

# Microbeam Imaging of Crystals by Coherent Diffraction at 34-ID-C

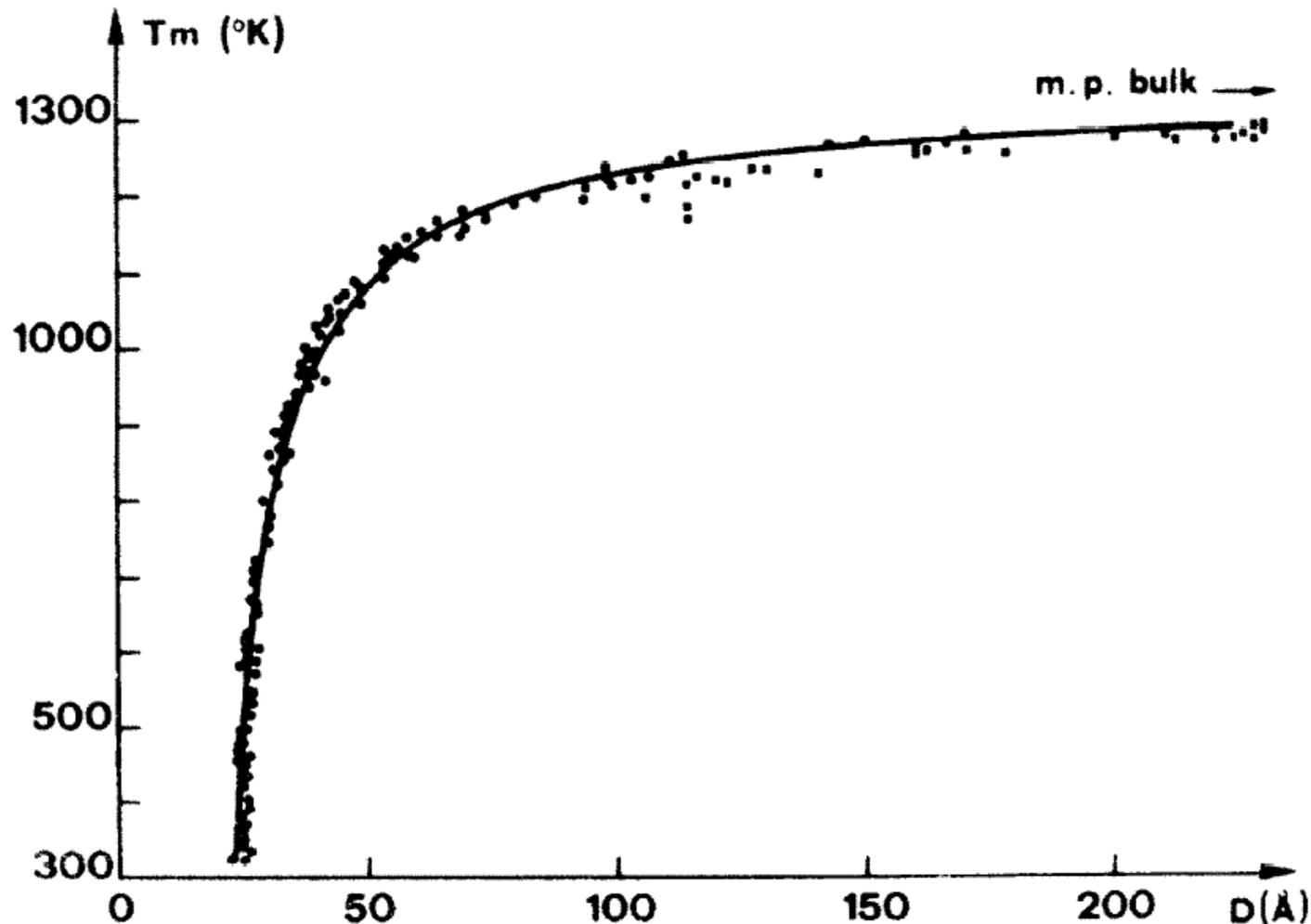
- Ian Robinson
- Ivan Vartanyants
- Franz Pfeiffer
- Mark Pfeifer
- Garth Williams
- Wei Zhang
- Curtis Benson

University of Illinois

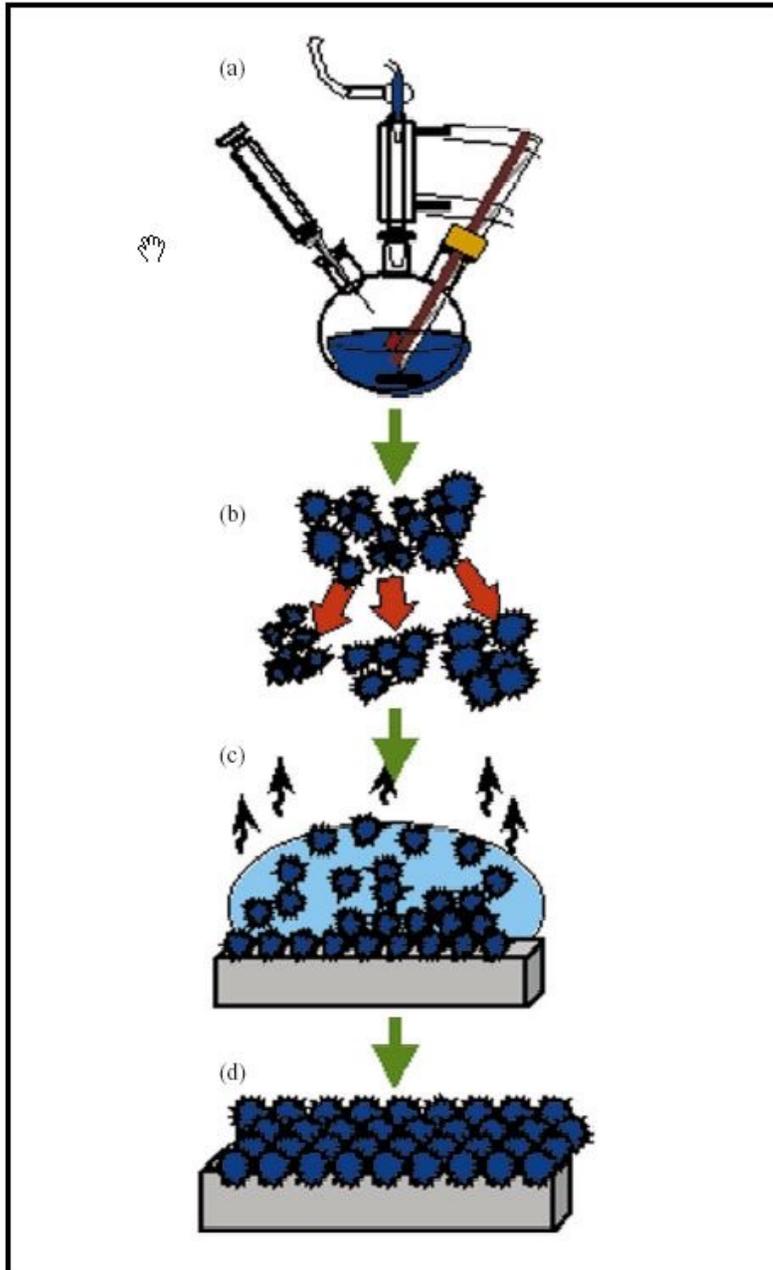
SAC Review of APS  
Jan 2004

# Size-dependent Melting of Au Particles

P. Buffat and J-P. Borel, Phys. Rev. A 2287-97 (1975)

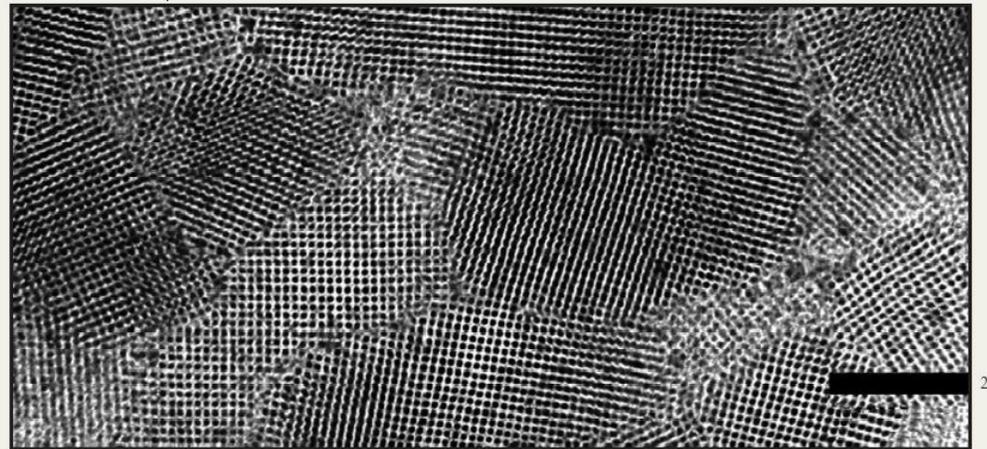


# Chemical Synthesis of Nanocrystals



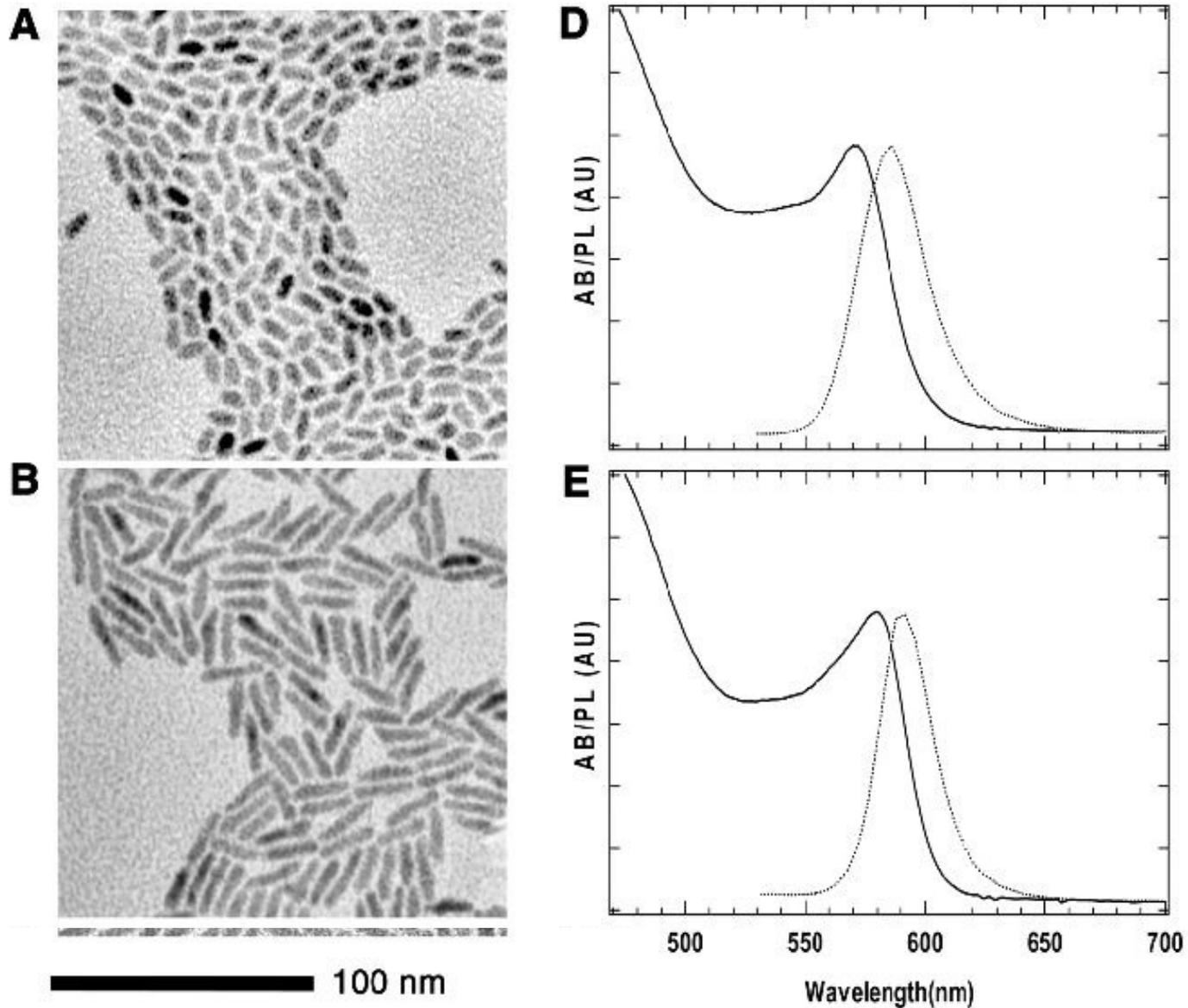
- Reactants introduced rapidly
- High temperature solvent
- Surfactant/organic capping agent
- Square superlattice (200nm scale)

