

# Pump-Probe Deformation of Nanocrystals

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Diamond Light Source

Scientific Potential  
of Free Electron Lasers

The Royal Society

April 2010

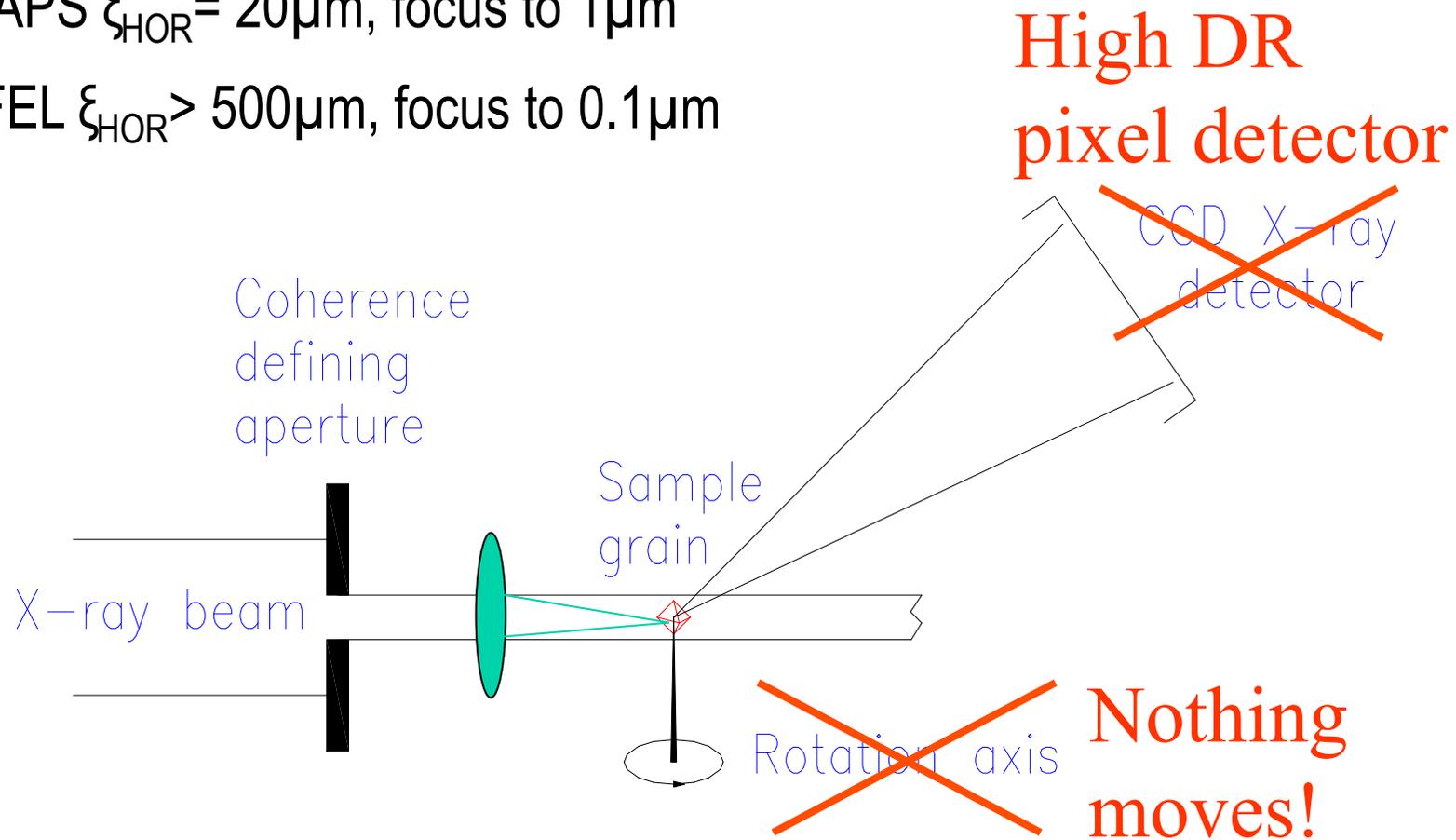
# Outline

- Coherent X-ray Diffraction Imaging
- Small crystals
- Domain structures
- Fluctuations
- LCLS planning
- XFEL requirements

# Coherent X-ray Diffraction Imaging

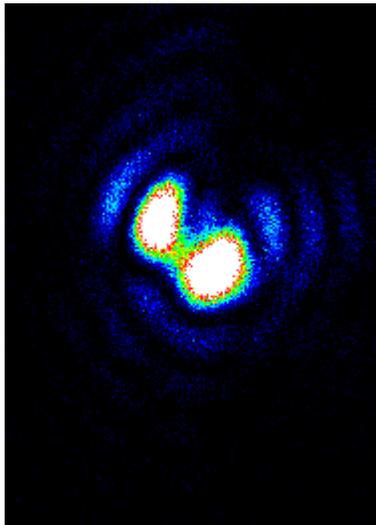
APS  $\xi_{\text{HOR}} = 20\mu\text{m}$ , focus to  $1\mu\text{m}$

