Experimental Tools and Techniques

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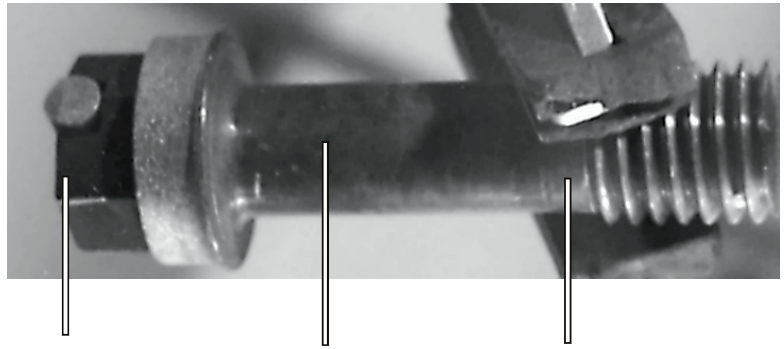
Why and When Do You Use a Given Technique?

- Mechanical testing (bulk investigation)
  - Tensile, creep, fracture toughness, shear punch, etc
- Microstructural characterization
  - Bulk techniques
    - SANS, EXAFS, PAS, Electrical Resistivity, X-ray diffraction, SEM, Optical, confocal microscopy, He & H analysis
  - Micro-characterization
    - TEM & ATEM, Atom probe, Scanning Tunneling Microscope
    - In-situ deformation studies
      - TEM, SEM, optical
    - Post-irradiation annealing (defects, RIS)
- Use multiple techniques to confirm, add additional information

