A Study Guide to FMS Exam III

Fundamentals of Materials Science

Spring, 2017

Study Guide for Exam III

Fundamentals of Materials Science, Spring, 2016

The following review guide serves as a general learning objective, most of which will be included in the exam. This guide may not include all the details that you are expected to master to get a high score, so please review the lecture notes carefully so that you will be able to complete Problems I~V in the exams. Problems VI, as usual, will be largely dependent on homework assignment for the chapter of *Imperfections in Solids* and the chapter of *Dislocation and Strengthening Mechanism* of our textbook.

Exam Date: May 3, 2017
Exam Time: Regular lecture hours

Imperfections in Solids

1. Important concepts. See the end of the chapter in your textbook.
2. What kinds of defects belong to each category? Such as dislocation belongs to linear defect.
3. What is a vacancy and self-interstitial? Which one has lower energy of formation and why?
4. Calculate the equilibrium number of vacancies in a material at specific temperatures, given the relevant constants.
5. What is the definition of alloy?
6. Name the two types of solid solution. What is solubility limit? What are solute and solvent?
7. What are the factors of high solubility in substitutional solid solution and interstitial solid solution?
8. You need to know how to calculate concentration both in weight percent and atom percent. You also need to know how to do the conversion between atomic and weight percent.
9. Know various concept related to edge dislocation and screw dislocation, such as dislocation line, dislocation core, etc.
10. How to determine the magnitude and direction of Burger's vector? What is the relationship between Burger's vector and dislocation line for each dislocation type?

11. Dislocation basics as delineated in the lecture notes.
12. Understand different planar defects, such as grain boundary, tilt boundary, twin boundary, etc. Be able to recognize what defects are from schematic drawing. Describe the atomic structure within the vicinity of a grain boundary, and a twin boundary.
13. Microscopic techniques including optical, scanning electron and transmission electron techniques. Know their magnification. Understand the grain boundary features under optical microscope.
14. By what means do people observe dislocation?

Deformation and Strengthening Mechanisms

1. Important concepts. See the end of the chapter in your textbook.
2. Describe the motion of both edge dislocation and screw dislocation with respect to the direction of applied shear stress.
3. How do edge and crew dislocation move at an atomic level?
4. What is defined as dislocation density? Know approximately the order of magnitude for several metals after certain deformation or heat treatment process.
5. Understand dislocation strain fields, dislocation interaction, and dislocation multiplication. Where are the sources for dislocations to multiply? How do dislocations interact for the same sign and different signs?
6. What is called a slip system? What are the typical slip systems for BCC, FCC, and HCP metals? Why FCC/BCC metals are more ductile than HCP metals?
7. What is defined as resolved shear stress and the critical resolved shear stress? What is Schmid factor? Know how to calculate the critical resolved shear stress under an external applied stress.
8. Know the difference between slip in single crystals and slip in polycrystals.
9. What are the three ways to strengthen metals? What are the key ideas of each strengthening method?
10. Why a metal having small grains is stronger than on having large grains?
11. Where do impurity atoms tend to stay in the crystal lattice with dislocation defects? Why do they want to stay there?
12. You should be able to use Hall-Petch equation to do some related calculations. What is Hall-Petch equation all about?
13. For different strengthening methods, do they increase the strength of the metals while at the same time reduce the ductility? Are there exception?

14. What is another way to express the degree of deformation in addition to strain? Percent cold work!
15. What happened during recovery, recrystallization, and grain growth, both in microstructure and mechanical properties? What are the purposes of recovery and recrystallization?
16. What is recrystallization temperature? Usually how high is this temperature? What is the relationship between crystallization temperature and deformation?
17. What are the driving forces for recrystallization and grain growth?
18. During grain growth, what are the directions for atomic diffusion and grain boundary motion?