XFEL  $\xi_{\text{HOR}} > 500\mu\text{m}$ , focus to  $0.1\mu\text{m}$



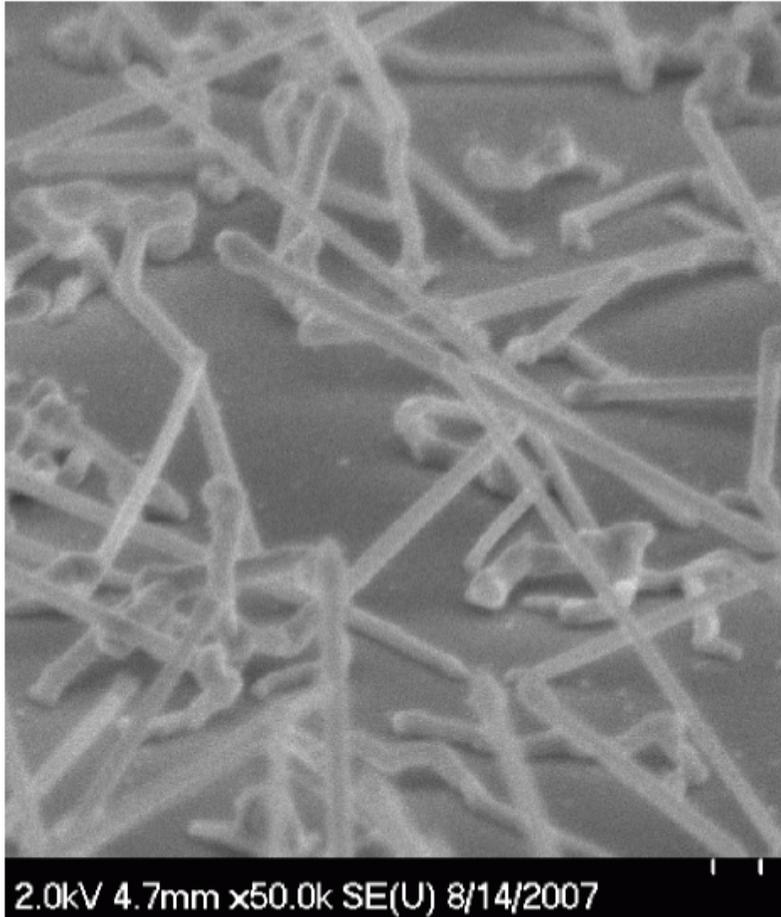
# Gold nanocrystal reconstruction

showing support used for 20 HIO followed by 10 ER

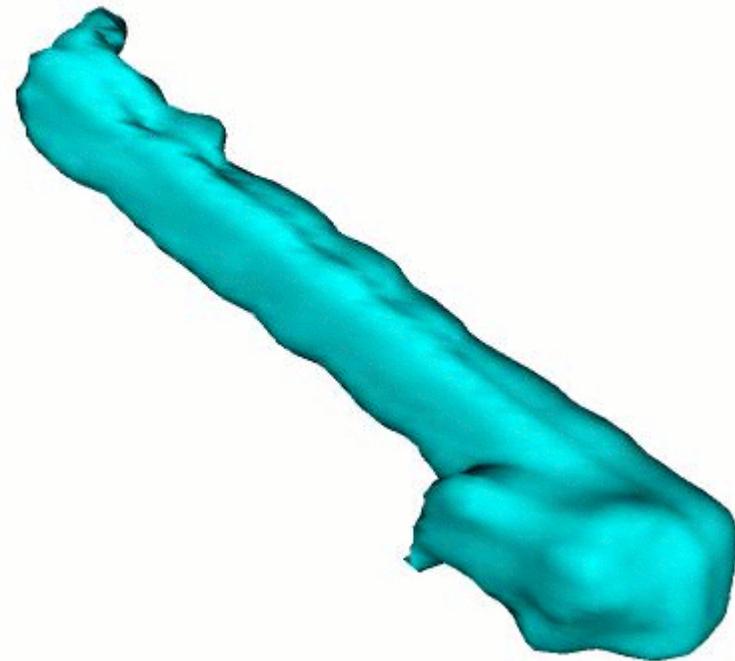


# Reconstruction of InP nanowire

CVD on Si, Suneel Kodambaka, UCLA

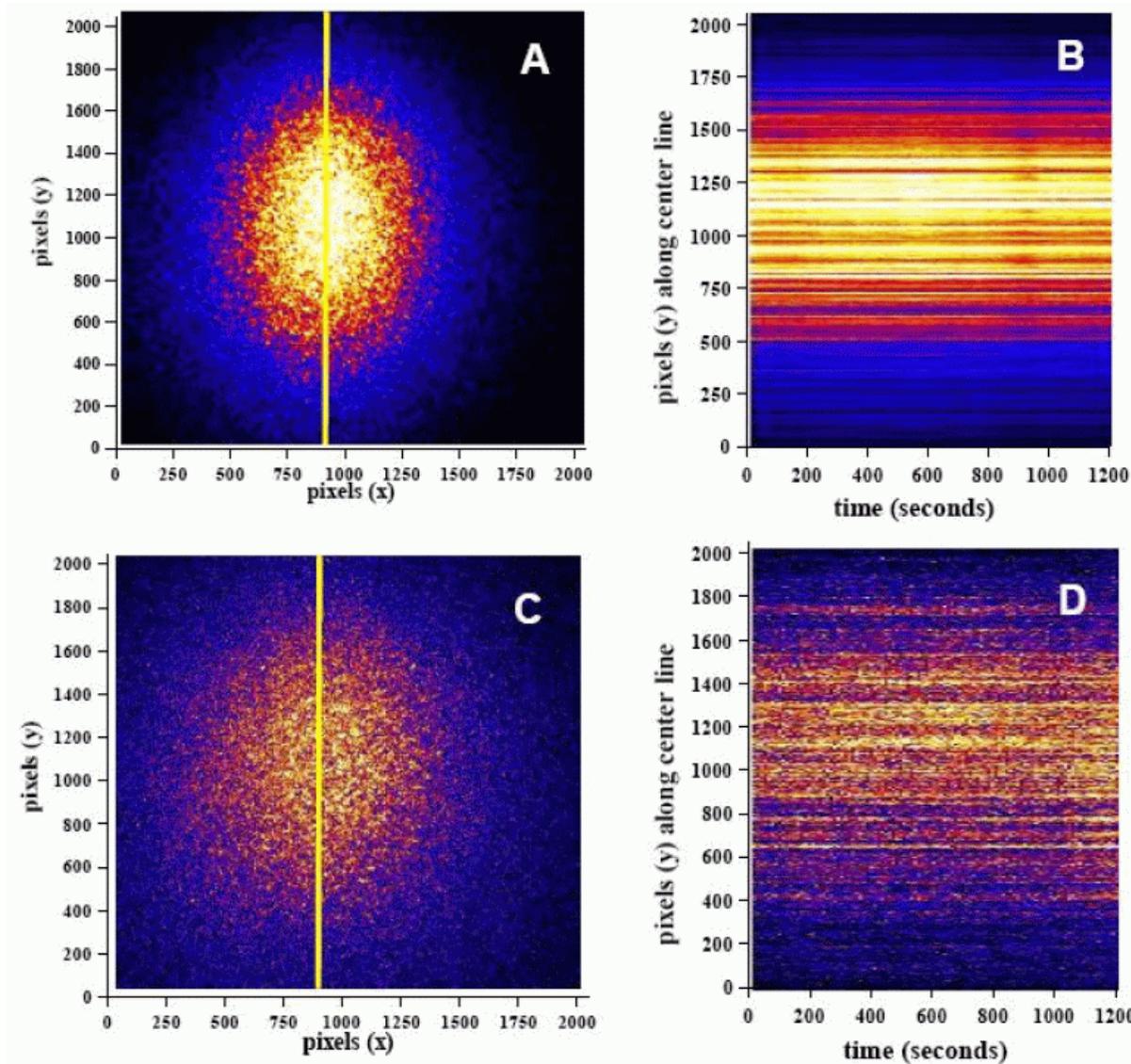


InP nanowires grown on Si (111)



# $\text{Pr}_{0.5}\text{Ca}_{0.5}\text{MnO}_3$ at $\text{MnL}_{\text{III}}$ edge (650 eV)

J. J. Turner et al, New Journal of Physics 10 053023 (2008)

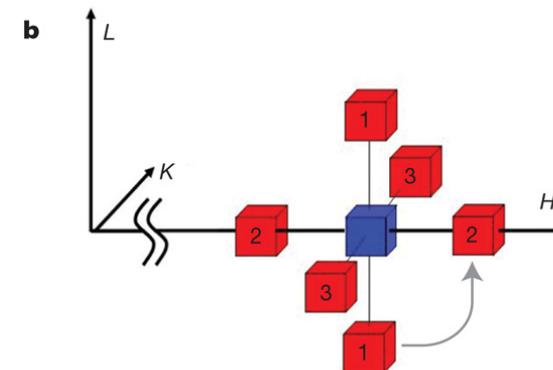
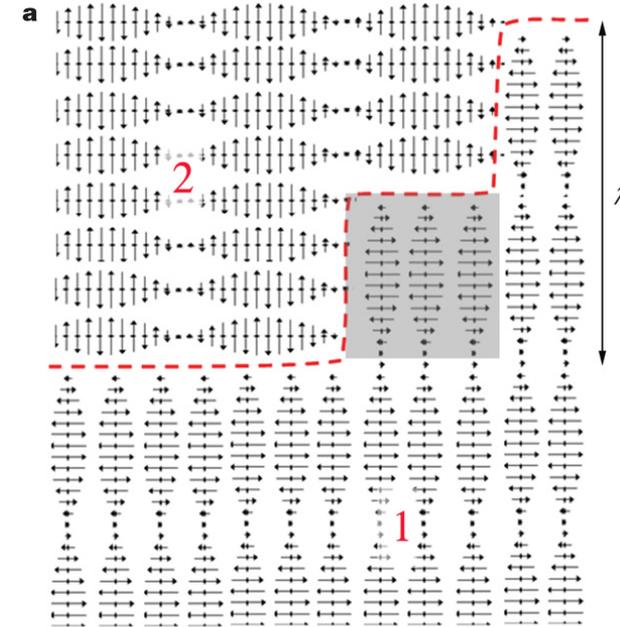
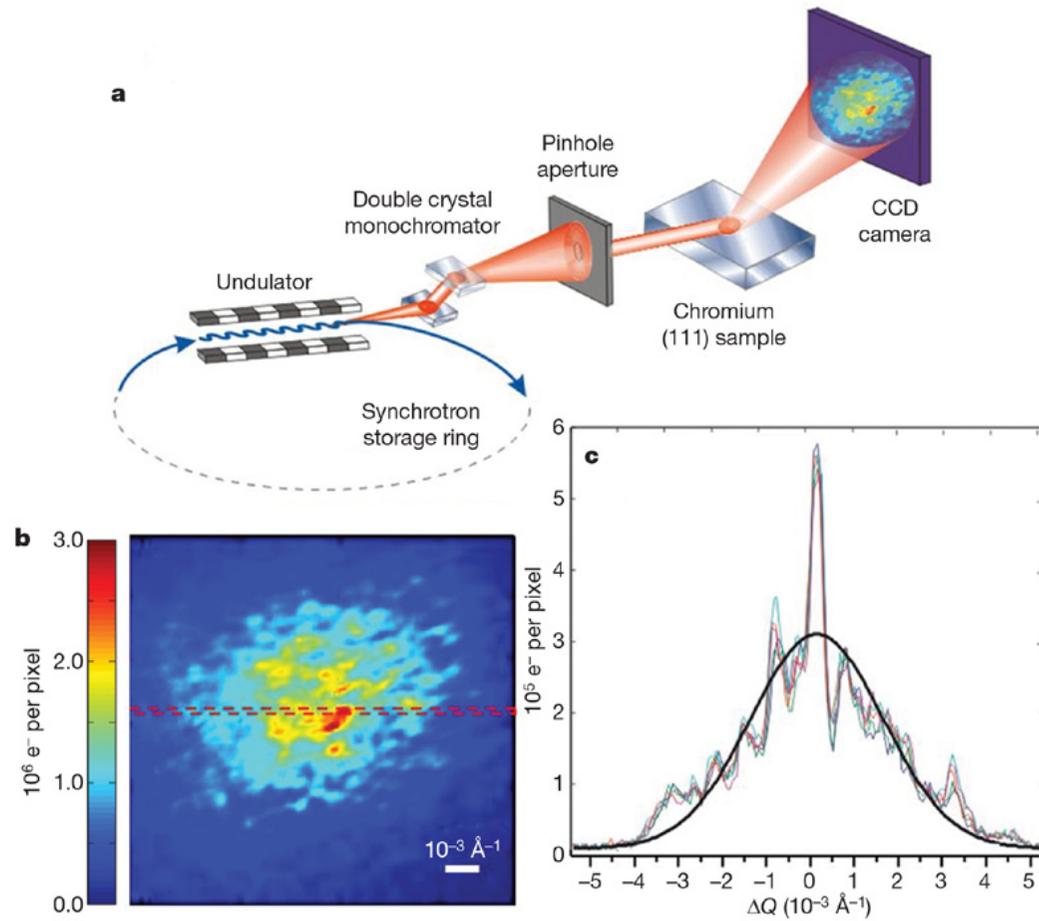


