Department of

MATERIALS SCIENCE AND ENGINEERING

Doctoral Written Exam

Day 1

Core Areas:

MATERIALS PHYSICS AND CHEMISTRY
ADVANCED MECHANICAL BEHAVIOR

Thursday, May 24, 2007

Department of Materials Science and Engineering

DOCTORAL WRITTEN EXAM – Day 1
May 24, 2007

Your exam packet for day I contains a total of six (6) questions from two (2) core areas, MATERIALS PHYSICS AND CHEMISTRY and ADVANCED MECHANICAL BEHAVIOR, plus 10 answer sheets. Each question is on a separate page. A copy of the Table of Constants is included for your reference. **You must submit 2 questions from each core area for grading**. You will have 4 hours to complete the questions. You can obtain extra answer sheets from the proctor, if needed. Please use the following procedure:

Write a four (4) digit code of your choice, and your name on the 3 X 5 card provided. Use this code in place of your name to identify all answer sheets you submit for both days of the exam. Renee will keep the code information, sealed in an envelope, until after the exams are graded.

For each answer, use the question sheet as the first page of your answer. If additional pages are required, use the blank answer sheets provided. At the end of the examination, staple each question sheet and corresponding answer sheets for each question separately, put this instruction sheet on top of the questions you are turning in, and place them in one side of your exam folder. Place all other exam pages in the other side of your folder, and return everything to the proctor, or Renee if you finish before 1:30 P.M.

Please be sure to complete the information required on each page.

GOOD LUCK!

CODE NUMBER ________________

CHECK THE 4 QUESTIONS YOU WISH TO HAVE GRADED.

MATERIALS PHYSICS AND CHEMISTRY:	ADVANCED MECHANICAL BEHAVIOR:
1. ____	4.____
2. ____	5.____
3. ____	6.____

Day 1 – MATERIALS PHYSICS AND CHEMISTRY **CODE #________**

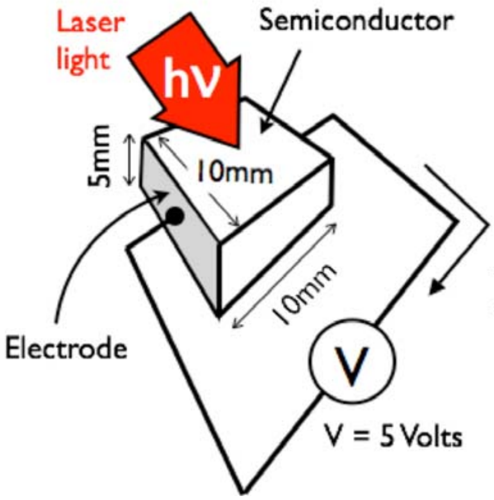
1.

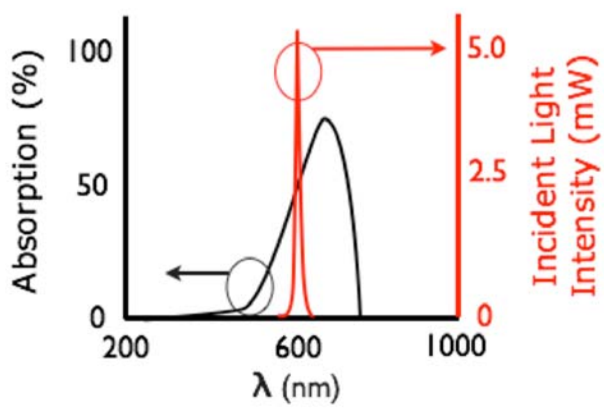
An experiment with a slab of pure material is illustrated below, along with the results. If the carrier lifetime is 100 picoseconds and the effective electron and hole masses are both $0.5 \cdot m_e$, use the Drude model to calculate the following:

A. The steady state photogenerated carrier densities, *n* and *p*

B. Electrical current, *I*

C. The electrical current through the slab at room temperature, in the dark.





2.

a) Calculate the Fermi energy of a monotomic, body-centered cubic crystal from Group I of the periodic table, with 0.2 nanometer distance between nearest neighbors.

b) Calculate the Fermi energy of a monotomic, face-centered cubic crystal from Group I of the periodic table, with 0.2 nanometer distance between nearest neighbors.

c) Draw an equilibrium energy band diagram for a system consisting of a slab of material from (A) in contact with a slab of material from (B). Label all relevant quantities and explain your answer.

3.

a) Do you expect diamond to have a higher electrical conductivity than silicon? Why / why not?

b) Do you expect diamond to have a higher thermal conductivity than silicon? Why / why not?

c) Do you expect iron to have a higher electrical conductivity than steel? Why / why not?

d) Do you expect iron to have a higher thermal conductivity than steel? Why / why not?

(Assume room temperature. To receive full credit, explain the relevant physical mechanisms, using diagrams and equations where appropriate.)

4.

a) Assume that a bcc crystal slips on {110}<111>. For a tensile axis parallel to the [123] crystal axis, calculate the Schmid factor for all possible slip systems (Use of a stereographic projection is recommended.)

b) Is this crystal oriented for single slip or for multiple slip?

c) What is the conjugate slip system for tensile deformation if the initial tensile axis is parallel to the crystal axis?

d) What is the conjugate slip system for compressive deformation if the initial compression axis is parallel to the [123] crystal axis?

5.

There is experimental evidence that 100 dislocations can form in alpha iron by the reaction $(a/2)[11\bar{1}] + (a/2)[1\bar{1}1] \rightarrow (a)[100]$. Show this reaction on a sketch of iron unit cell and determine that the reaction is energetically feasible

6.

A sheet tensile specimen has a thickness of 1.00 mm in one region and a thickness of 0.98 mm in a region where the thickness is a minimum, but of uniform width. The material obeys power-law hardening: $\sigma = K\varepsilon^n$. How high must the exponent, n, be to assure that a strain of $\varepsilon = 0.20$ is reached in the thicker part in a tension test?