

The Last Homework of the Year!

Homework 10
Due 2 December 2003

- 1 In order to reduce the sputtering yield of a Ti alloy, a thin layer (thickness $\ll R_p$) of carbon is deposited on the alloy before implantation with N to improve the alloy's wear properties.

Using the model of sputtering given in Chapter 9, give a physical explanation of how the carbon layer can reduce the sputtering yield of Ti.

Give an estimate of the maximum retained dose expected for pure Ti and for carbon coated Ti.

- 2 Using the thermodynamic equations for mixing:

$$D = D_0 \left(1 - \frac{2 \cdot \Delta H_{\text{mix}}}{kT} \right) \quad \text{and} \quad \frac{4 \cdot D_0 \cdot t}{\phi} = \frac{0.268 \cdot F_D \cdot r^2}{N \cdot E_d}$$

and assuming a deposited energy $F_D(E) = 4 \times 10^3 \text{ eV/nm}$, atomic density $N = 6 \times 10^{22} \text{ atoms/cm}^3$, displacement energy $E_d = 25 \text{ eV}$, and $\Delta H_{\text{mix}} = 90 \text{ kJ/gram-atom}$

What is the cascade temperature for $4Dt/\phi = 15 \text{ nm}^4$ and $\langle r^2 \rangle^{1/2} = 1 \text{ nm}$ and 5 nm ?

What is the cascade temperature for $4Dt/\phi = 30 \text{ nm}^4$ and $\langle r^2 \rangle^{1/2} = 1 \text{ nm}$ and 5 nm ?

- 3 For two Ni-Al compounds, the value of ΔH_{mix} in kcal/gram-atom is 7.1 for Ni_3Al ($n_c = 12$) and 12.2 for NiAl ($n_c = 8$).

Calculate the heat of mixing parameter Ω_H for both compounds

Calculate the bond enthalpy, H_{AB} between Ni and Al atoms

- 4 Calculate the mixing rate using the following equation

$$\frac{d(4Dt)}{d\phi} = \frac{K_1 \cdot F_D^2}{\sqrt[3]{N^5 \cdot \Delta H_{\text{coh}}}} \cdot \left(1 + K_2 \cdot \frac{\Delta H_{\text{mix}}}{\Delta H_{\text{coh}}} \right)$$

using the thermodynamic model for Ni/Al, Au/Ag, and Pt/Ti, assuming a deposited energy of $F_D = 500 \text{ eV/nm}$.