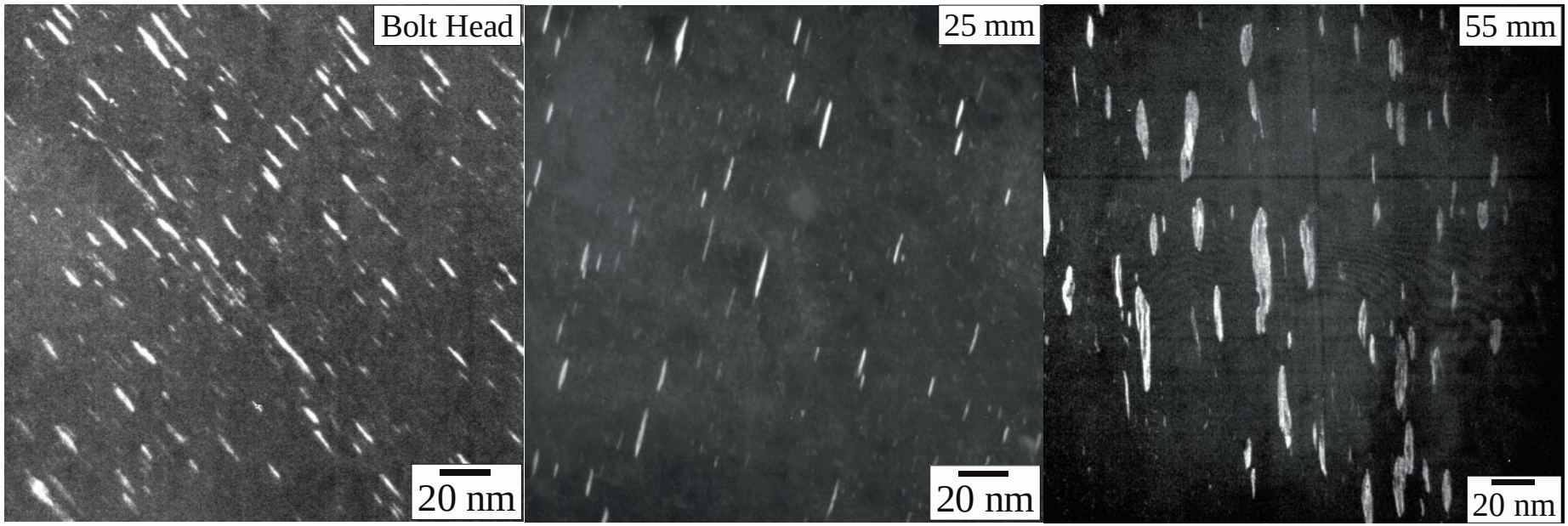
TEM and ATEM

- Both techniques cable of probing microstructure at a very small level, with a point to point resolution of less than 0.5 nm, magnifications of 5000x to 8,000,000x depending on mode of operation
- Information on crystallography, bulk and ppt phases, microchemistry, charge states, dislocation and defects, grain boundaries and interfaces
- ATEM provide probes sizes down to 0.5 nm with high probe currents (B up to High Z elements)
  - Compositional profiles and general information from grain boundaries and interfaces using 0.5 nm steps across boundaries
  - Combine standard EDS techniques with image filters, electron energy loss spectroscopy, compositional mapping

