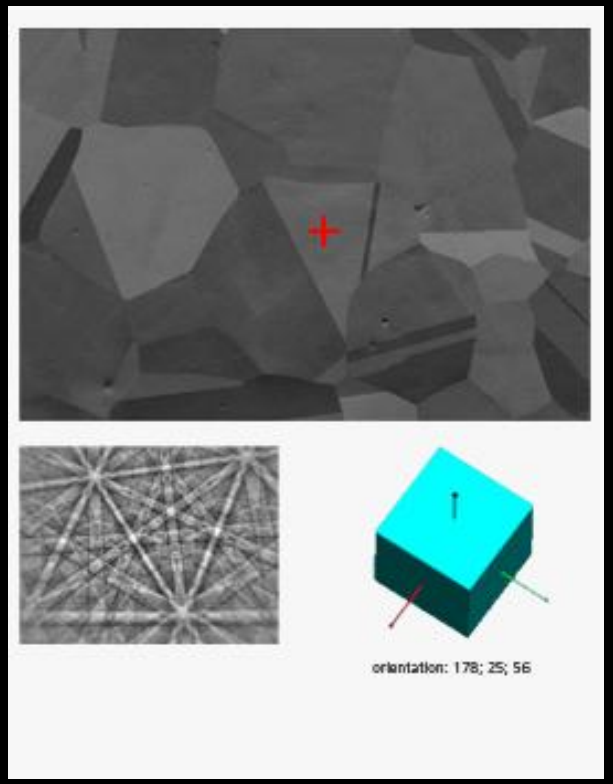

Incident Beam
X-rays
primary backscattered electrons
Auger electrons
secondary electrons
Sample

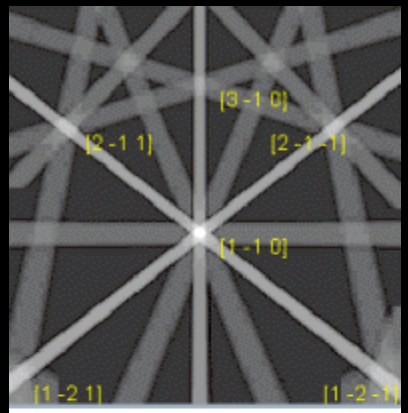

high-voltage cable
filament
anode
electron beam
condensor lens
scanning coils
objective lens
energy dispersive x-ray detector
adjustable aperture
backscattered electron detectors
secondary electron detector
EBSD Detector
Sample
Stage
sample chamber
infrared camera
to pumps

