



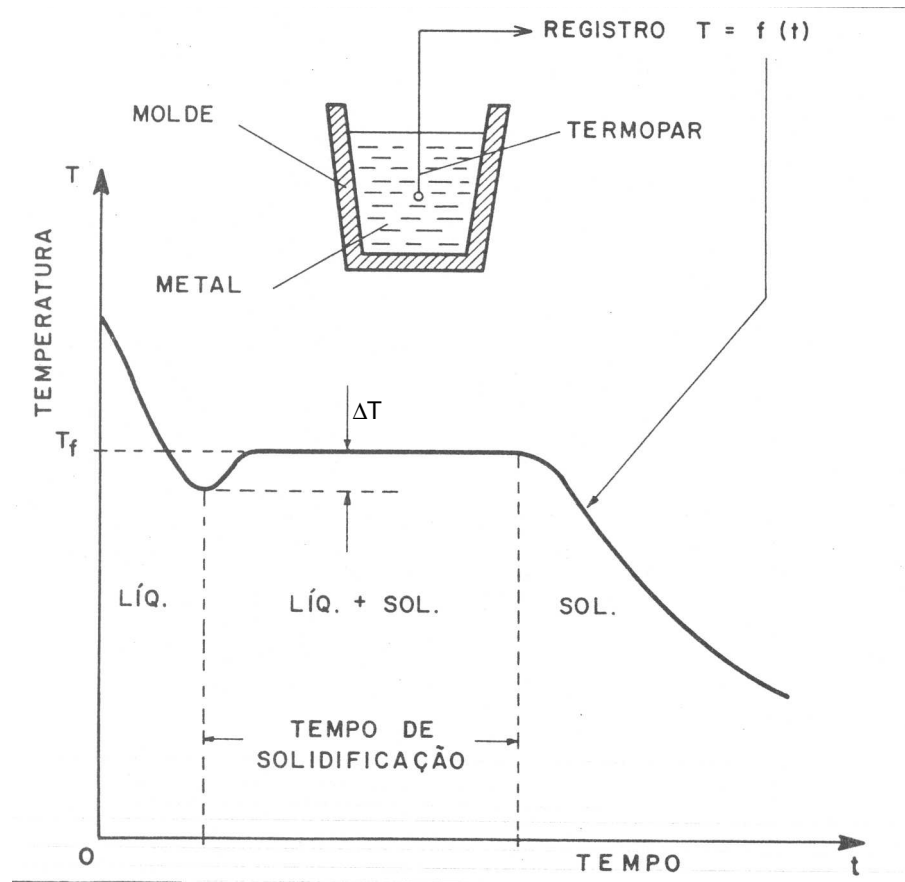
Transformações de Fases



Solidificação

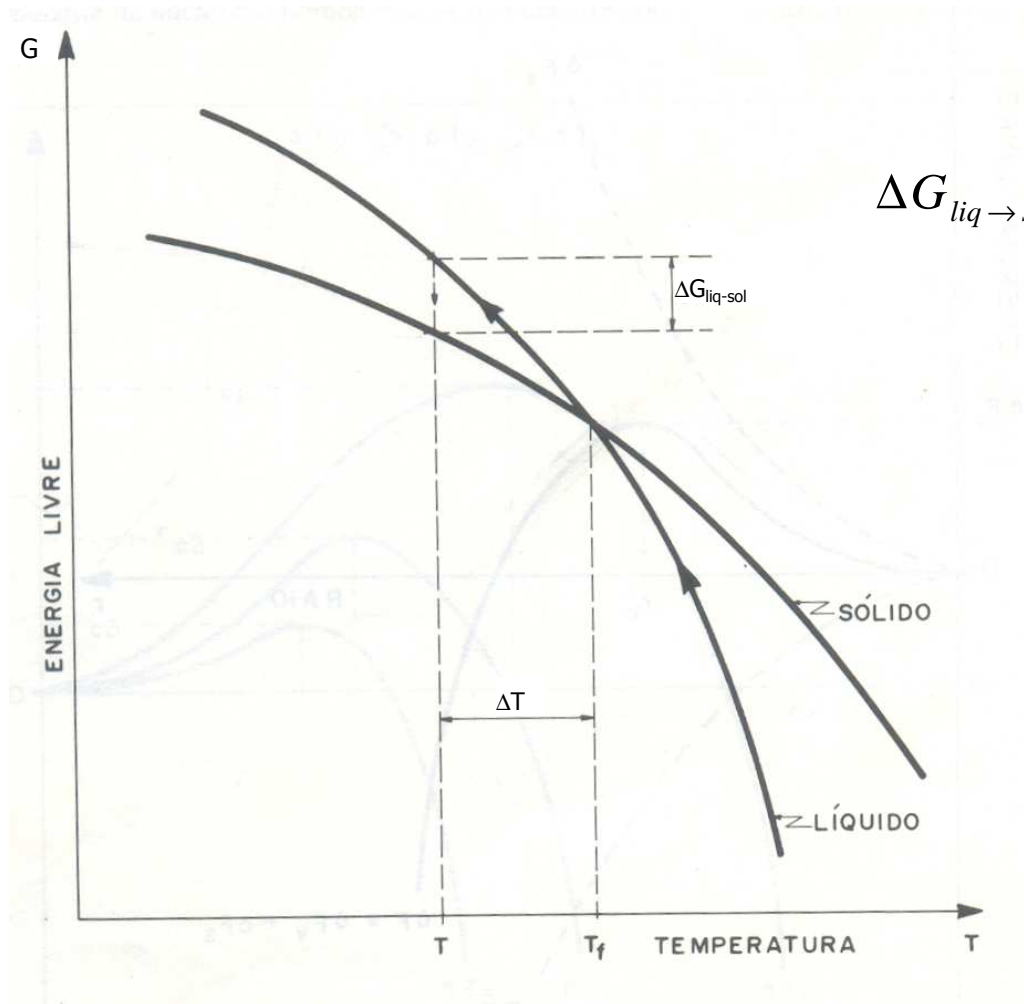
- Exemplo de Solidificação

Super-resfriamento Térmico



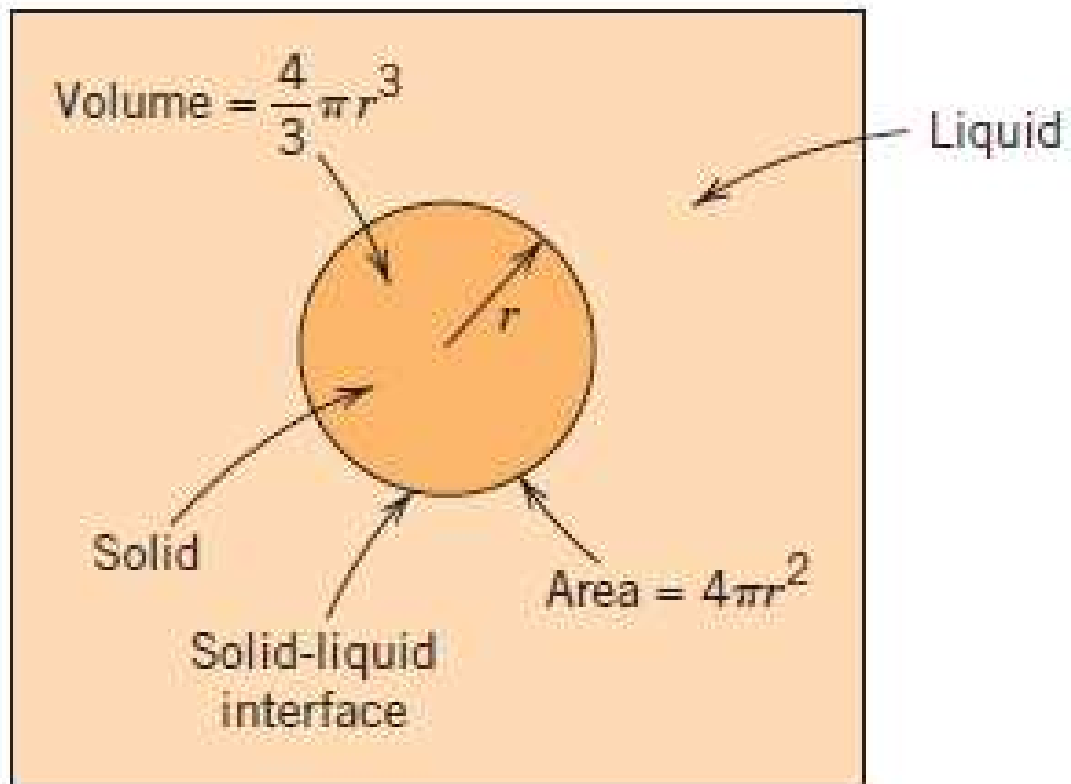
- Líquido super-resfriado 1
- Líquido super-resfriado 2

