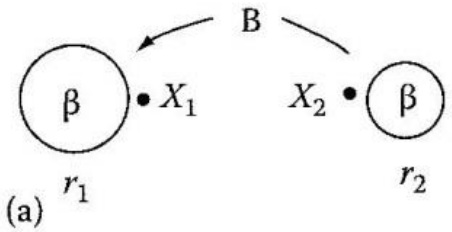
EMA5001 Lecture 20
Precipitates Coarsening, Massive Transformation, & Order-Disorder Transformation

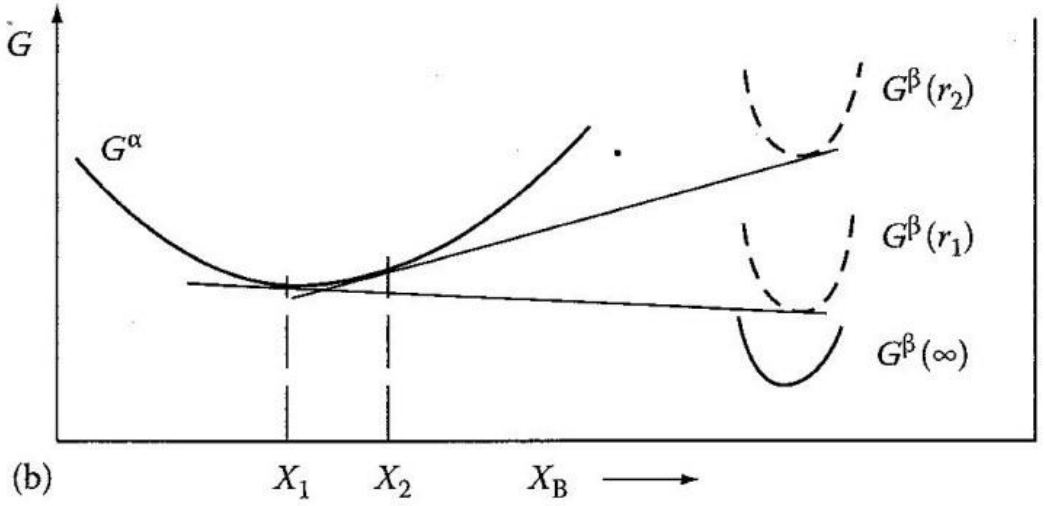
FLORIDA INTERNATIONAL UNIVERSITY

Particle Coarsening (1)

- **Fine precipitates (e.g., dispersed in a matrix phase) tend to coarsen**
- **Driving force - Reduction of total interfacial energy**
  - No chemical driving force
  - Total elastic strain energy remain constant



- **Change of local solute concentration in matrix due to particle sizes**
  - Smaller the particle, the higher the chemical potential and higher concentration
  - Solute atoms diffusing from smaller particles to larger ones, leading to shrinkage of smaller precipitates and growth of larger precipitates over time



Phase Transformations in Metals & Alloys, Porter, 3rd Ed, 2008, p. 310

Particle Coarsening (2)

- **Coarsening kinetics**

$$\left(\bar{r}\right)^3 - r_0^3 = kt \qquad k \propto D\gamma X_e$$

$$\frac{d\bar{r}}{dt} \propto \frac{k}{\bar{r}^2} \propto \frac{D\gamma X_e}{\bar{r}^2}$$

- **Coarsening of microstructure (e.g., precipitates) is typically undesirable**

  To reduce coarsening rate

  - Decrease interfacial energy
  - Decrease diffusion coefficient (or temperature)
  - Decrease equilibrium solubility

Massive Transformation (1)

