Lecture 17

Precipitation Hardening:

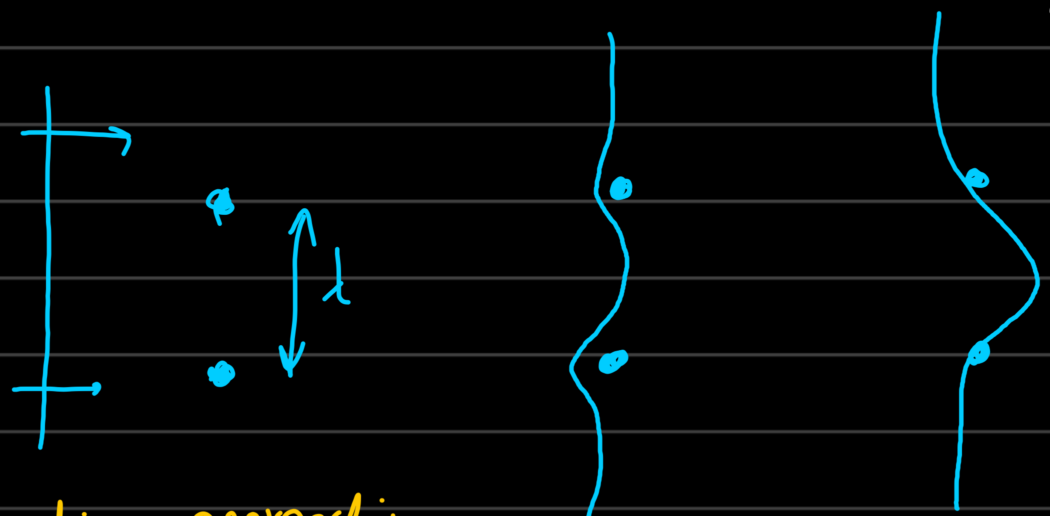
↳ precipitate shearing by dislocations.
  ↳ in soft precipitates
  ↳ coherent misfit b/w ppt & matrix.

↳

$$\lambda = \frac{4(1-f)r}{3f}$$

Dispersion hardening

If lattice misfit is incoherent
  ↳ overaged hard precipitates
  ↳ dislocations cannot pass through.



dislocation approaching 2 particles ($\lambda > R$)

dislocation starts to bend.

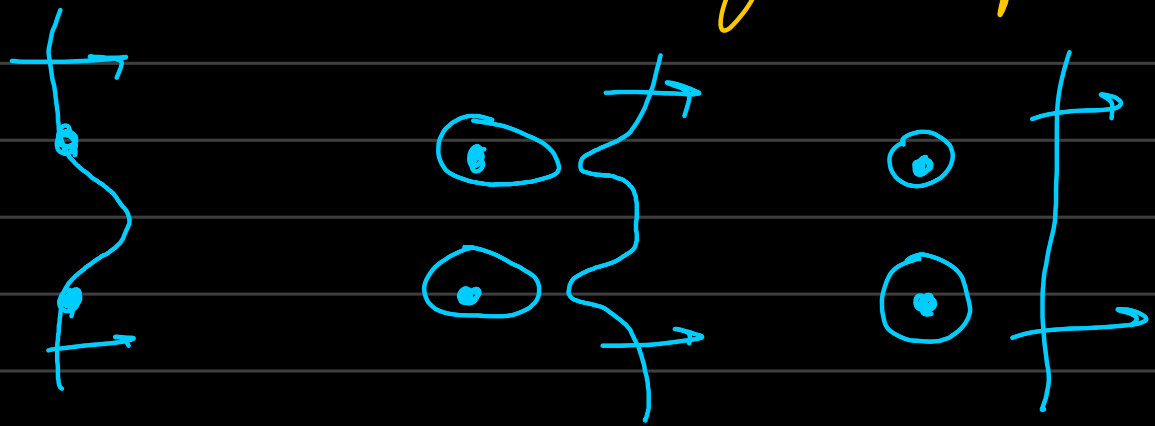
It reaches critical curvature.

$$R = \frac{Gb}{2\tau_o} \quad ; \quad \lambda = 2R$$

$$\therefore \boxed{\tau_o = \frac{Gb}{\lambda}}$$

* YS is determined by shear stress required to bow a dislocation.