Variación da Energia Livre Líquido - Sólido



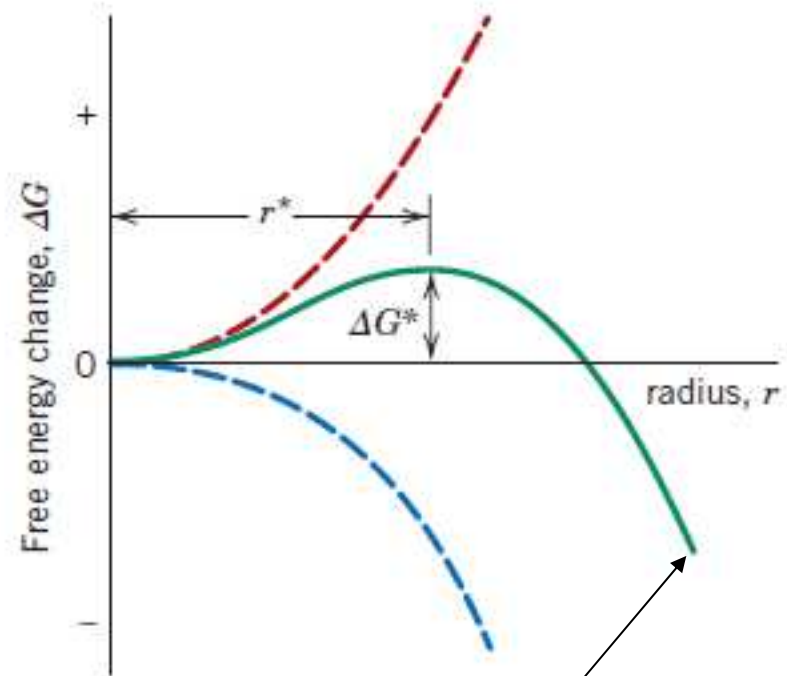
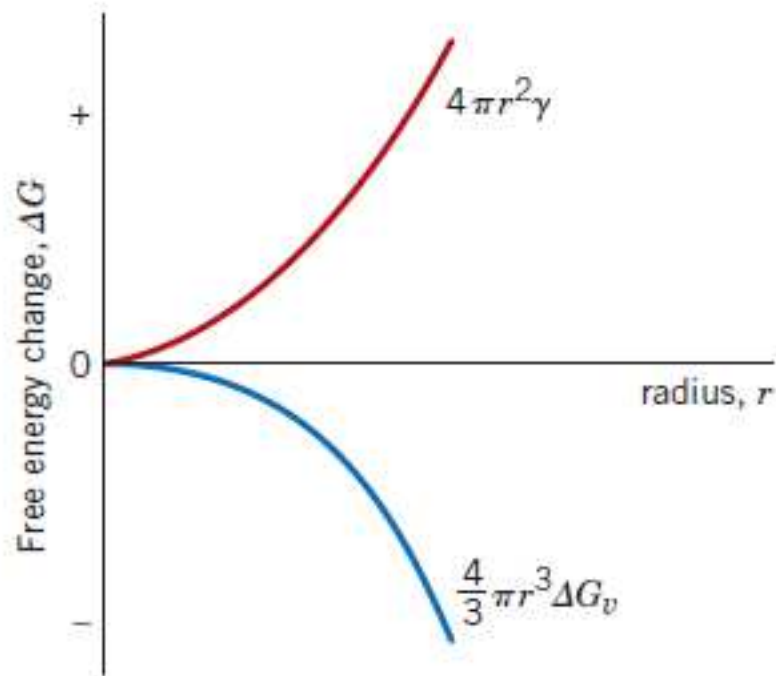
$$\Delta G_{liq \rightarrow sol} = - \frac{\Delta H_f \Delta T}{T_f}$$