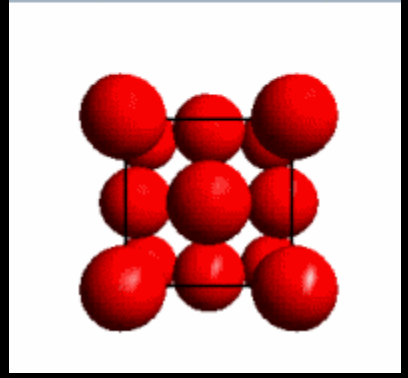
# SEM image



# Kikuchi Patterns

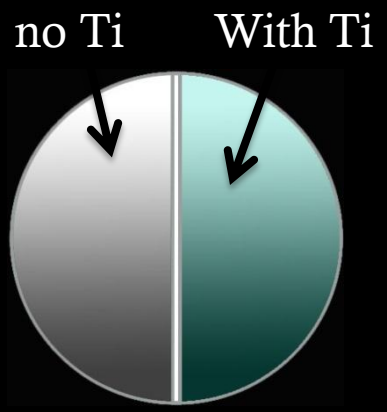


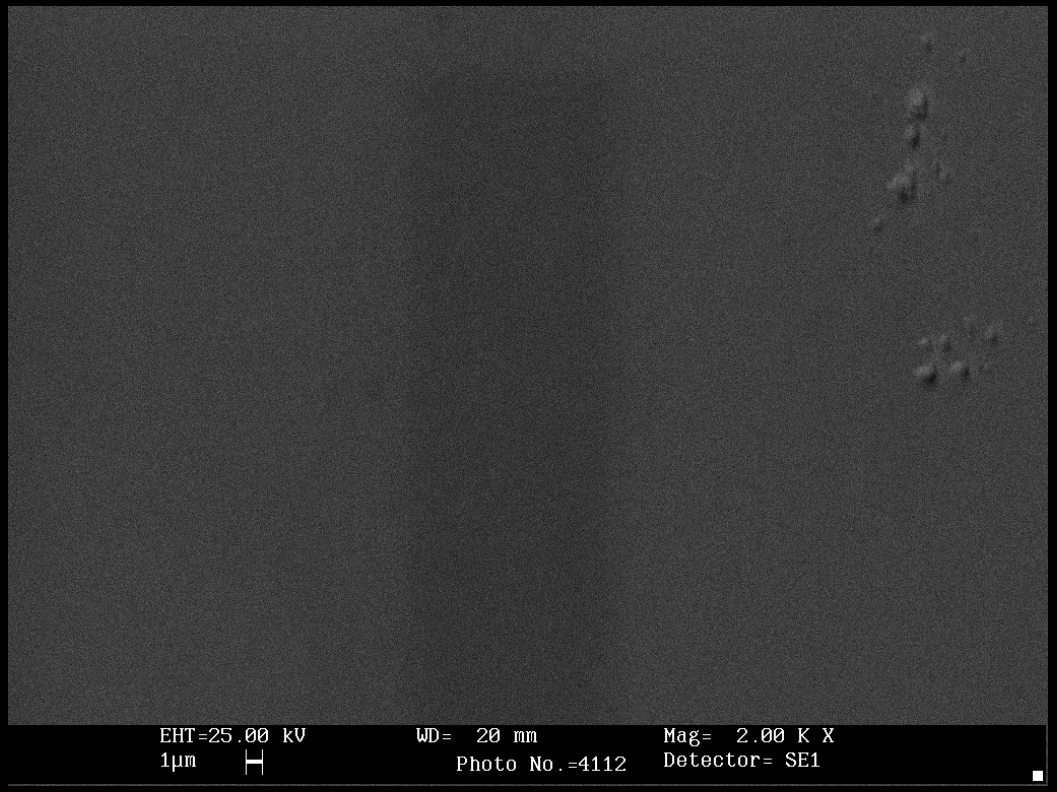



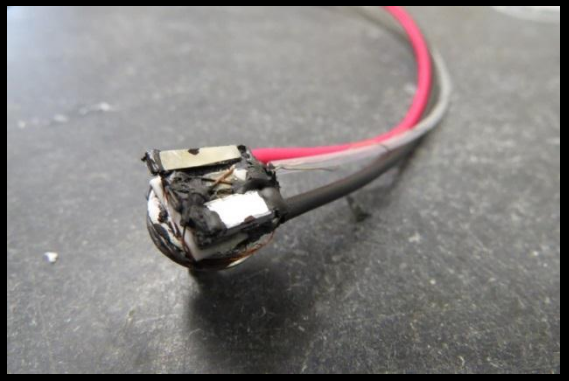
# Our thin films

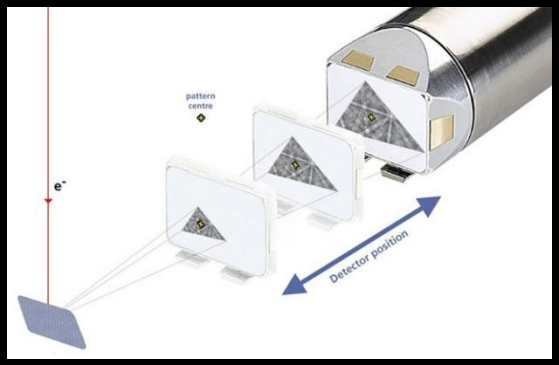
- Thin silver films on silicon substrate
- On the order of 1 μm thick
- Some with Ti layers



