Deformation microstructures observed in high strain rate deformed FCC metals

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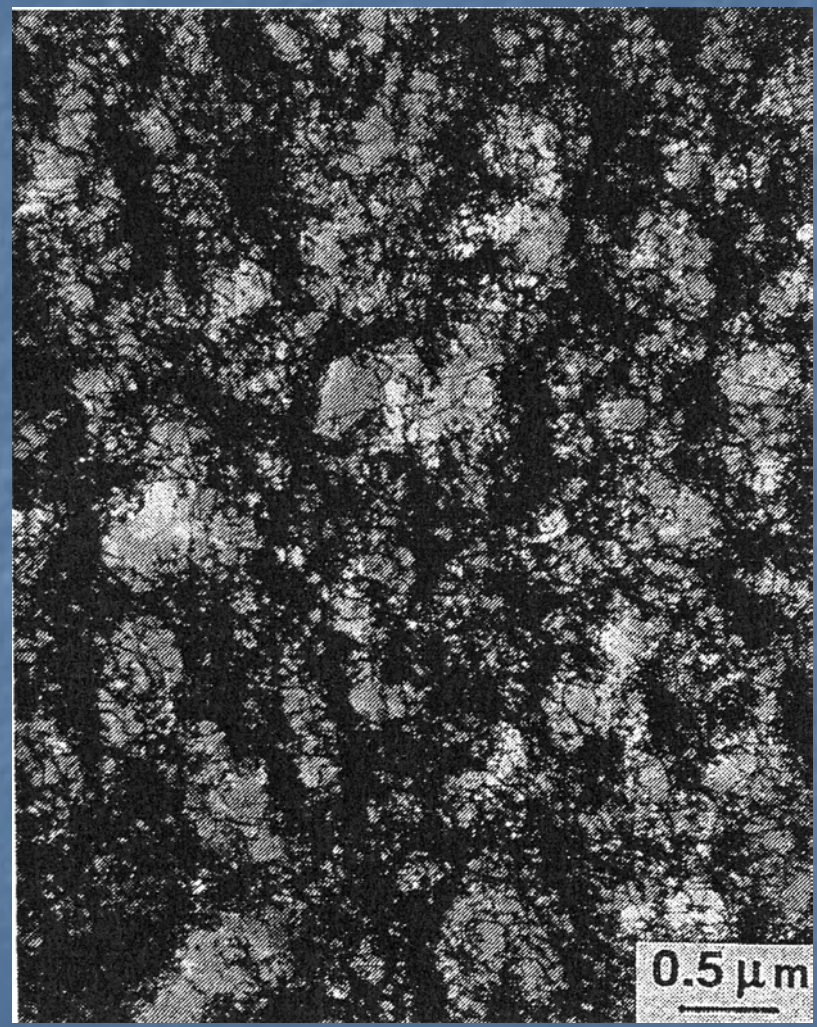
Overview

- Types of Structures
  - Dislocation cell structures
  - Deformation twinning
  - Microbands
- Effected by:
  - Grain size
  - Stacking fault energy (SFE)
  - Strain Rate
  - Temperature

Cell Structures

- Prevalent at low temperatures & low strain, high strain rates
- Increased propensity as grain size decreases



Gray, George. In "Modeling the Deformation of Crystalline Solids" TMS Proceedings, 1991 p. 145-158