Nucleação Homogênea



Exemplo de tensão superficial

Nucleação Homogênea



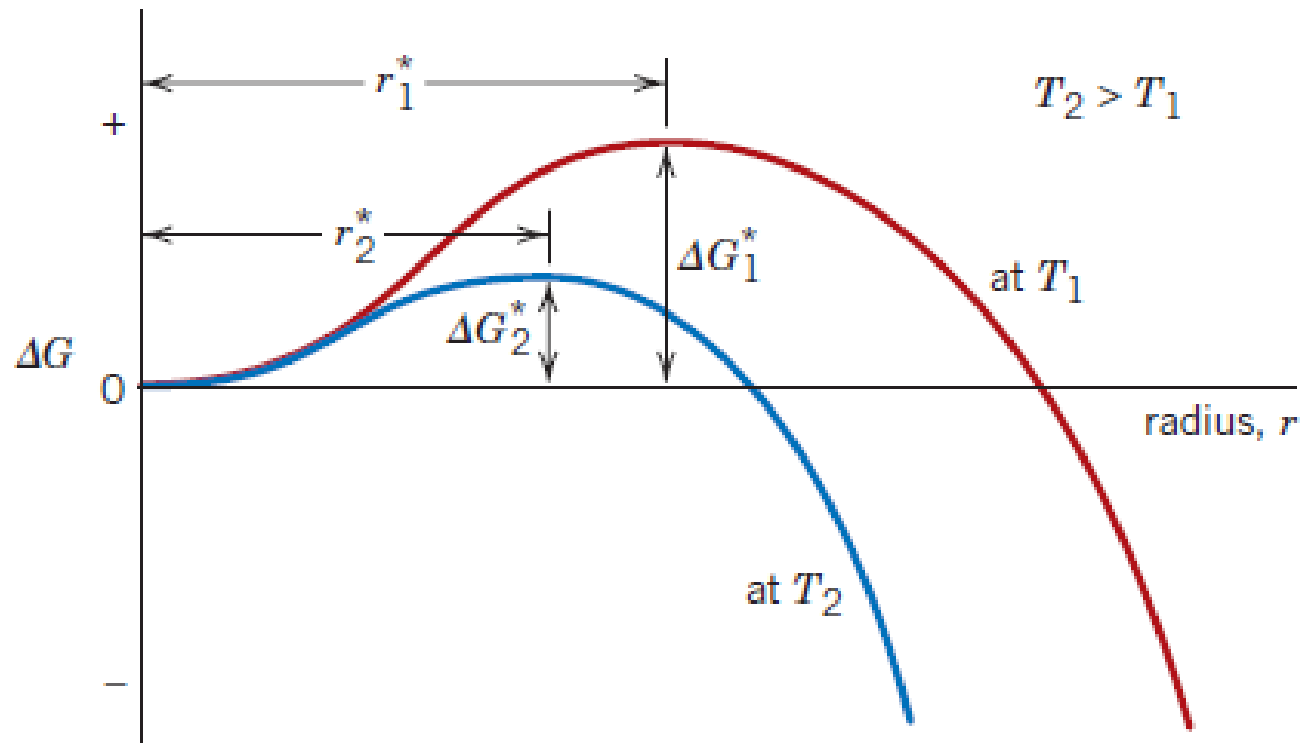
$$r^* = -\frac{2\gamma}{\Delta G_v}$$

$$\Delta G^* = \frac{16\pi\gamma^3}{3(\Delta G_v)^2}$$

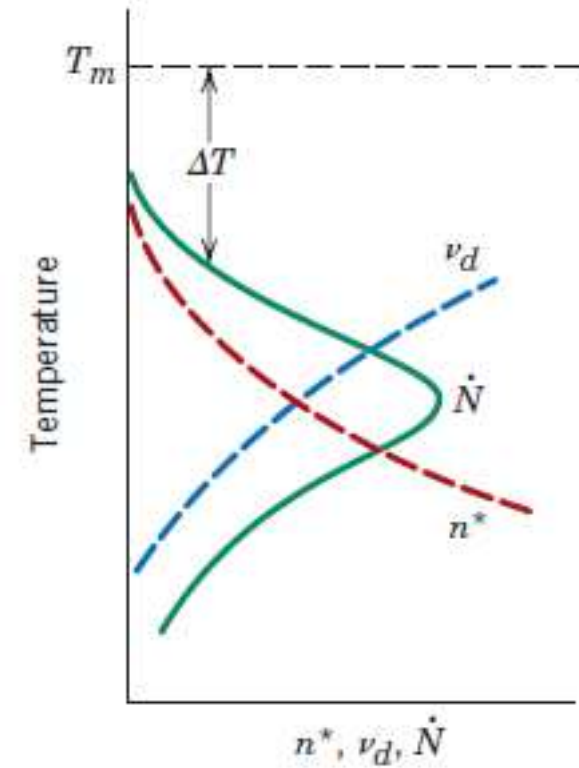
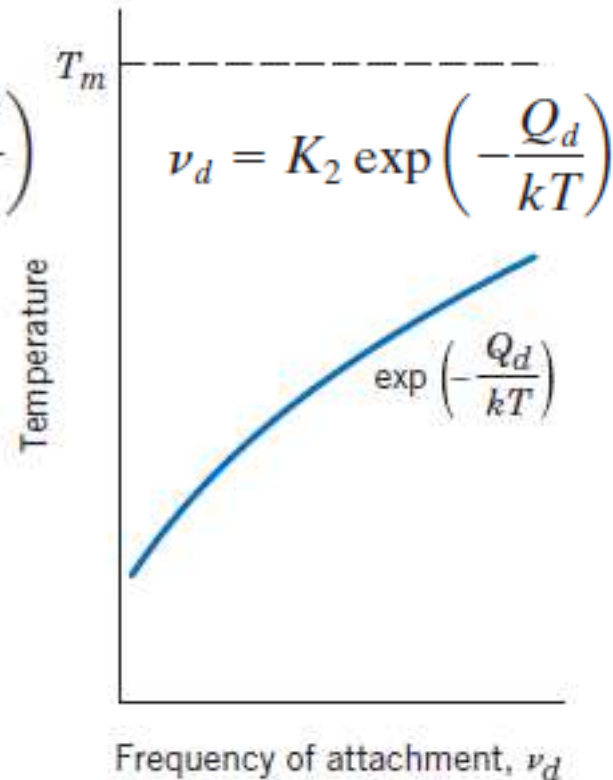
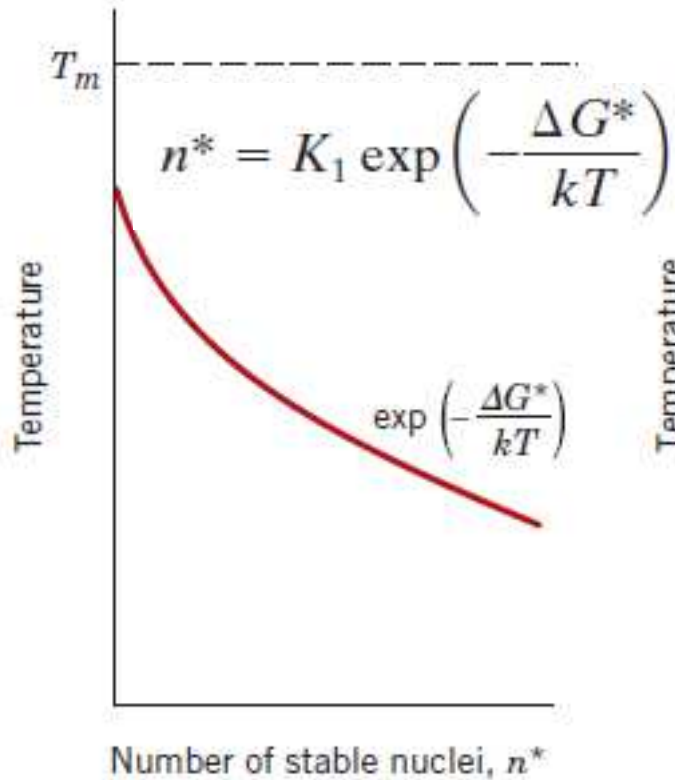
$$\Delta G_v = \frac{\Delta H_f(T_m - T)}{T_m}$$

$$\Delta G = \frac{4}{3}\pi r^3\Delta G_v + 4\pi r^2\gamma$$

Nucleação Homogênea x ΔT

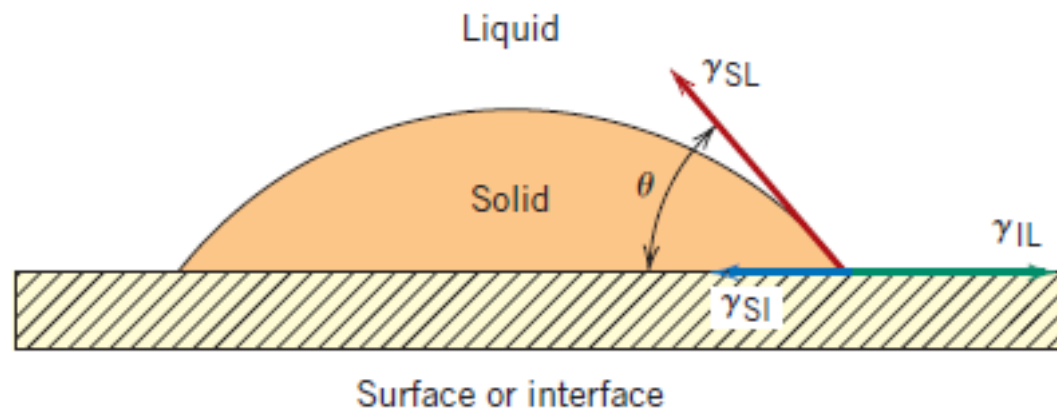


Taxa de Nucleação Homogênea



$$\dot{N} = K_3 n^* \nu_d = K_1 K_2 K_3 \left[\exp\left(-\frac{\Delta G^*}{kT}\right) \exp\left(-\frac{Q_d}{kT}\right) \right]$$

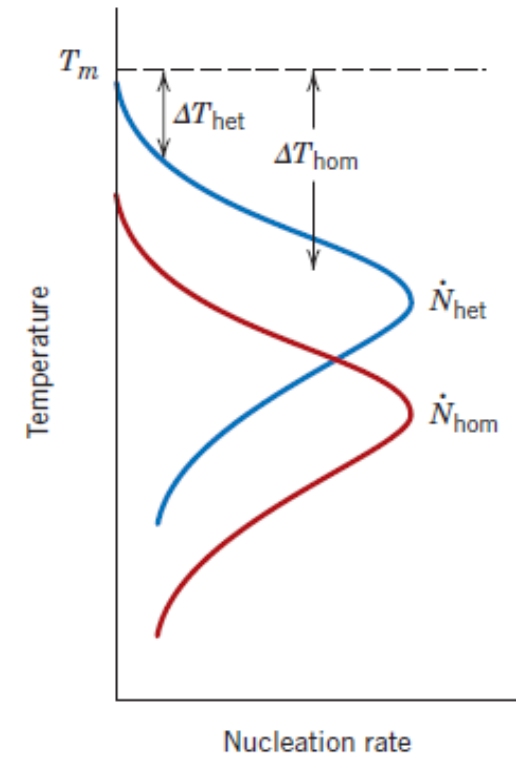
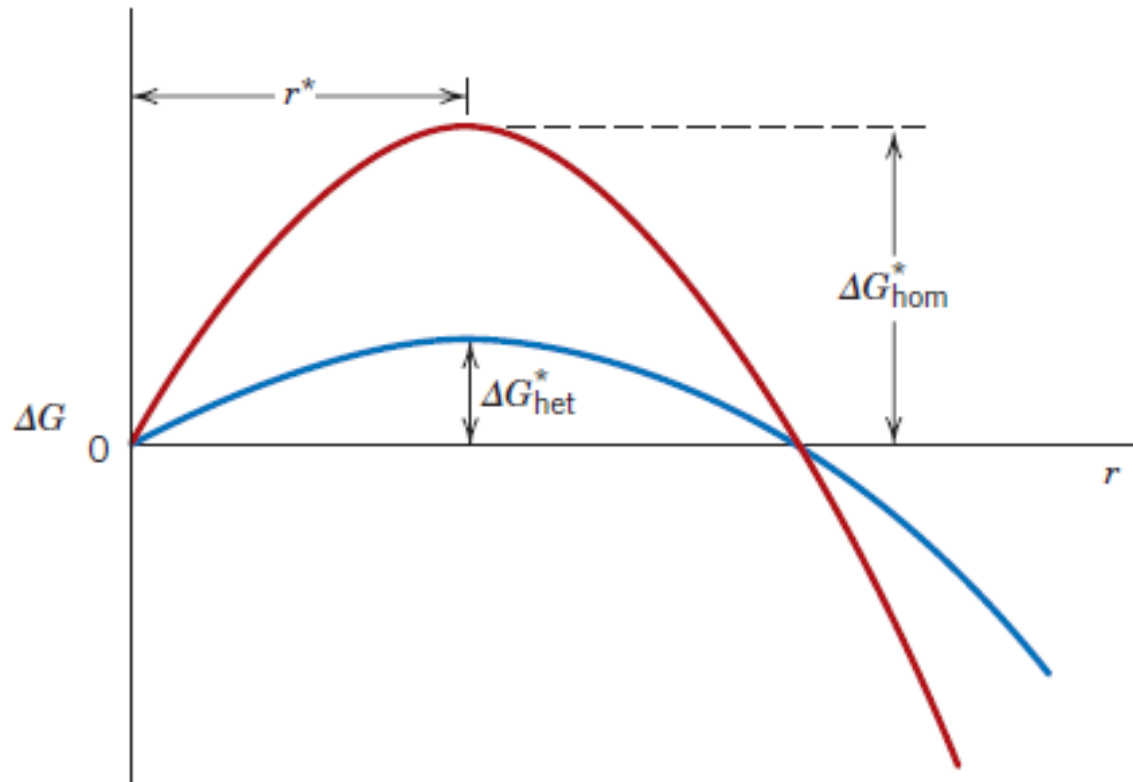
Nucleação Heterogênea