# Experimental Set-up

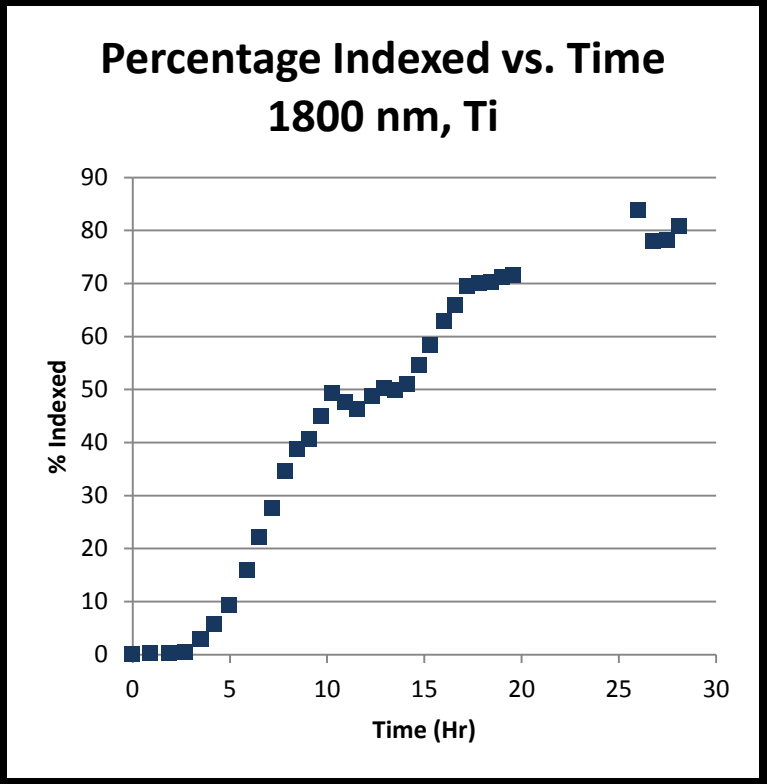


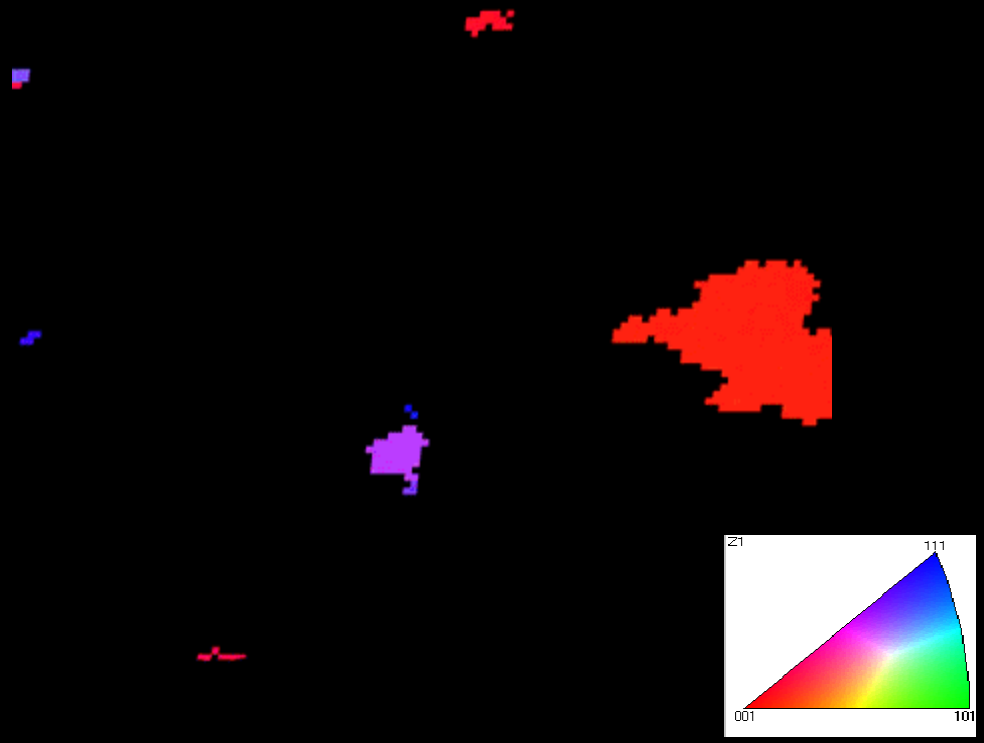





# Results

## 1800 nm, with Ti

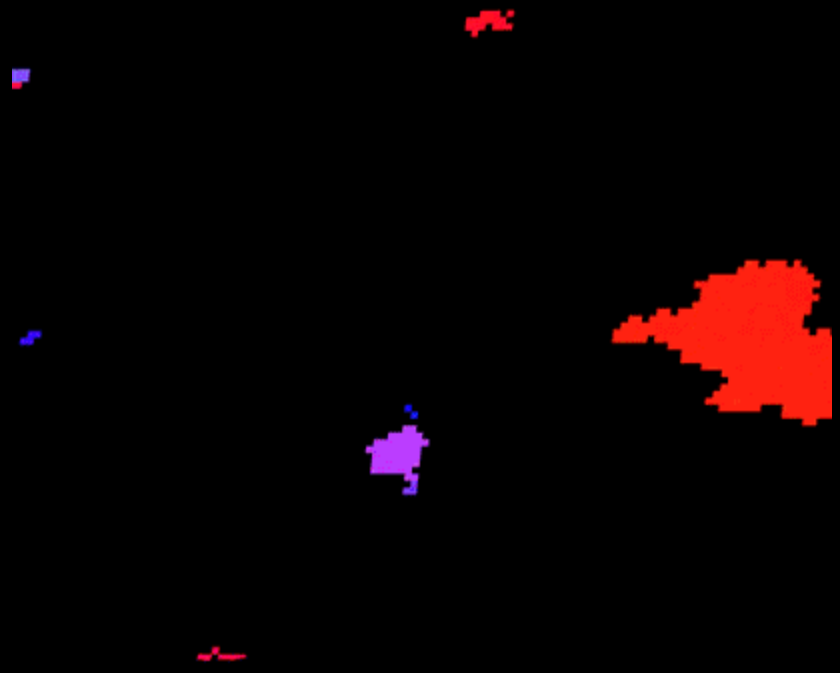


# Results

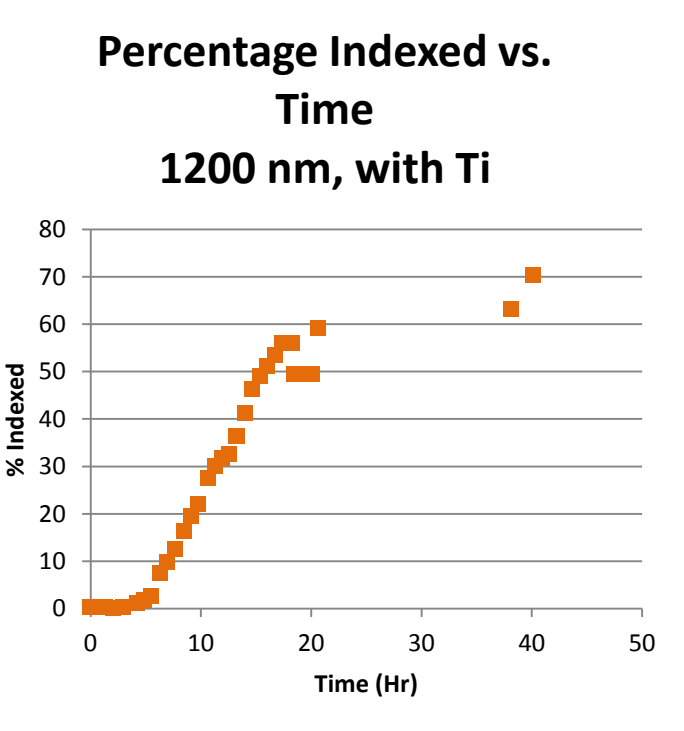
## 1800 nm, with Ti

- Changes in color due to refocusing and recalibration.
- Grain boundaries are not shown.
- Solid colors could be multiple grains.



