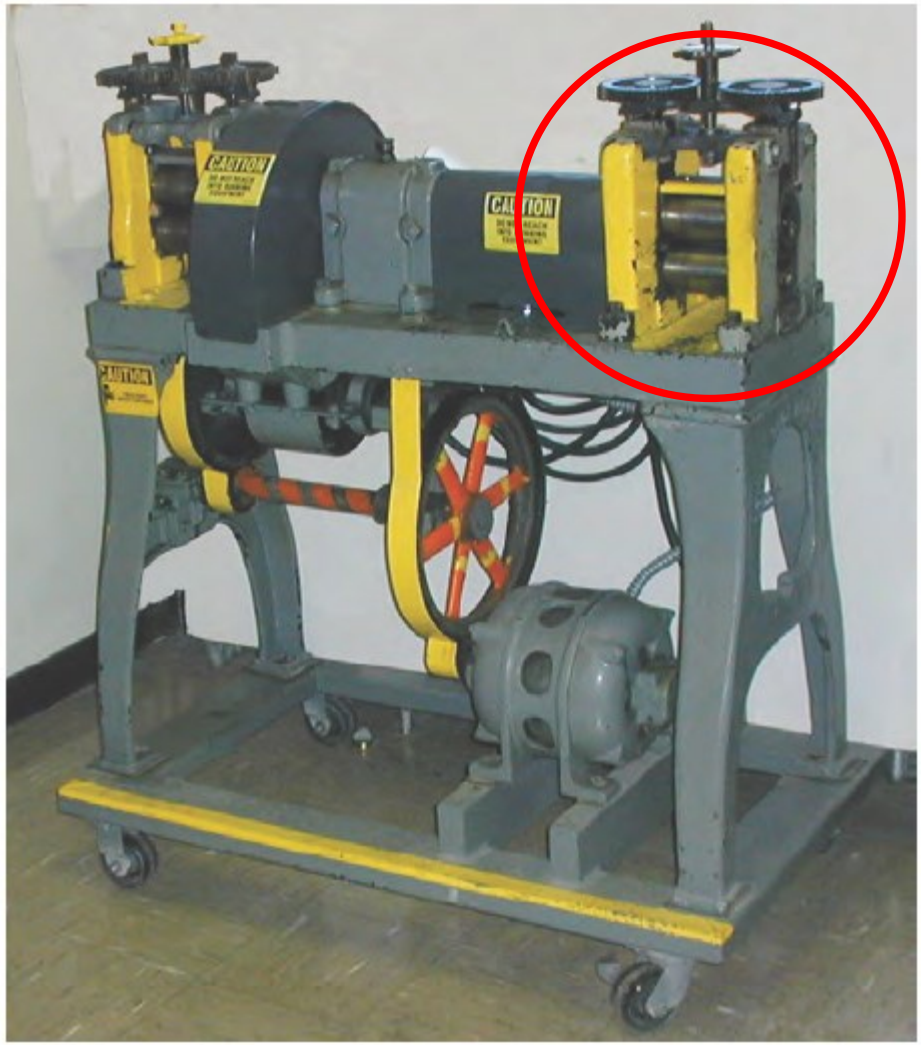
ME 330: Engineering Materials

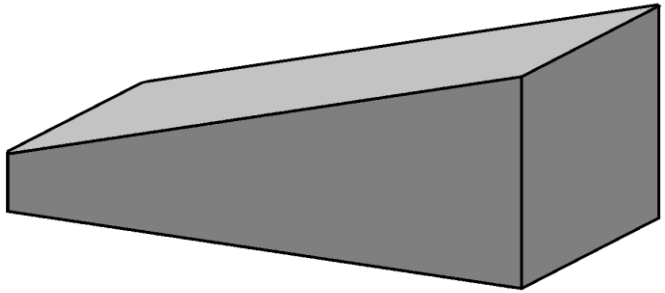
Lab - 3

Cold Work and Annealing

Overview



Target



Wedge

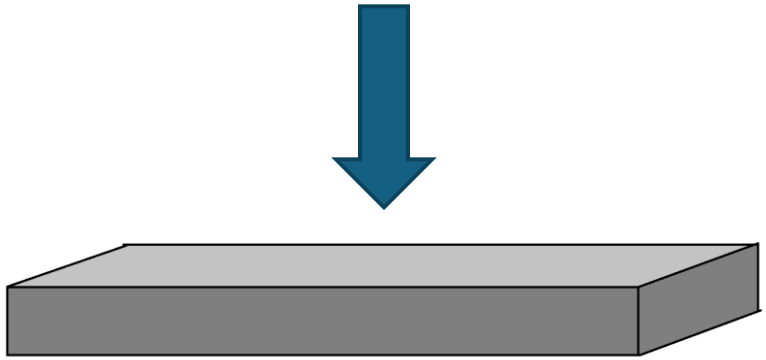
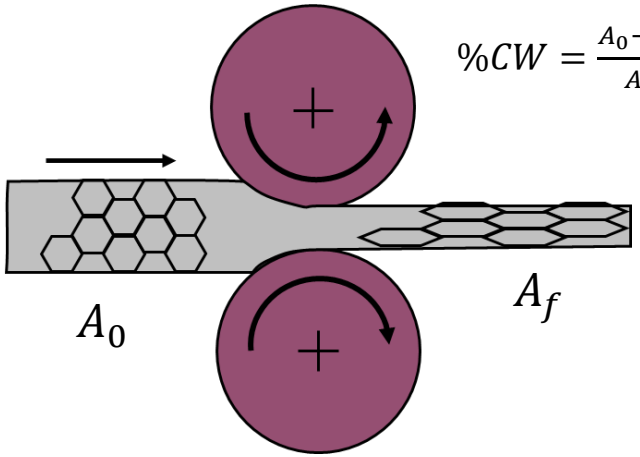


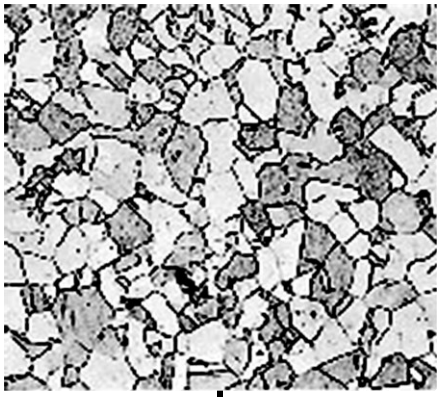
Plate (uniform thickness)