$$\gamma_{IL} = \gamma_{SI} + \gamma_{SL} \cos \theta$$

$$S(\theta) = \frac{(2 + \cos \theta)(1 - \cos \theta)^2}{4}$$

Heterogênea x Homogênea

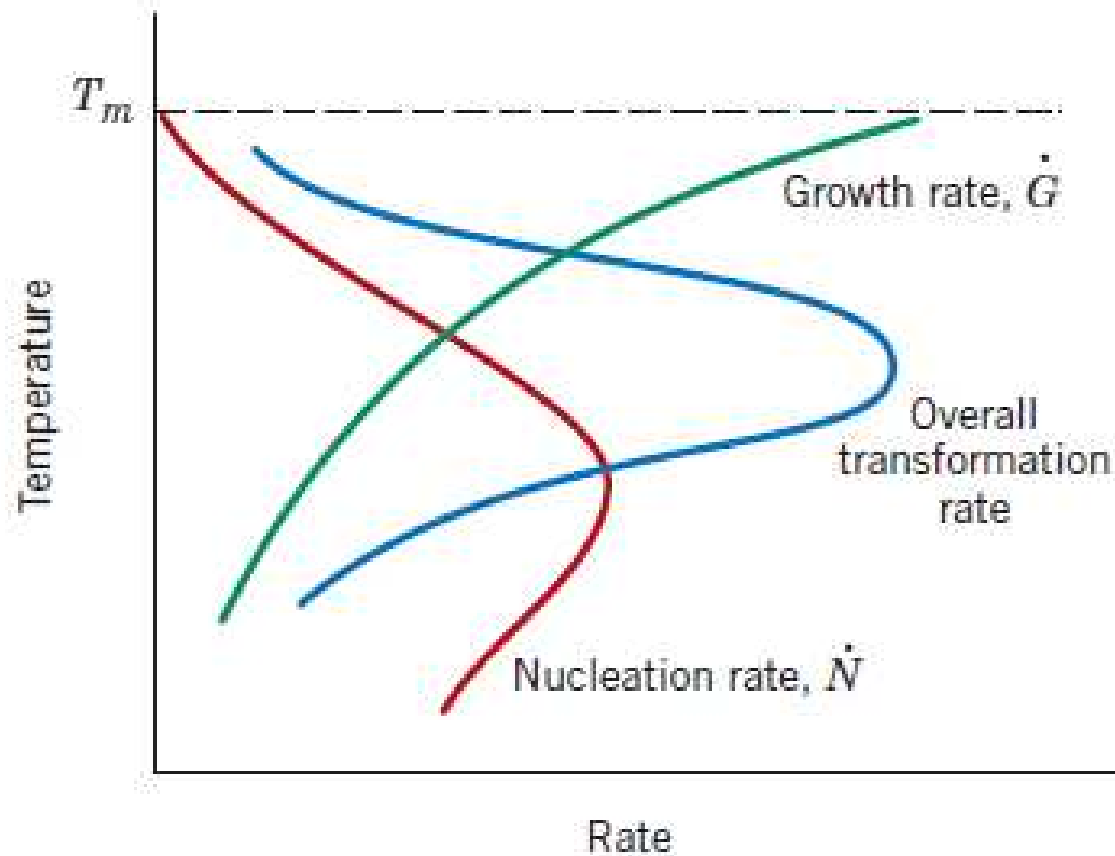


$$r^* = -\frac{2\gamma_{\text{SL}}}{\Delta G_v}$$

$$\Delta G^* = \left(\frac{16\pi\gamma_{\text{SL}}^3}{3\Delta G_v^2} \right) S(\theta)$$

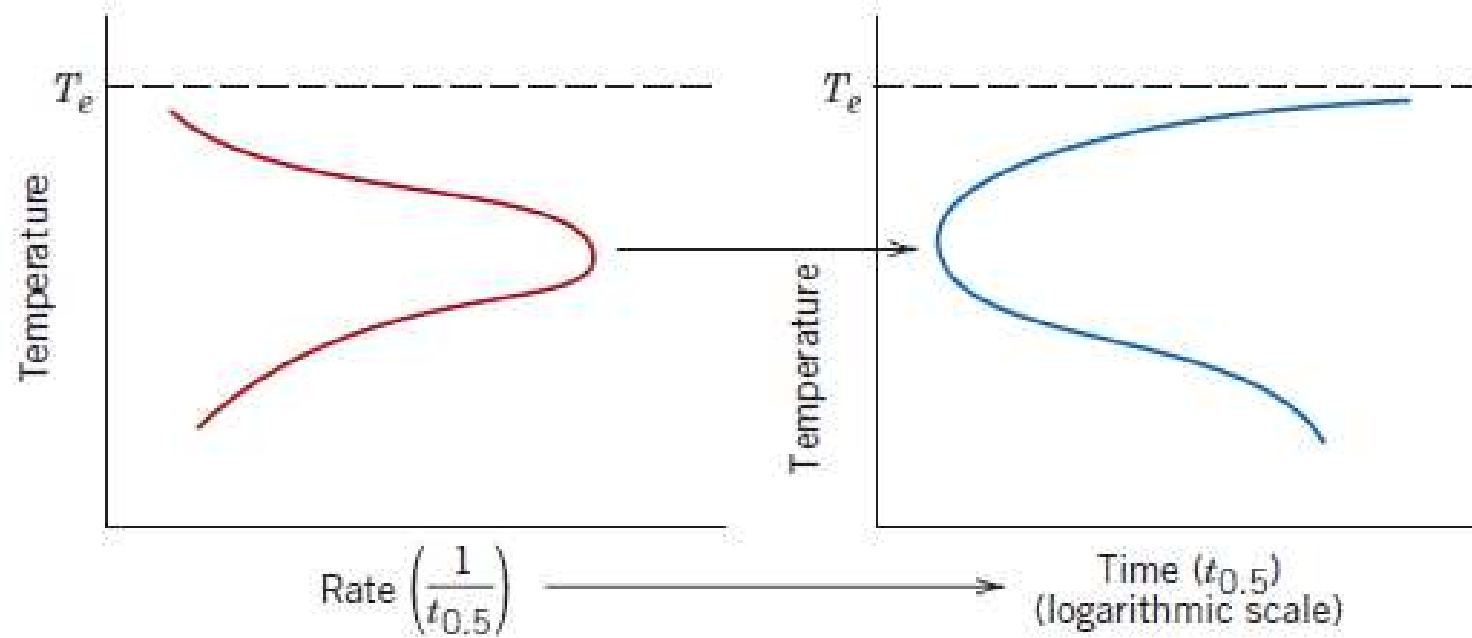
$$\Delta G_{\text{het}}^* = \Delta G_{\text{hom}}^* S(\theta)$$