Faulted Loops at Each Location

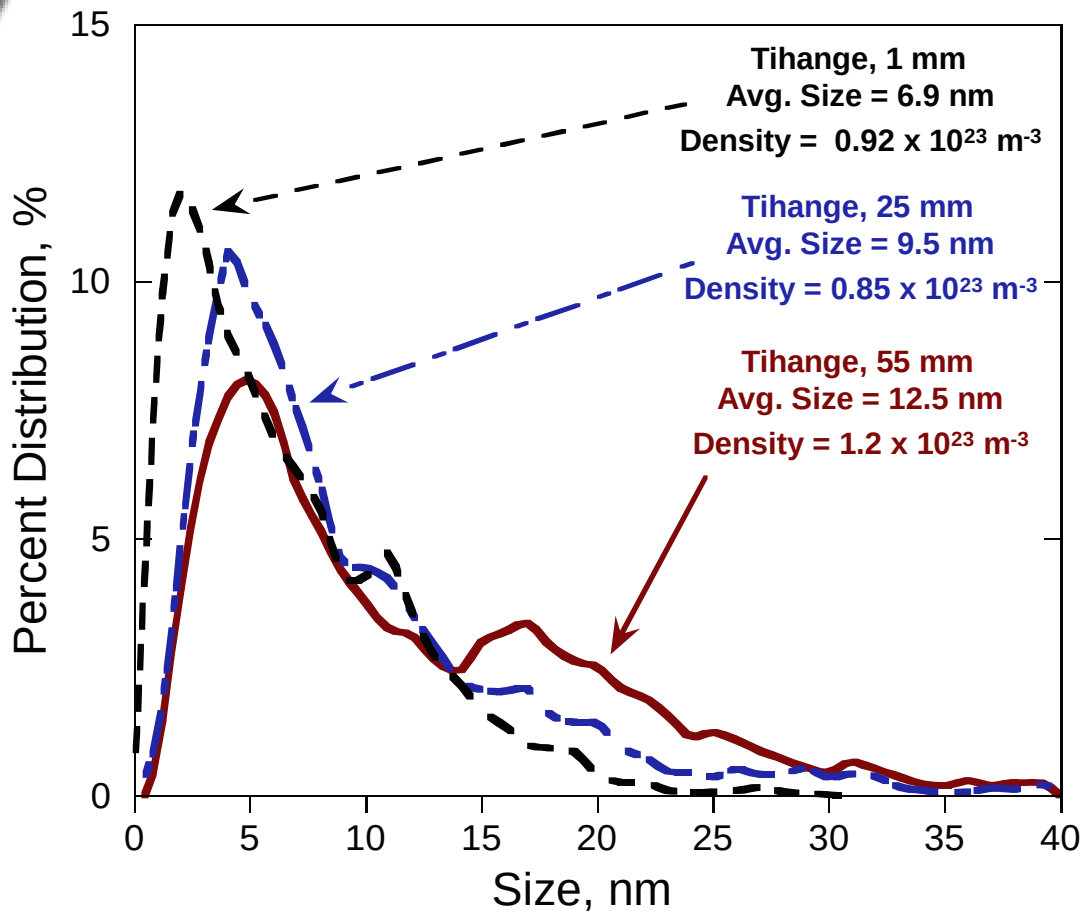


Bolt head	Bolt shank	Near Threads
1 mm	25 mm	55 mm
320°C, 19.2 dpa	343°C, 13.2dpa	333°C, 8.7 dpa



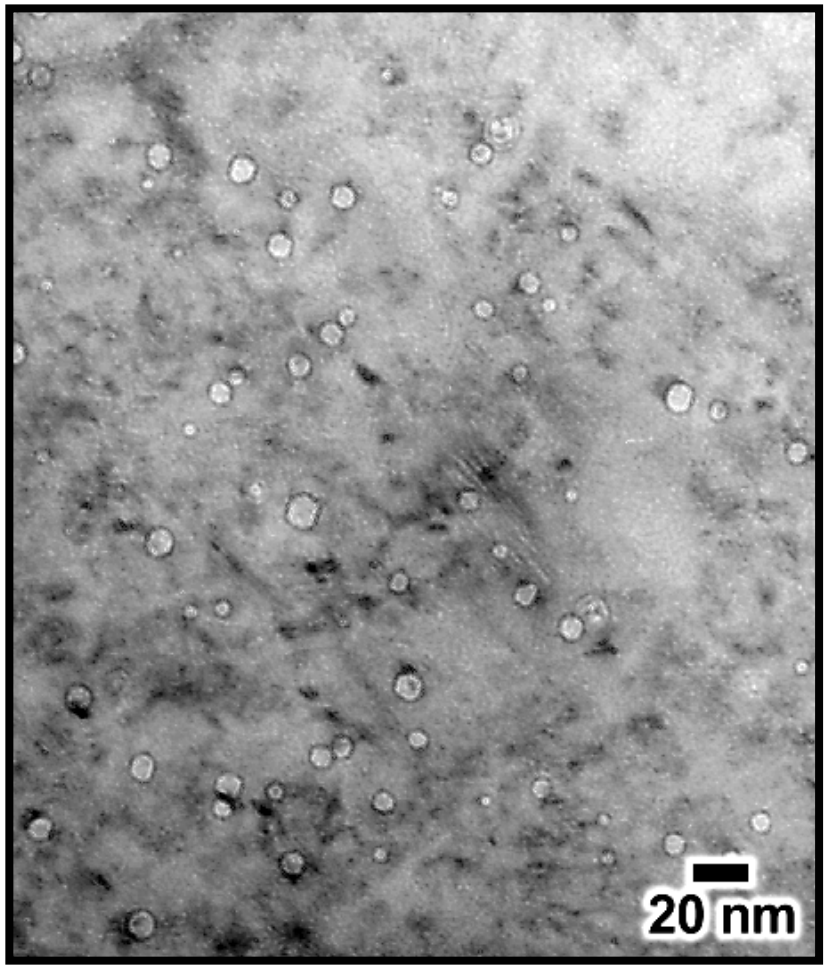
320°C, 19.2 dpa 343°C, 13.2 dpa 333°C, 8.7 dpa