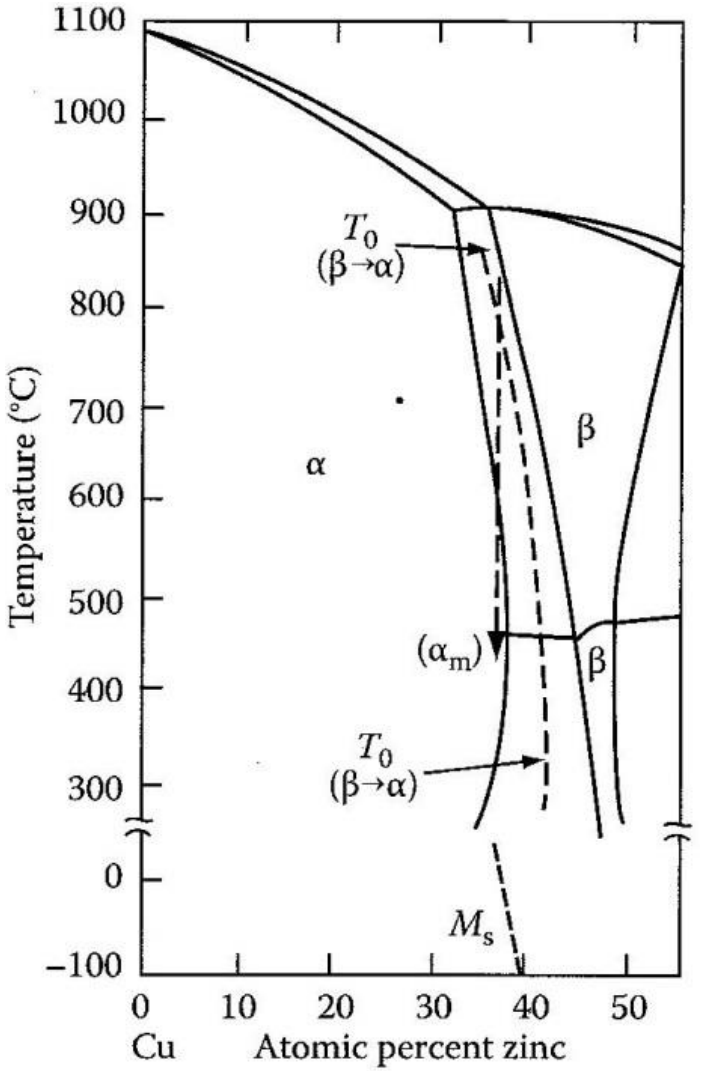
❑Massive transformation:

- Diffusionless civilian phase transformation happening at relatively high cooling rate

$$\beta \rightarrow \alpha$$

❑Features

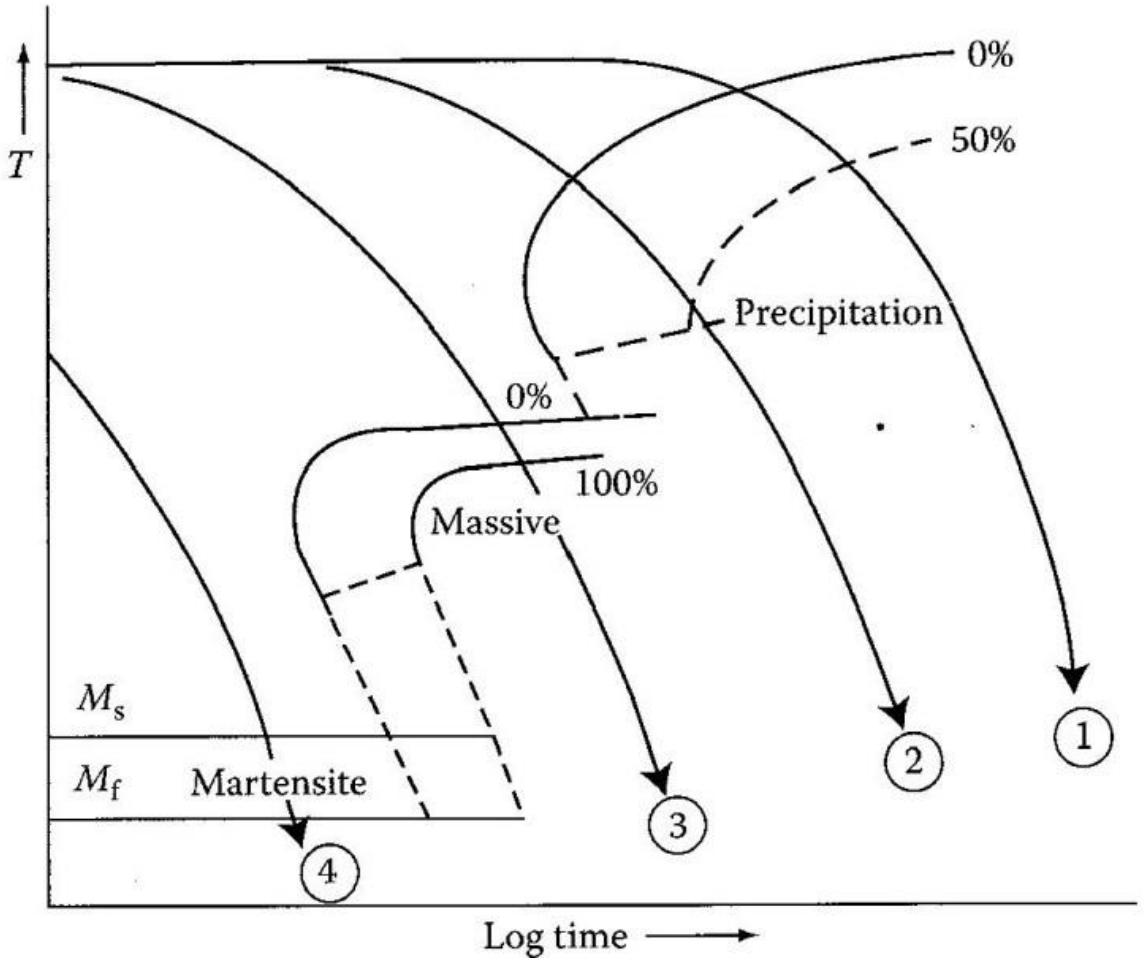
- Same composition -
  Effectively no long-range diffusion
- Interface controlled
- Irregular incoherent interfaces
- Fast transformation
- Hard to completely avoid precipitates nucleation
- May also go through Martensite transformation at even higher cooling rate