Crescimento

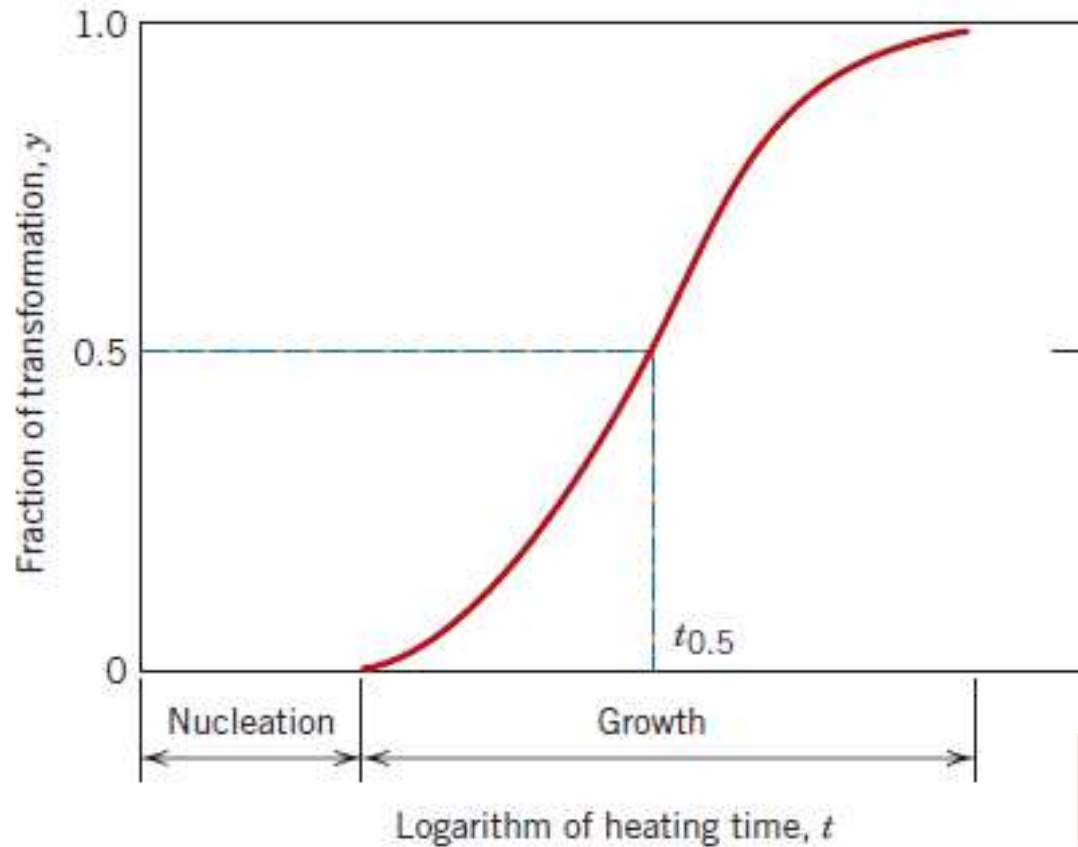


$$\dot{G} = C \exp\left(-\frac{Q}{kT}\right)$$

Diagrama TTT

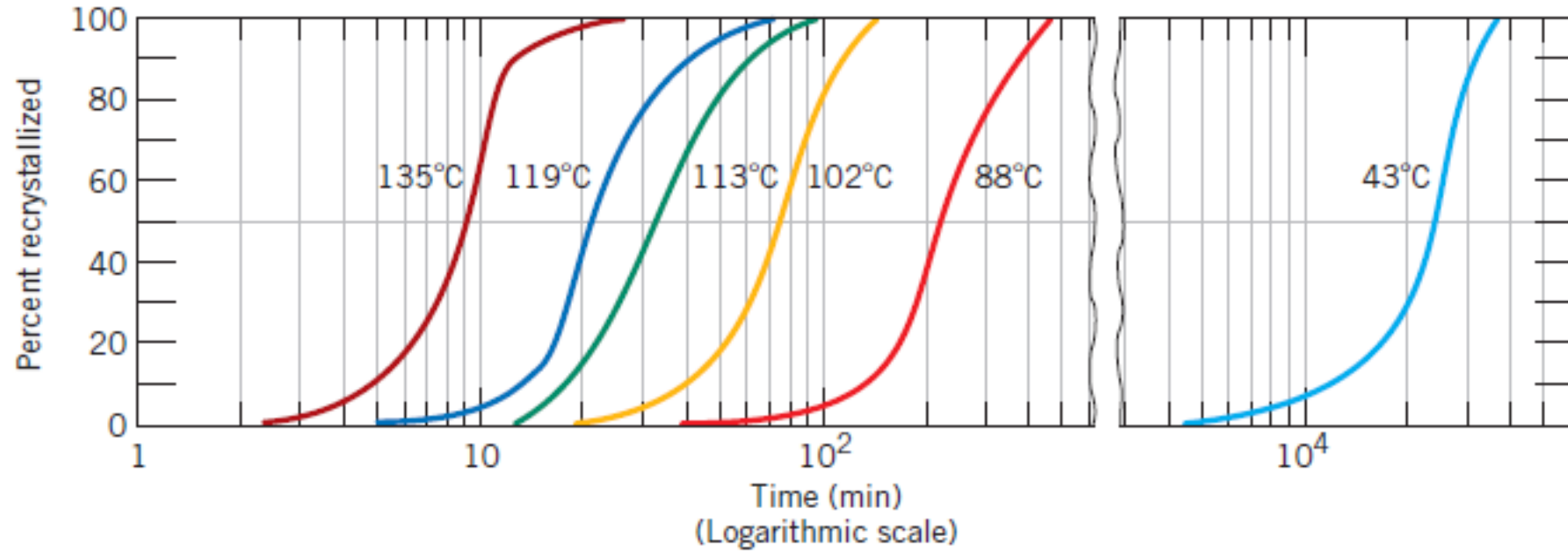


Fração transformada x Tempo

