Lecture 16

Annealing of cold worked material.

Cold work —Anneal→ Recovery → Recrystallization → grain growth.

driving force is strain energy stored

driving force is free energy in dislocations.

driving force is grain boundary free energy.

→ these driving forces are global thermodynamic

Polygonization:

statistically stored edge dislocations

↳ initially arranged haphazardly get aligned during recovery ⇒ Polygonization.

→ low angle tilt grain boundaries are formed post rearrangement.

↳ misorientation angle $< 15°$.

$$D = \frac{b}{\theta}$$

D → avg dist b/w dislocations

b → burgers vector

θ → misorientation angle.

→ low angle grain boundaries occurs within a grain and hence are also referred to as subgrains, cells.

* Recrystallization:
  - LAGB in interior of sub-grains will glide towards pile up on grain-boundaries.
  - This LAGB pile-up at grain boundaries increases misorientation angle beyond >15°.
  - This leads to HAGB formation which makes the subgrain a grain in itself.

→ This is called recrystallization.

Hot working & Cold Working:

plastic deformation above $T_{0.5}$ → recrystallization temp.

plastic deformation below $T_{0.5}$

$T < 0.3$ → cold

$0.3 < T < 0.6$ → warm

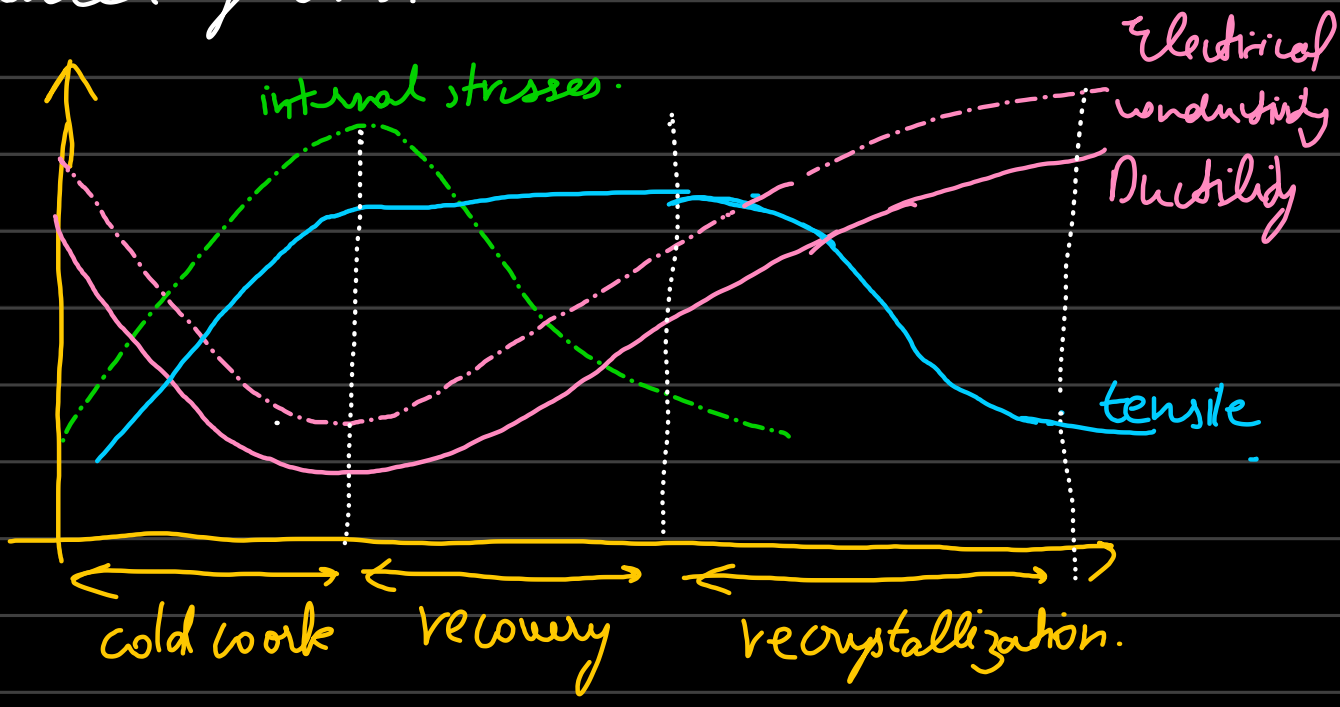
$T \geq 0.6$ → hot working

→ In hot working regimes, the recovery mechanisms override the strain hardening mechanisms.

Grain growth:

↳ Ostwald ripening: → grain coarsening

↳ larger grains grow in size by compensating smaller grains.



Solid-solution strengthening:

↳ alloying: impurity atoms distort lattice and develop stresses.

↳ small impurities in compressive side

↳ large impurities in tensile side

Empirical relation: $\boxed{\sigma_y \propto C^{1/2}}$

σ_y → yield strength.

C → conc. of solute atoms

* Alloying increases yield strength and tensile strength.