$(0, \frac{1}{2}, 0)$   
Orbital ordered  
T=205K

$(0, \frac{1}{2}, 0)$   
Near phase  
transition  
T=232K

# Antiferromagnetic Domains in Cr

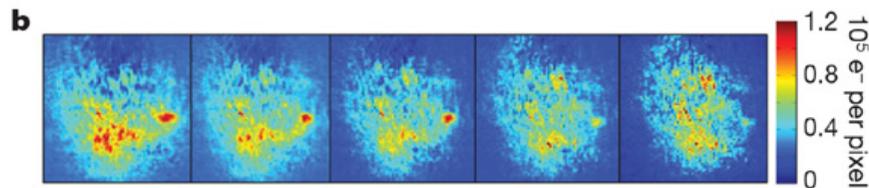
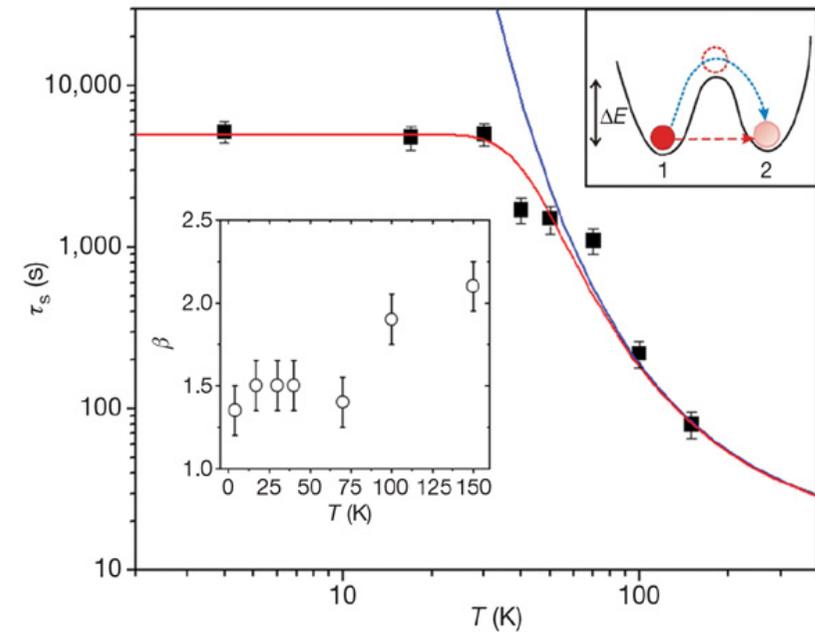
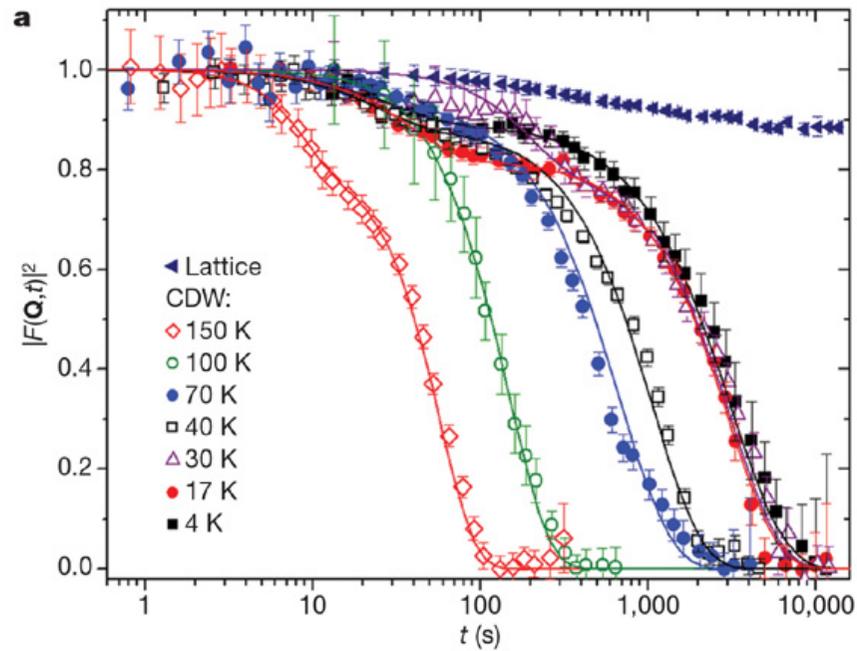
O. Shpyrko et al, Nature 447 68 (2007)



I. K. Robinson, RoySoc 2010

# XPCS of Domain Fluctuations in Cr

O. Shpyrko et al, Nature 447 68 (2007)



# FeAl antiphase domains (001)

Lorenz Stadler, PhD dissertation, TU Wien (2005)

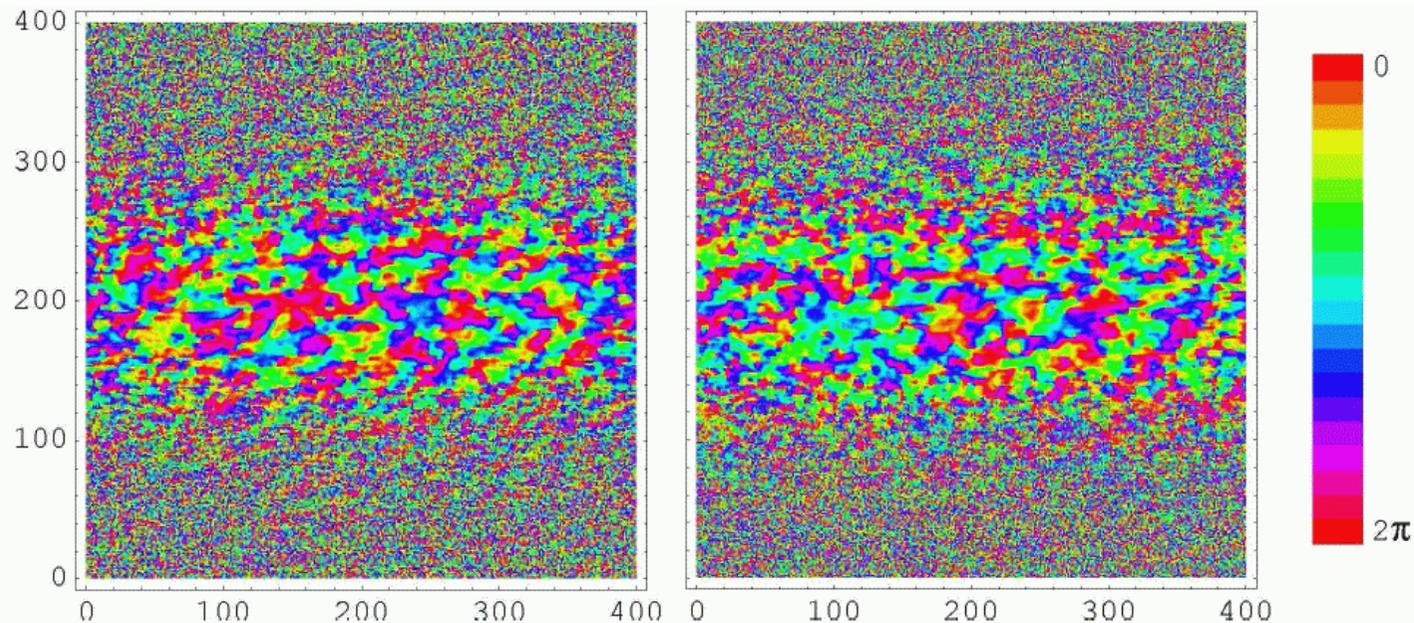
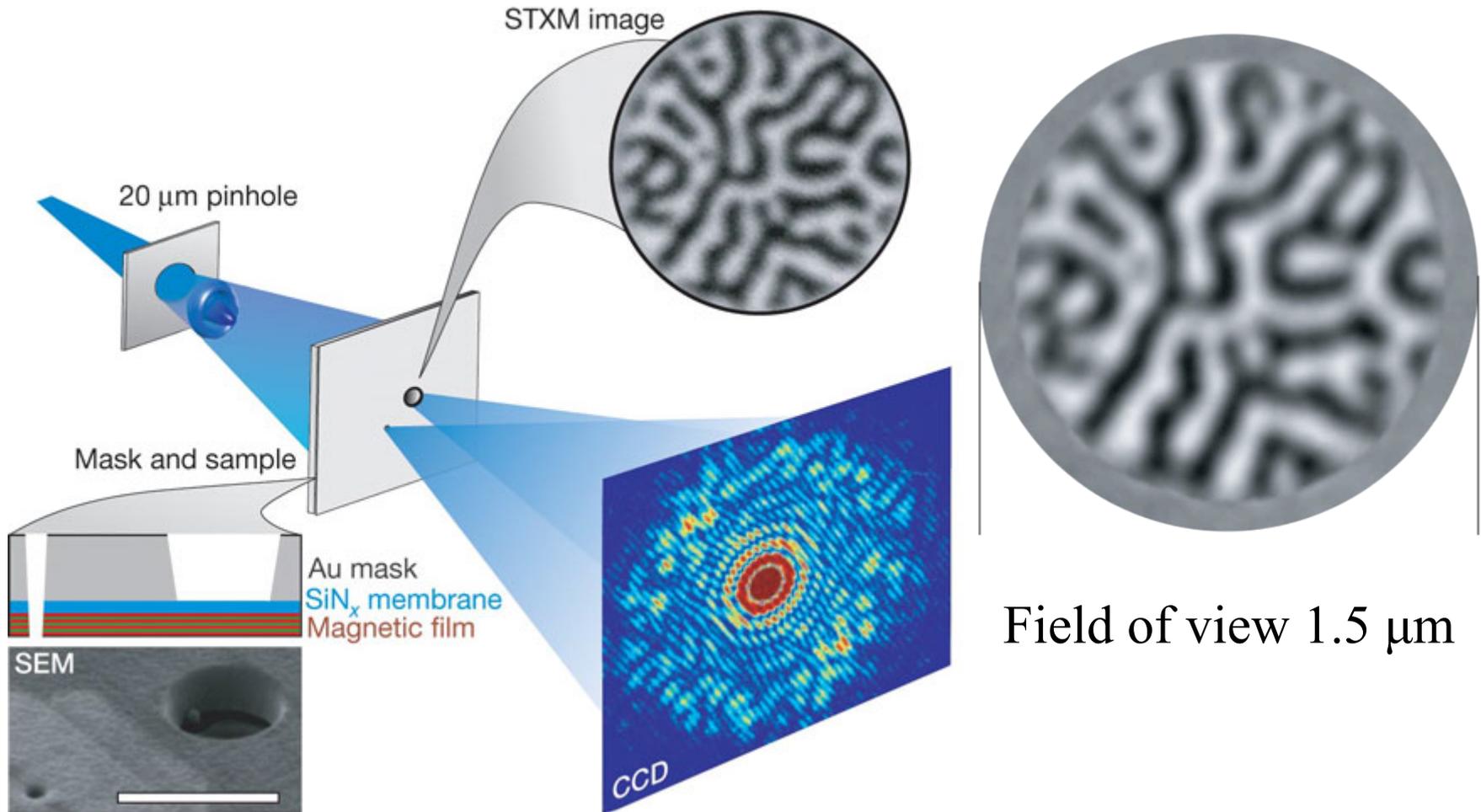


