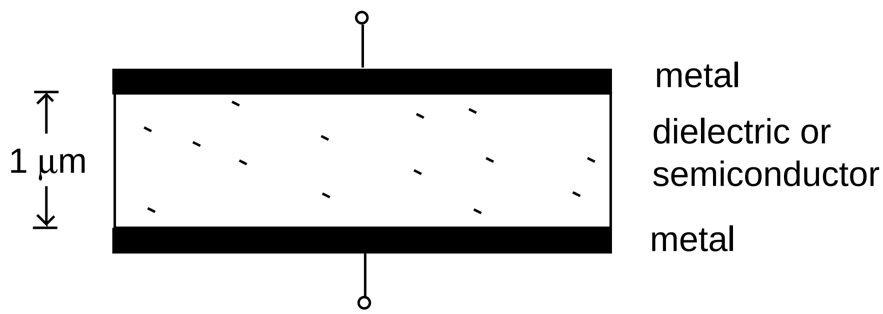
Homework #4 - October 15, 1998

Due: October 22, 1998 at lecture

1. (30 points) Problem 6.2 of del Alamo's notes. Add one more question:

e) Derive an expression for the C-V characteristics. Sketch.

2. (30 points) Consider a parallel-plate capacitor with Al electrodes as sketched below. The separation between the plates is 1 μm.



Calculate the capacitance per unit area of this device when the following materials are utilized as dielectric:

i) SiO_2
ii) intrinsic Si
iii) n-type Si with $N_D = 1 \times 10^{15}\ cm^{-3}$
iv) n-type Si with $N_D = 1 \times 10^{17}\ cm^{-3}$

In all cases, the contact between the Al plate and the dielectric material is intimate.

3. (40 points) In this experimental problem, you are going to measure the I-V characteristics of a "real" Si Schottky diode and you are going to fit them with a simple model.

Access to the device is made available through a new *Web-based Microelectronics Device Characterization Set-Up* that is being developed by Lane Brooks at MIT. This is an experimental set up designed to allow the educational use of professional microelectronics characterization equipment to a large number of users in a remote way. A tentative manual for the use of this system is enclosed. Access to the set-up is available through Athena or a personal computer running Netscape 4.0 or higher.

In this problem, a Si Schottky diode is connected to a HP4155 Semiconductor Parameter Analyzer. This tool is basically a fancy curve tracer. Using this tool, you can easily obtain I-V characteristics of the device. How to use the software interface to the HP4155 is described in the manual.

Do the following:

1. Obtain I-V characteristics of the Schottky diode through the Web. The device is connected between SMU1 and SMU2. Take measurements between -1.5 and 1.5 V. Download the data and port them into your favorite spreadsheet program. Graph the I-V characteristics in a linear scale and in a semilog scale. For this later part, you will have to graph the absolute of the current. Turn in these graphs. Make a note of the day and time that this data is obtained and downloaded. Thisnk about the distribution of measurement points so that sufficient measurements are taken in all regions of interest.

2. Develop algorithms to extract the saturation current, I_S, the ideality factor, n, and the series resistance, R_s of the diode. Make necessary assumptions and state them. Describe the algorithms that you have developed and the values of the extracted parameters that you have obtained. Describe difficulties or shortcomings of the models that you have used.

3. Graph together in both linear and semilog scales the following characteristics:

   - the experimental I-V characteristics;
   - the "ideal" I-V characteristics obtained using the extracted values of I_S and n, and setting $R_s = 0$;
   - the modeled I-V characteristics obtained using the extracted values of I_S and n, and R_s.

   Comment on the importance of R_s in obtaining a good quality fit to the measured characteristics. Comment on the remaining shortcomings of the model. Can you speculate what is missing in the model that might be responsible for the residual discrepancies?

You should start this problem early. This is the first time that the Web-based set-up is being used by a significant number of people. Remote access to the set-up is limited to the hours indicated below. If you encounter problems, please e-mail Lane, Samuel or me. If the diode characteristics look funny, let us know. The diode is real and it can be damaged if improperly measured. We will be changing the diode from time to time, so do not expect identical results everytime you access the site. Please give us all kinds of feedback on this experience.