C. B. Murray, IBM J. Res. & Dev. **45**  
47 (2001)

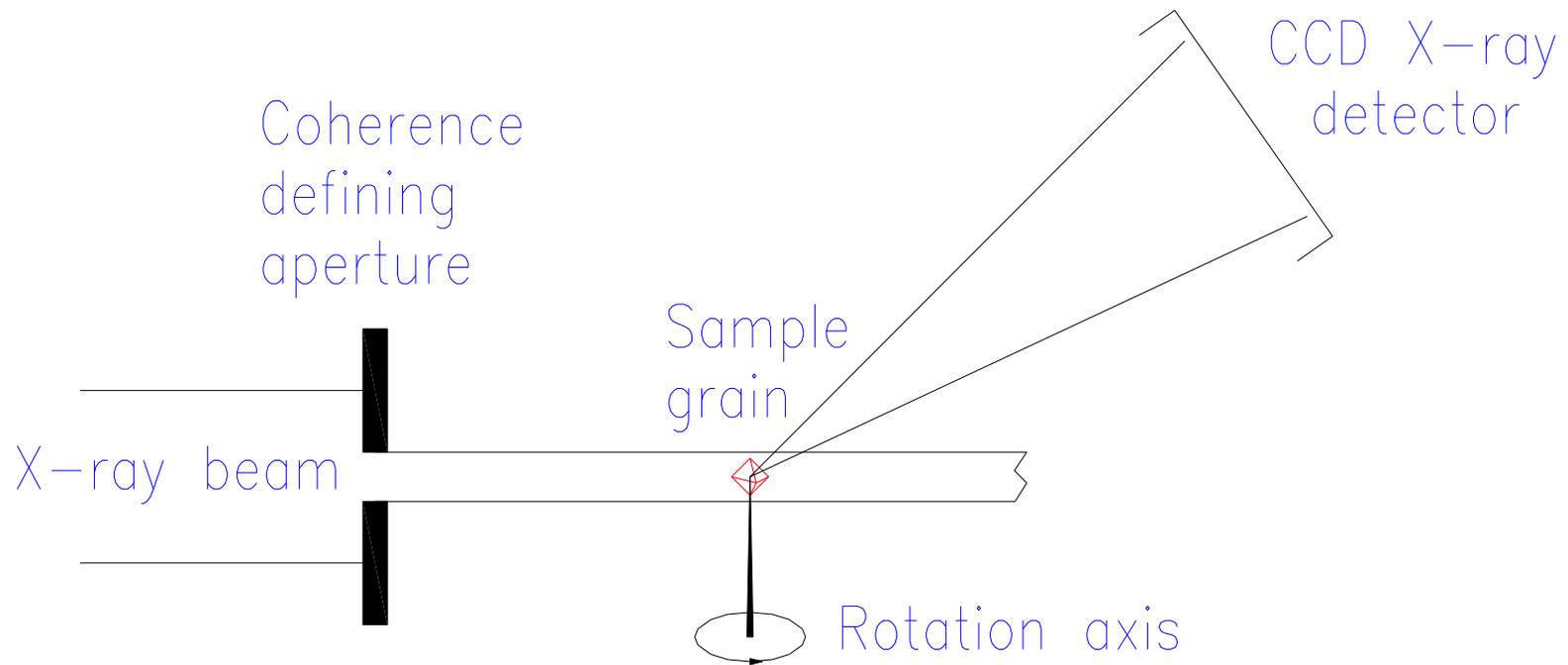


# Rod-like Nanocrystals of CdSe

J. Hu et al., Science **292** 2060 (2001)

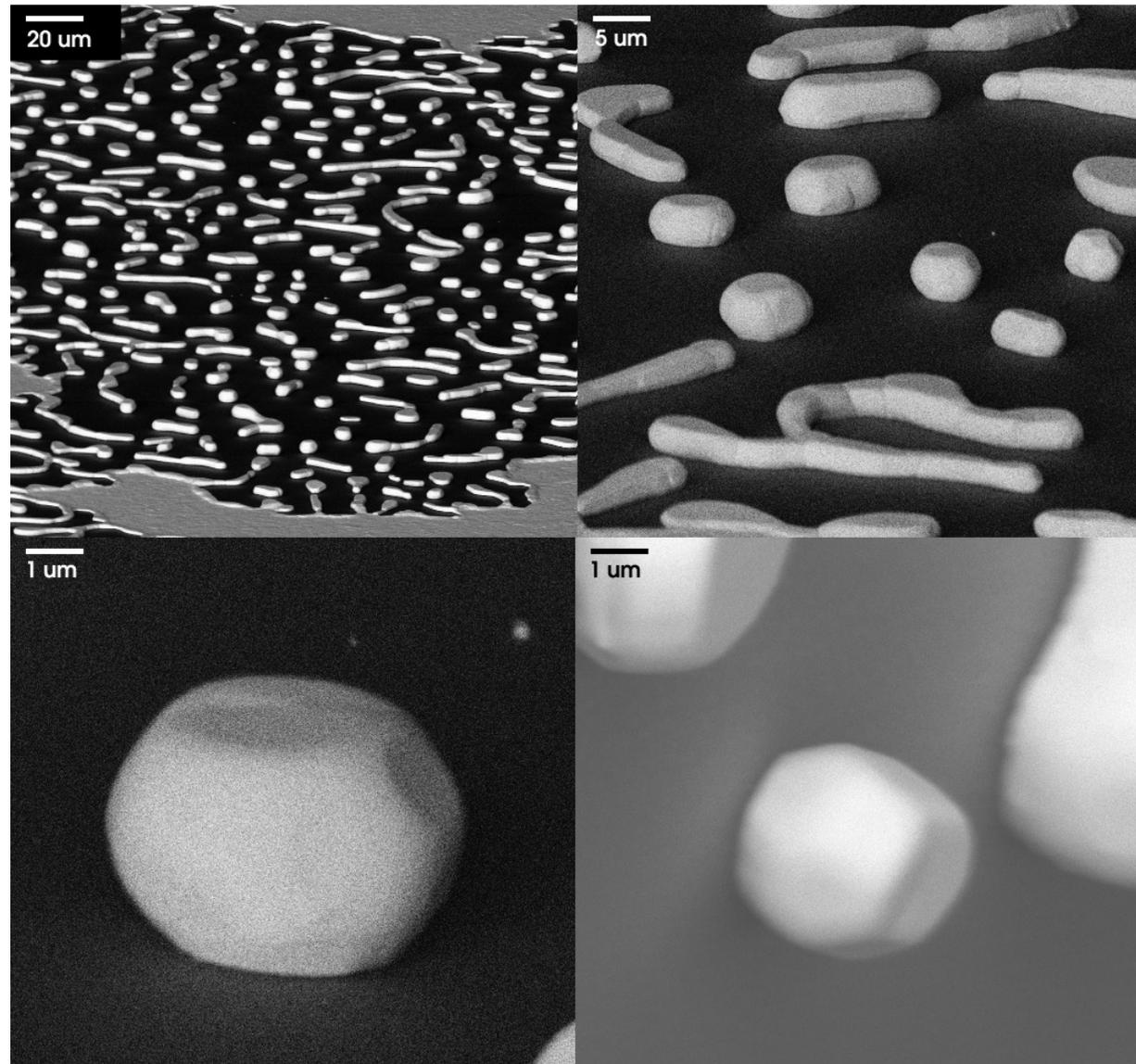


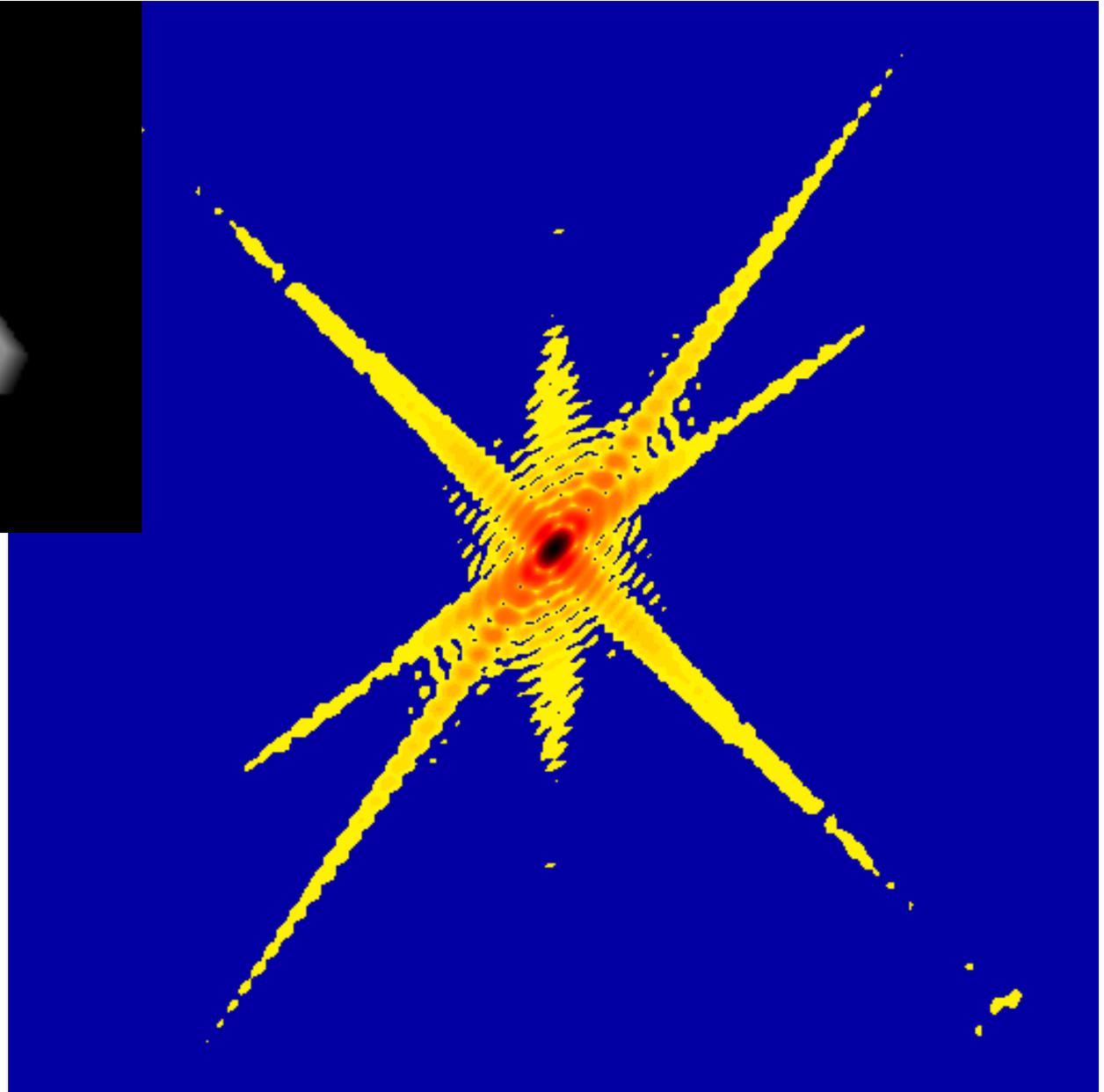
