Phase Transformation in Metals

MSE-S304

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Time-Dependent (Transient) Nucleation

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- ***Assumption:*** **Steady state concentration of embryos (Hetro- phase fluctuations) exist in the parent phase at all times.**

- **In most experiments, material is rapidly cooled from stable state at temperature T1 (higher than T0) to a metastable state at temperature T2 (lower than T0), where the transformation occurs.**

- **At temperature T2, initial embryo distribution of the second phase (at t=0) is then the same as their distribution at temperature T1.**

Time-Dependent (Transient) Nucleation

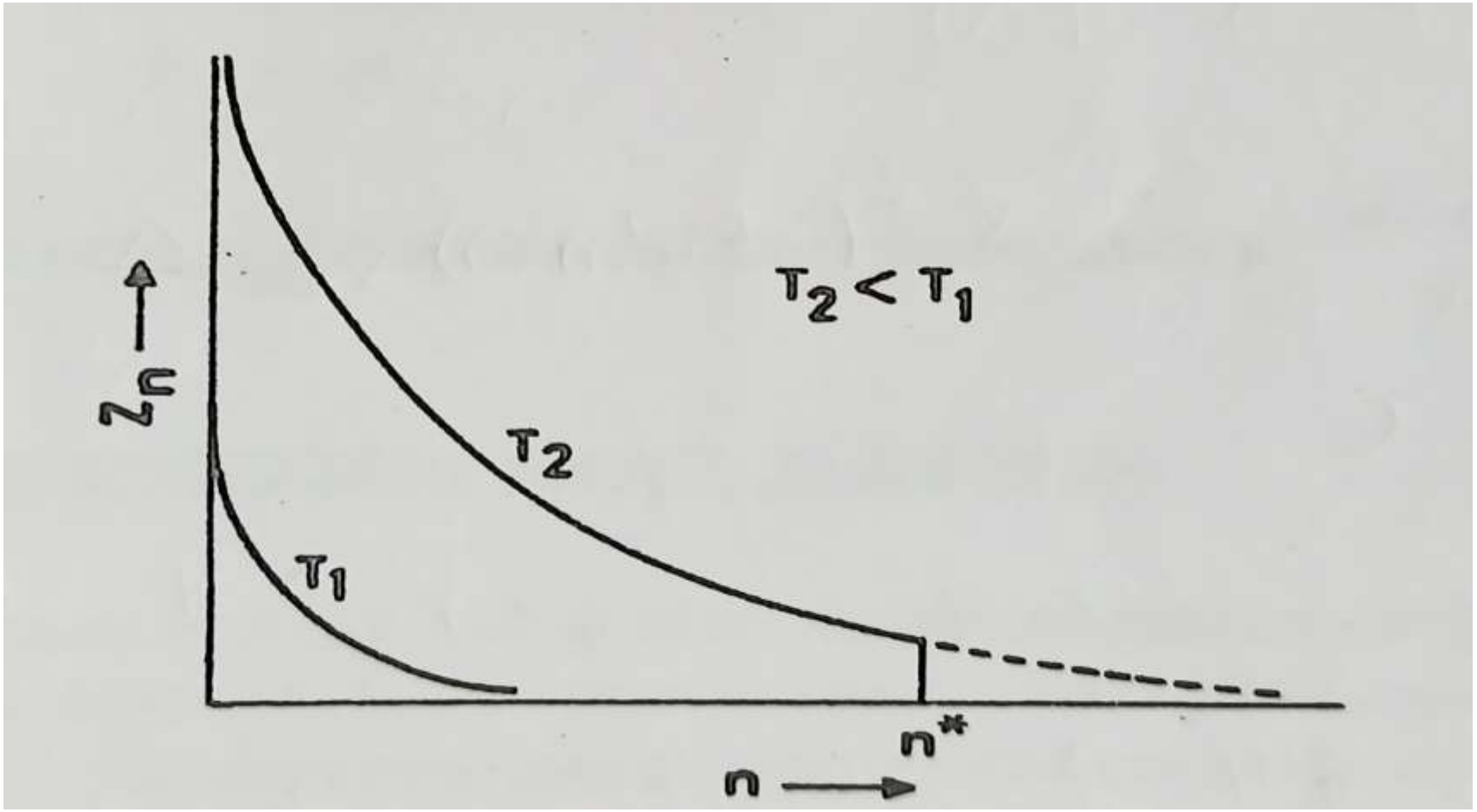
- *It takes some time before new equilibrium embryo distribution characteristic of temperature* ***T2*** *is established.*

- *During this transient period, nucleation rate of the second phase at* ***T2*** *would be* ***function of time.***

- *Concentration of critical embryos of size* ***n**** *for nucleation at* ***T2*** *is practically* ***zero*** *at* ***t=0.***

- *It corresponds to concentration of embryos of size* ***n**** *at* ***T1.***

Steady state embryo distribution of the product phase above T_1 and below T_2 the equilibrium transition temperature



Time-Dependent (Transient) Nucleation

➢**With time, it increases to its steady state concentration Zn* as:**

$$Z_n(t) = Z_{n^*} \exp\left(-\frac{\tau}{t}\right)$$

n* **-** ***Number of atoms in critical embryo.***

τ – ***Relaxation time for the process.***

τ = n*/ Dc

Dc – ***Analogous to diffusion coefficient.***

Time-Dependent (Transient) Nucleation Rate

$$I_t = I_h \exp\left(-\frac{\tau}{t}\right)$$

I_h – Steady state nucleation rate at T_2.

τ – Relaxation time for the process.

$\tau = n^* / Dc$

Dc – Analogous to diffusion coefficient.