↳ The dislocations segment meet and anhilate each other. leaving a loop behind.



* dispersion of non-coherent particles cause matrix to strain hardening rapidly.

* additional stress imparted on matrix.

$$\Delta\sigma = \frac{0.13Gb}{\lambda} \ln\left(\frac{r}{b}\right)$$

dispersoids

Orowan–Ashby equation.

→ Eg: Oxide Dispersed Steel (ODS)
{ $Al_2O_3 + TiO_2$ in Steel matrix }

* Material merit charts: Ashby Charts.

Phase Transformation Hardening:

↳ Eg: Austenite ⟶ Martensite (α')

{dispersive/military transformation}

↓

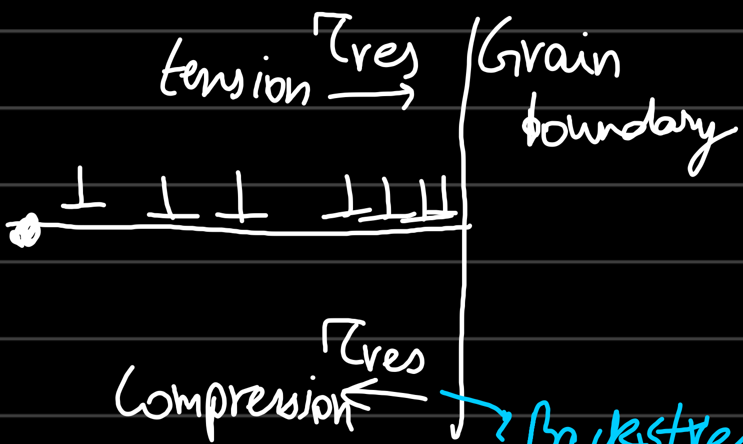
Much harder than equilibrium ferrite.

$\gamma \rightarrow \alpha$ {ferrite}

{diffusive transformation}

Bauschinger Effect:

YS is lower in compression than tension.



dislolation glide easy during compression as ξ is lower.

Backstress imparted.

Failure Mechanisms

1) Fracture

{What causes fracture failure in materials}

{What happens if a component in service has a defect/crack}

→ brittle fracture causes catastrophic failure

↳ refers to breaking of material into 2 or more pieces.

↳ Crack nucleation & crack propagation.

Brittle fracture: faceted fracture surface

Ductile fracture: Cup & Cone fracture surface.

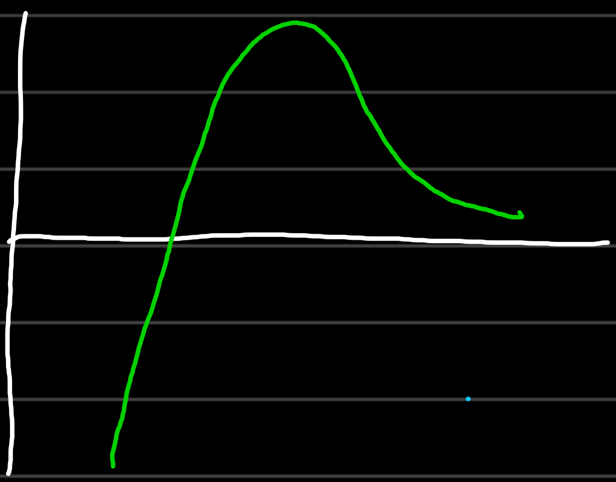
→ absence of gross plastic deformation before fracture.

→ Transangular fracture: cuts across the grains irrespective of orientation.

→ Intergranular fracture: cuts between the grain {through grain boundary}

↳ weakens GB {grain > grain boundary} → interphase boundaries

Mechanics of Fracture:



Theoretical cohesive strength:

strength required to break bonds.

$$\sigma_c = \sqrt{\frac{E\gamma}{r_0}}$$

γ: Surface Energy

r_0: equilibrium dist b/w atomic centers.

$$\boxed{\sigma_c \approx \frac{E}{10}}$$

* Theoretical Strength of glass ~10GPa
  Actual strength of glass ≃ 50MPa.

  ↳ As size ↑ses, strength ↓ses.

* Griffith failure theory:

  ↳ fracture strength and crack length are related.

↳ glasses weak & brittle due to stress concentrations