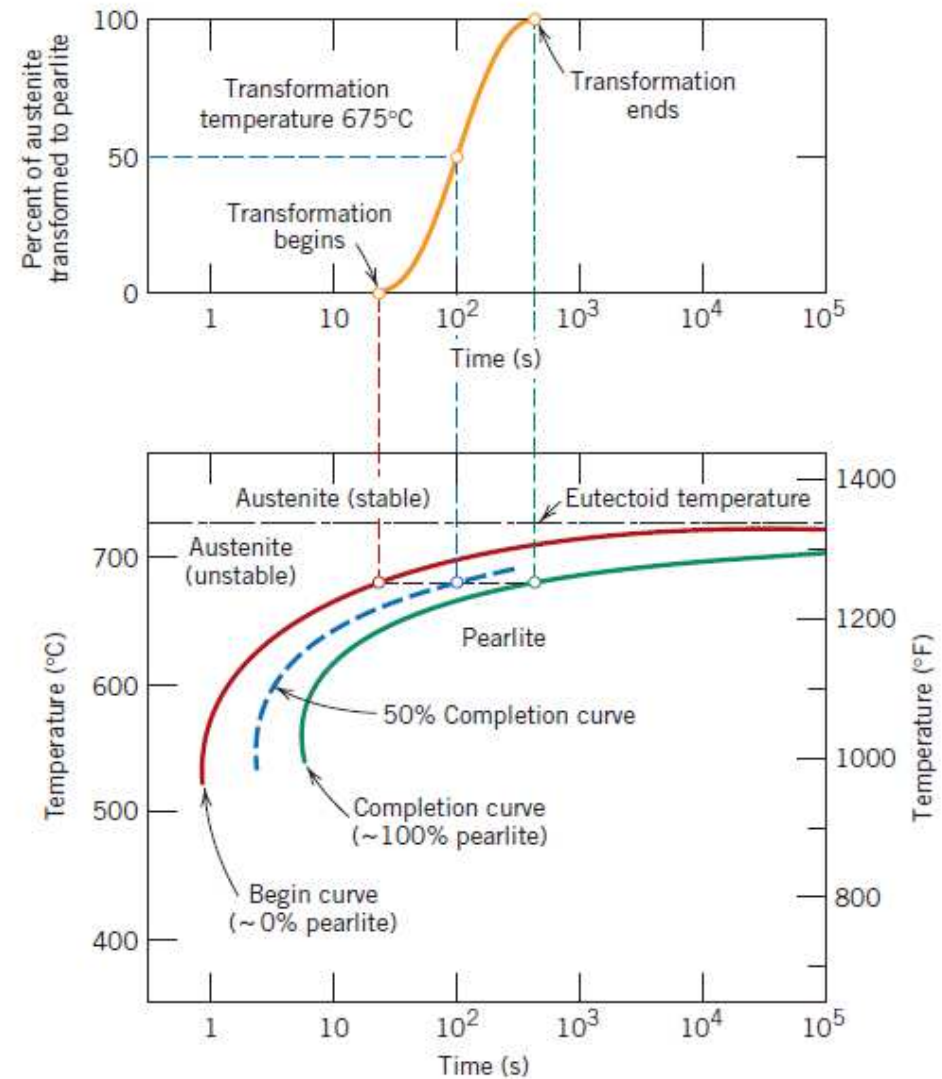


$$y = 1 - \exp(-kt^n)$$

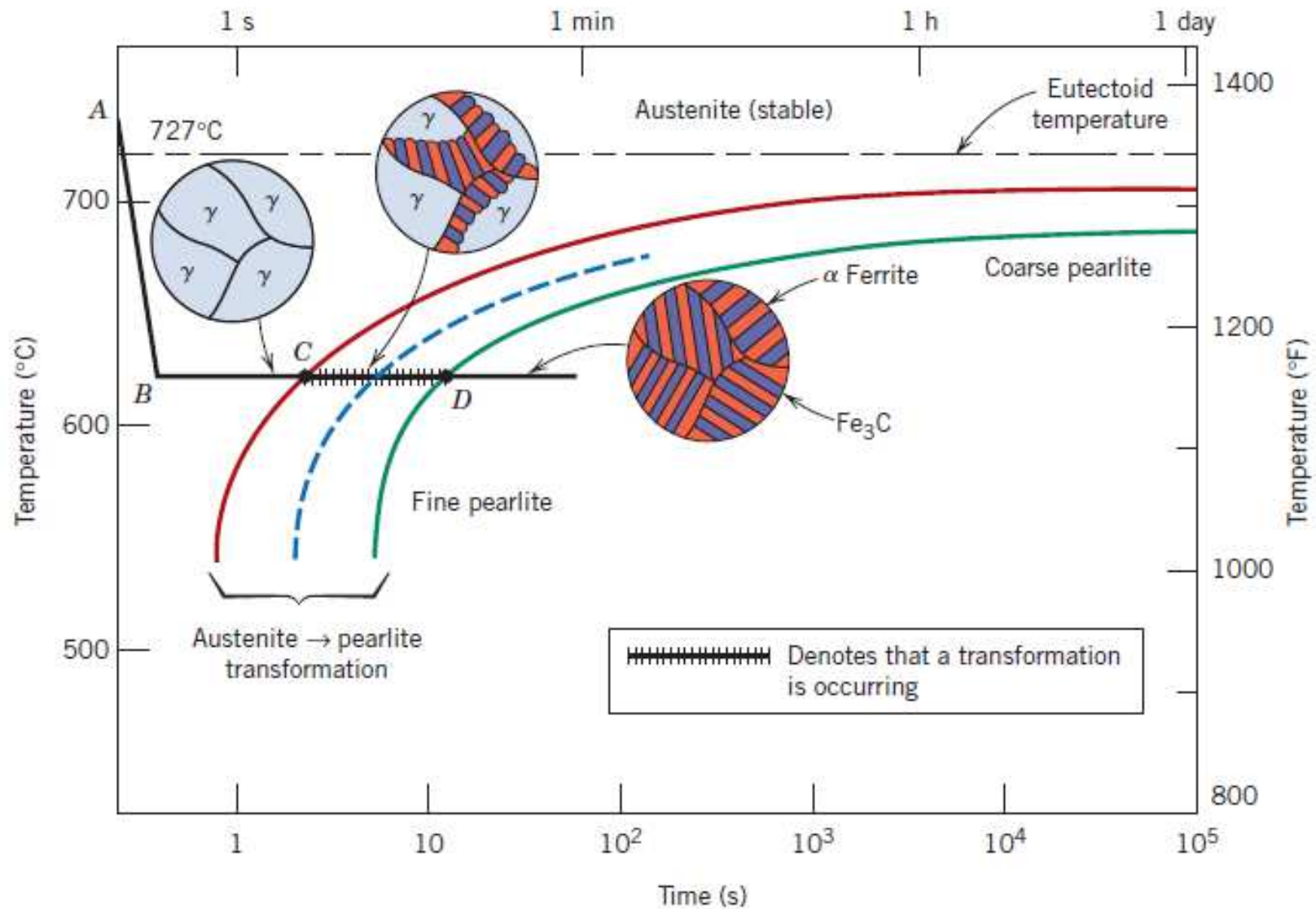
Efeito da temperatura



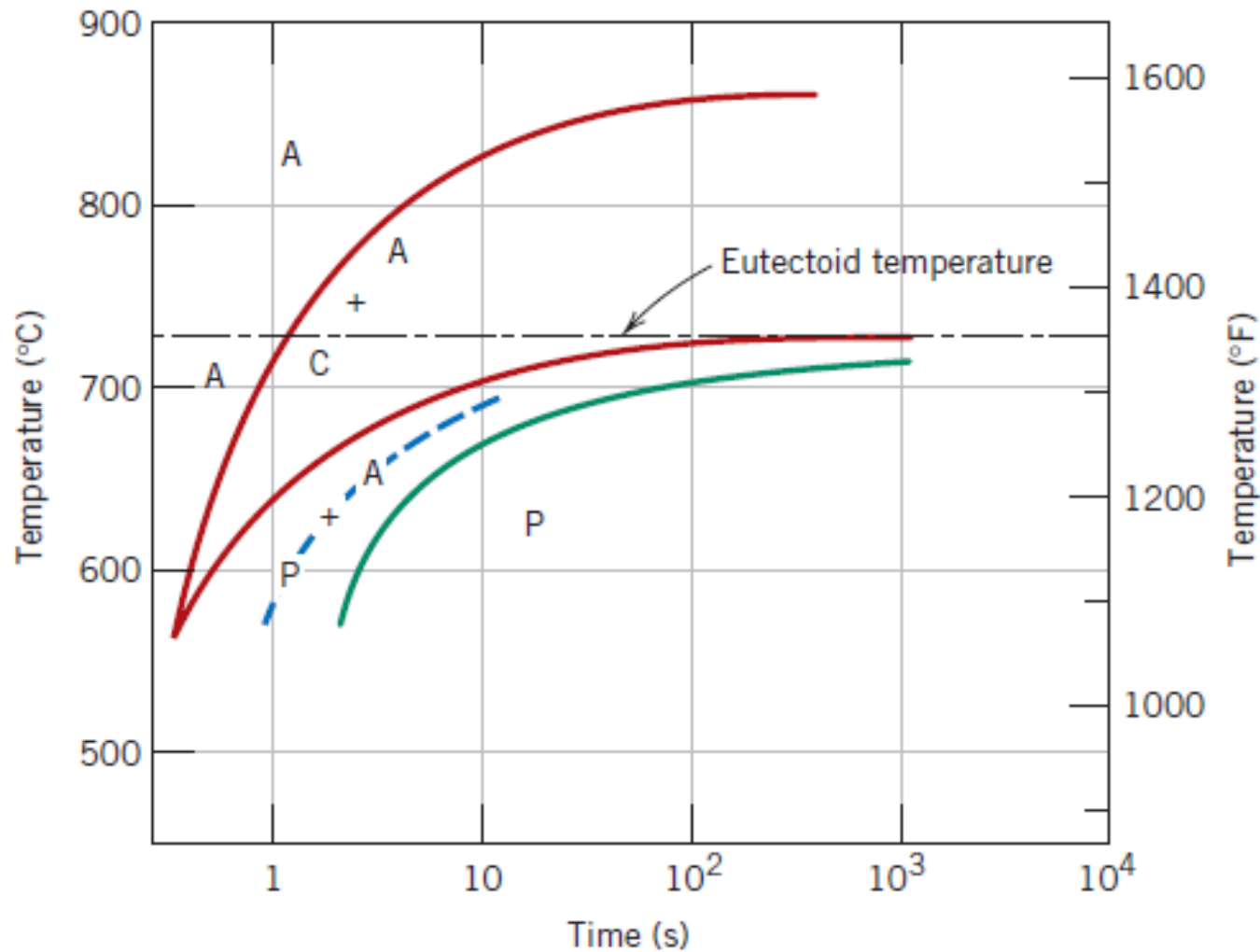
Exemplo de TTT (aço eutetóide)