→ Rule of mixtures:

In multiphase alloy, the properties of the alloy will be the weighted average of the individual phase properties.

↳ Iso-strain: $\sigma_{avg} = f_1\sigma_1 + f_2\sigma_2$

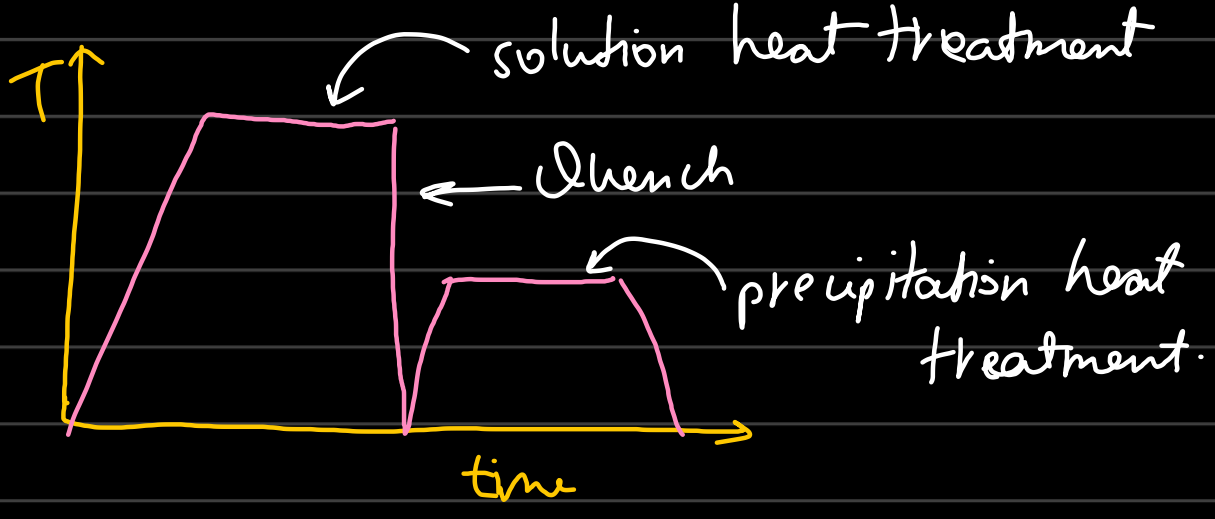
Iso-stress: $\varepsilon_{avg} = f_1\varepsilon_1 + f_2\varepsilon_2$

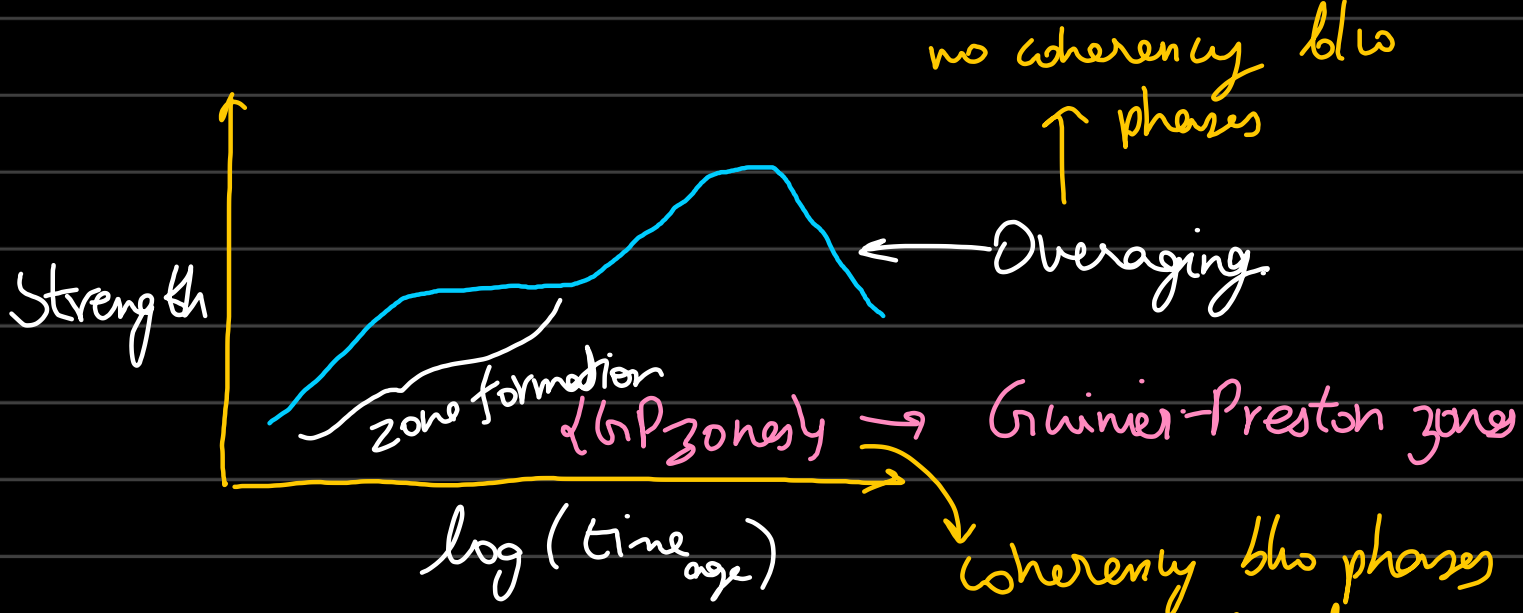
↳ Precipitation Strengthening.