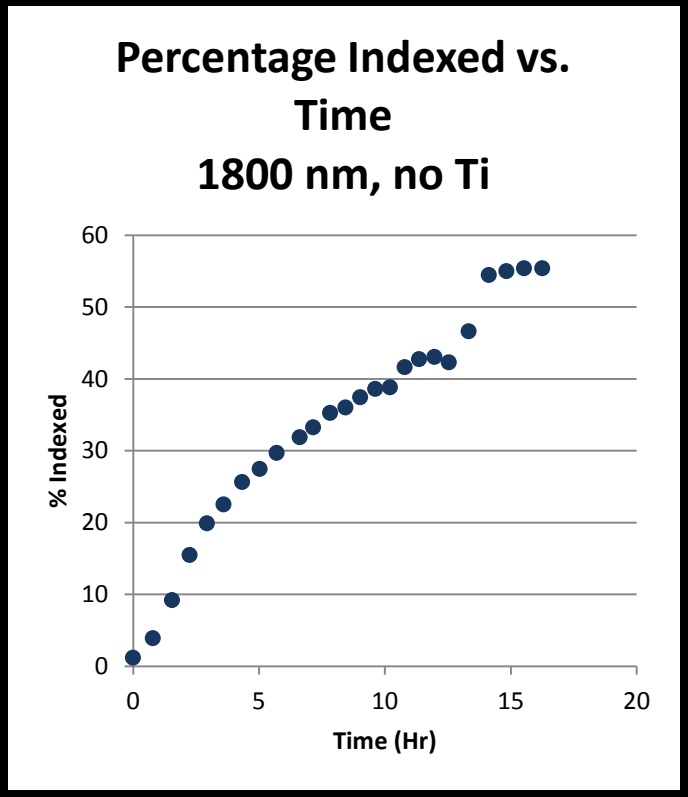
# Results

## 1200 nm, with Ti



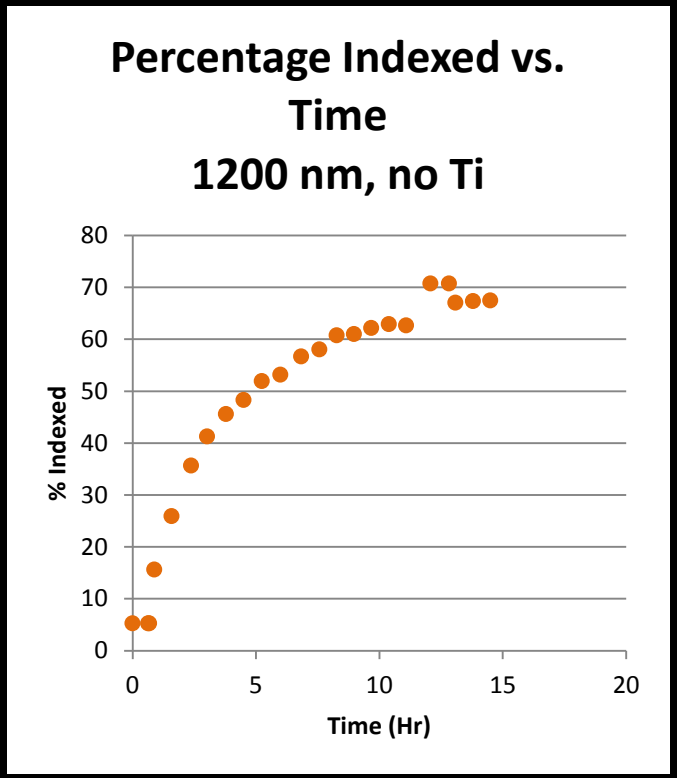
# Results

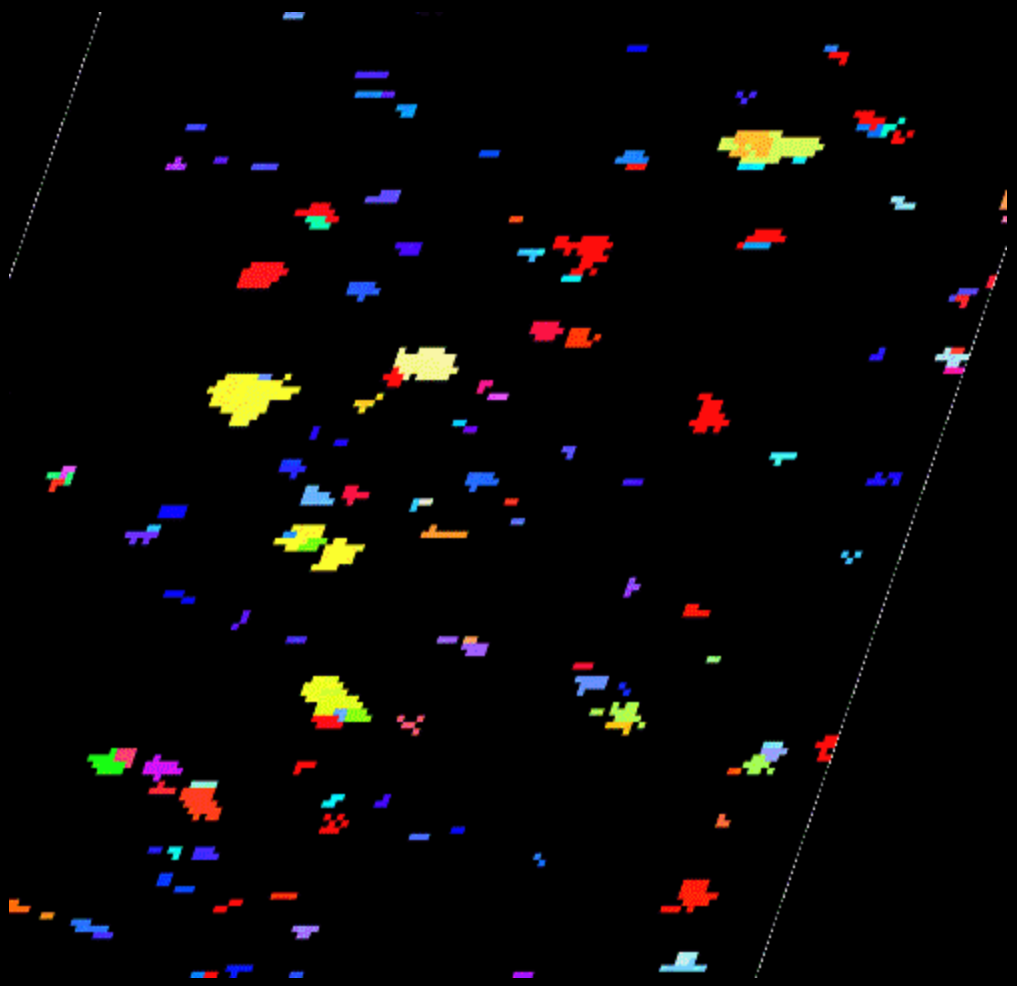