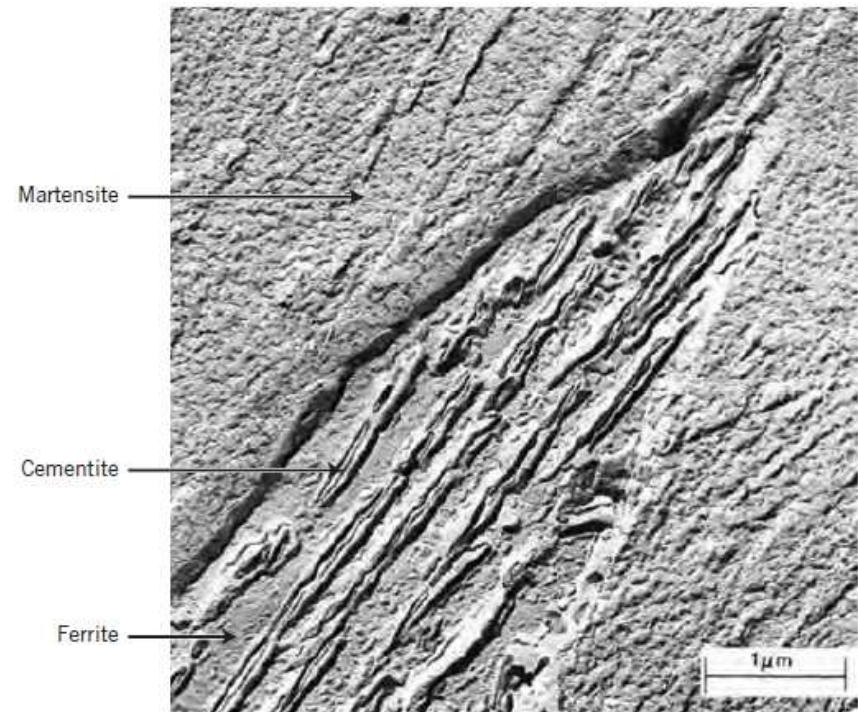
Evolução da microestrutura



Outro exemplo: aço hipereutetóide

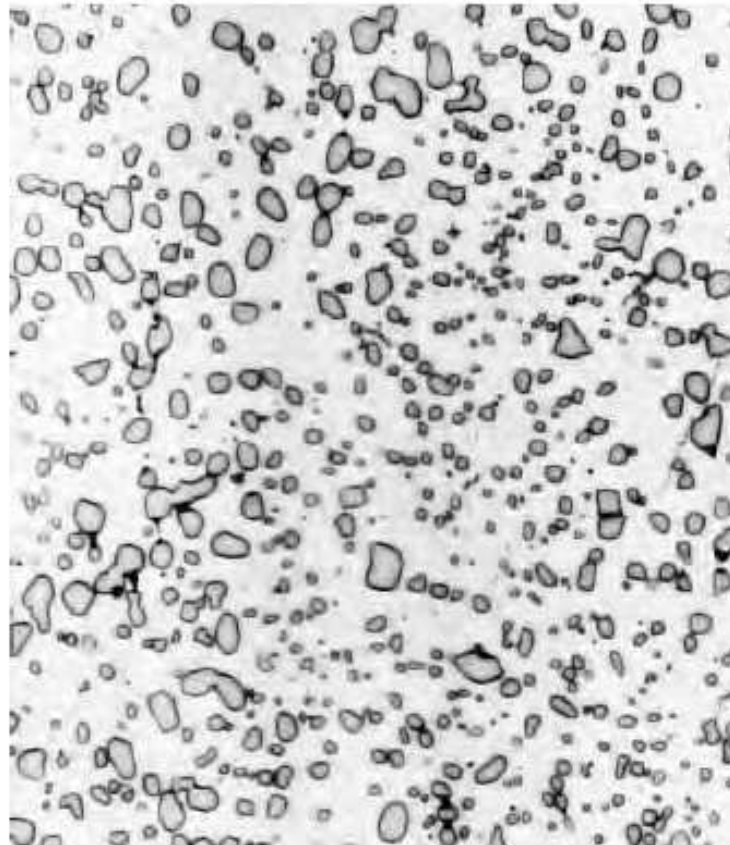


Perlita Grossa, Perlita Fina e Bainita

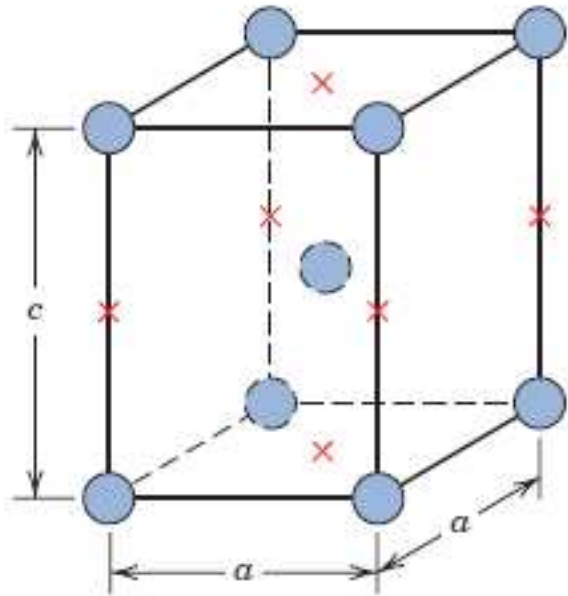


Esferoidita

- Redução da superfície específica (G menor, mais próxima do equilíbrio)