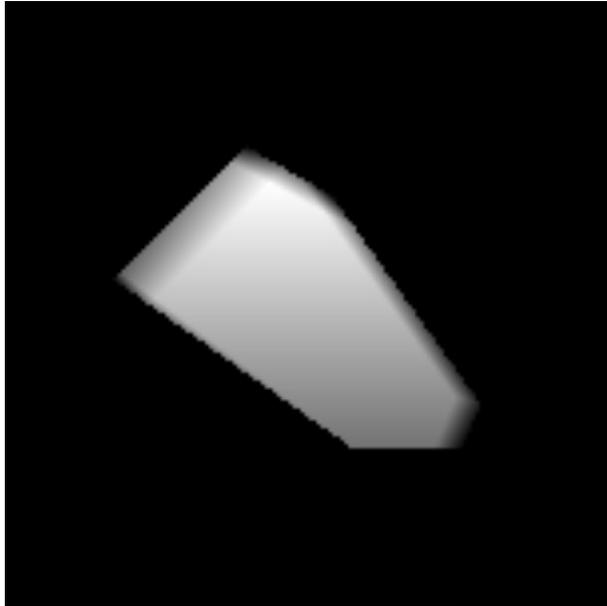
# Lensless X-ray Microscope



# SEMS

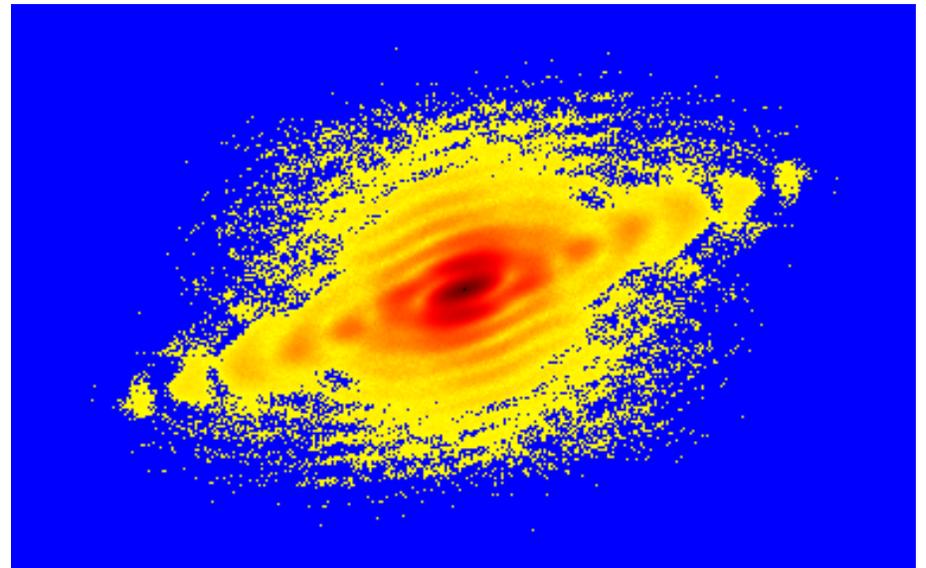
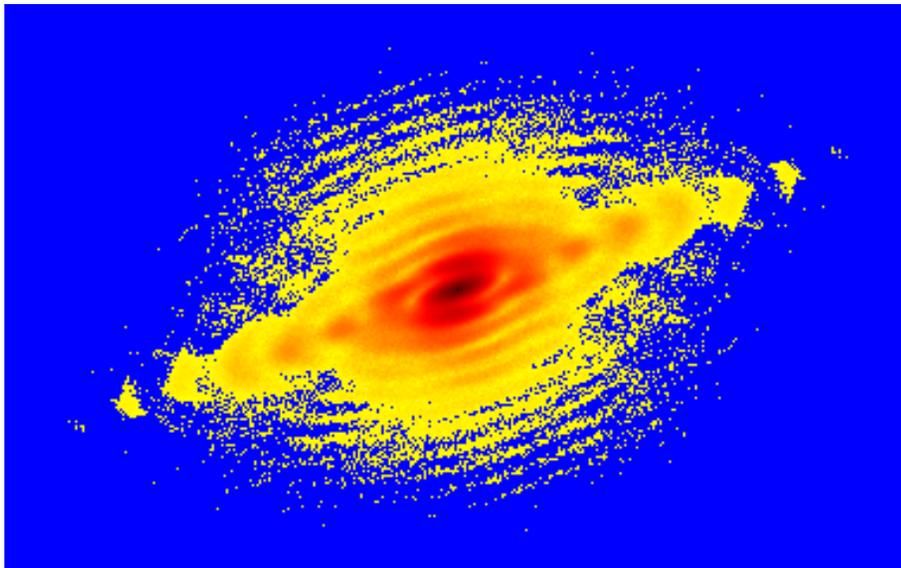
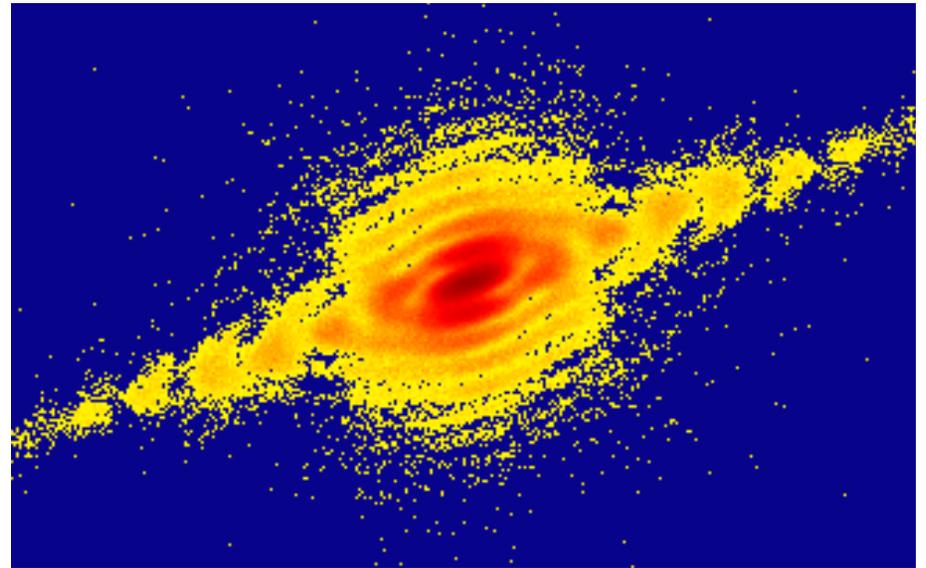
- Au blanket film
- Quartz substrate
- Annealed at 950°C for 70 hrs.





