國立清華大學 102 學年度碩士班考試入學試題

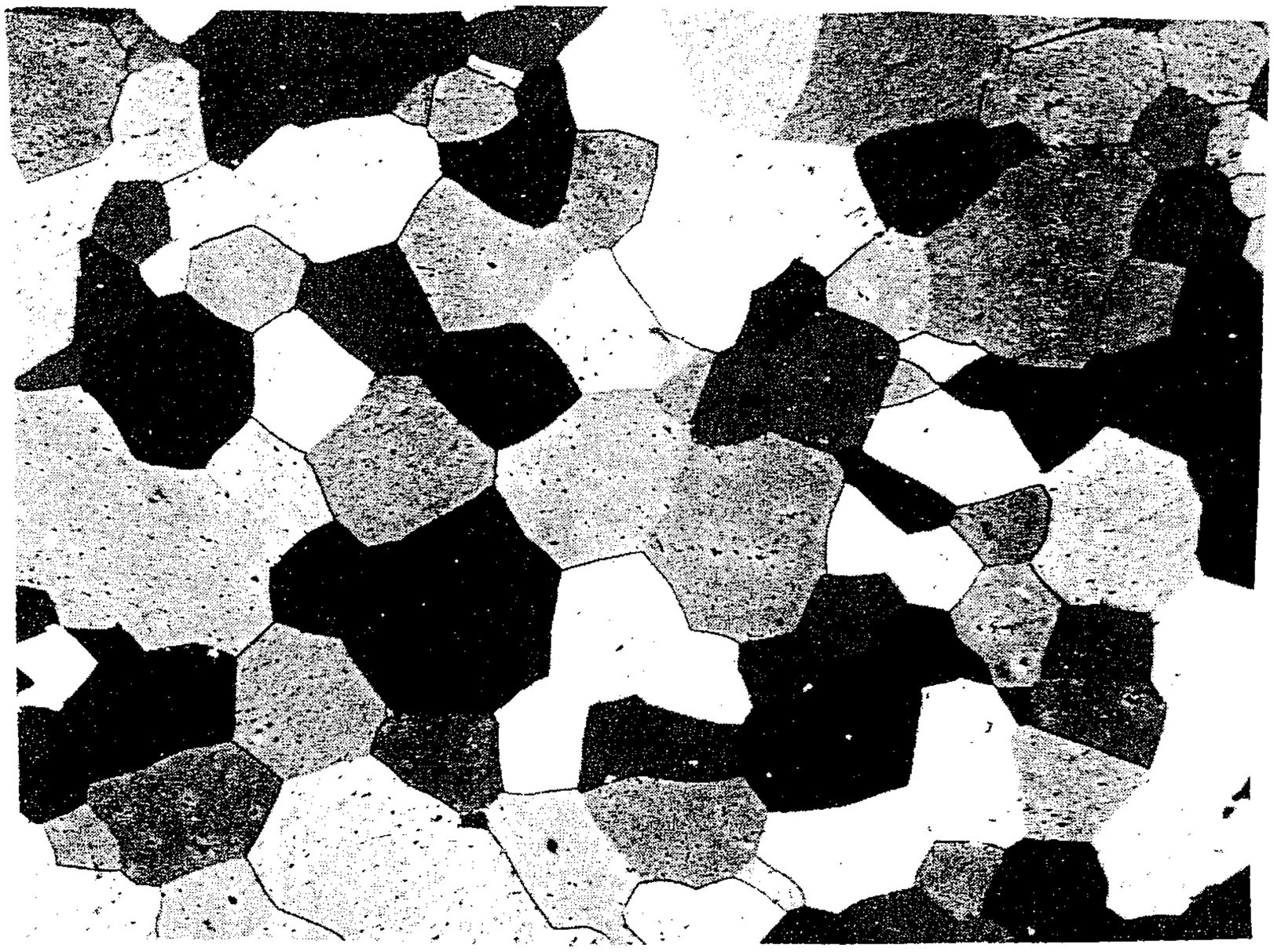
系所班組別：工程與系統科學系碩士班甲組、核子工程與科學研究所甲組(工程組)

考試科目（代碼）：物理冶金 (2501) (2705)

Physical Metallurgy MS Entrance Examination

1. (a) Please draw an engineering stress-strain curve and a true stress-strain curve for a polycrystalline fcc metal. (b) Derive the Considere's Criterion and to address the importance of this criterion. (c) A typical cross-head speed in a tensile testing machine is 5 mm/min. What is the nominal engineering strain rate imposed by this cross-head speed on a typical engineering tensile specimen with a 50 mm gage length? (d) Estimate the dislocation velocity that would be obtained at this strain rate in an iron specimen with a dislocation density of 10^{14} m/m^3. Assume that the Burgers vector of iron is 0.248 nm. (e) If in a very slow tensile test a strain-rate of 10^{-7} sec^{-1} is used, what dislocation velocity would be expected in the above iron specimen? (15%)