Deformation Substructures as Function of Strain

- Polycrystalline OFHC Copper
- 40 μm average grain size

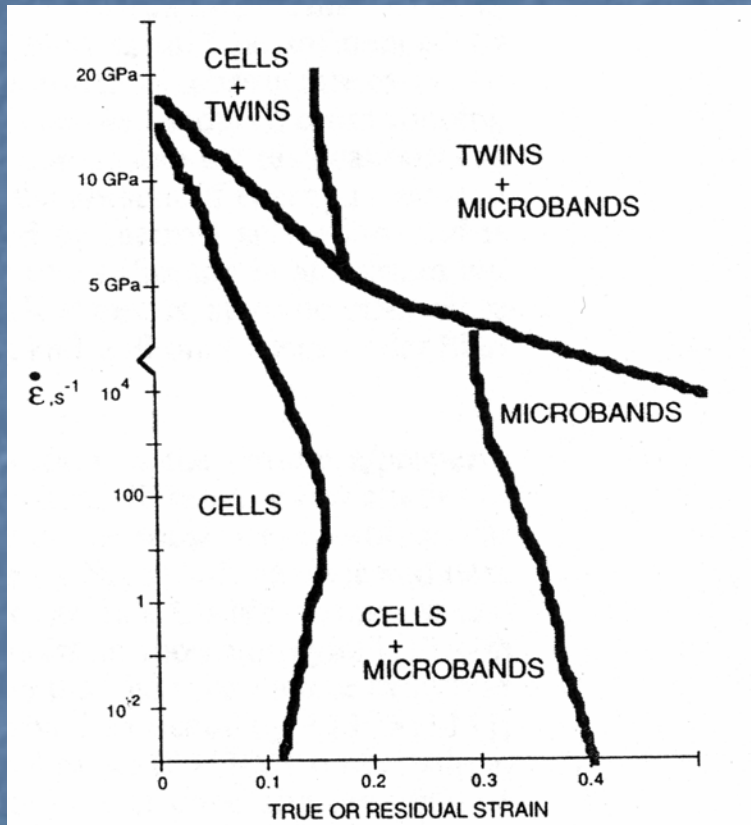


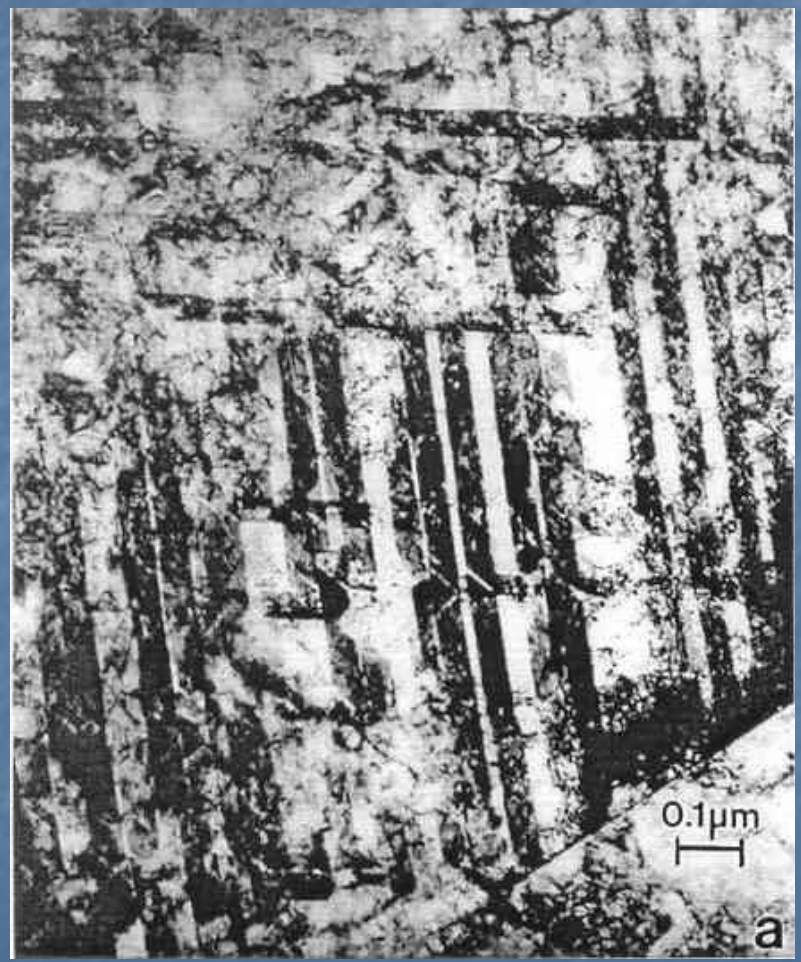
Figure 1: Substructure Morphology Map of Copper as a function of Strain Rate

Gray, George. In "Modeling the Deformation of Crystalline Solids" TMS Proceedings, 1991 p. 145-158

Deformation Twinning

- Prevalent in FCC metals deformed at low temperatures or high strain rate
- Strong dependence on SFE: Lower SFE → more twinning

Nickel



Murr & Esquivel, J. of Mat. Sci **39** (2004) p. 1153-68

Critical Twinning Pressure

- Decreases with increased temperature
- Decreases with increased strain rate
- Decreases with large grain size

