國立高雄大學 102 學年度研究所碩士班招生考試試題

科目：材料科學導論
考試時間：100 分鐘

系所：化學工程及材料工程學系（乙組）
本科原始成績：100 分

是否使用計算機：是

A. **<Crystal Structure> (20%)**

Si belongs to diamond crystal structure.

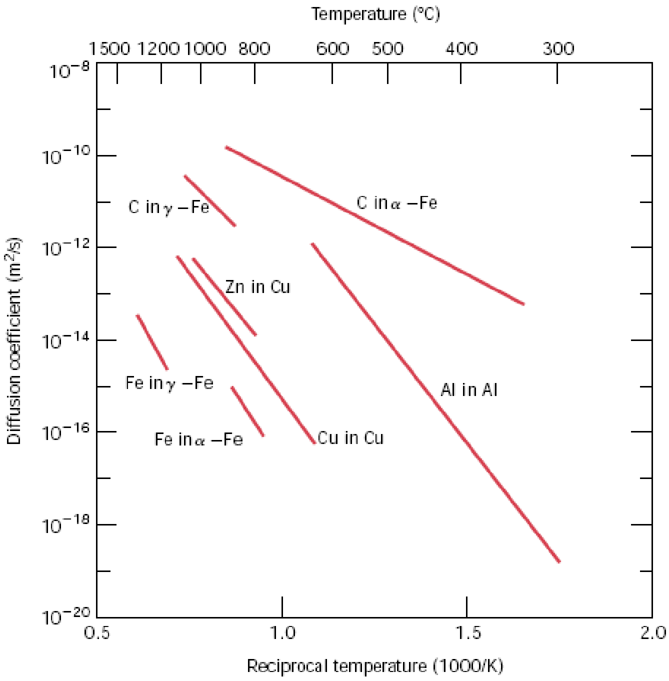
A-1. Plot and explain the unit cell of the diamond structure, and calculate the atomic density in single-crystalline Si (unit: number/cm^3) (Hint: lattice constant of Si = 0.543 nm)

A-2. Calculate the atomic packing factor (A.P.F.) of diamond structure.

A-3. If a XRD pattern of a Si wafer shows only a diffraction peak at 69.5 degree (2θ), identify the possible corresponding diffraction plane (wavelength of X-ray used is 0.154 nm). Besides, why the (100) and (200) peaks are not present on the XRD pattern? (Hint: sin 69.5° = 0.937, sin 34.75° = 0.569)

B. <Diffusion> (10%)

B-1. The figure shows a plot of the logarithm (to the base 10) of the diffusion coefficient versus reciprocal of absolute temperature for several metals. Determine the values of the activation energy and the preexponential for diffusion of C in α-Fe. (Hint: R = 8.314 J/mole·K; lnD = 2.3 logD)



C. <Phase Transformation> (25%)

C-1. Plot the Fe-Fe_3C phase diagram; describe the phase transformations for eutectic, eutectoid, peritectic reactions and the corresponding temperatures and compositions

C-2. Estimate and plot the microstructure of an eutectoid steel upon very slow cooling from 1000℃ to 726℃ (the temperature just below eutectoid temperature). Calculate the weight fraction of each phase and describe their compositions. (Assume the cooling rate is slow enough so that the phase transformation can reach equilibrium. The solubility limit of C in Fe is about 0.022 wt.% at 726℃.)

C-3. Plot the isothermal transformation diagram for an iron-carbon alloy of eutectoid composition. Plot the time-temperature paths to show how the structures of (a) 100% Pearlite, (b) 50% Pearlite & 50% Bainite, and (c) 100 % Martensite can be generated, respectively.

D. <Glass, Ceramics> (10%)

D-1. What are the differences between glasses and ceramics? Plot the specific volume vs. temperature curves of crystalline and non-crystalline materials, respectively, and explain their behaviors and related mechanisms involved.

D-2. What is the definition of glass-ceramic? Describe their characteristics of structures and properties. Plot a continuous cooling transformation diagram to show how they can be prepared.

E. <Physical Properties> (25%)

E-1. Carrier concentrations and carrier types of semiconductors can be changed by doping. Explain how to use the Hall measurement to obtain carrier concentrations and determine p/n types of semiconductors. Explain the mechanisms involved from the viewpoint of material physics.

E-2. Si is a semiconductor with the energy band gap of about 1.1 eV. What wavelength ranges of light will be absorbed by Si? The band gap is dependent on physical size or strain involved inside the sample. Propose a method to determine band gaps of semiconductors. Explain the mechanism involved.

E-3. Why Si is not a good light-emitting material? Explain the reasons by the energy band diagram.

F. <英翻中> (10%)

Materials science: The road to diamond wafers

Diamond could rival silicon as the material of choice for the electronics industry, but has been held back by the difficulty of growing large enough wafers. This problem may now be solved.

Diamond is the king of gemstones. Less well known is that it could also be an outstanding semiconductor material, superior in many ways to silicon, which is currently the most widely used electronic material. Diamond devices could operate at higher temperatures (more than 400°C) and higher power than those of silicon, as well as being faster, denser and more resistant to radiation. But practical diamond electronics will need large-area, single-crystal diamond wafers to be fabricated, analogous to the 6–12-inch silicon wafers commonly used in the semiconductor industry. Two papers from Golding and colleagues now show that this may be possible if sapphire wafers are used as substrates on which to grow the diamond. (*Nature 424, 500-501 (31 July 2003)*)