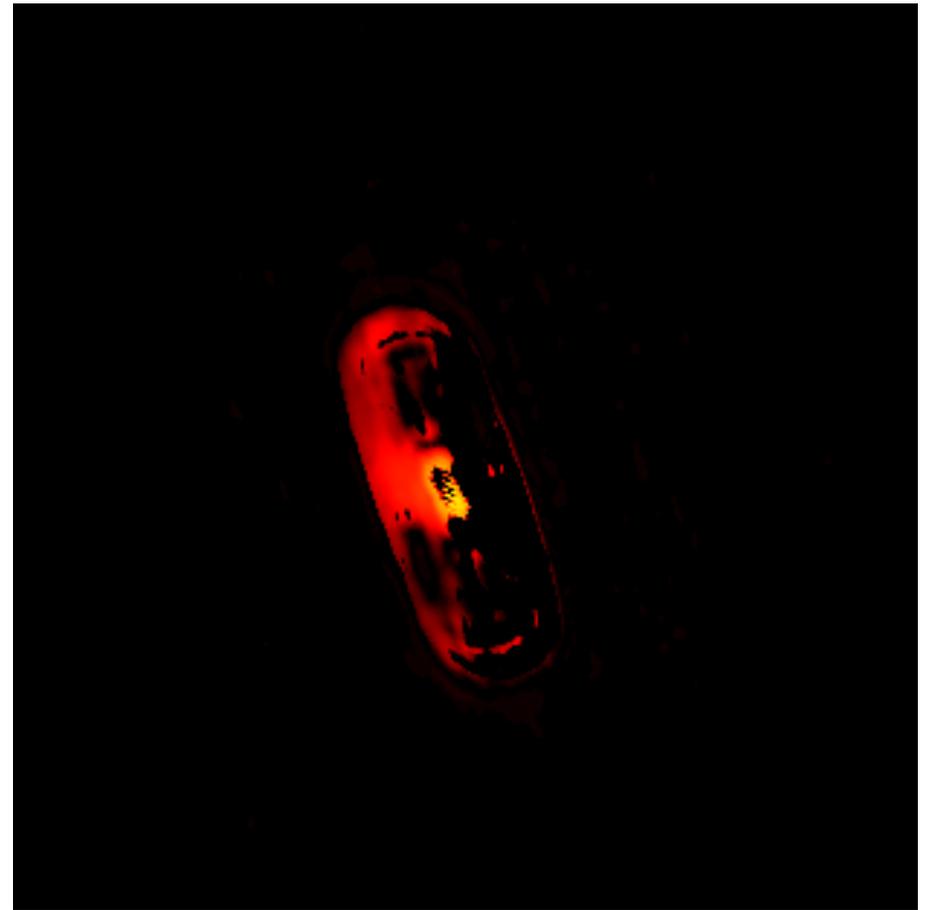
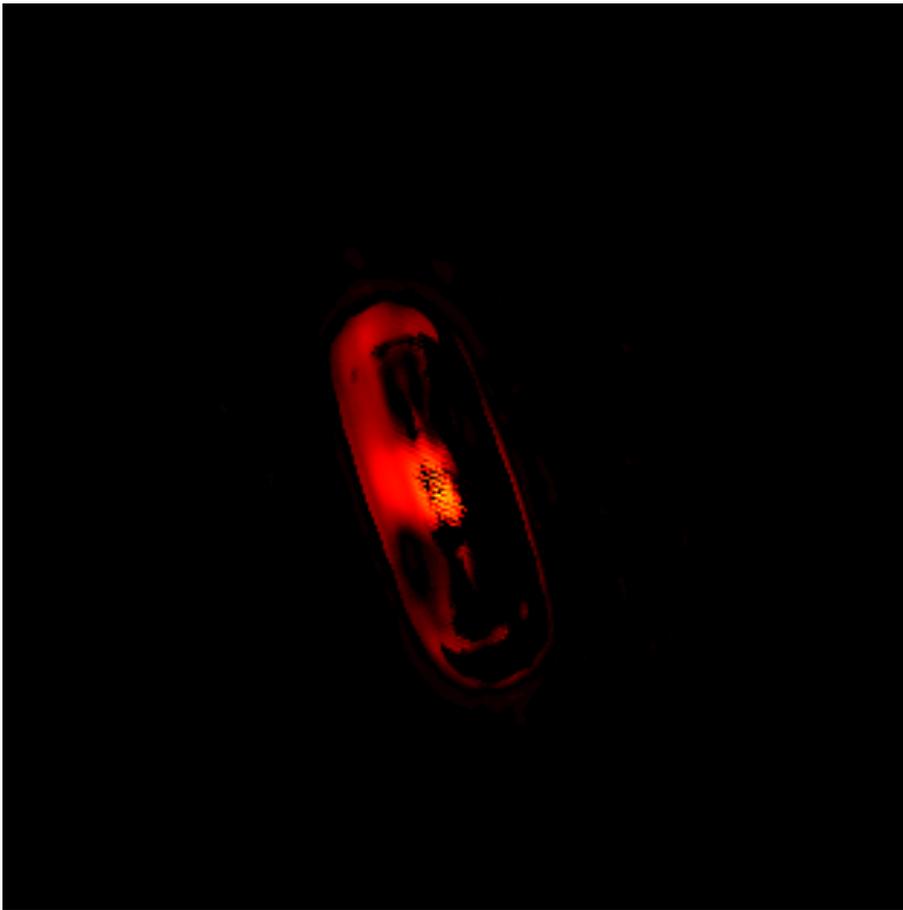
# Symmetrized Data and two best fits

Chisq=0.0005

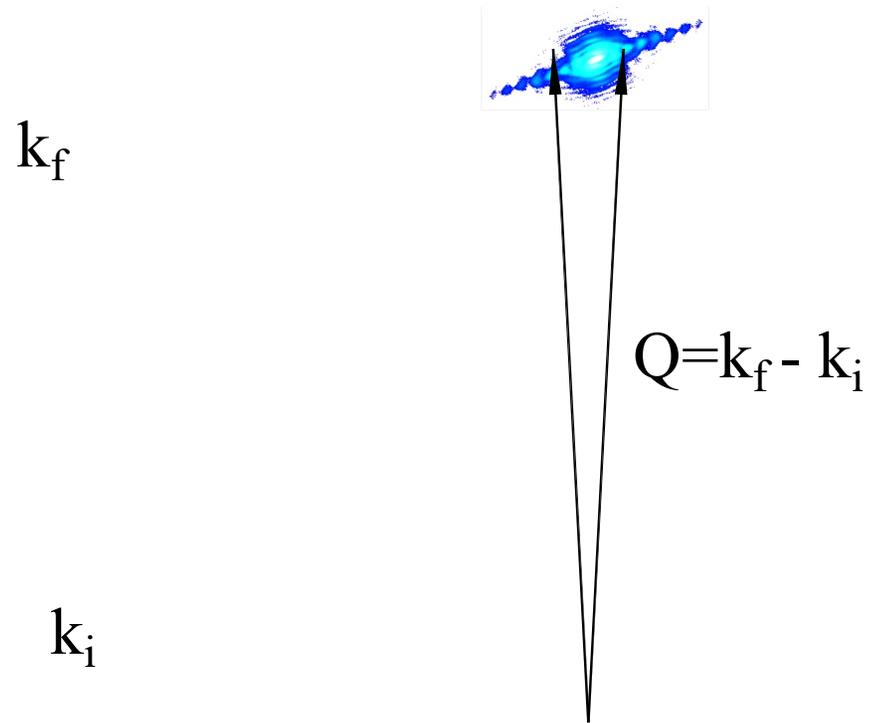


# 2D Reconstructions

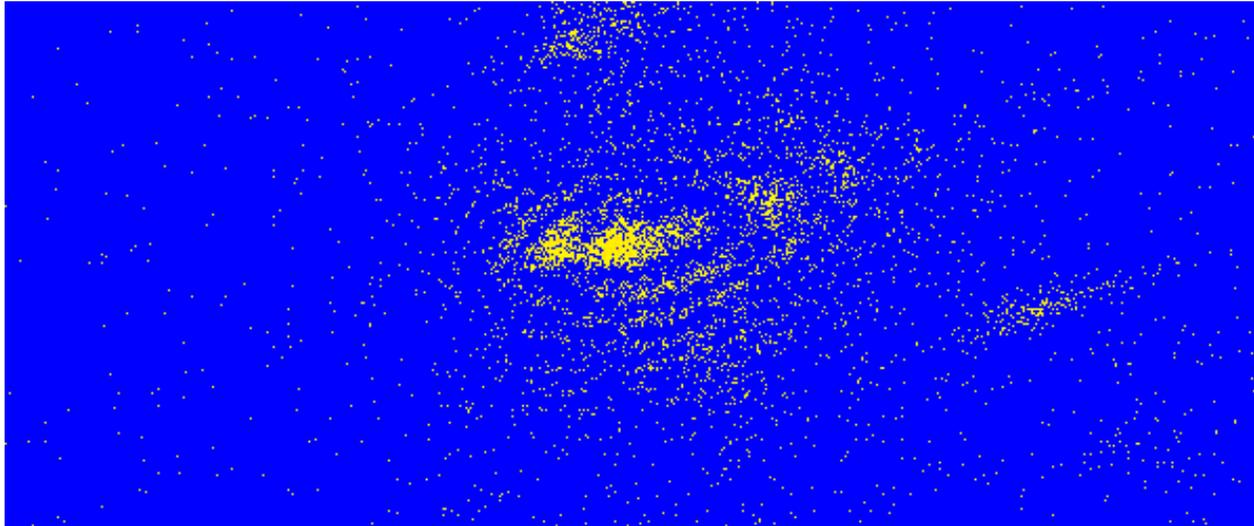
chisquare = 0.0005

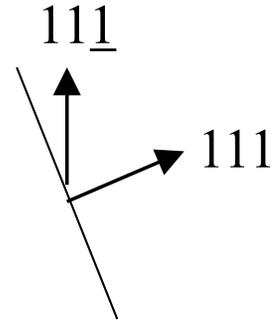
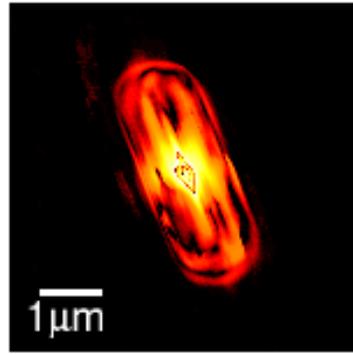
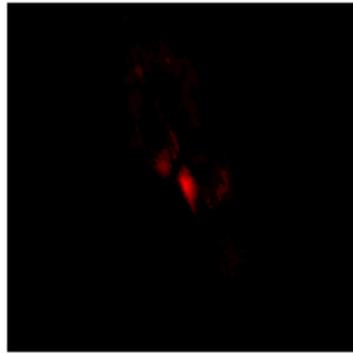


# 3D Diffraction Method

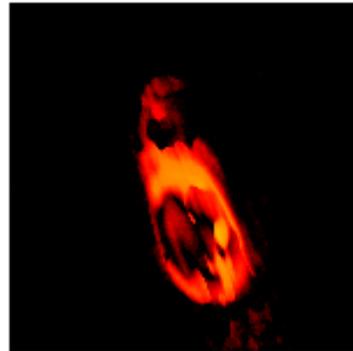
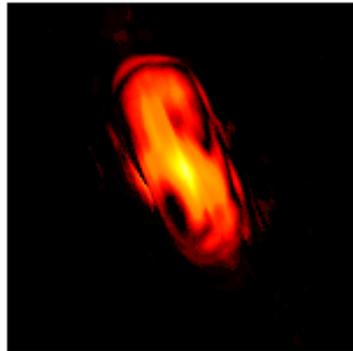
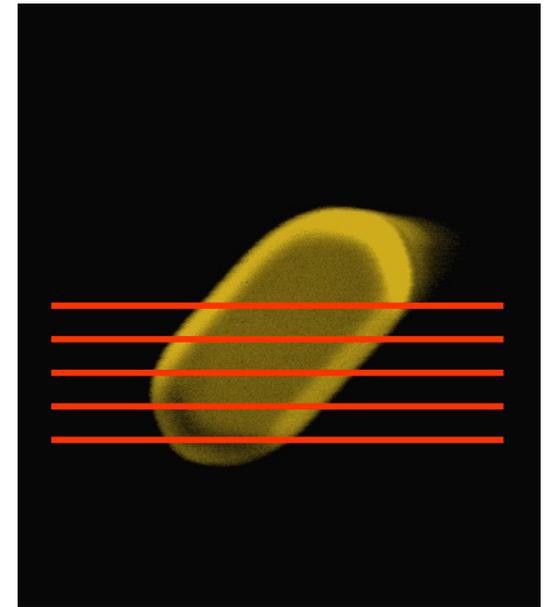
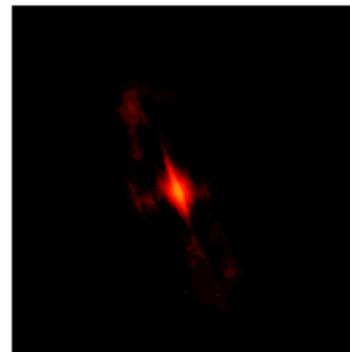
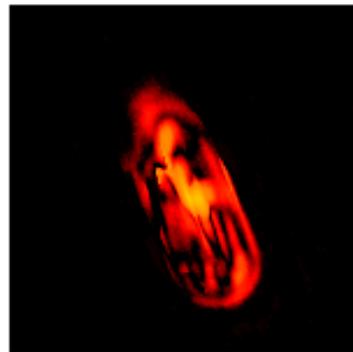
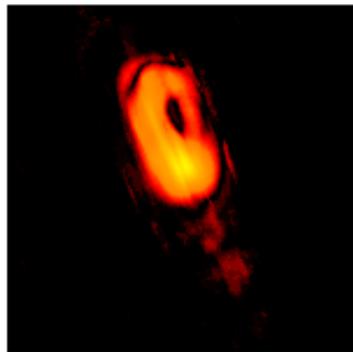
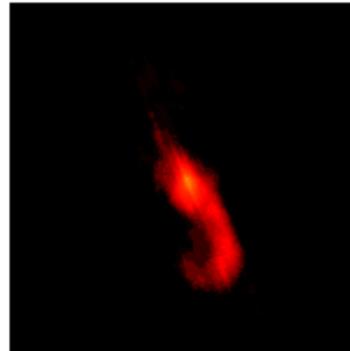
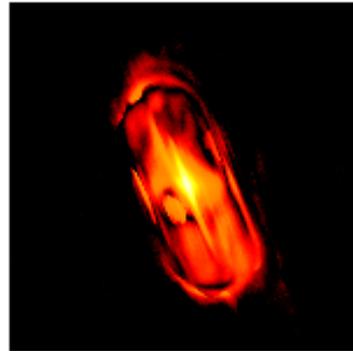
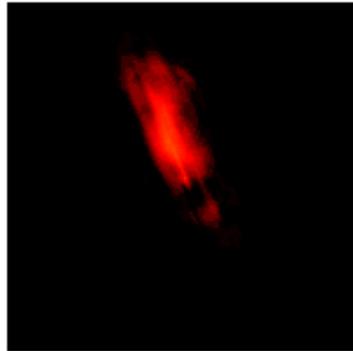


