國 立 清 華 大 學 命 題 紙

95 學年度 工程與系統科學 系（所） 甲 組碩士班入學考試

科目 物理冶金 科目代碼 3301 共 2 頁第 1 頁 *請在【答案卷卡】內作答

1. Answer the following questions:

(a) As you have learned in your physical metallurgy class, diffusion rate in solid may be different through different path. Give the order of diffusion rate in the following three paths: lattice, surface, and grain boundary. (2%)

(b) Diffusion rate is a thermally activated process. What is the dependence between diffusion rate and temperature? Write down the Arrhenius equation of diffusion rate vs. temperature. (3%)

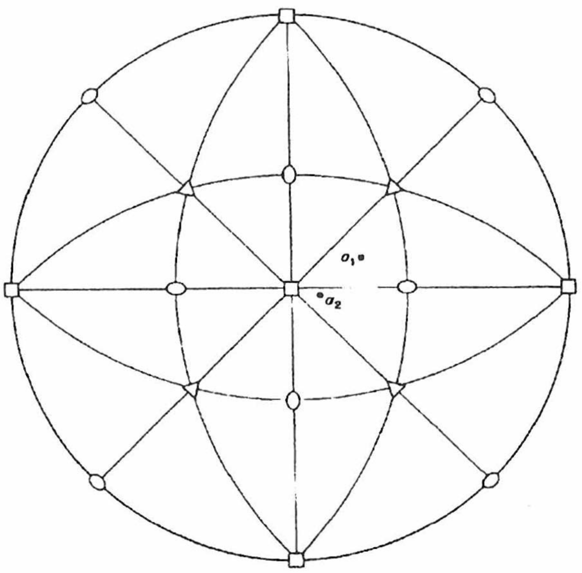
(c) Theoretically the activation energy of an Arrhenius type reaction can be obtained from Arrhenius plot. What is the meaning of activation energy? Draw an Arrhenius plot and describe how to obtain activation energy of a reaction from experimental data. (10%)

(d) Which diffusion rate is faster, interstitial diffusion or substitutional diffusion? Explain the reason. (5%)

(e) Based on your argument in (d) explain why secondary hardening of high speed steel occurs at about 500°C. (5%)

2. Figure 1 shows a (001) standard graphic projection for a cubic crystal. If an fcc single crystal is strained at a_1 and a_2 direction, where a_2 is a direction close to [001], and a_1 is a direction at the same angle with [001], [101], and [111].

Figure 1

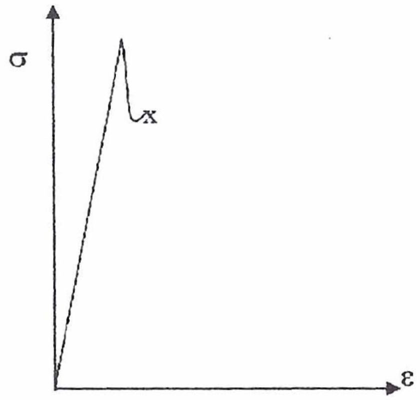


(a) Draw the schematic stress-strain curves for the specimens strained at a_1 and a_2, respectively. Explain the deformation processes related to dislocations during the tension of the specimen. (5%)

(b) If the tensile axis is along a_1, which slip system is the primary slip system? Which one is the conjugate slip system? What is the final tensile axis direction? (5%)

(c) If the specimen is a bcc single crystal, what will be the differences of the stress strain curve when strained at a_1 and a_2, respectively, compared with the behavior of an fcc single crystal. Explain the reasons. (5%)

3. A graduate student performed a tensile test on a "binary metal alloy", and found the first part of a stress-strain curve:



The test was stopped abruptly at 'x', and the specimen had **not** fractured and was in fine shape. There is nowhere to determine the structure of the specimen due to no available resources (i.e., no microscopes, analytical equipment, X-ray machine, etc.); all he really had was the tensile test machine. Based on the physical metallurgy principles, the student suggested two possibilities for the stress drop: 1) The stress drop results from twin formation 2) The stress drop results from breakaway of dislocations from solute atmospheres.

Propose a simple experiment, without using any instrument other than tensile machine, which would allow him to unambiguously determine whether event (1) or (2) from above has occurred. (20%)

4. When edge dislocations form a low angle boundary, the misorientation is a function of their spacing, d: $\theta = b/d$, where b is the Burgers vector and θ is the misorientation. The energy of such a stack of dislocations is: $E = \frac{\quad}{4\pi(1-\nu)}\theta$, where μ is the shear modulus and ν is the Poisson's ratio.
(a) In the "second stage" of polygonization, low angle boundaries combine. Calculate the energy change when two low-angle boundaries, each with a misorientation of 5°, combine into one, using the above equations. (10%)
(b) On the basis of your calculation in (a), identify the driving force for coarsening of the subgrain structure in the second stage of polygonization. (10%)

5. By adding alloy elements, a new Fe-C-based alloy is produced. Similar to the conventional Fe-C alloy, the alloy can be quenched to a Martensitic state; however, it is strange that in this state the alloy is rather weak. Further examination showed that the martensite is not BCT Martensite, but rather has a nearly ideal FCC structure. Since the structure of material will certainly affect the properties, the strengthening mechanisms of FCC martensite are different from BCT martensite. Describe the strengthening mechanisms that normally operate in BCT Fe-C Martensite, and on this basis, explain why the new FCC Martensite is not so strong. (20%)