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Your Name Goes On This Line

E106 Fourth Examination
2 May 2001
Suggested Exam Time: 70 minutes.
Due in Prof. Spjut's office
by 10 AM or 11 AM on 3 May 2001

In this examination you may use the class texts and *any notes* that you have taken in class or made in preparation for the exam. You may also use your homework and quizzes, and my homework solutions. *All other references are forbidden*. There are two sections to the exam. The first section consists of four short problems, each worth 12 points. They are designed to be answered quickly, without a great deal of derivation or calculation. To pass the class you must get three of the four essentially correct. The second section consists of two problems, each worth 26 points. The total possible for the exam is 100 points. Within each section, the problems are of equal weight but *not* of equal difficulty. There is partial credit. Please write neatly and *on one side* of your paper only. You may work on your problems in any order, but please assemble your completed exam with the problems in the correct order and in the correct section. For safety, you may want to write your name on every page.

Section I – Skills Questions (12 Points Each)

1. A 354 m long wire of unobtainium has a diameter of 0.413 mm and a resistance of 27.05 Ω. What is the resistivity of unobtanium?

2. A bismuth-doped sample of bavarium (a fictitious Group-IV semiconductor) has a conductivity at saturation of $305(¾m)^{-1}$. The bavarium is doped with 1.0×10^{-7} atom-fraction bismuth. For bavarium $\mu_h = 0.21$ m^2/V-s , $\mu_e = 0.45$ m^2/V-s and $A_{Bv} = 77.55$ g/mol . What is the density of bavarium?

3. A 0.033 μF flat-plate capacitor, 0.500 mm thick and 0.593 m long, uses Bakelite ($\varepsilon_r = 5.3$) as the dielectric. What is the width of the capacitor?

4. A 0.1 m long sample of polybutylene terephthalate (PBT, $E = 2.53$ GPa) is placed in a restraining fixture at 25°C, where it experiences no stress. At 78°C the sample experiences a compressive stress of 20.1 MPa. What is the linear coefficient of thermal expansion for PBT?

Section II – Long Questions (26 Points Each)

1. You have been asked to evaluate new materials for a 100 ft. extension cord. The candidate materials are annealed Alloy 1100 aluminum, annealed C11000 copper, and commercially pure silver.
   a) Which material would make the thinnest extension cord?
   b) Which material would make the least expensive extension cord?

2. The constant-surface-concentration model for creation of a diode is not very realistic. A more accurate (but still not perfect) model is to assume that a thin layer of dopant is deposited on the surface and the sample is then rapidly heated to the processing temperature, held at the processing temperature for the required time and then rapidly cooled. The mathematical model is

$$C = \frac{M}{2\sqrt{\pi D t}} \exp\left(\frac{-x^2}{4Dt}\right) ,$$

   where M is the amount of dopant originally deposited on the surface, x is the distance from the surface, t is the processing time, C is the dopant concentration at a given x and t, and D is the diffusivity of the dopant in the semiconductor. A sample of Al-doped Si has a conductivity of $500(¾m)^{-1}$. 6.5×10^{18} atoms/m^2 of arsenic is deposited on the front surface of the sample and the sample is heated to 1350°C, held there for 2 hours, and then cooled to room temperature.
   a) What is the depth of the p-n junction?
   b) What is the conductivity at the surface of the sample?

Table 1: The Diffusivity of As in Si

T°C	D $10^{-16}\mathrm{m}^2/\mathrm{s}$
1100	0.1516
1125	0.2610
1150	0.4410
1175	0.7316
1200	1.193
1225	1.914
1250	3.024
1275	4.707
1300	7.224
1325	10.94
1350	16.36
1375	24.16
1400	35.27