# 3D Diffraction Data 1 micron Au crystal



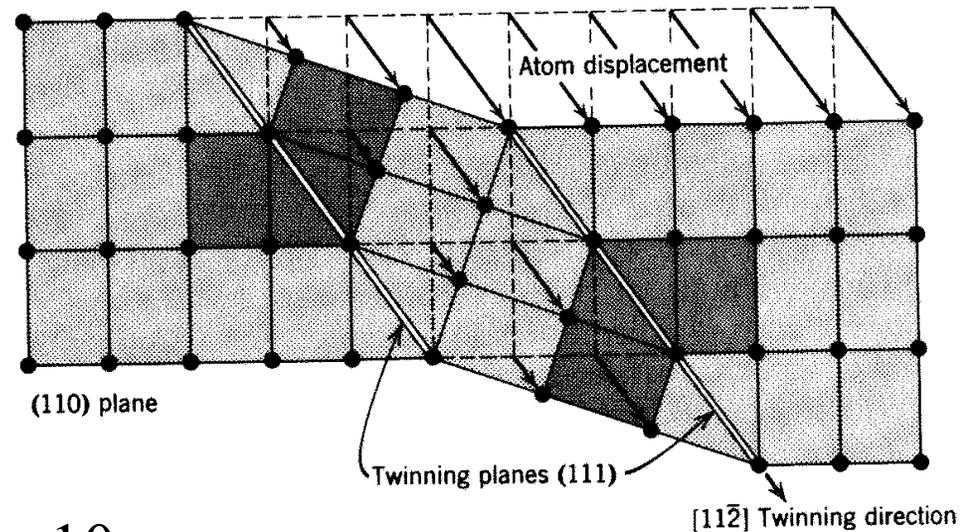


Slices through  
plan view SEM:



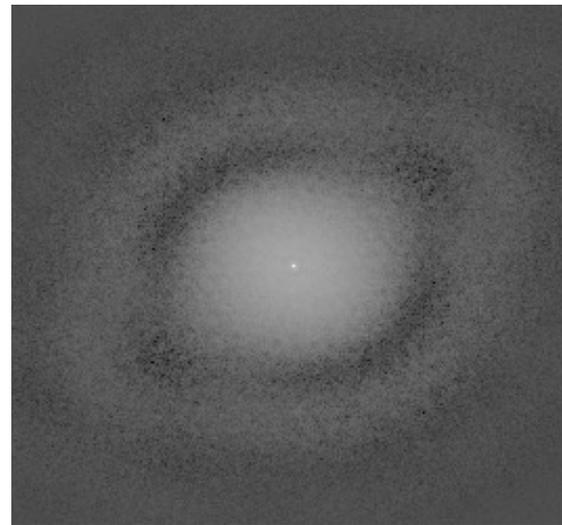
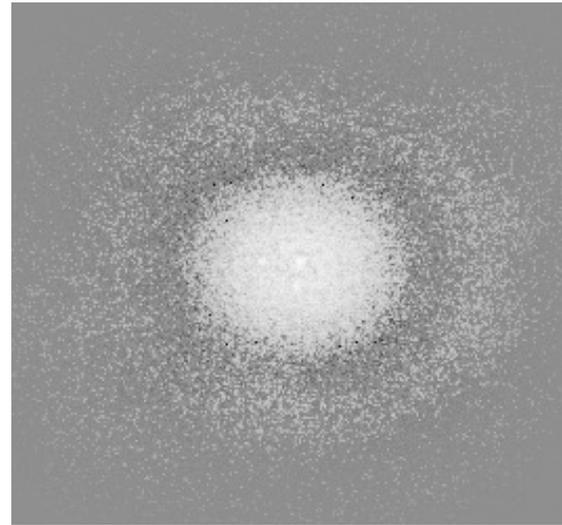
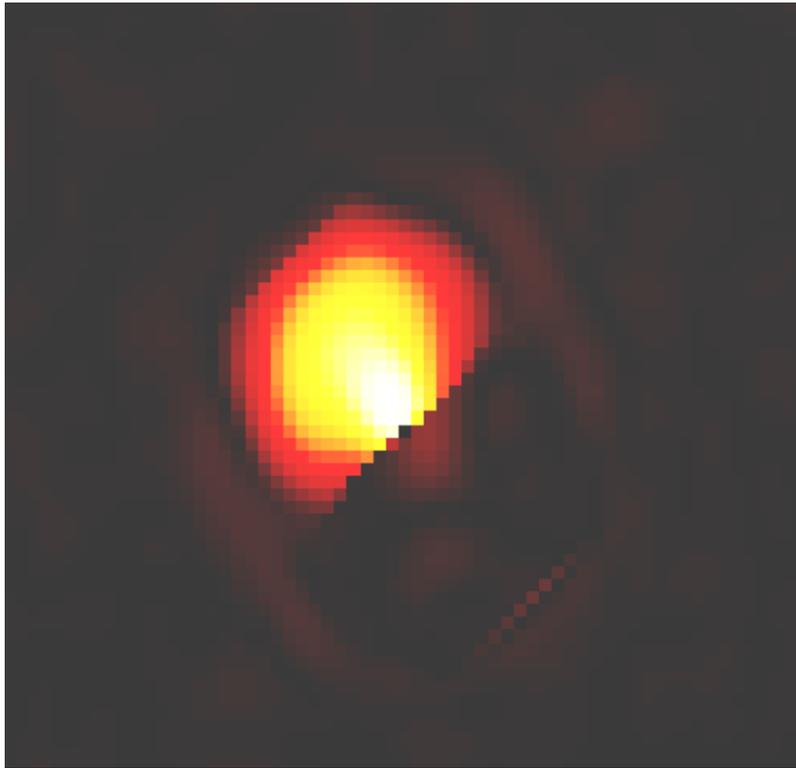
# Twinning in deformed FCC metals