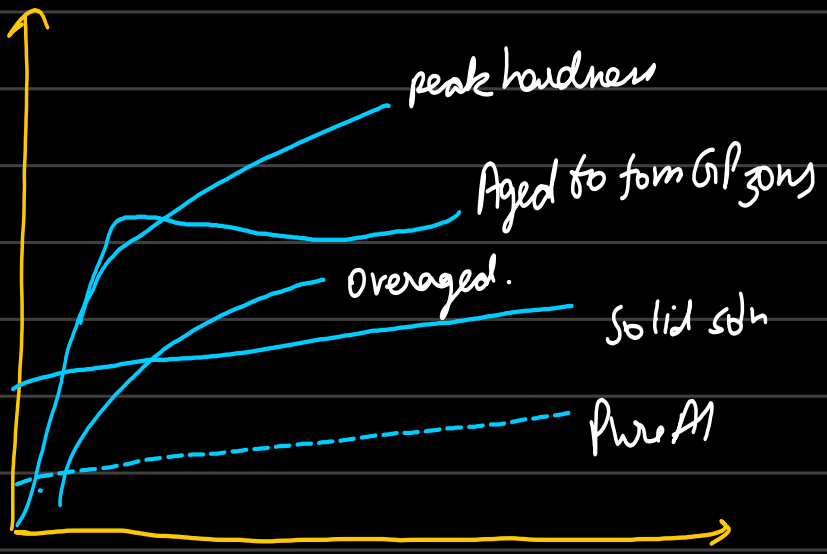
↳ also referred to as age-hardening.

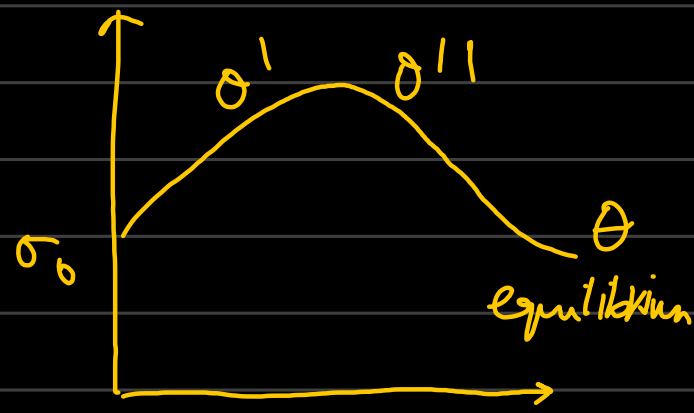
↳ 2-step heat treatment:

i> Solution heat treatment:

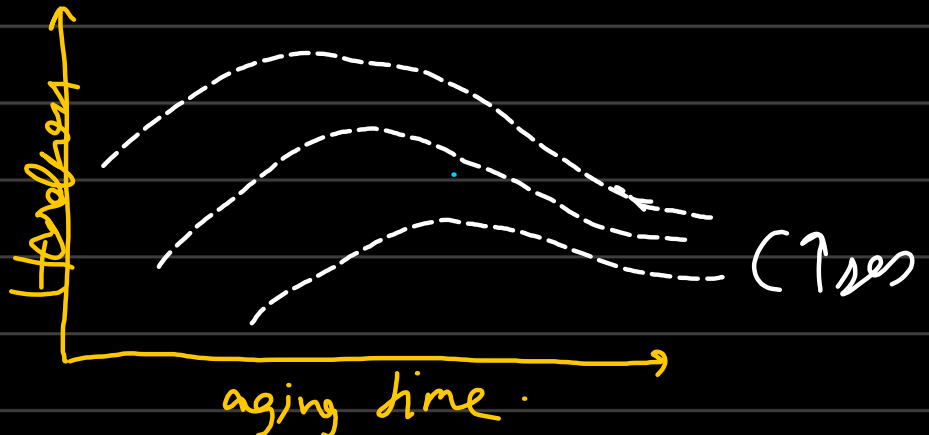








Eg: Al (ss) + phase with $CuAl_2$ precipate (θ)



θ'' ⇒ GP zones ⇒ coherent precipitates

θ ⇒ equilibrium precipitate ⇒ incoherent.

* Second phase act in two ways with dislocations.
  - ↳ they may be cut by dislocations
  - ↳ they can be bypassed.

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

↓ mean interparticle distance.