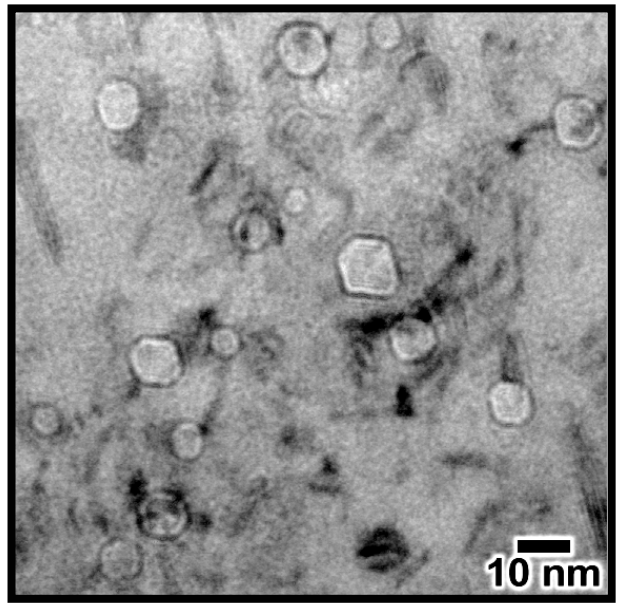
Frank Loop Size Distribution and Density in Tihange Baffle Bolt



- Frank loop size distributions exhibit only minor differences
- Density of loops the same within experimental error
- Compared to lower temperature irradiations, Frank loops extend to larger sizes