J. Wulff, "Structure and Property of Materials III" (1965)

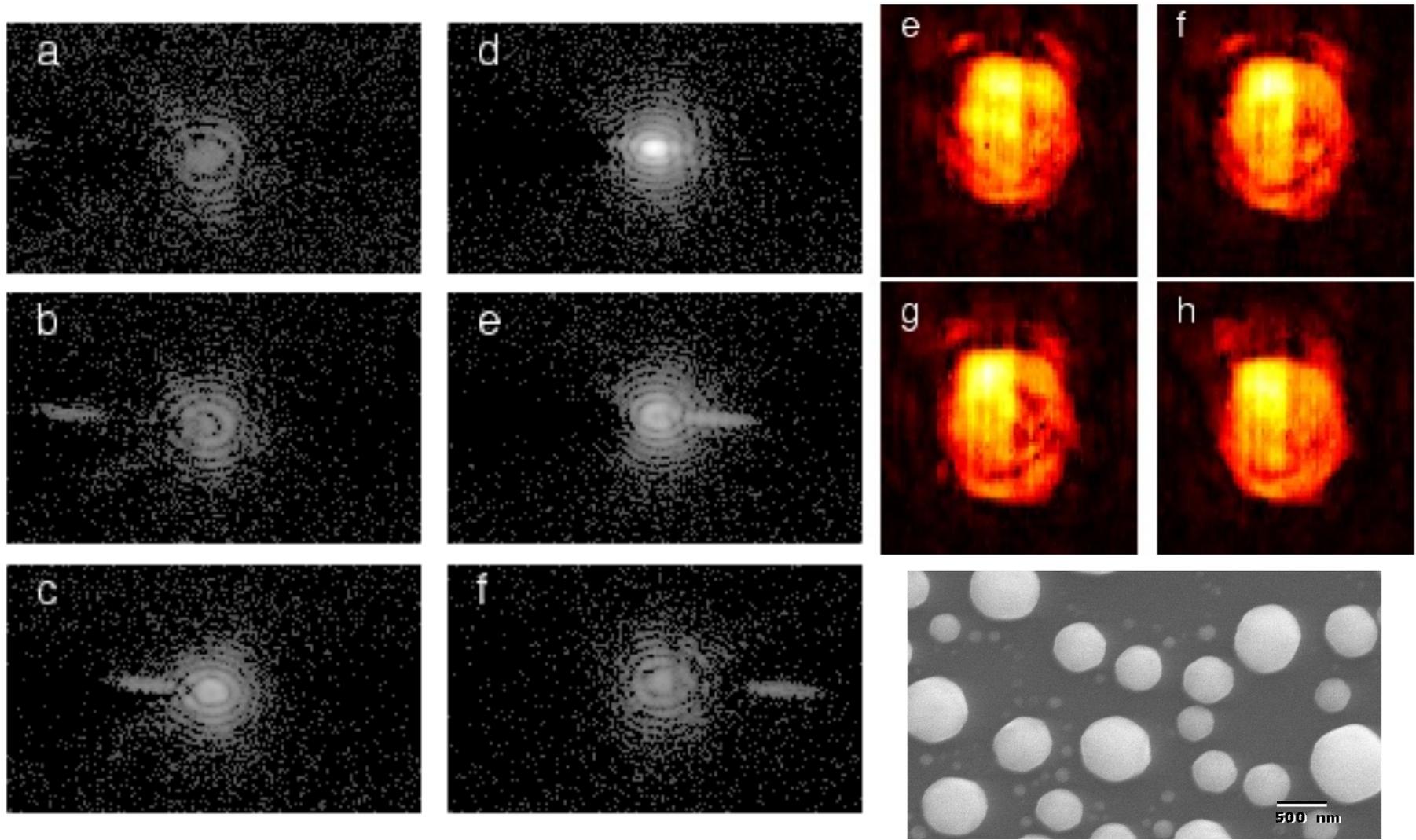


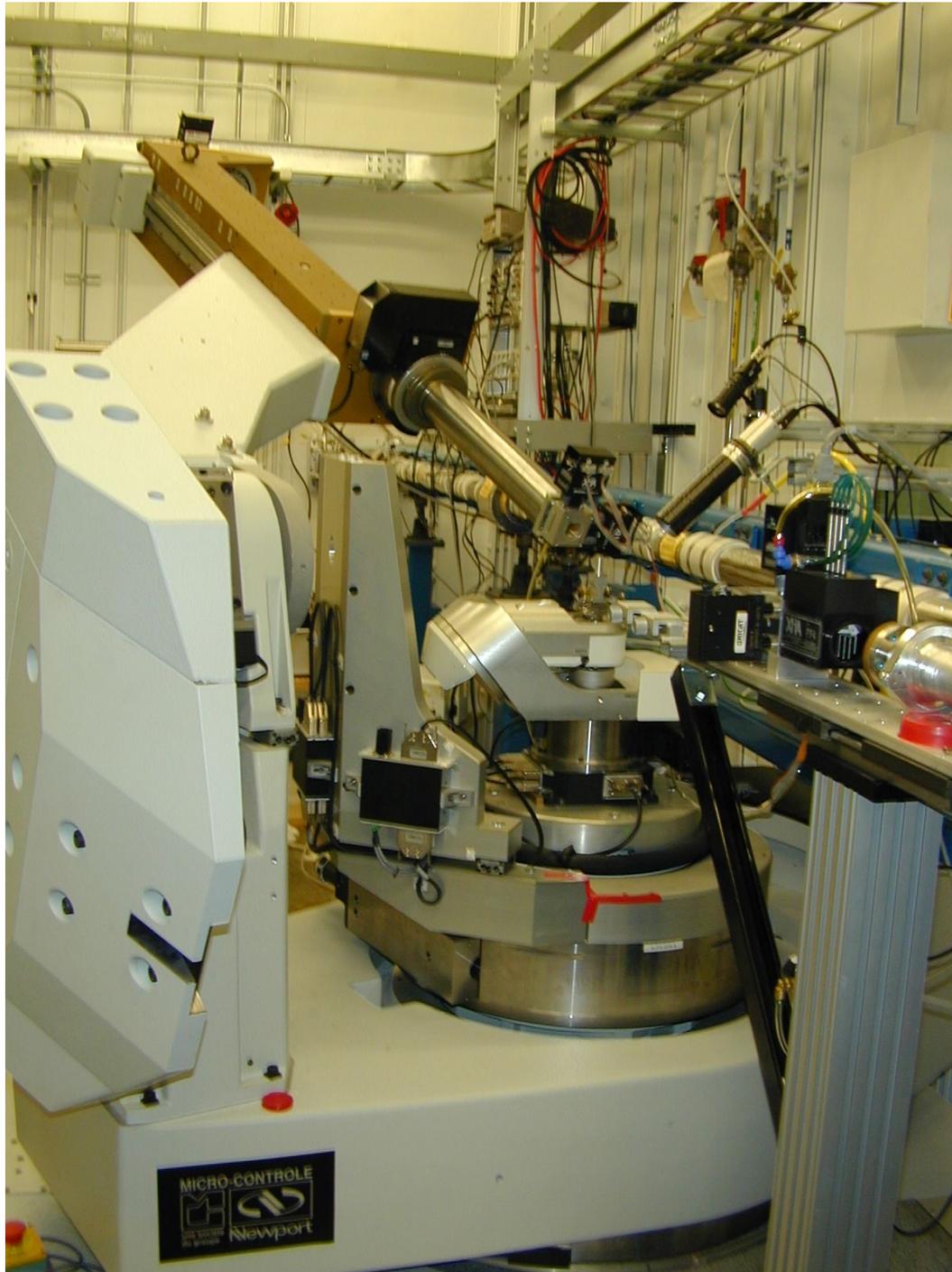
■  $\sim 10\mu\text{m}$   
Cu

# Reconstruction of Pb Nanocrystal

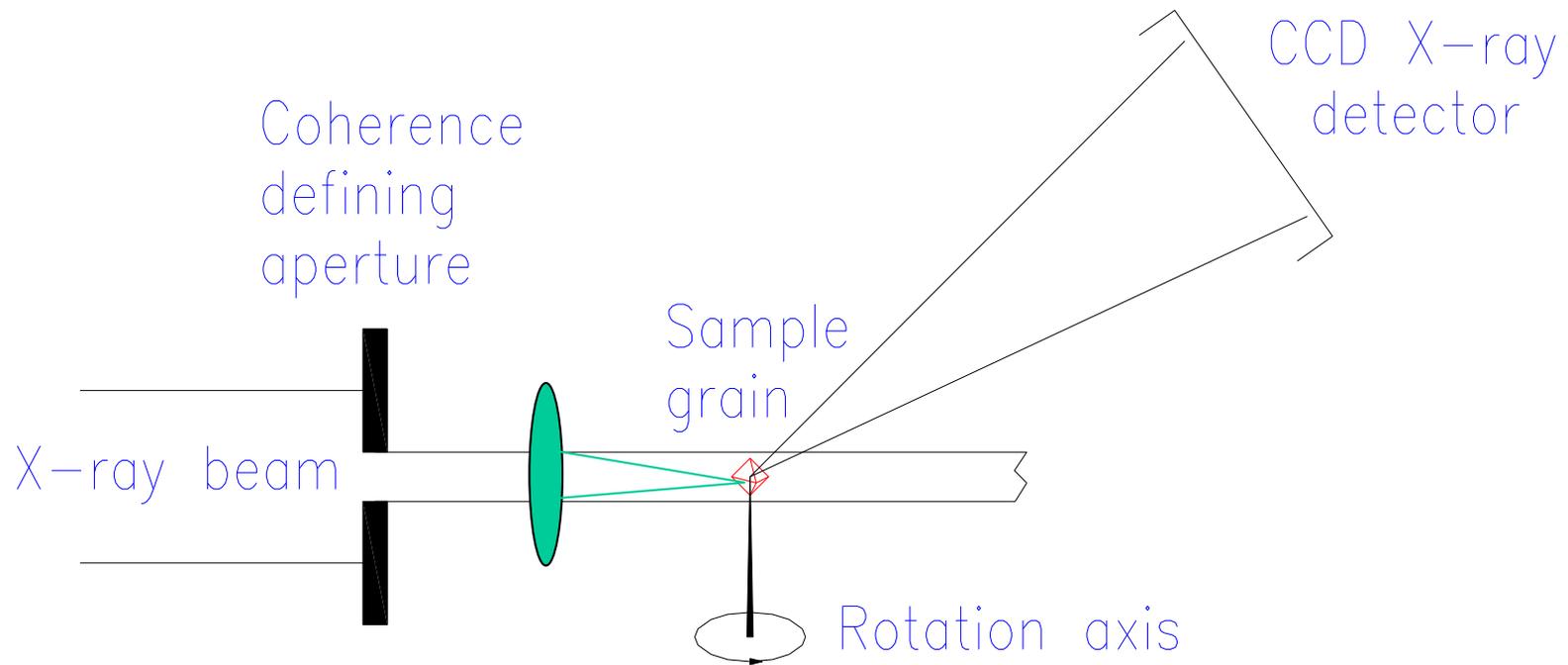


# 3D reconstruction of Pb nanocrystals

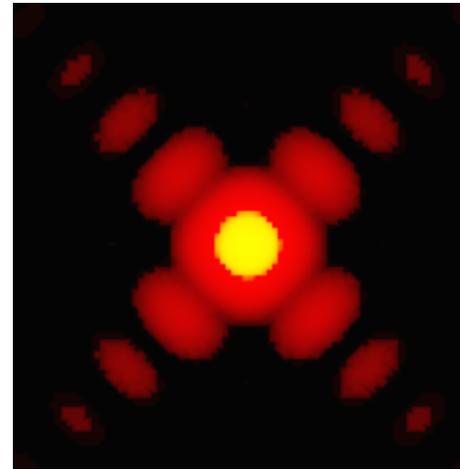
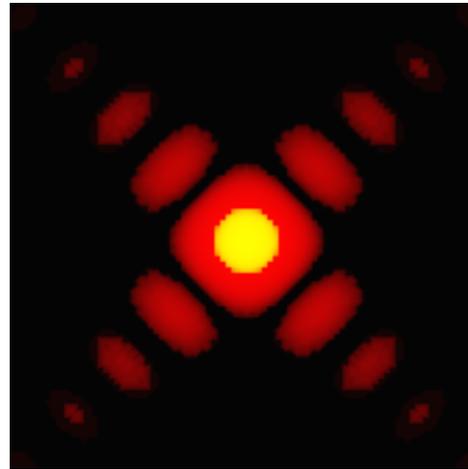




# Lensless X-ray Microscope

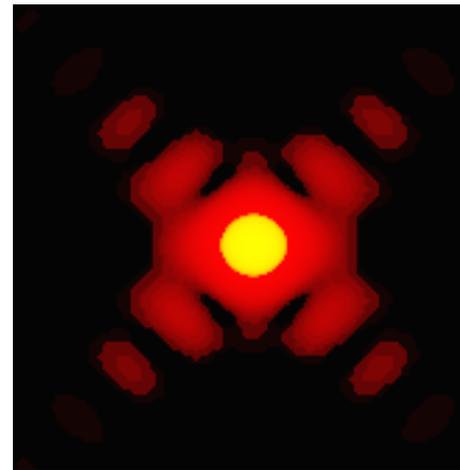
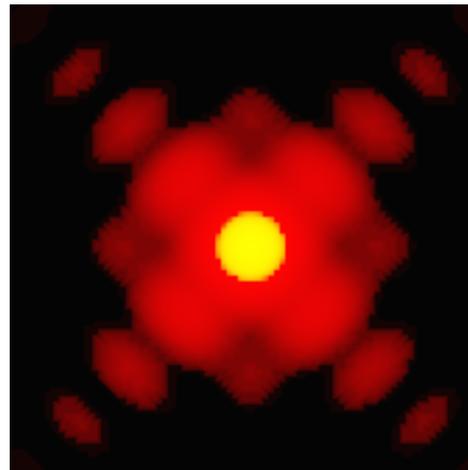