Phase Transformations in Metals & Alloys, Porter, 3rd Ed, 2008, p. 353

Massive Transformation (2)

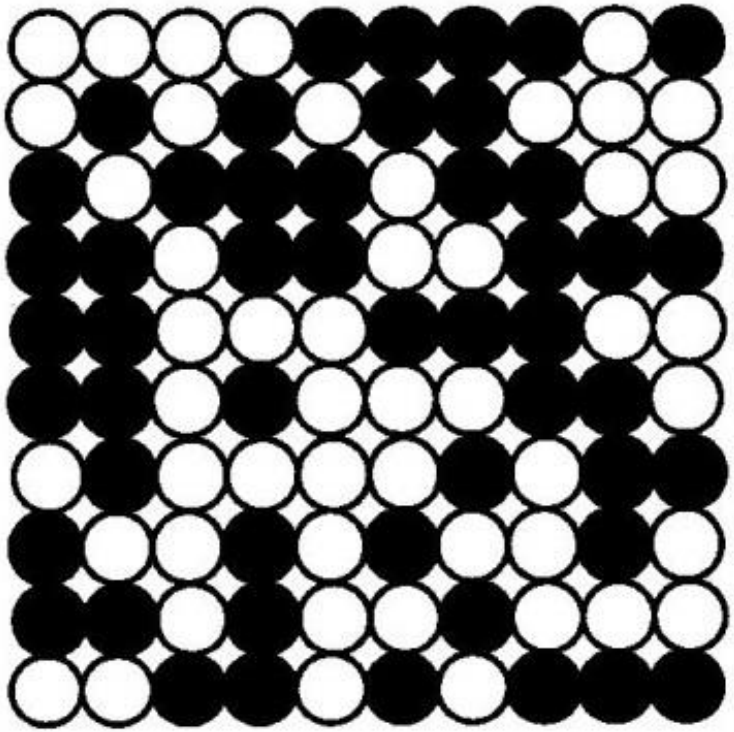
- **Cooling rate**
  - Fast enough that no effective nucleation and growth of precipitates
  - Slower enough so that diffusionless military type phase transformation (Martensite phase transformation) does not occur



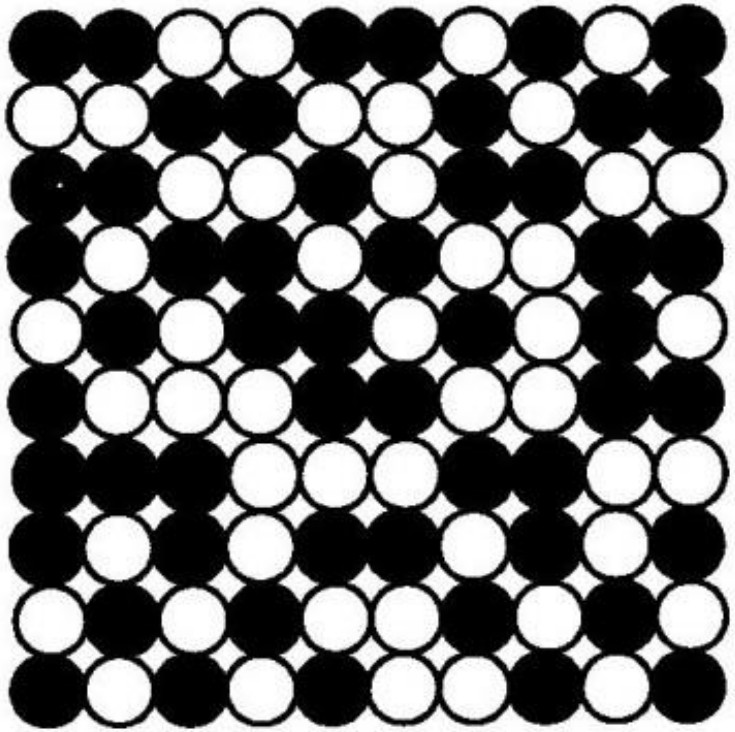
Phase Transformations in Metals & Alloys, Porter, 3rd Ed, 2008, p. 354