Figure 7.11: Typical reconstructed phases from runs with different combinations of algorithms and supports derived from the 2D Gaussian fit of the illumination function. Numbers in brackets denote how many iterations of the particular algorithm were done each cycle. Graphs on the left are from reconstruc-

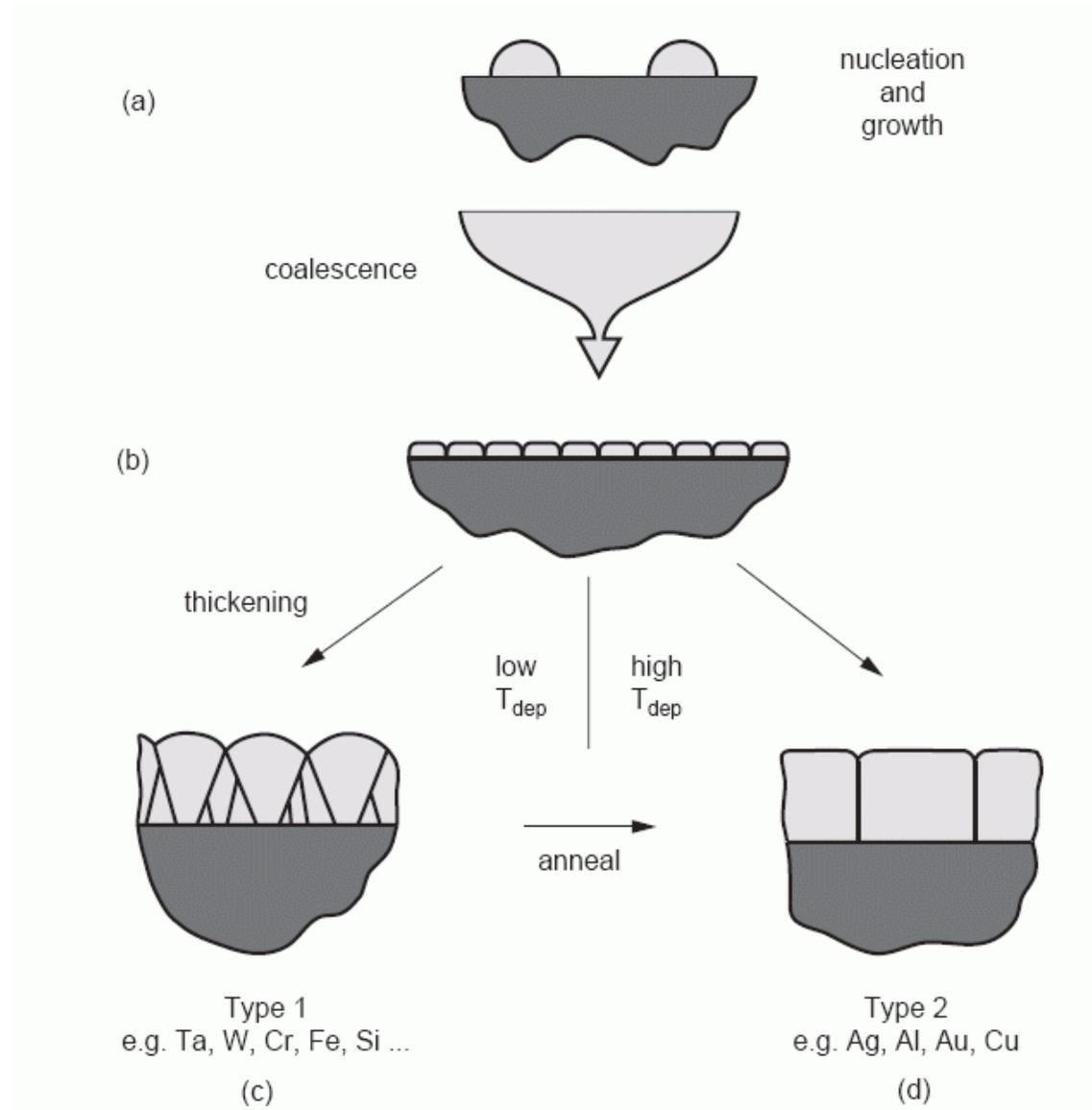
# X-ray Holography of Pt/CoML Domains

S. Eisebitt et al. Nature 432 885 (2004)

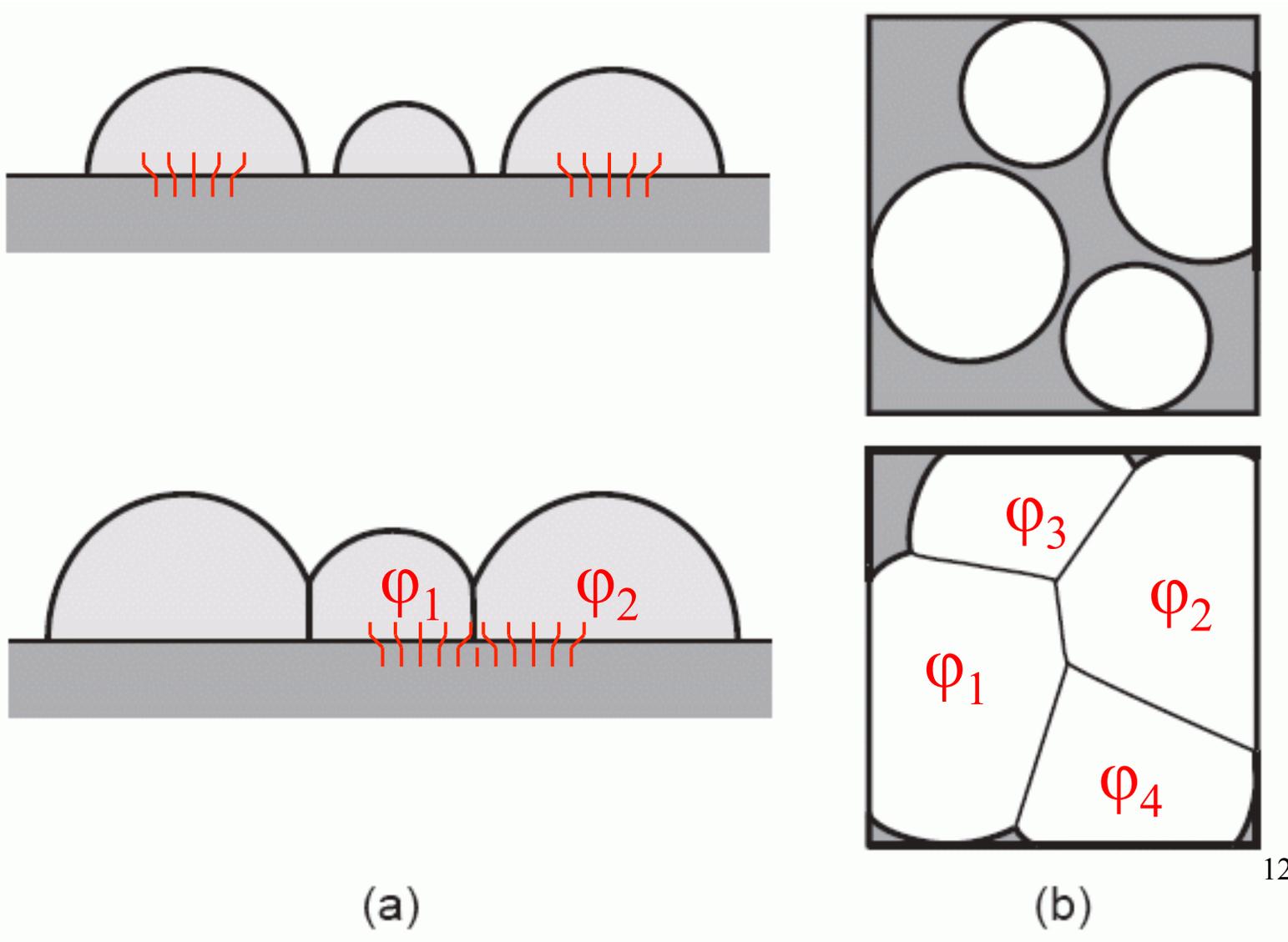