## 1800 nm, no Ti

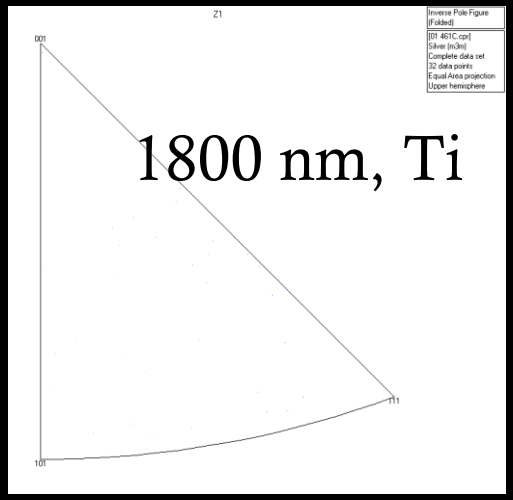


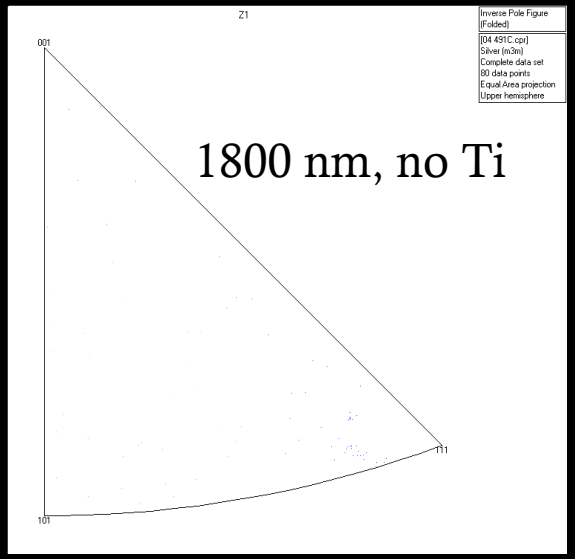
# Results

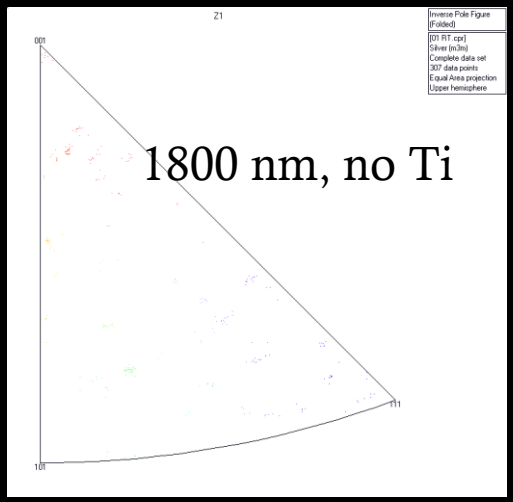
## 1200 nm, no Ti

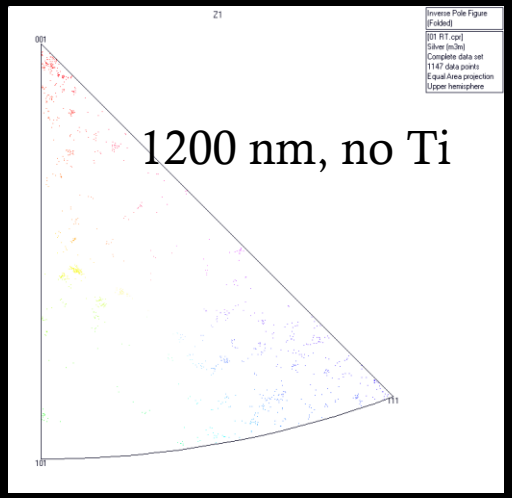


