MSE250 Overview / Review

Updated October 8, 2011

Bonding

Do you understand how to deduce the type of bonding present in a given material?

How is a material’s bonding energy diagram related to properties such as strength, thermal expansion, melting point, and density?

Crystals

- symmetry

  Can you visualize the packing of circles in various crystal directions/planes for FCC and BCC?

  Can you derive the relationship between the lattice parameter, *a,* and the radius of close-packed circles, *r*, for various crystal structures?

  What is polymorphism?

- “navigation”

  Can you determine crystal directions and Miller indices of crystal planes? [Remember to indicate the origin you are using!]

  [direction] <family of dir.’s> (plane) {family of planes}

- packing

  What does “close-packed direction” mean?

  Can you estimate of the planar density of atoms on a crystal plane just by looking at their packing?

  [Remember not to use the definitions of linear and planar density given in the book, but those given in lecture!]

- defects
  - point

    What are 3 kinds of point defects?

    What is the Arrhenius equation, and what does it represent?

    How do you determine the solubility of two materials?

  - line (a.k.a. dislocations)

    What is a Burgers vector? What does it represent, and how is it oriented in the 3 line dislocation systems (edge, screw, mixed)?

  - surface

    Given two surface crystal orientations, which would have a higher/lower surface energy (i.e. which surface would it be easier/harder to remove an atom)?

  - grain boundary

    What is polycrystallinity?

    How do the 4 defect types compare with each other energetically?

Diffusion

What are Fick’s first and second laws, and when is it appropriate to use each?

Where does temperature come into the equations?

What are some processes seen in the class where diffusion occurs?

Are you solving problems efficiently, especially for second-order non steady state questions? Often, the question can be simplified greatly by gathering all constants together and equating the remaining variables (e.g. $D_1t_1 = D_2t_2$).

Mechanical Properties

- definitions

Can you define all these terms concisely and completely, and give their significance? Utilize the σ-ε graph, but also explain physical mechanisms like slip and bonding (bond energy diagram!).

- Stress
- Strain
- Elastic vs. plastic deformation
- Elastic recovery
- Yield strength
- Ultimate tensile strength / necking
- Fracture
- Ductility / brittleness
- Toughness
- Hardness
- Modulus of resilience (J/m^3, energy density!)
- Poisson's ratio

For common metals like aluminum or steel, what are ballpark values for the terms above which are intrinsic properties?

When asked to solve for change in length/thickness upon loading, make sure that you are checking that the applied stress is less than σ_{yield}, or else it is very *wrong* to use the equations given for the elastic region.

- factor of safety

Most real materials are designed such that their yield strength is 3 to 5 times larger than the loads they are typically subject to; this guards against unwanted plastic deformation.

- plastic deformation
  - slip

Can you write the complete logic flow of how to define the critical resolved shear stress of a material? (Remember: it is a material property, just as much as the yield stress or ductility)

Can you **quickly** (in under 5 seconds) visualize the common slip systems (i.e. the densest planes and the closed-packed directions) for FCC, BCC, HCP, and simple cubic?

If one were to calculate the strength of a perfect crystal, how would this compare to the strength of an imperfect (real-life) crystal with defects? Physically explain this discrepancy (think of how many bonds need to break to cause a shirt of atoms in the two cases).

What are the stress fields above and below an edge dislocation?

	What is the energy/stress required to move a dislocation line proportional to?
- twinning	What is twinning? Compare it with slip.
Strengthening	How does each of the three strengthening methods hinder dislocation motion? Draw pictures of each process.
	How does hindrance of dislocation motion relate to material properties (yield strength, ductility, toughness, ultimate tensile strength)?
- Heat treatment/ annealing	What is the difference and relative effect of recovery versus recrystallization?
	Why is cold work necessary for recovery or recrystallization to occur?
	Draw the morphology of a polycrystalline material after it has been cold hardened, and after various times and temperatures of recrystallization. Explain the mechanisms that are occurring in each step of the process using terms given in class.

General comments

This review guide does not cover equations or example problems in homework/class, but should prepare you well for understanding all the concepts needed in this course; consult your other study sources for the "complete picture". Questions appearing on the quiz will not be asked again in the exam – at least, not in the same form.

The first exam will take place in class next Friday, October 14. It will be closed-book, closed-notes. You will be provided with an equation sheet at the exam. A calculator is allowed.

The significance of study sources, with the most important being first, should be:

Lecture notes
Quiz / homework
Discussion handouts
Textbook

Here's a nice practice exam I found. You should be able to answer everything; solutions are provided!
http://oregonstate.edu/instruct/engr322/Exams/Previous/S09/ENGR322MT1.html

Email me at tanaaron@umich.edu regarding questions or to set up a meeting time/place. Good luck!