# Thin film growth after deposition

C. V. Thompson, Annu. Rev. Mater. Sci. 2000. 30:159–90



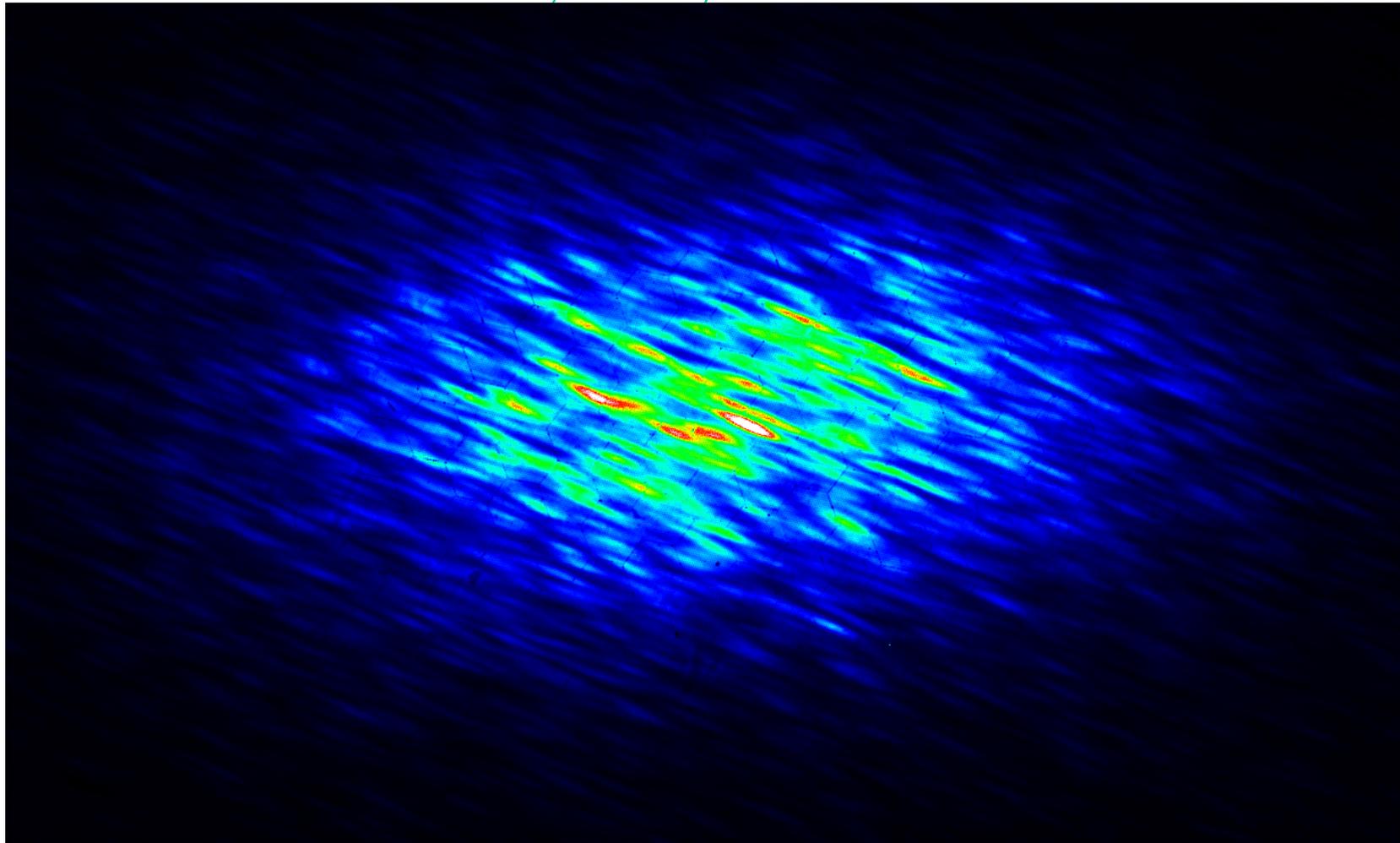
# Epitaxial growth effects



# Niobium (110) Thin Film Grains

1  $\mu\text{m}$  steps across 3  $\mu\text{m}$  beam of KB mirror focus

Richard Bean, I-16, Nb110-35 Jan 2009



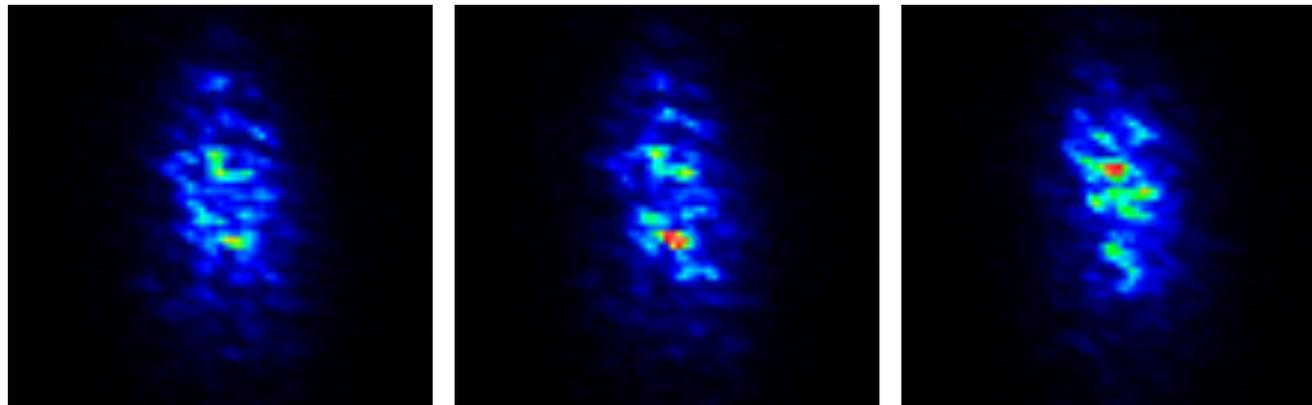
# Charge Density Wave Dynamics

CDW peak of TaS<sub>2</sub> crystal at room temperature

2x2um beam, 20x20um pixels at 2m

6sec exposure, 200 counts/pixel in peak