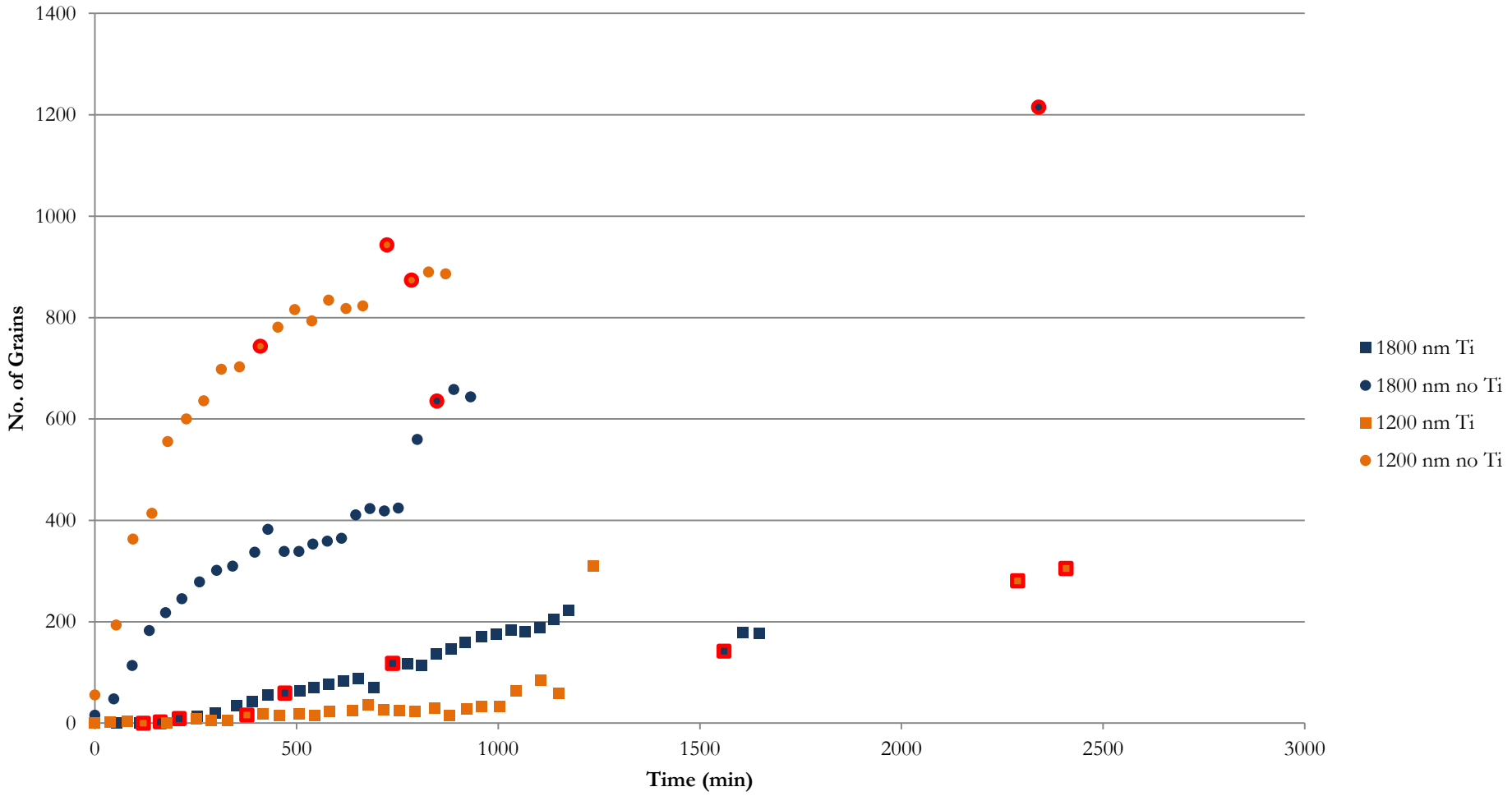

Z1
Inverse Pole Figure
(Folded)
[01 461C.cpr]
Silver (m3m)
Complete data set
32 data points
Equal Area projection
Upper hemisphere
001
111
101
1800 nm, Ti