# Spherical and cylindrical waves



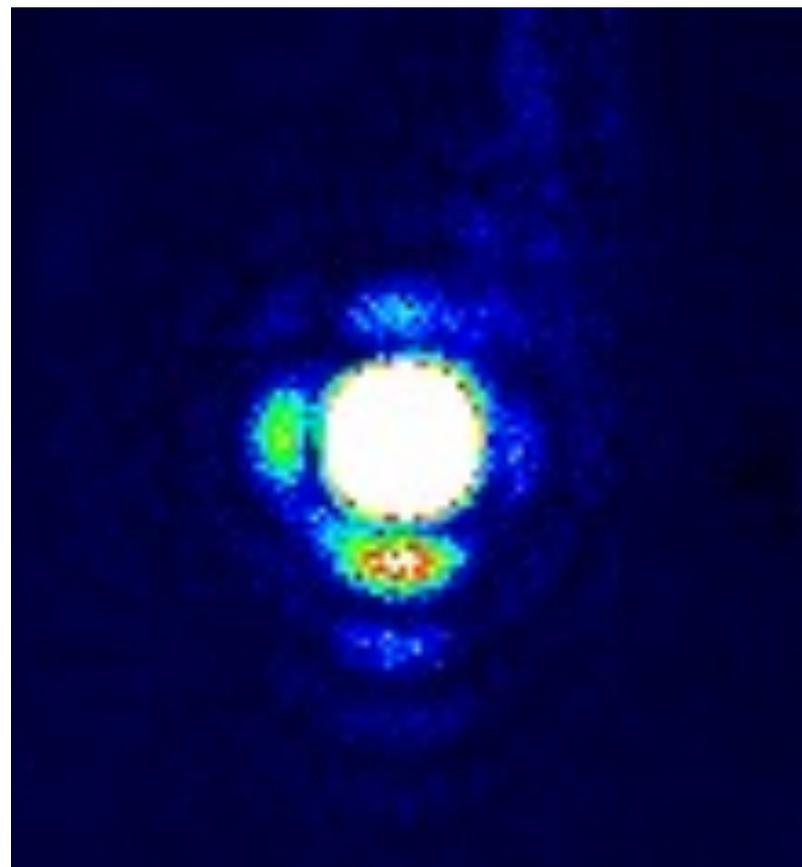
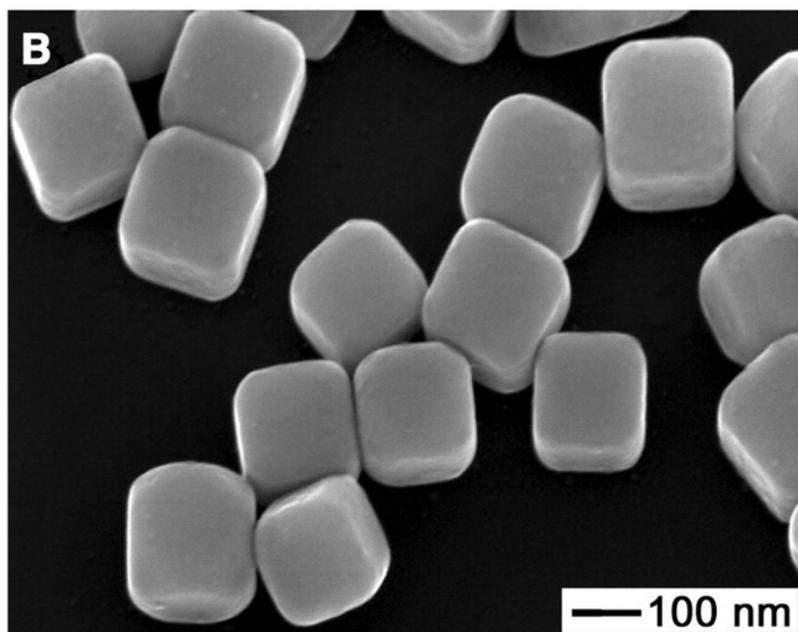
$\pi/4$

$\pi/2$



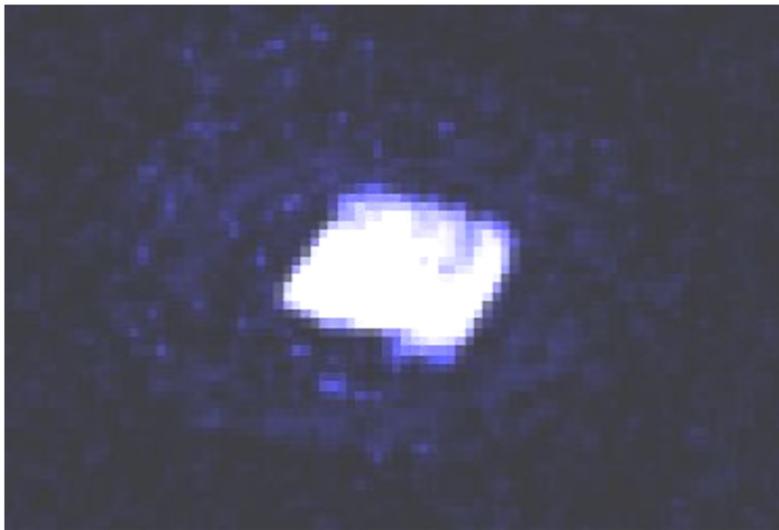
$\pi/4$  (x)

# Chemically Synthesized Silver Nanocubes

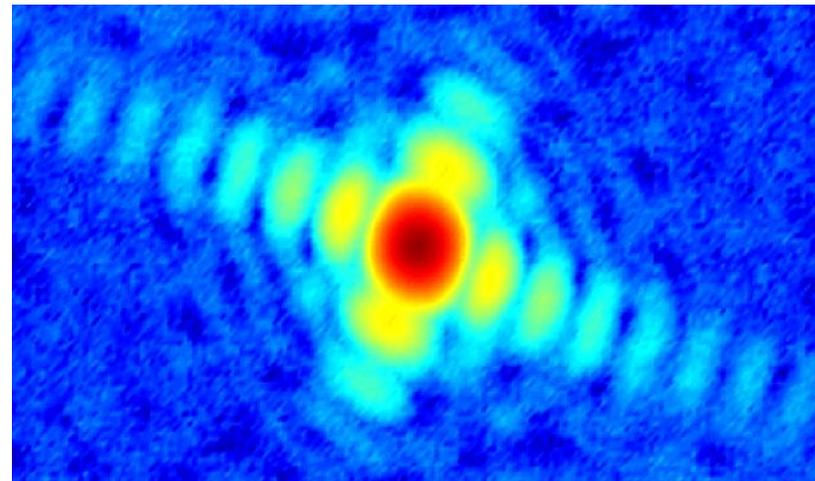
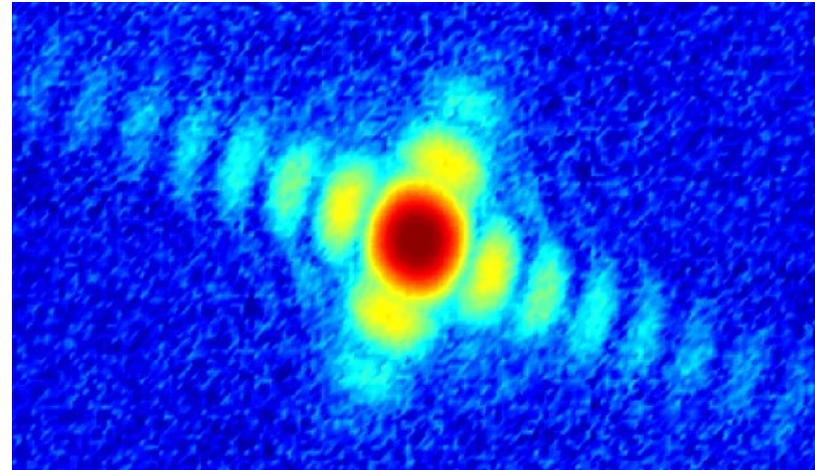


Yugang Sun and Younan Xia,  
*Science* 298 2177 (2003)