JunDar Su and Oleg Spyrko, 34-ID-C

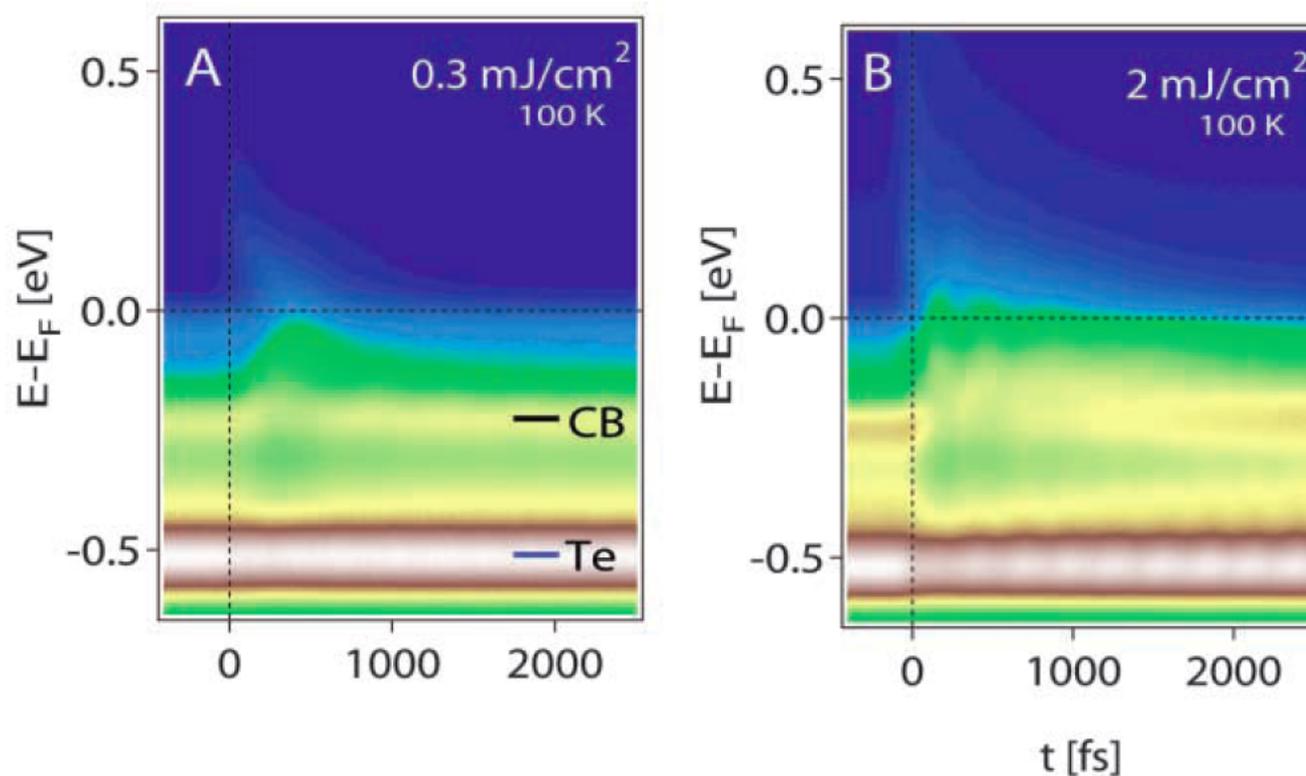


# Charge Density Wave Dynamics

CDW excitation in  $\text{TbTe}_3$  by 1.5eV IR pump

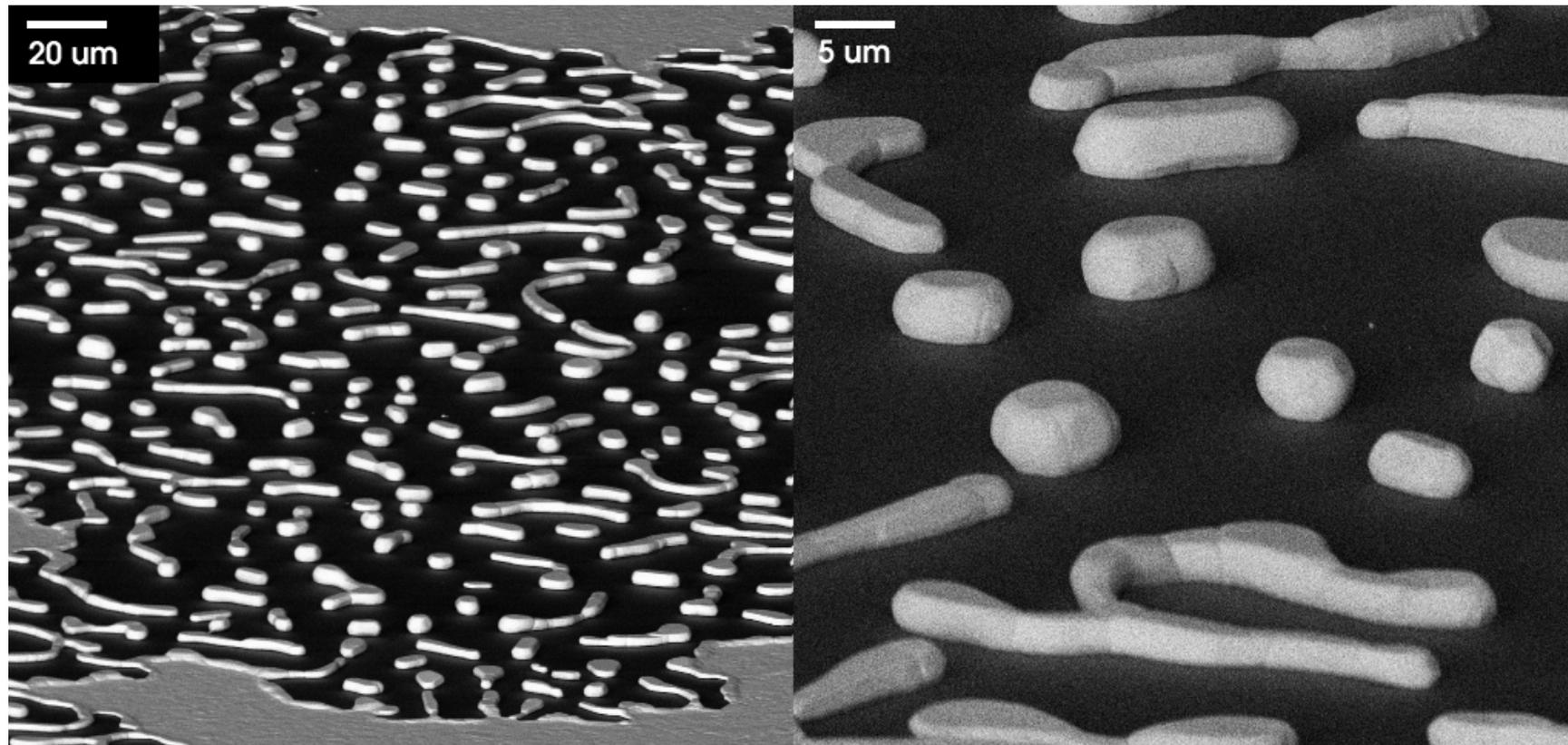
Schmitt et al, Science 321 1649 (2008)

Z-X Shen ARPES group at ALS

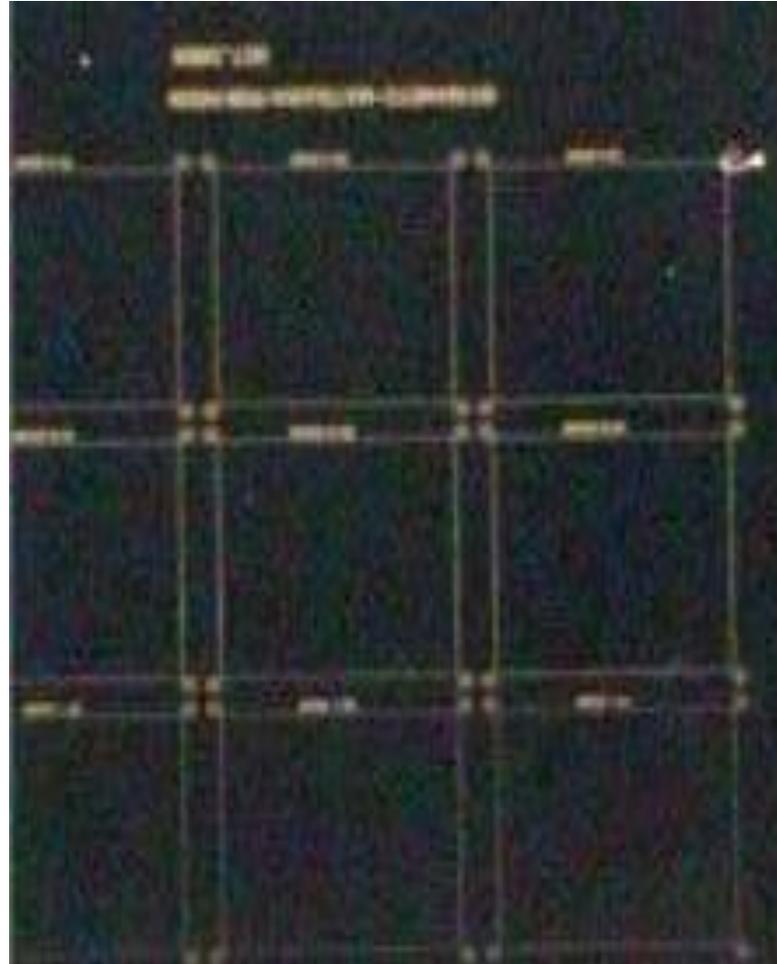
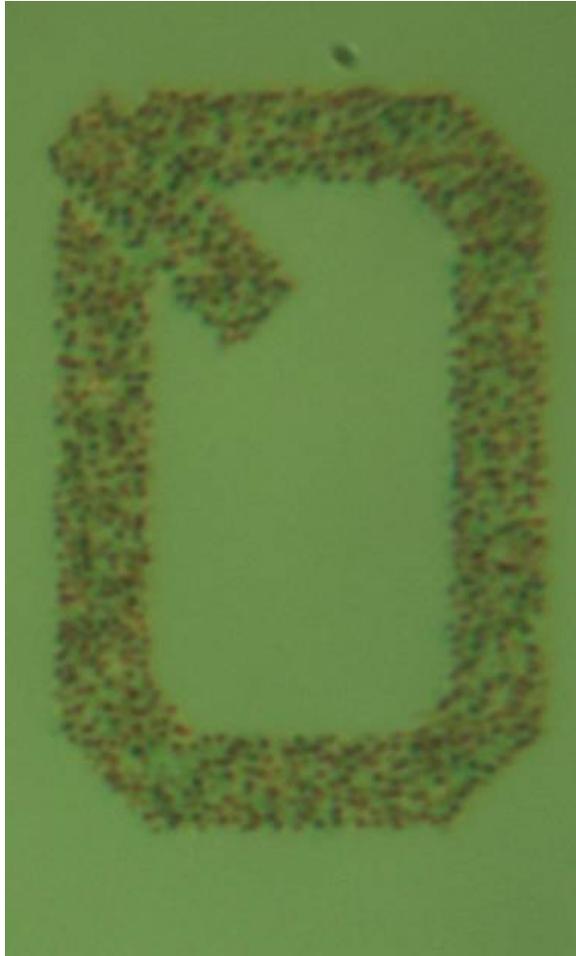


# Dewetting to coalesce into crystals

Garth Williams thesis (2005)

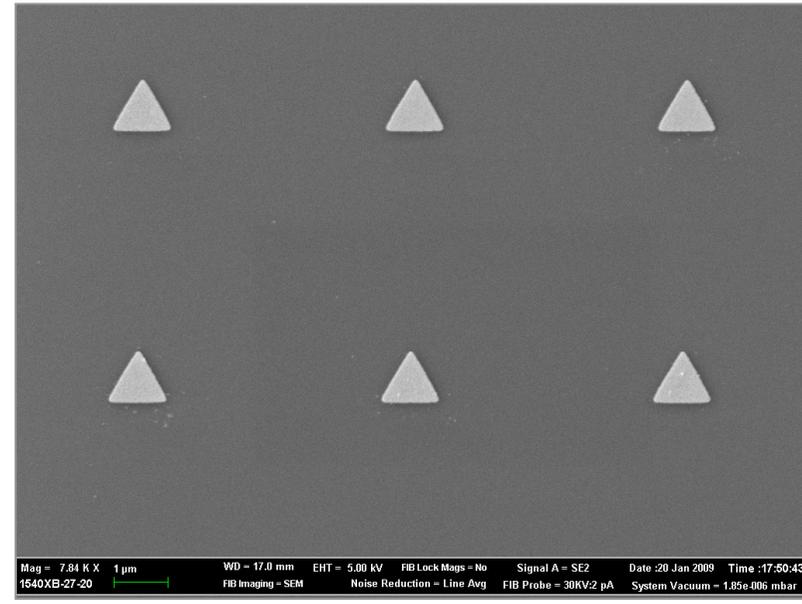
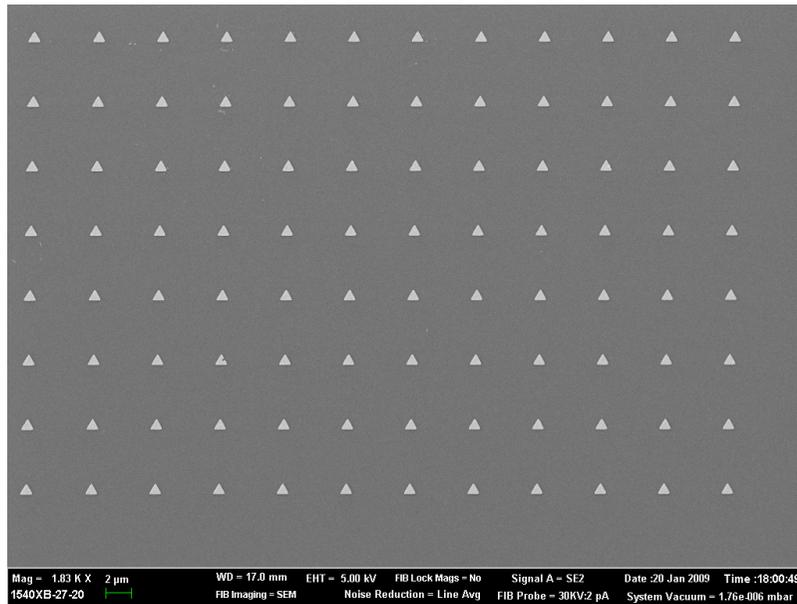