Typical Stress-Strain Curves



$$\%CW = \frac{A_0 - A_f}{A_0} \times 100\%$$

Equiaxed grains

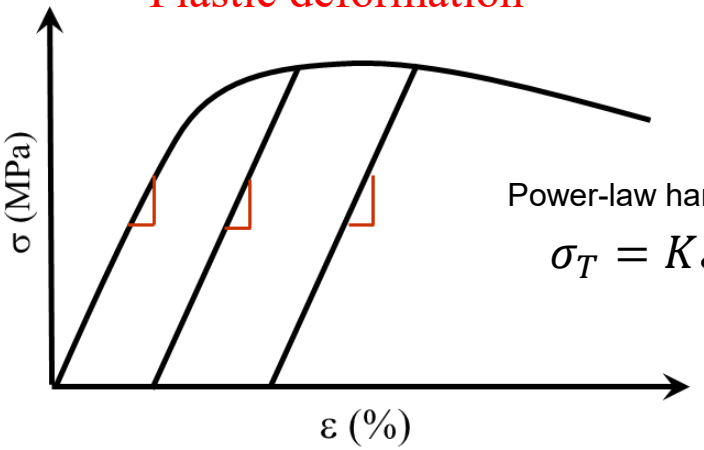


Low dislocation density

Increase in hardness and strength

Decrease in ductility

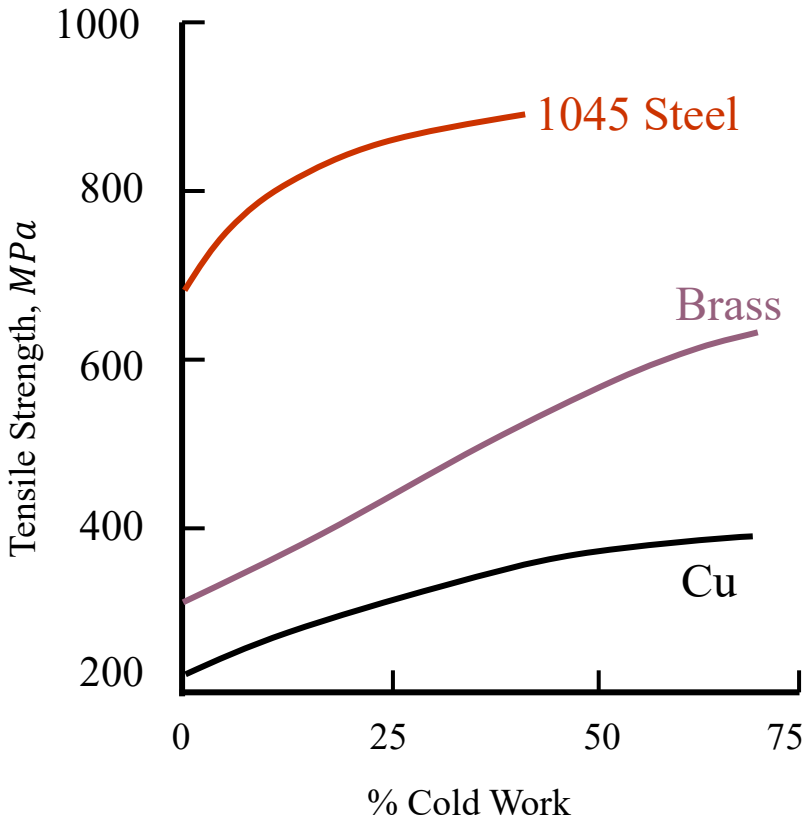
Plastic deformation

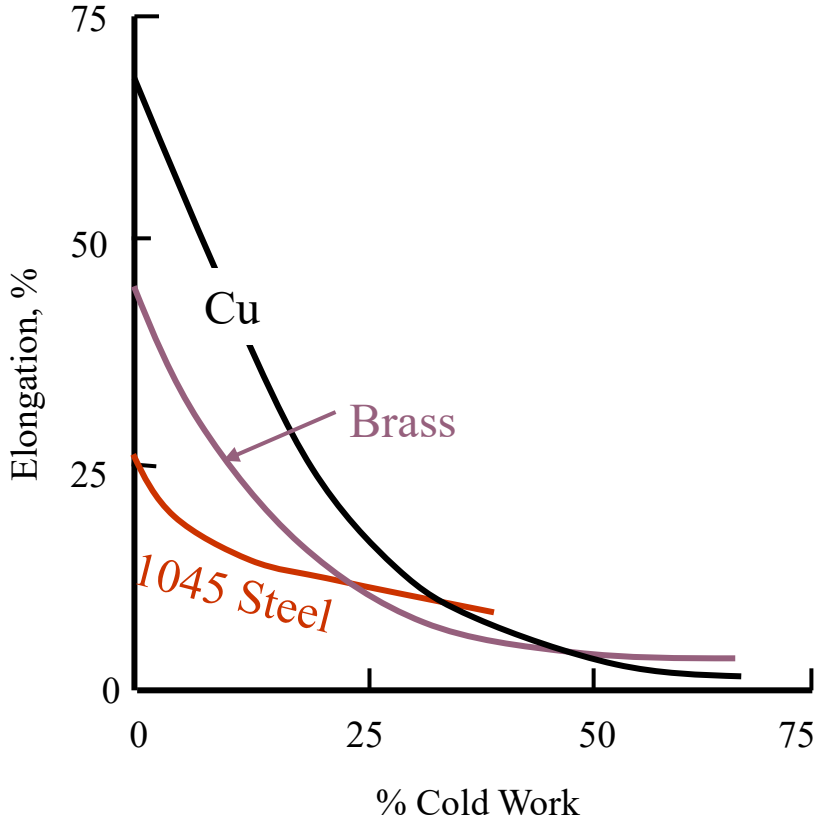


Power-law hardening

$$\sigma_T = K\varepsilon_T^n$$

Mechanical Properties and Cold Work





Cold Work $\Rightarrow$ Higher strength, lower ductility

Annealing Process

- Cold work ⇒ dislocation interactions ⇒ high strain energy
- Structure wants to reduce total energy
  - Raise temperature ⇒ facilitates atomic motion

- Material is heated to a high temperature and held for time:
  - Atoms to rearrange themselves into a lower energy state
  - Diffusion driven process
- Governed by both *time* and *temperature*:
  - High temperatures and short times
  - Lower temperatures and longer times.
- Removes the effects of cold work
  - Dislocation density will decrease
  - Grains become equiaxed.

Stages of Annealing

- ***Recovery***
  - Stresses around dislocations are relieved.

- ***Recrystallization***
  - New equiaxed grains nucleate from dislocations.
  - Return to nearly pre-cold worked structure & mechanical properties.

- ***Grain Growth***
  - Grain boundaries have high energy.
  - Grains grow to reduce overall grain boundary area.
  - Grain boundaries migrate due to diffusion of atoms.