EXAM: Course Physical Materials Science
April 3rd 2014; 9.00-1200h, 5118.-156

Please mention your name + student number on each page, insert page numbers and write on page #1 the total # of pages submitted.

(total: 10 pts)

-1- Concepts (1 pt)

Summarize in *a concise way* the following concepts:
(a) Lomer lock
(b) Shockley partial dislocation
(c) Σ– grain boundary
(d) Hall-Petch relationship
(e) diffuse force fields
(f) twinning in bcc
(g) Frank-Read source
(h) slip system in Si
(i) Kear-Wilsdorf lock
(j) stair rod dislocation

- 2- Dislocations: General (2 pts)

(a) What are the assumptions in the mathematical derivation of the displacement fields of an arbitrary stationary lattice dislocation in an infinite anisotropic linear elastic continuum?

(b) How many stress components are present of an edge dislocation in an infinite isotropic linear elastic continuum? Give an explanation.

(c) How can you measure experimentally the total dislocation density and what about the mobile dislocation density?

- 3- Interactions among dislocations (2 pts)

(a) Two edge dislocations of opposite sign having the same line sense lie on parallel slip planes. Describe the interacting force as a function of the distance between the two dislocations (isotropic linear elasticity).

(b) Describe the interacting force as a function of the distance between the two parallel screw dislocations with the same line sense (isotropic linear elasticity). Show that two pure screw dislocations (same line sense) making an angle of 45^{o} with each other (i.e. *non-parallel and non-coplanar*) do not repel or attract each other (isotropic linear elasticity).

(c) Discuss the situation in physical terms (not mathematical) when 2 superlattice extended edge dislocations in an ordered $A_3B/L1_2$ alloy (f.i. Ni_3Al) approaches perpendicularly a twist grain-boundary.

-4- Dislocations and interfaces (2 pts)

(a) Derive an expression of the interface energy of a semi-coherent interface as a function of the misfit strain between two dissimilar materials having lattice parameters a_1 and a_2, and shear moduli μ_1 , μ_2 , respectively.

(b) On the level of specific interface dislocations, the interface of (a) consists of an *infinite* array of Frank partial interfacial dislocations (see Figure 1-A below).

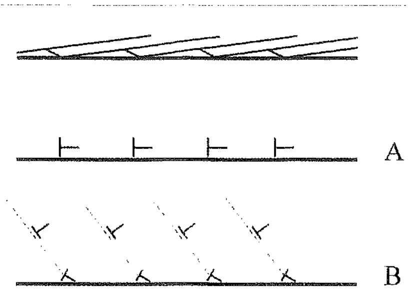

Figure 1

Describe in physical and in mathematical terms the interactions among the interface dislocations as a function of the mutual distances along the interface. Consider also the case that the *infinite* array of Frank partial dislocations has been split into stair-rod and Shockley partials(Figure 1-B). Describe the interactions again but now only in physical terms using Thompson notation.

-5- Dislocations and point defects (2 pts)

(a) Describe in mathematical and physical terms the interaction between an impurity and a stationary edge dislocation as a function of the difference in size of the impurity with respect to the size of the matrix atoms (isotropic linear elasticity).

(b) Consider the *total climb force* when a stress σ_{xx} is acting over the core of an edge dislocation (see below Figure 2 A). What is the *total force,* in the presence of both an applied stress σ_{xx} and a vacancy concentration c that is different form the standard-state concentration c_0 ? Then, show that the local equilibrium concentration of vacancies near the dislocation core can be described by :

$c = c_0 e^{\frac{\sigma_{xx} v_a}{kT}}$ where v_a is the atomic volume.

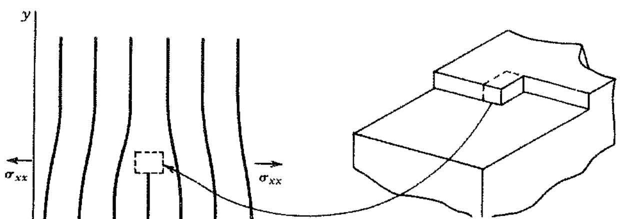

Figure 2 A

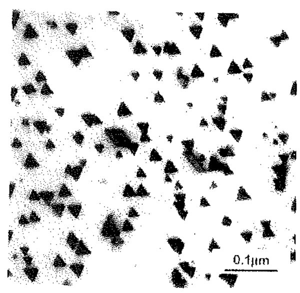

Figure 2 B

- 6- Dislcoation loops (1 pt)

Explain in Thompson notation the occurrence of tetrahedral (stacking fault) defects in quenched gold (see above, Figure 2 B).