# Annealing of Patterned Substrates

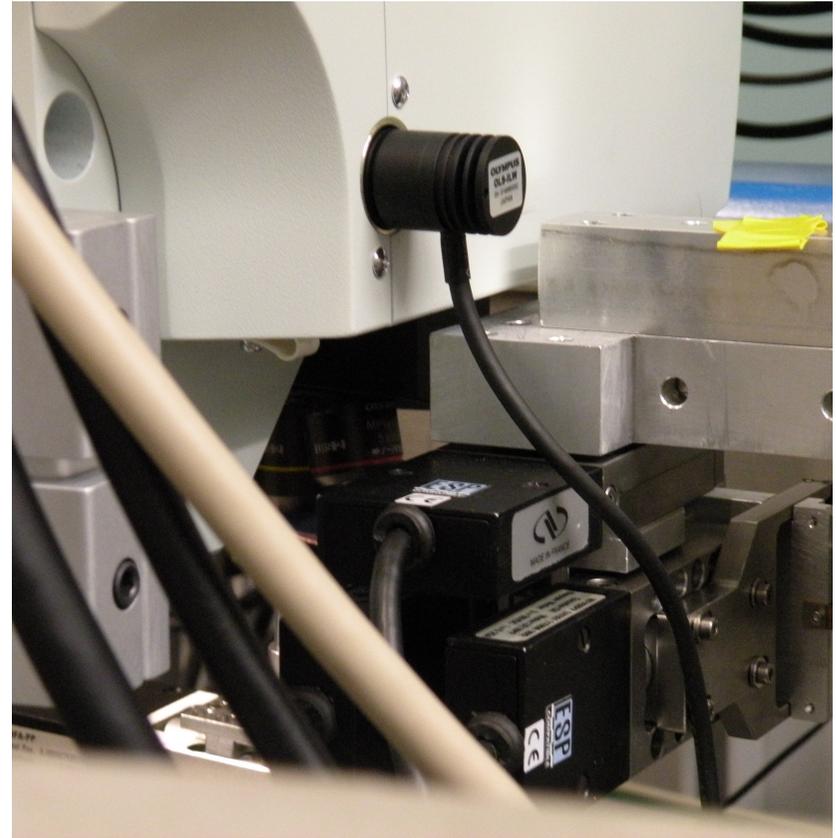
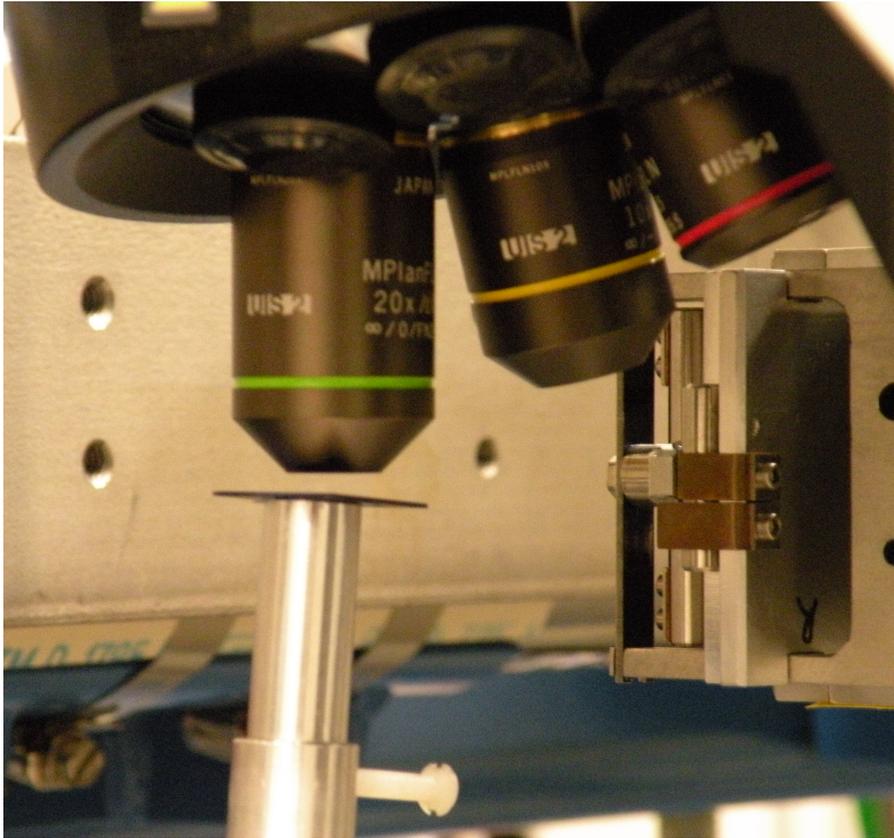


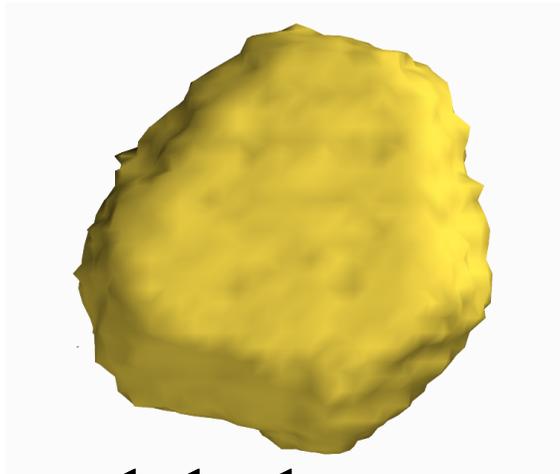
# Patterned Au nanocrystal samples

N. Shimamoto, Waseda University, Japan

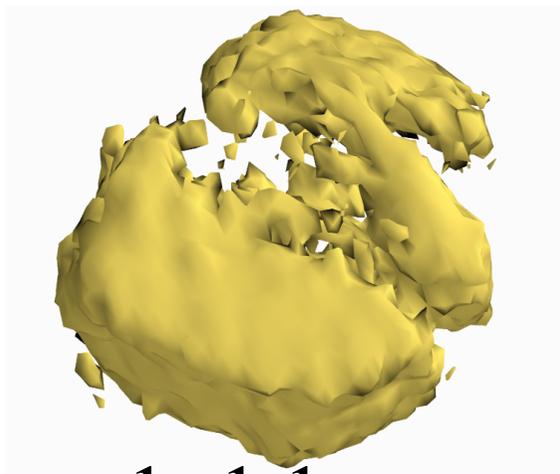


# Confocal Alignment Microscope

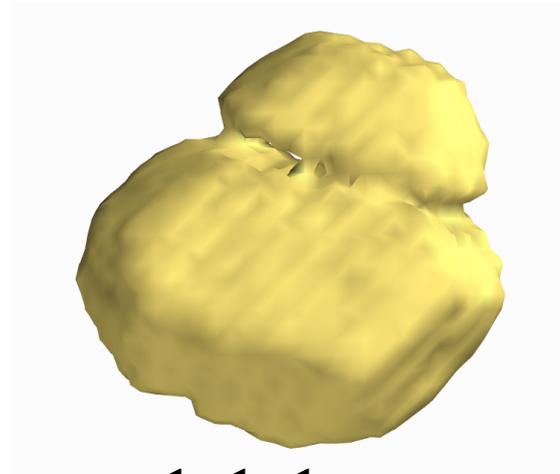




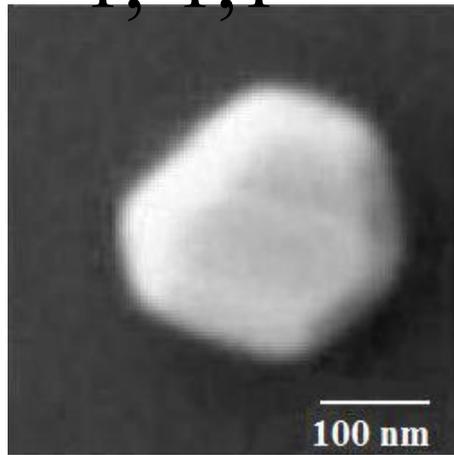
1,1,-1



1,-1,1

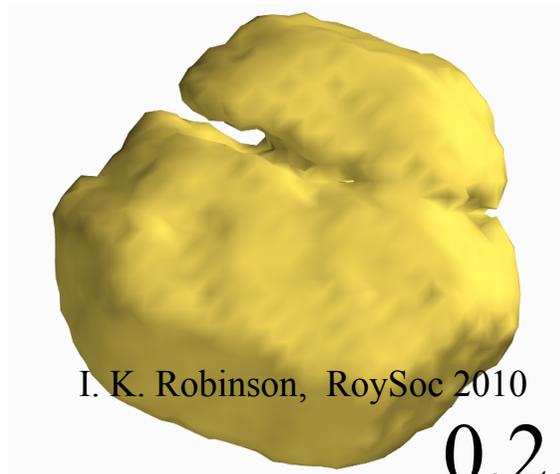
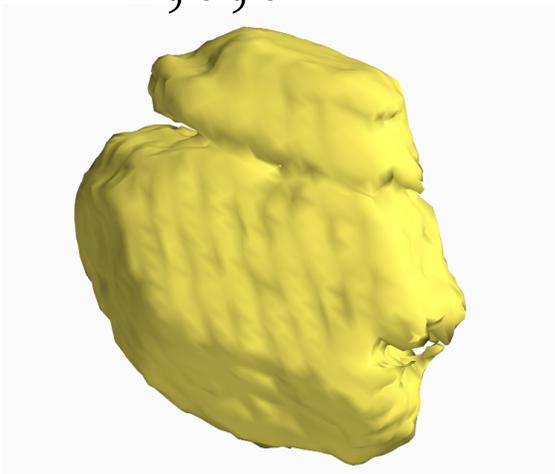