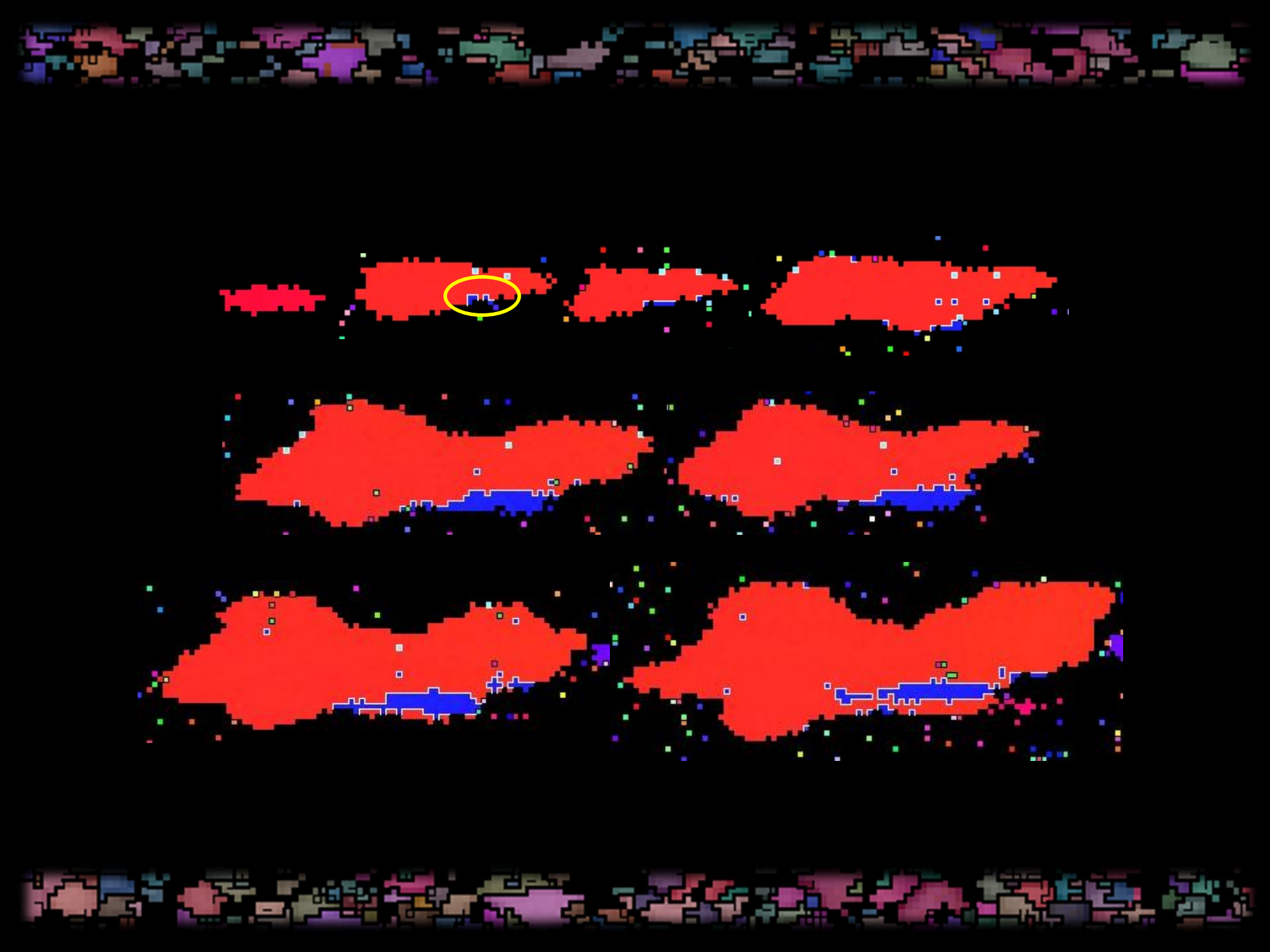

Z1
Inverse Pole Figure
(Folded)
[04 491C.cpr]
Silver (m3m)
Complete data set
80 data points
Equal Area projection
Upper hemisphere
001
111
101
1800 nm, no Ti

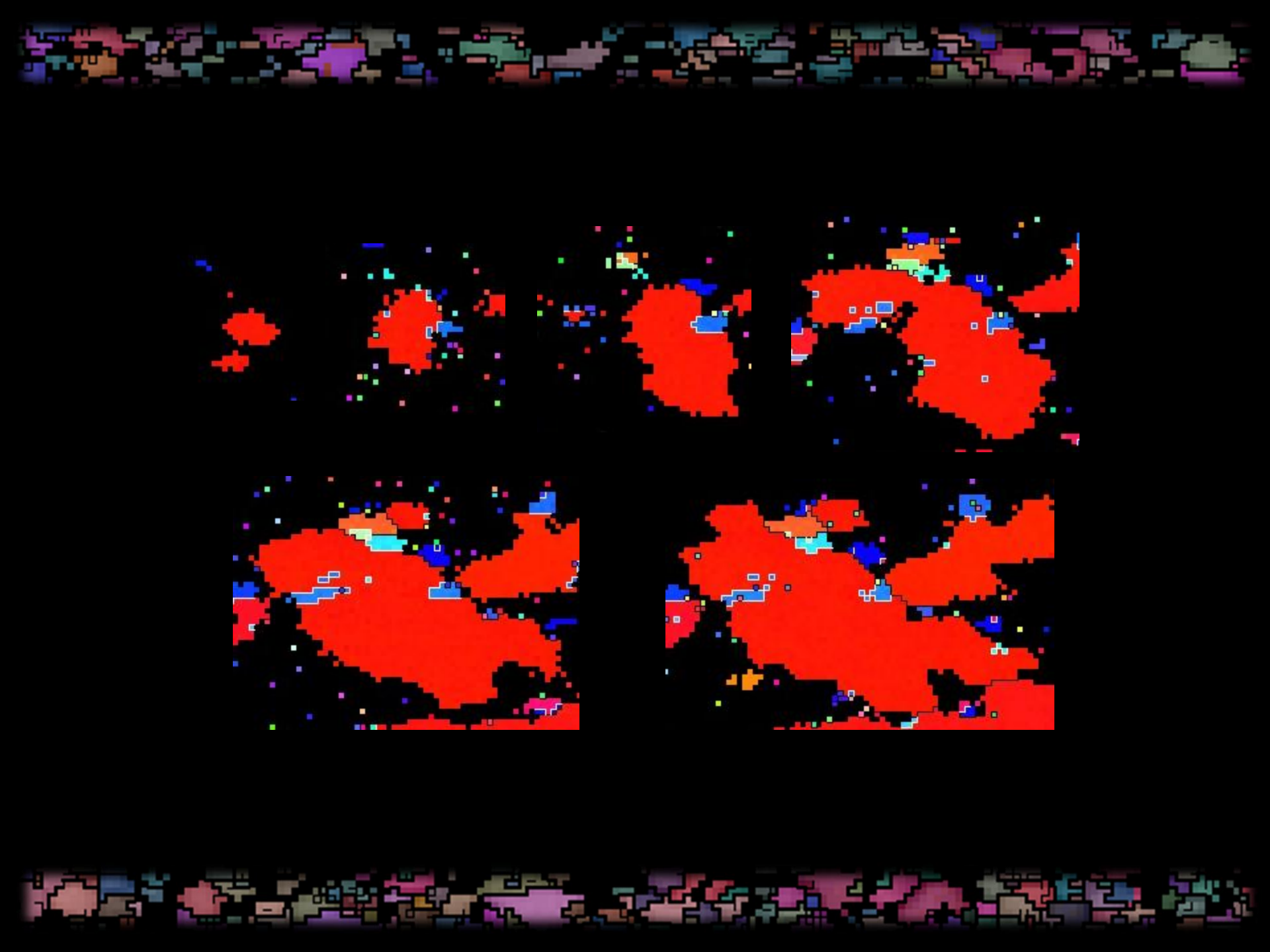

Z1
Inverse Pole Figure
(Folded)
[01 RT.cpr]
Silver (m3m)
Complete data set
307 data points
Equal Area projection
Upper hemisphere
001
111
101
1800 nm, no Ti