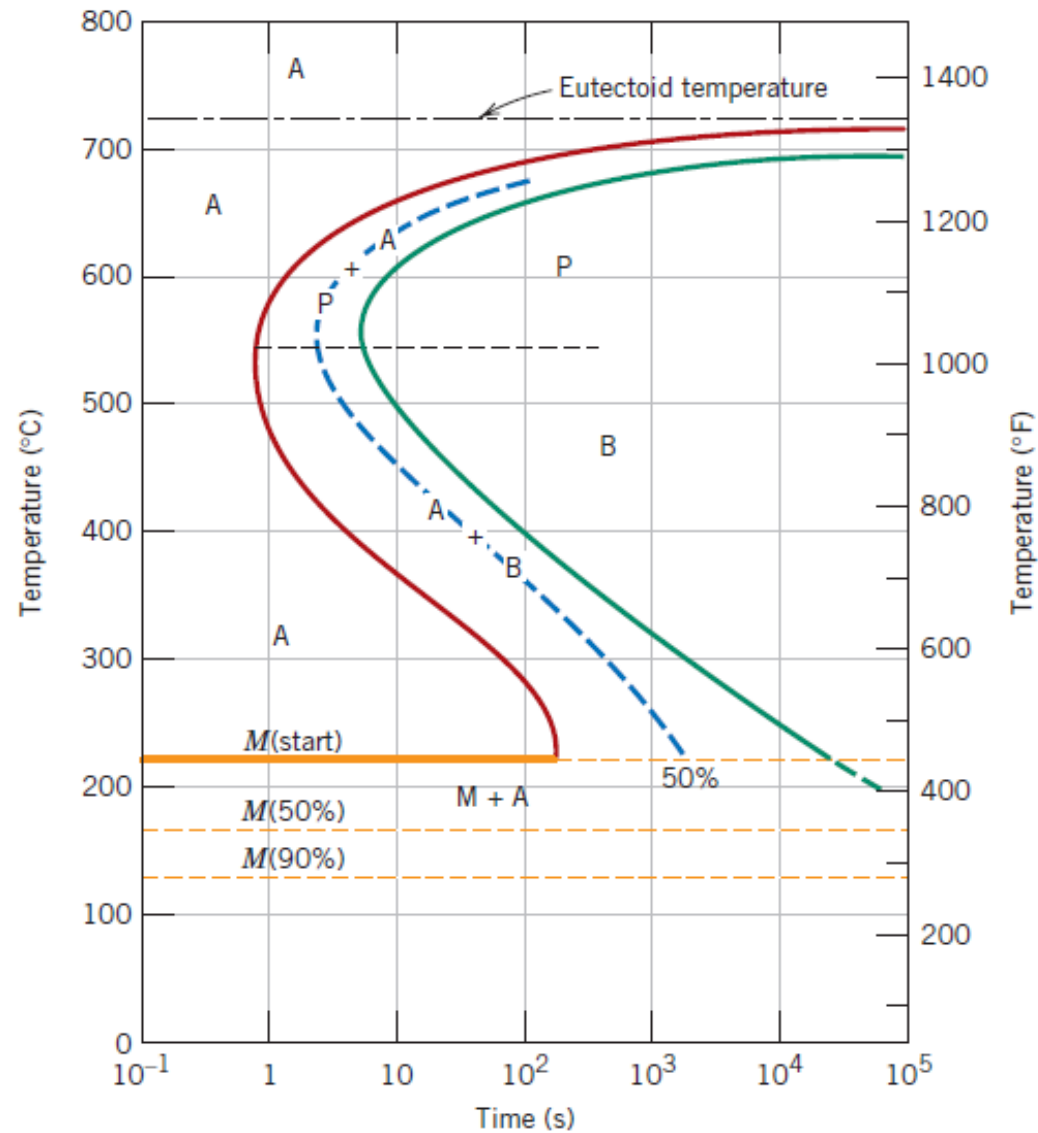


Exemplo de fase metaestável: Martensita



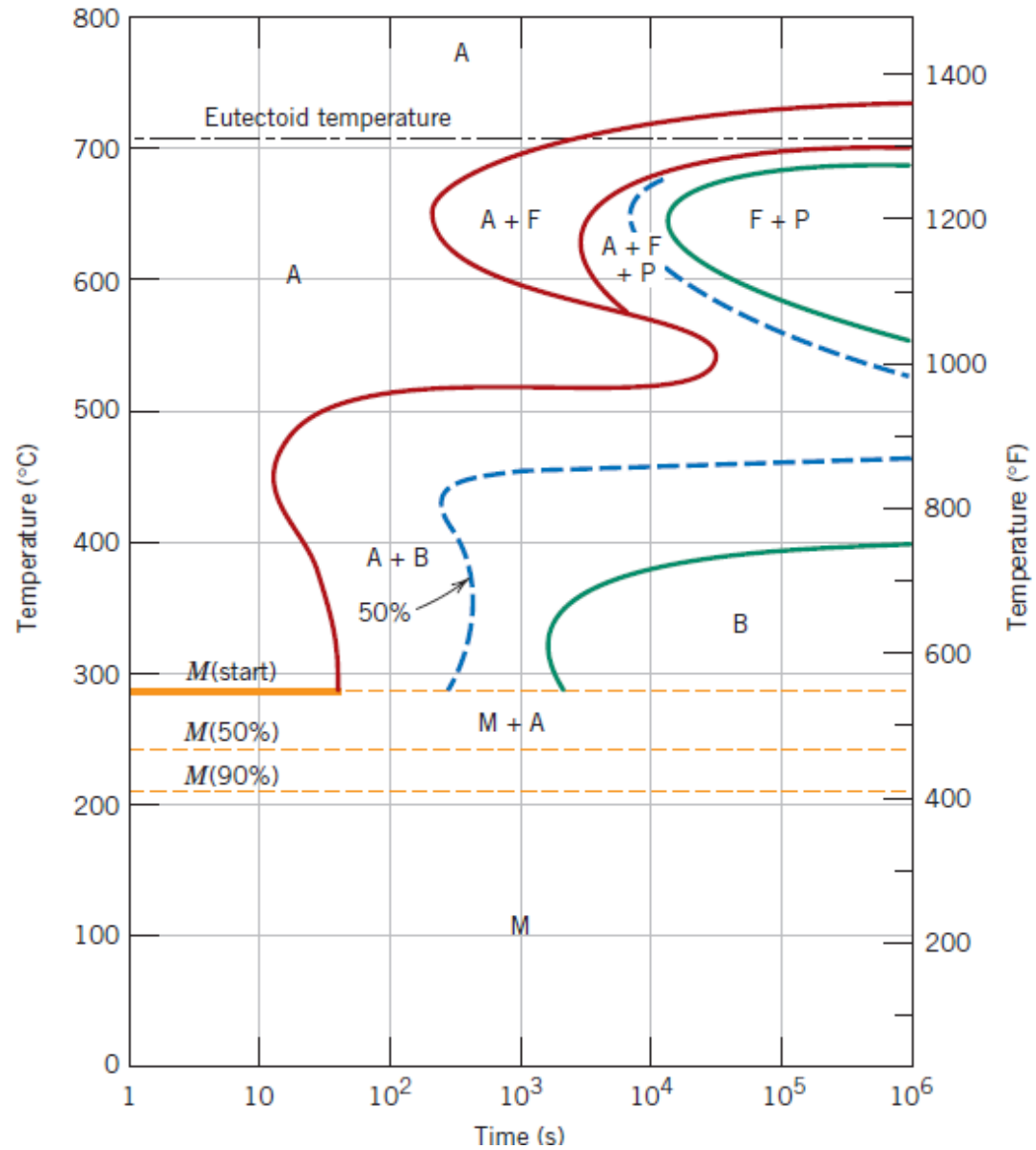
Exemplo de TTT

Aço AISI 1080

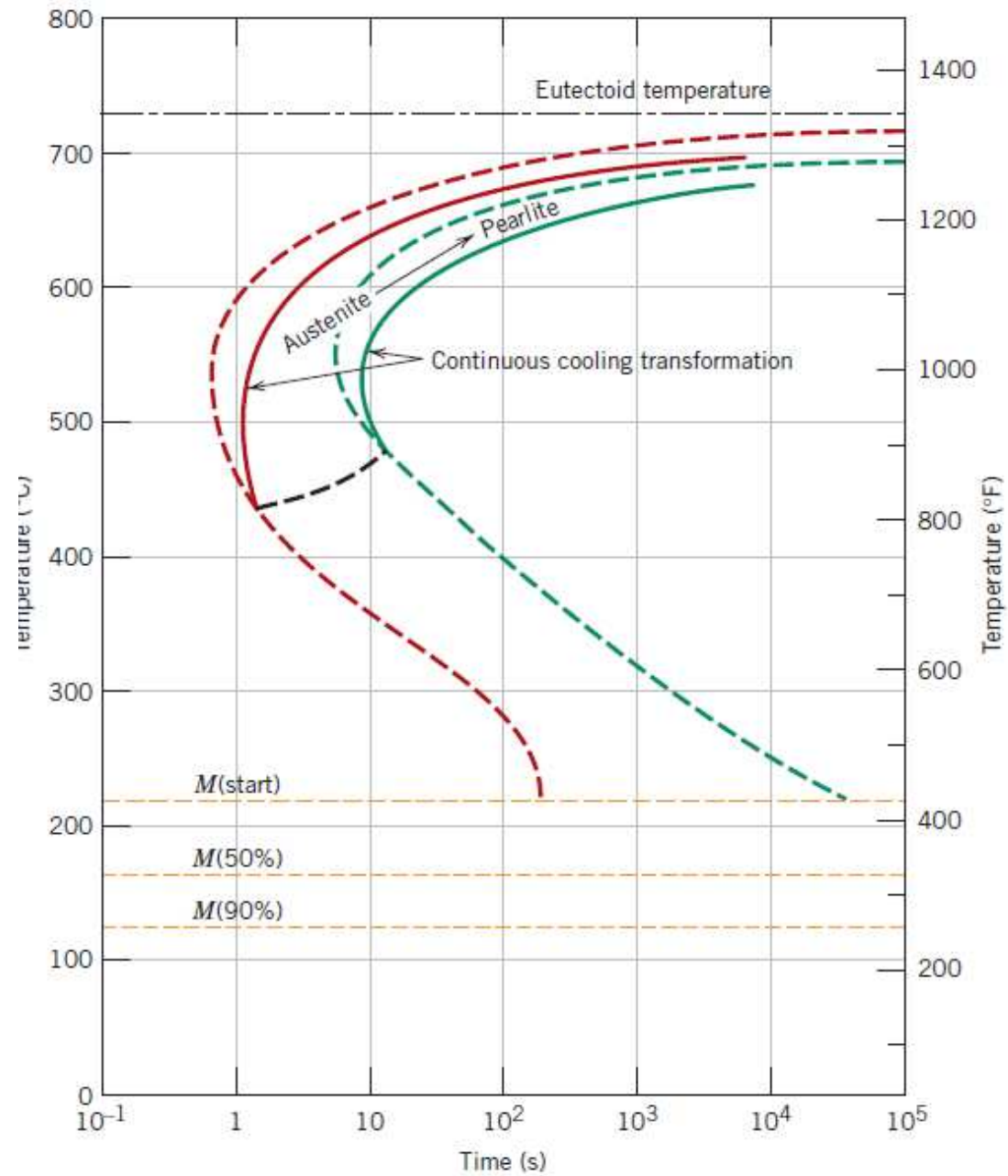


Outro exemplo

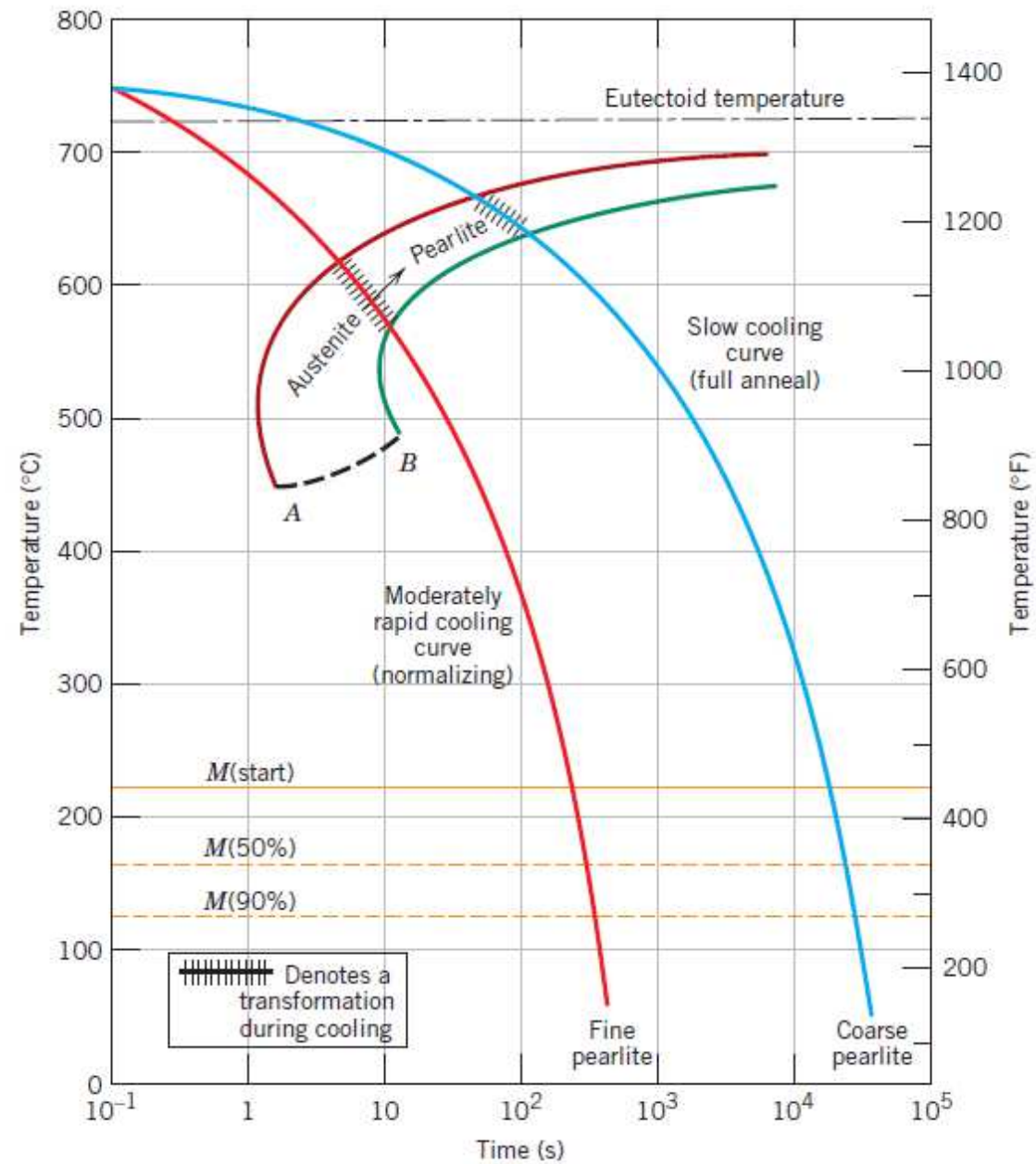
Aço AISI 4340



CCT



CCT



CCT

Aço AISI 4340