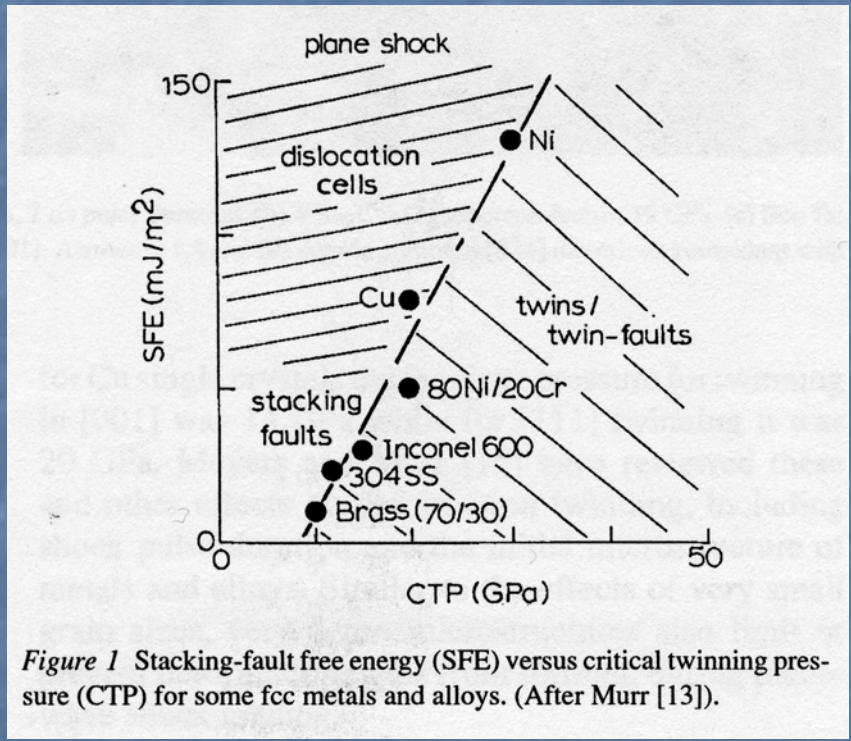


Figure 1 Stacking-fault free energy (SFE) versus critical twinning pressure (CTP) for some fcc metals and alloys. (After Murr [13]).

Murr & Esquivel, J. of Mat. Sci **39** (2004) p.1153-68

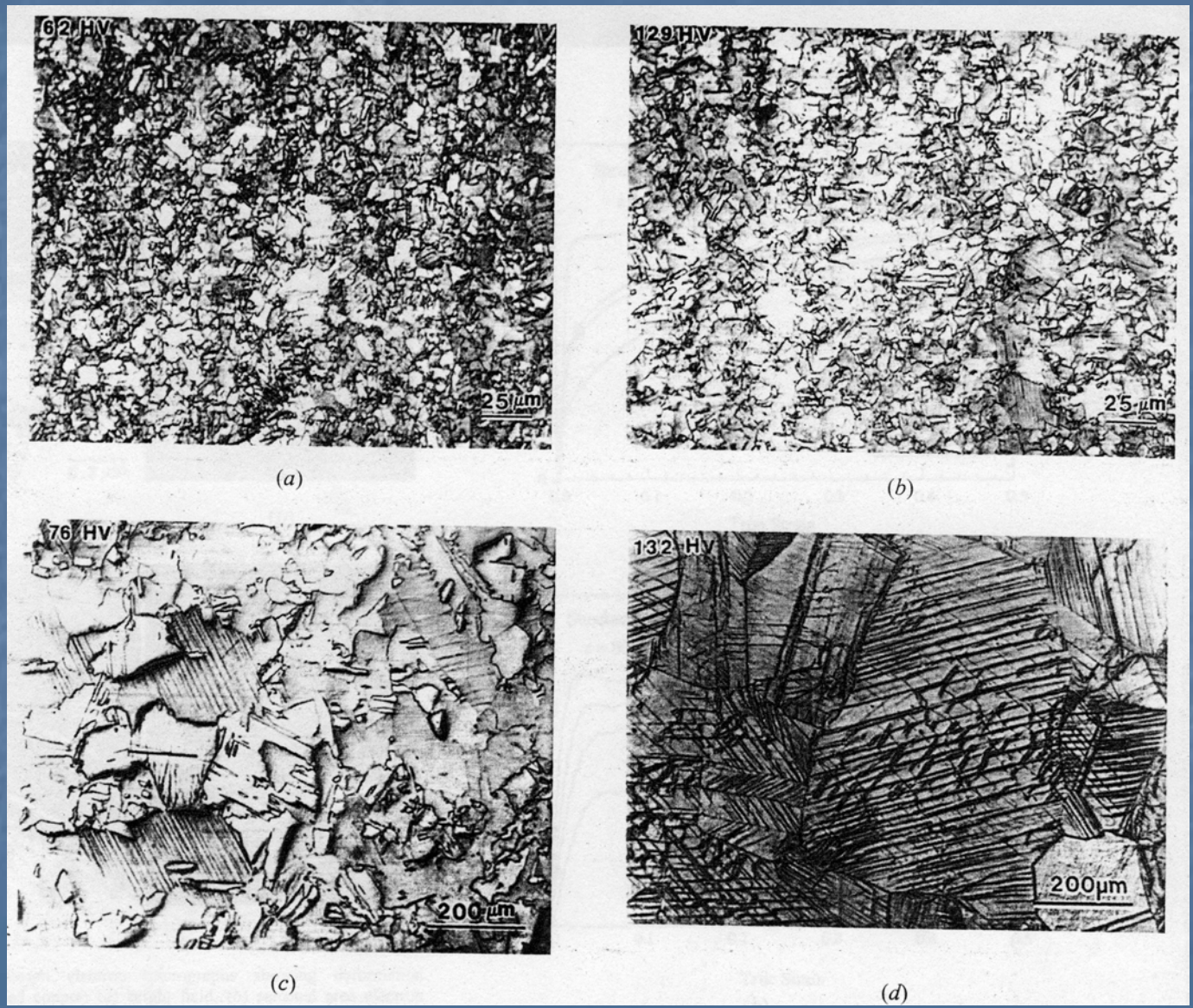
Effect of grain size on deformation twinning