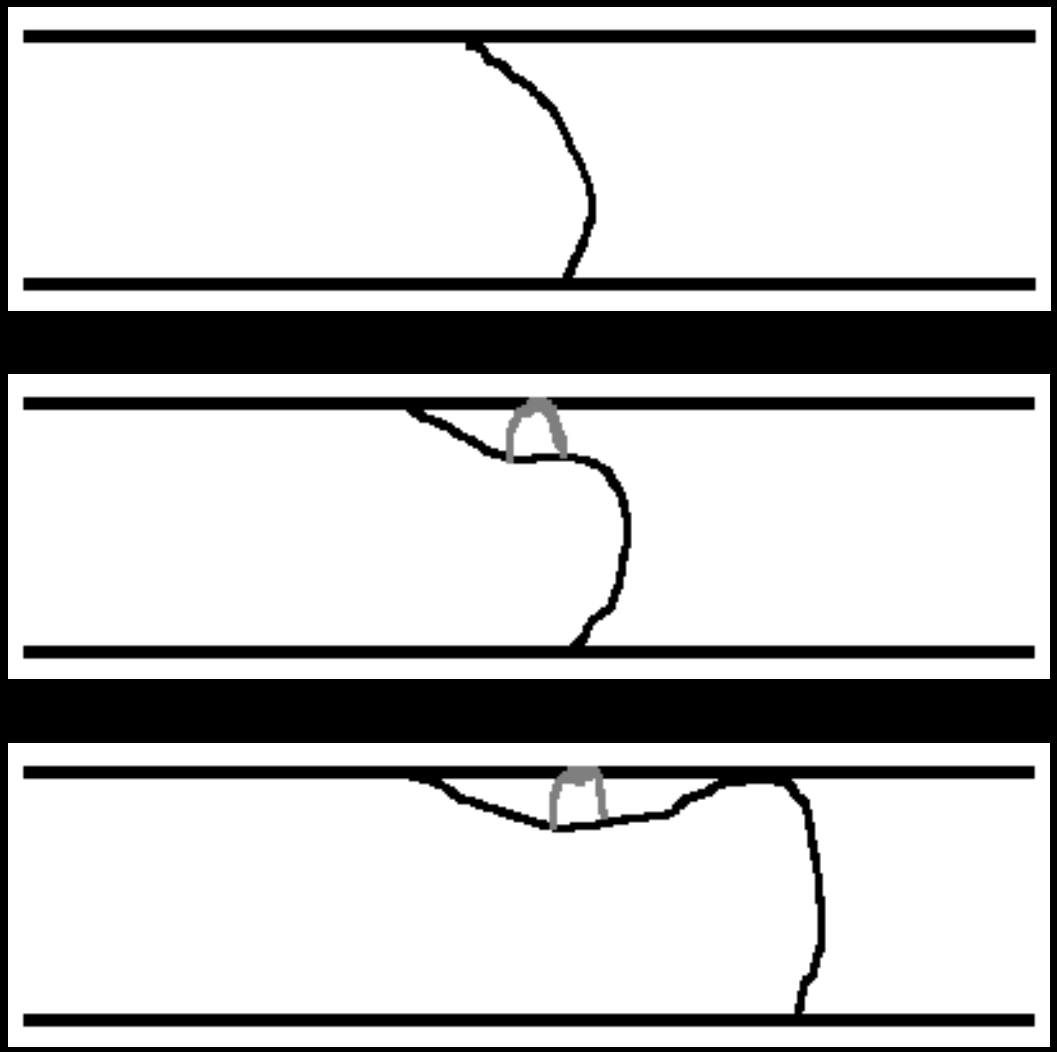

Z1
Inverse Pole Figure
(Folded)
[01 RT.cpr]
Silver (m3m)
Complete data set
1147 data points
Equal Area projection
Upper hemisphere
001
111
101
1200 nm, no Ti

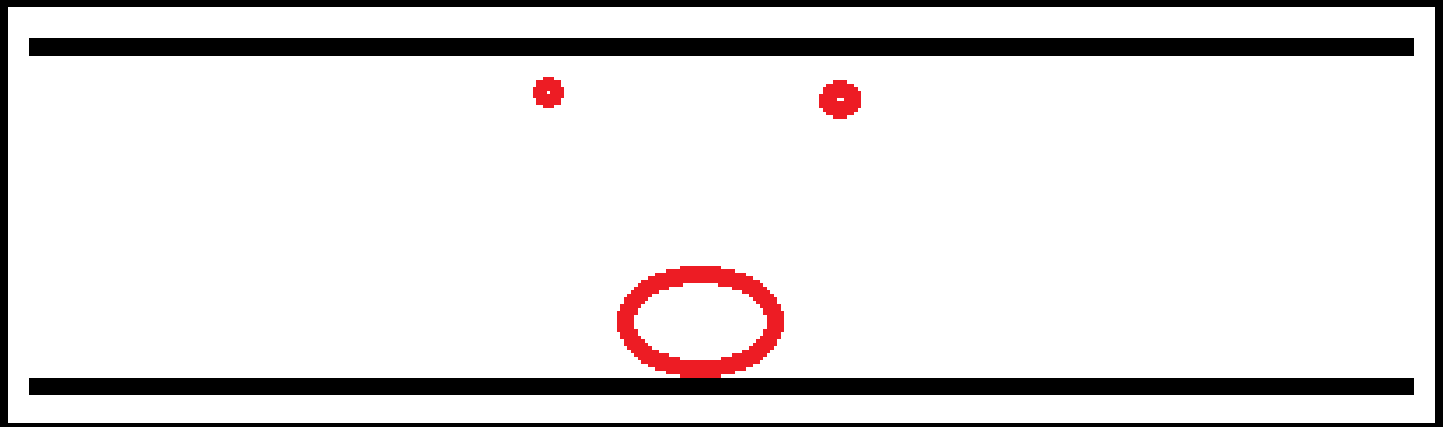
# Total No. of Grains vs. Time











# Questions?