2. Please (a) Calculate the average grain size of this photograph which is a commercial austenitic stainless steel specimen photographed with polarized light at magnification of 400X. (b) What is the ASTM Grain-Size Number of this specimen? (10%)



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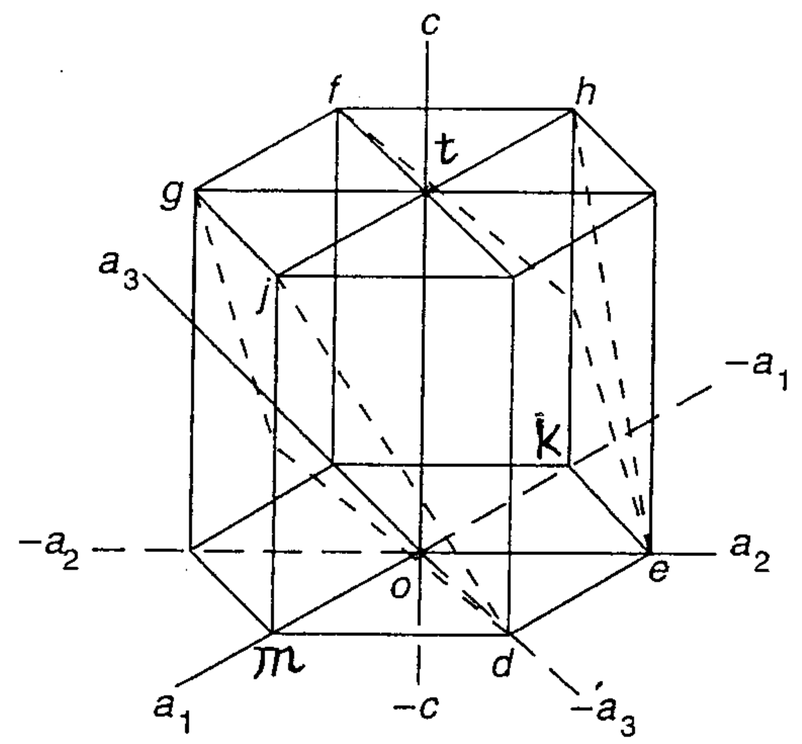
3. Assume that a spherical precipitate particle forms in an aging hardening alloy and that the volume free-energy change associated with the formation of the particle is 62 MJ/m^3. The energy of the interface between the particle and the matrix is 0.42 J/m^2. (a) Please determine the critical radius r_0 and the free-energy change at that radius ΔG_{r0}. (b) Please draw the free energy of a particle as a function of its radius. (c) If the precipitate has a total volume fraction of 1.5% and the particles are all of the same size r = 2 r_0, compute the number of particles per cubic meter. (d) Compute the total change in free energy due to the formation of all the precipitate particles in a cubic meter in (c). (e) It is known that the Orowan mechanism can be expressed as: σ (Mpa) = $5.9f^{1/2}/X\ln(X/b)$, where b=0.25 nm (Burgers vector), X is the particle diameter, f is the volume fraction of precipitate, please calculate the Orowan stress for this material. (20%)

4. (a) It has been estimated that the enthalpy for the formation of self-interstitial atom in Cu is about 385 kJ/mol. Compute the equilibrium concentration of these interstitial atoms in Cu at 800 °C. (b) The activation enthalpy for the movement of the self-interstitial atoms in Cu is believed to be about 9,640 J/mol. Estimate the jump frequency of these interstitials at 800 °C. (c) Determine the vacancy concentration of each element at its melting point as follows: Al, 0.76 eV, 660°C; Cu, 0.90 eV, 1083°C; Ni, 1.4 eV, 1453°C. (d) Determine the jump rate of Cu both at 25 °C and 1083°C, respectively. (H_m=121KJ/mol.) (e) There is some evidence that the vacancy concentration at the melting point may become so large and the jump rate so high that it is no longer possible for a macroscopic crystal to exist. Do the results of this problem support this view? Explain. (15%)

5. a) Briefly state the Wechsler, Lieberman, and Read theory. (b) Why martensite transformation is said to be an "athermal" transformation. (c) Describe the basic differences between the In-20%Tl alloy and the Fe-30%Ni alloy systems. (d) Draw a diagram of martensite transformation and mark the M_s,M_f,A_s,A_f,M_d,A_d, and define these terms for Fe-30%Ni system. (e) What is the effect of stress on martensite transformation. (15%)

6. Please determine the Miller indices of the following planes and directions.
(a) Planes ***defg***, ***dehj***, and ***dkfj***. (b) directions ***dt*** and ***fm***. (15%)



7. Lichen did a TEM examination on a Ni-5.5 wt% Al alloy which is strained 2.7% at 293 K and obtained the following picture at magnification of 37,500X. Please estimate the dislocation density of this material. （Assume the thickness of the TEM specimen is about 100 nm.）(10%)