# Reconstruction of Ag Nanocrystal

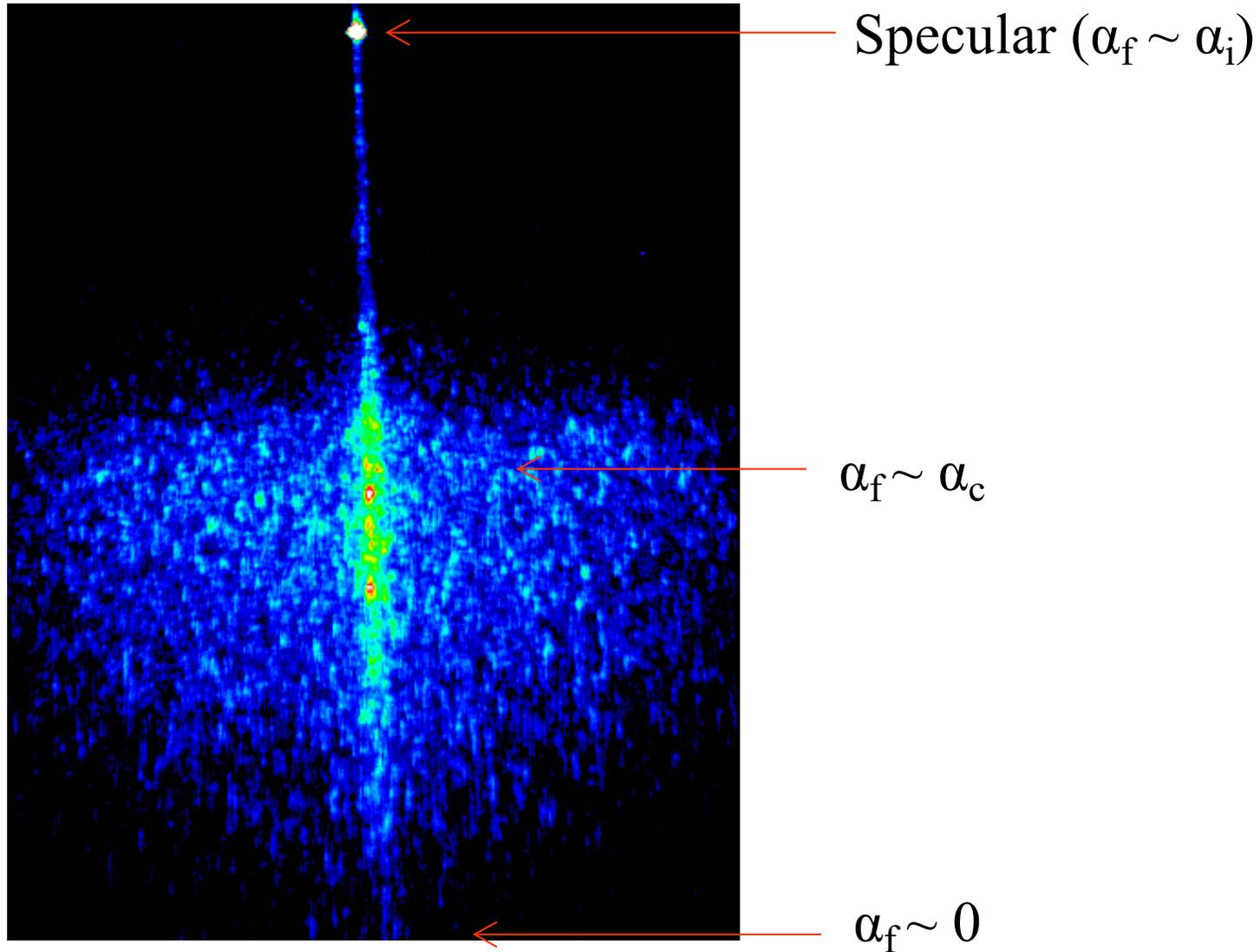


←→  
200nm



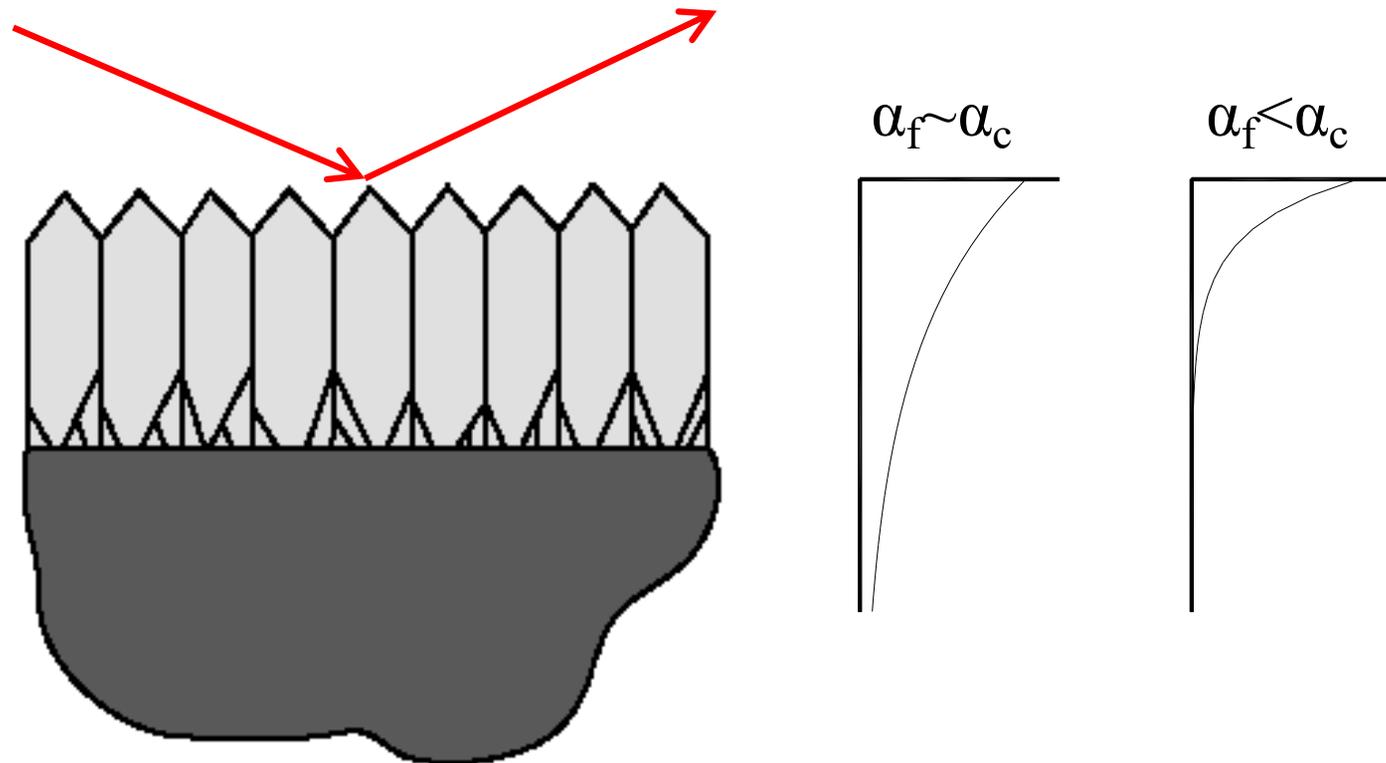
# Structure in “Yoneda” Peak

Grazing-exit diffraction from a 1000Å Au polycrystalline film



# Competitive Grain Growth

C. V. Thompson, *Ann. Rev. Mat. Sci.* **30** 159 (2000)

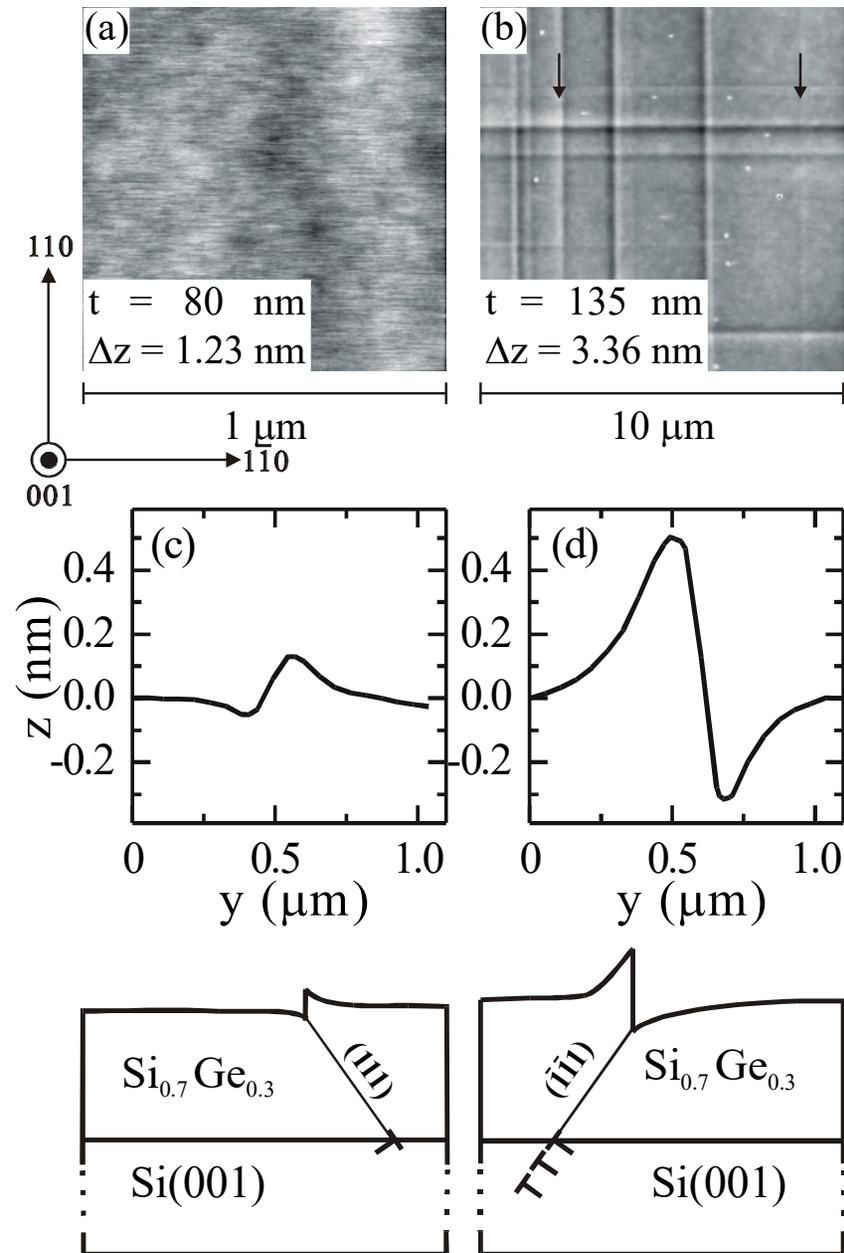


Low dislocation density GeSi films

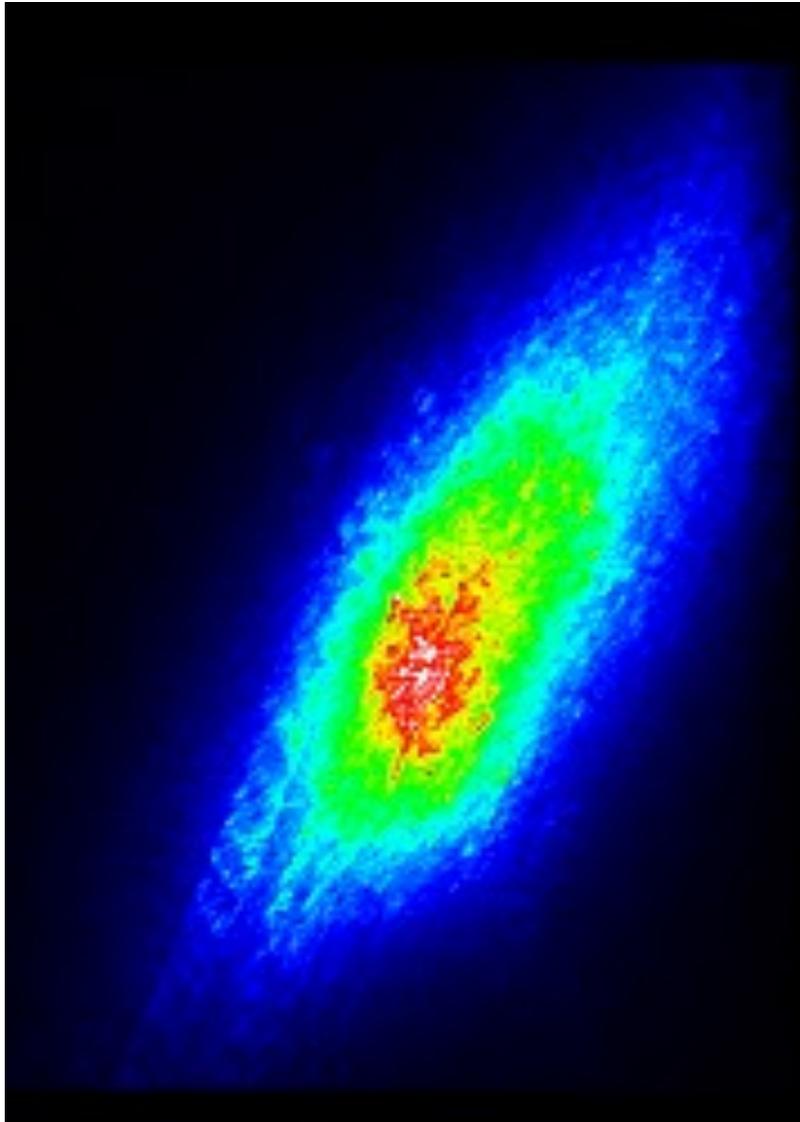
Thickness close to critical thickness

Dislocations aggregate at interface and glide to surface along  $\{111\}$

T. Spila, UIUC Thesis



# $\text{Ge}_x\text{Si}_{1-x}$ Film Diffraction



- 202 Bragg Peak
- 2800Å film
- 2° incidence angle
- 8.5 keV
- 20μm × 40μm beam  
onto KB mirror
- 1μm × 1μm focus
- 0.5μm sample steps
- APS 34-ID-C

# Conclusions and Outlook

- Inversion of CXD using oversampling
- Diffuse scattering acquires fine structure
- Internal structure of Au Nanocrystals
- Preservation of coherence upon focusing
- Image individual dislocation strain fields
- Localized manipulations of nanocrystals