Cavities in Tihange 316SS Baffle Bolt: 25-mm position



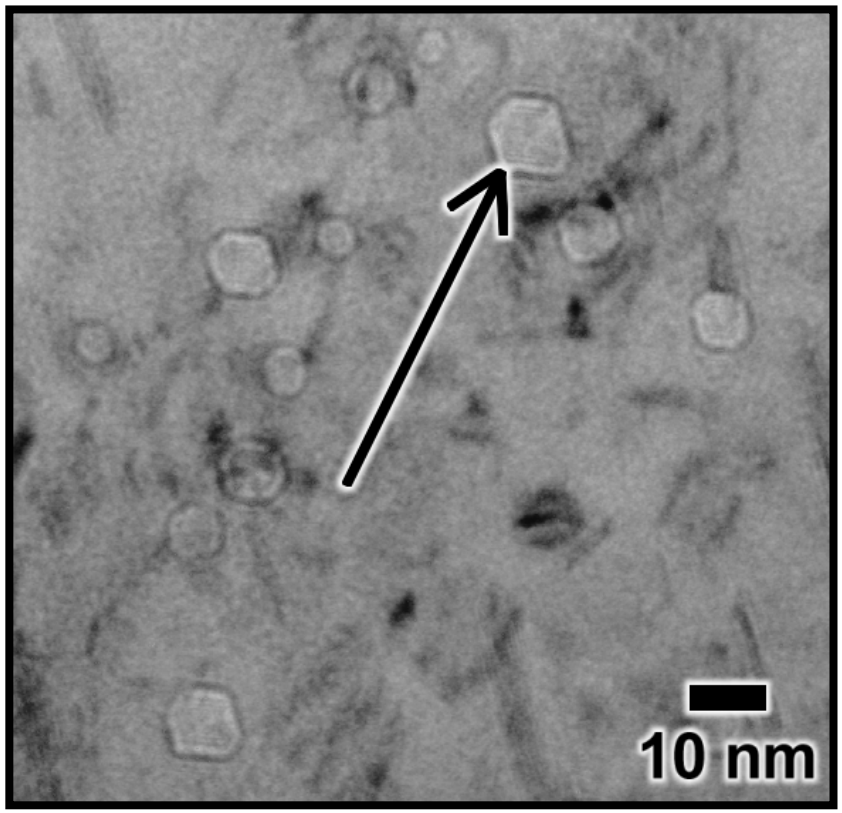


Avg. size = 8.6 nm

Density = 0.61 x 10^{22} m^{-3}

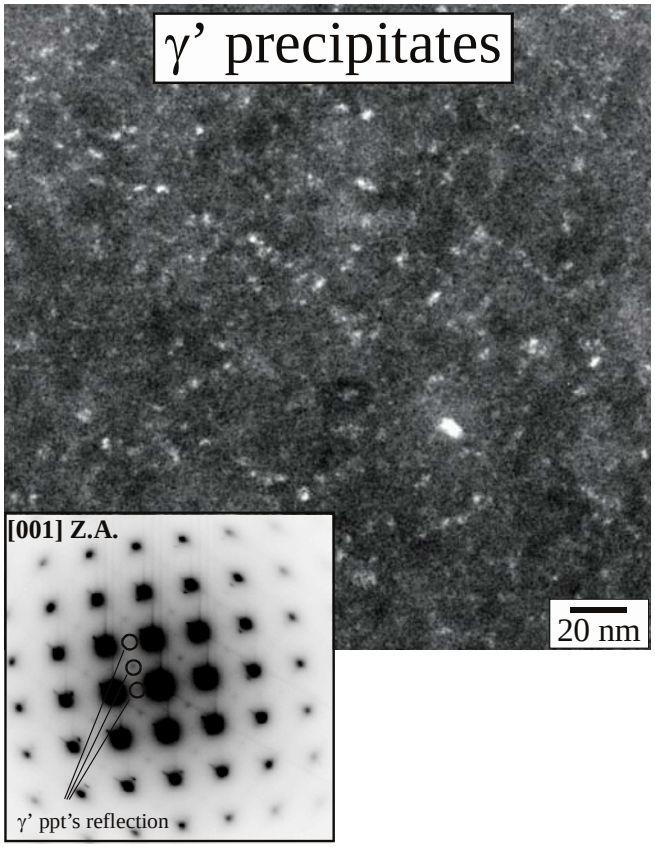
Swelling = 0.2%

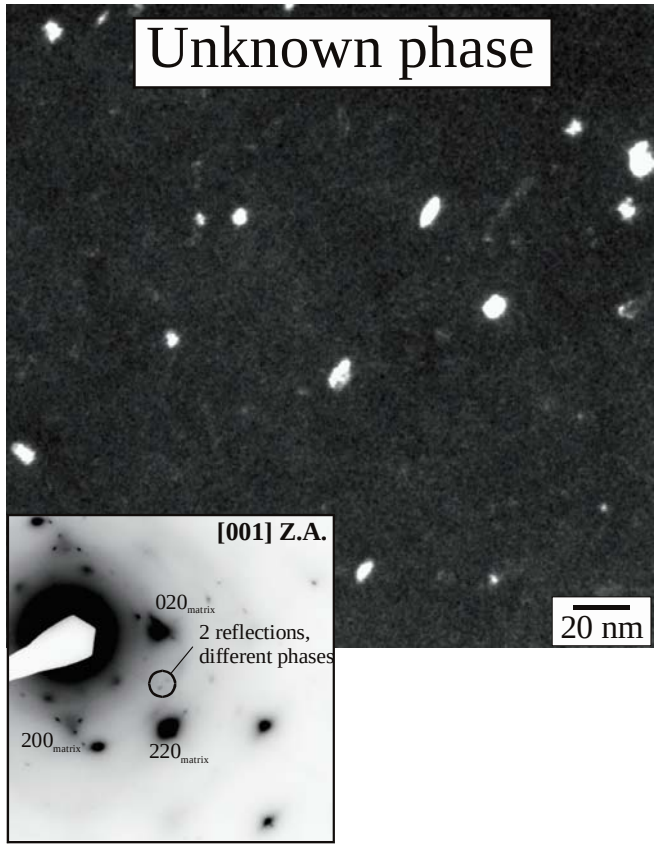
RIS at the Cavity Surfaces



	Wt%			
	Cr	Ni	Mo	Si
Void Surfaces	14.7	19.5	4.1	3.2
Grain Boundary	16.8	14.1	1.4	2.4

Precipitation in 316SS Baffle Bolt





- γ' precipitates: 0.6 x 10^{23} m^{-3}, avg. size ~3 nm
- 2nd precipitate phase, 0.2 x 10^{23} m^{-3}, avg. size 8.5 nm