9.5 µm

25 µm

117 µm

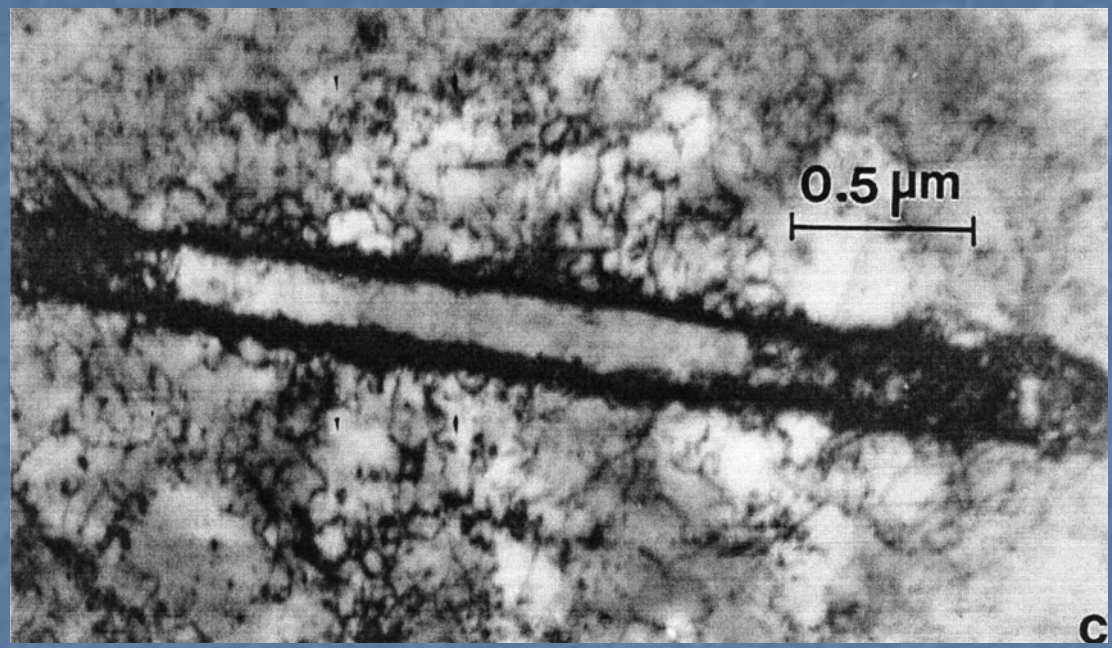
315 µm



Meyers, M. A., et al. Met Trans A **26A** (1995) p. 2881-93

Microbands

- Double dislocation walls ~200 nm apart. Carries shear strain.
- 2-3° misorientation with matrix
- Not dependent on crystal structure, material properties, or strain level
- Strong stacking fault energy dependence???



Formed from Orowan loops, cross-slip mechanisms or interaction of primary and cell boundary dislocations (depending on who you believe!!!!)

Murr & Esquivel, J. of Mat. Sci **39** (2004) p. 1153-68

Huang & Gray, Acta Met 37(12) (1989) p. 3335-47

Micro-bands & Deformation Twins

Deformation twin – microband transition mechanism unclear

Murr & Esquivel, J. of Mat. Sci **39** (2004) p. 1153-68

Summary

- Cell structures dependent on grain size, strain rate and temperature.
- Deformation twinning strongly dependent on grain size, temperature and SFE.
- Microbands seemingly dependent on SFE alone.