國立臺灣科技大學103學年度碩士班招生試題

系所組別： 材料科學與工程系碩士班丙組

科　　目： 材料導論

（總分為100分）

1. Calculate the bonding energy and bonding length of the $X^+ - Y^-$ by using the attractive and repulsive energies E_A and E_R as below

$E_A = \frac{-2.59}{r}$, $E_R = \frac{4.28 \times 10^{-5}}{r^{10}}$ **(10 points)**

(Note: unit of r is nm and unit of E_A and E_R are eV)

2. Element Platinum (Pt) is one of well-known materials for catalysts.
(1) Draw the schamitc diagrams and calculate planar densities (PD) for the three baisc planes of (100), (110) and (111) for Pt. **(15 points)**
(2) Based on the result of (a), please predict the surface energy order (from small to large) for these three planes and explain why. **(5 points)**
(3) As a materials engineer, please comment which plane (from (100), (110) and (111)) has the highest reactivity for catalysis applications. **(5 points)**
(Hint: Pt has the crystallographic structure of face centered cubic and atomic radius of 0.177nm)

3. The study of failure engineering is a very important for the field of materials scinece.
(1) Please point out the difference between trasgranular and intergranular fractures. **(5 Points)**
(2) Describe the structural changes for the fatigues of ductile metal after cyclic stresses **(10 Points)**

4. An *n*-type semiconductor has band gap energy (E_g) of 2 eV, donor level (E_D) of 0.05 eV and work function (ϕ_S) of 4 eV.
(1) Draw the energy levels of this semiconductor and the dependence of the Fermi energy (E_F) on temperature (T). **[5 points]**
(2) Draw the electron concentration versus temperature ($n_e - T$) curve of this semiconductor and mark different regions of electrical conductions. **[5 points]**
(3) Draw the energy band structures for rectifying contact and ohmic contact between a metal and this semiconductor. **[5 points]**
(4) Draw the current–voltage (I–V) curves for ohmic and Schottky contacts. **[5 points]**

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5. Addition of CaO to ZrO_2 forms a solid solution with cubic fluorite structure. We can write the defect reaction as

$$CaO(s) \longrightarrow Ca''_{Zr} + O_O + V_O^{\bullet\bullet}$$

(1) Give definitions of the three products in above reaction. **[5 points]**
(2) Write the defect reaction for the addition of Y_2O_3 to ZrO_2. **[5 points]**
(3) Why can the addition of CaO prevent crack of ZrO_2 during cooling? **[5 points]**

6. The Cu–Ag system is eutectic with maximum solid solubility of 8.8 wt% Cu (for Ag-rich alloy) and 8.0 wt% Ag (for Cu-rich alloy) at the eutectic temperature (779°C). The Si–Ge system is isomorphous. Diffusion couples were made by joining pure Cu to pure Ag and pure Si to pure Ge, respectively. The diffusion couples were held at 700°C for a length of time to allow some solid-state diffusion. Fick's first law of diffusion is $J = -D \cdot dC/dx$.

(1) Draw the concentration profile $C_{Ag}(x)$ for the Cu–Ag diffusion couple. **[5 points]**
(2) Draw the concentration profile $C_{Si}(x)$ for the Si–Ge diffusion couple. **[5 points]**
(3) Derive Fick's second law of diffusion. **[5 points]**