-1,1,1

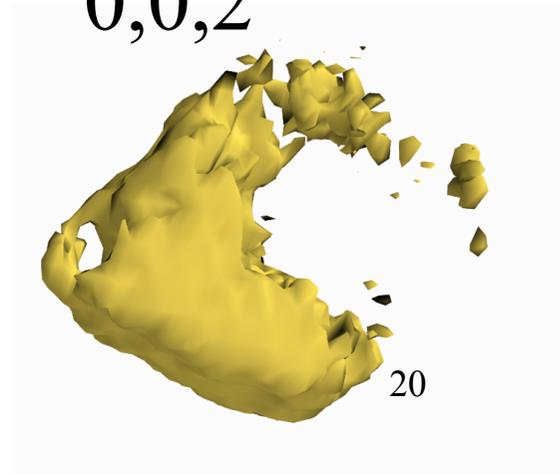


100 nm

2,0,0



0,2,0



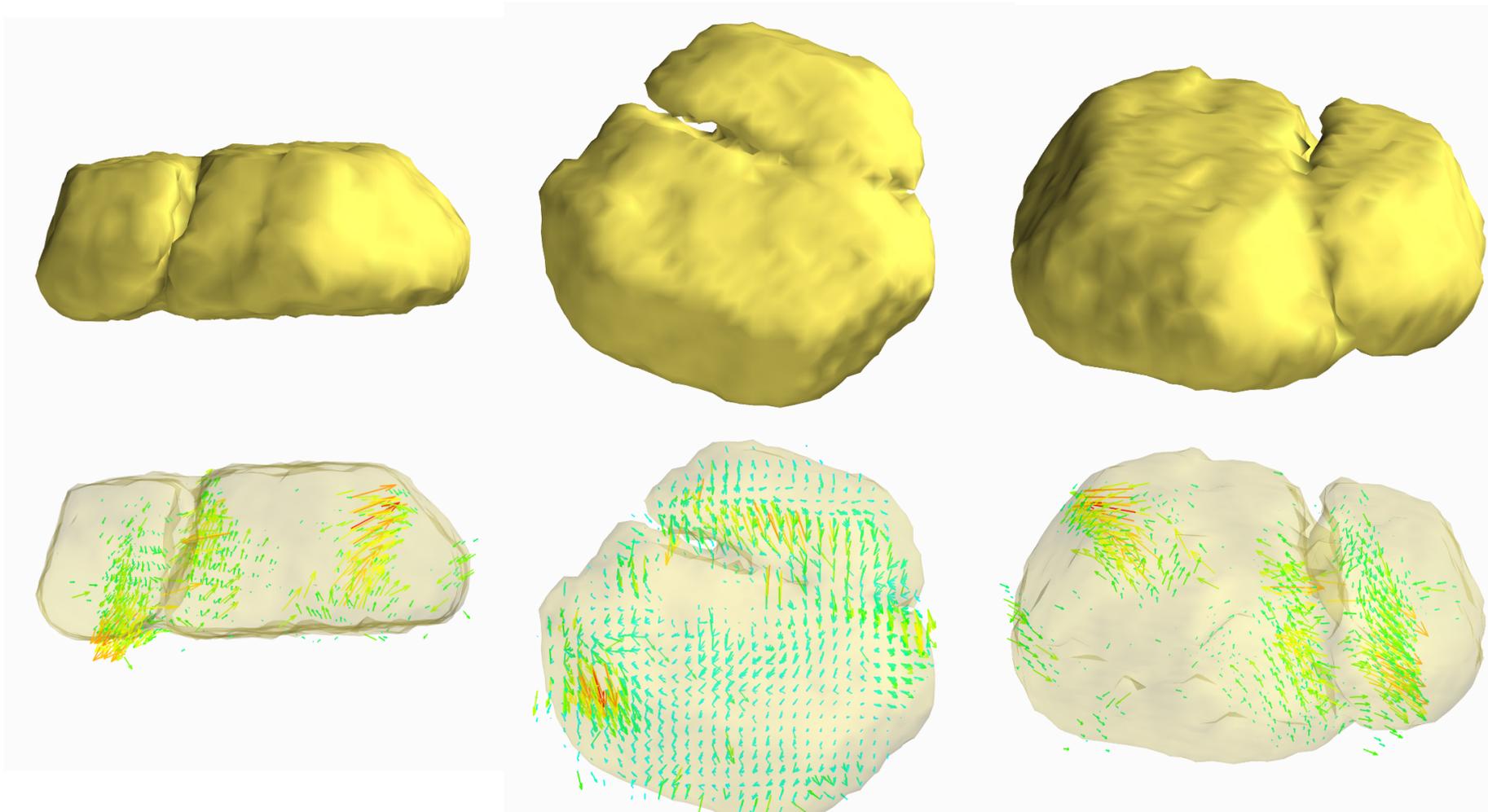
0,0,2

20

I. K. Robinson, RoySoc 2010

# Vector displacement field

Merged reconstructions from (11-1) (020) and (-111)

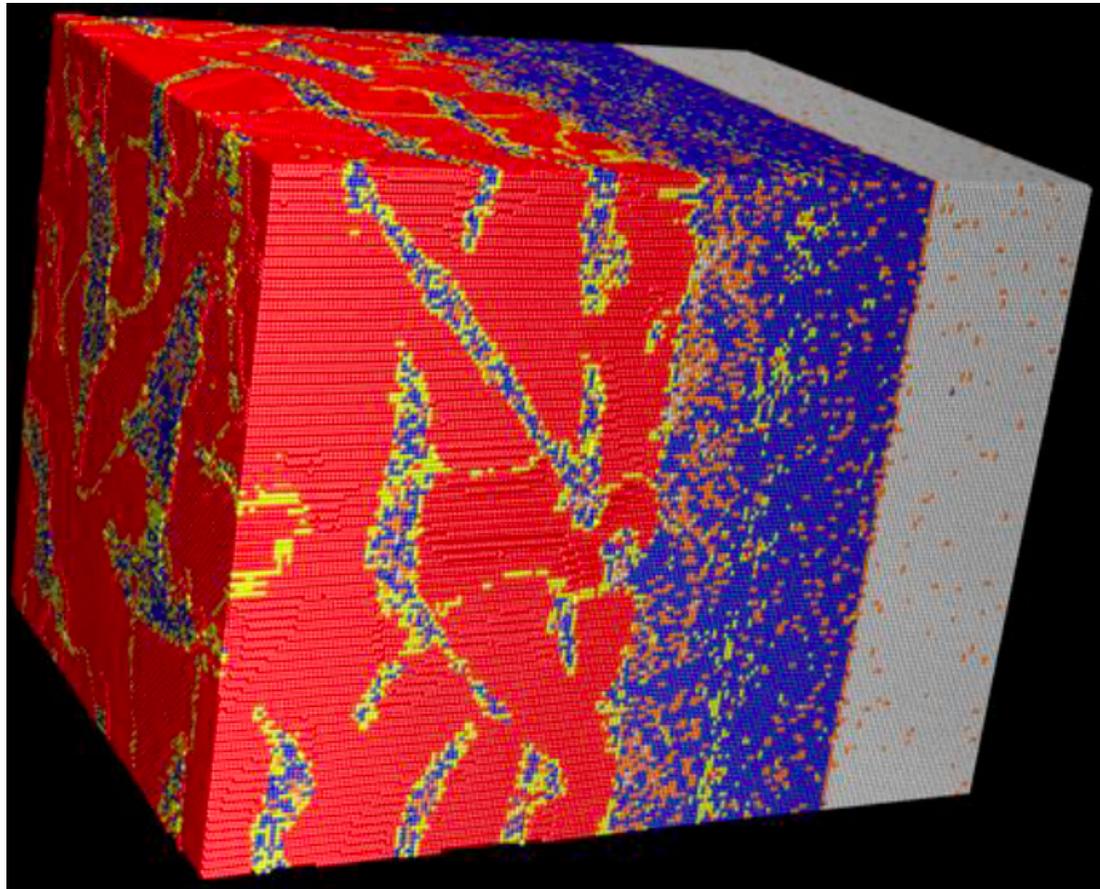


# MD simulation of Shock Wave

Damage in Fe along (001) direction

K Kadau, TC Germann, PS Lomdahl, and BL Holian.

Science, 296 1681 2002



I. K. Robinson, RoySoc 2010

# XFEL requirements

- Pump laser excitation source
- X-ray focussing system
- Goniometer, XYZ positioner
- Optical alignment system, Confocal
- DETECTOR
  - Far from sample (robot arm?)
  - Memory on pixel (500 channels)
  - Dynamic range  $>10^5$