Order – Disorder Transformation

- Ordering happen when there is preferred bonding of atom A to atom B (i.e., preferred A-B bonds over A-A or B-B bonds)



(a) 50 A atoms and 50 B atoms, P_{A-B} = 100, disordered

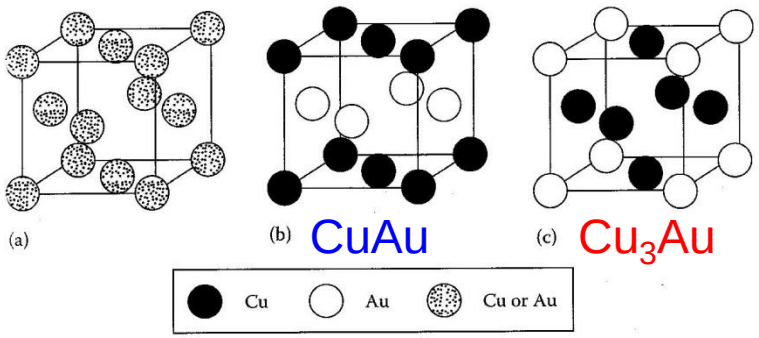


(b) 50 A atoms and 50 B atoms P_{A-B} = 132, Partially ordered

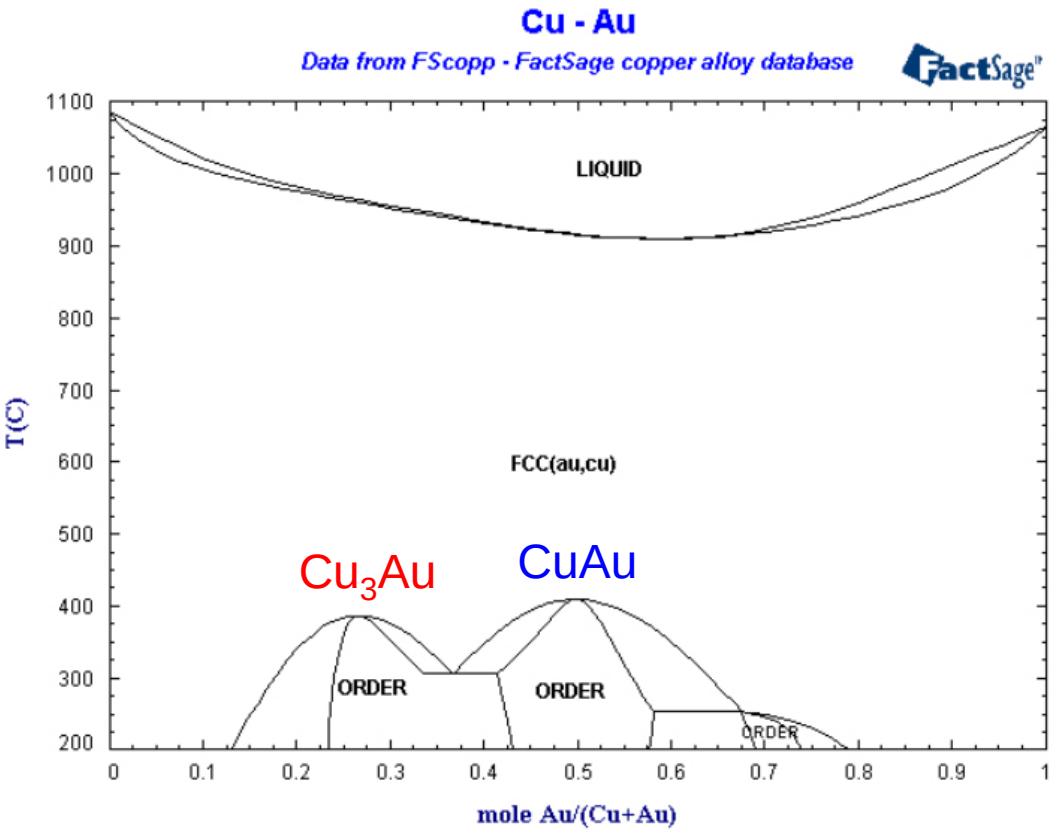
Phase Transformations in Metals & Alloys, Porter, 3rd Ed, 2008, p. 25

Features of Order-Disorder Transformation

❑Examples of Order-Disorder Phase



Phase Transformations in Metals & Alloys, Porter, 3rd Ed, 2008, p. 25



❑Features

- Occur with the same composition
- Can be 1st order (more common, e.g., Cu_3Au) or 2nd order (e.g., CuZn)
- Often goes through nucleation & growth process (e.g., Cu_3Au)
- Rate of transformation depends on many factors including structure