

**Homework #4 - October 14, 1999**

Due: October 21, 1999 at lecture

1. (45 points) Problem 6.1 of del Alamo's notes.
2. (15 points) Problem 6.3 of del Alamo's notes.
3. (40 points) This problem is about measuring the I-V characteristics of a Si Schottky diode and fitting them with a simple model. Access to the device is made available through the **Microelectronics WebLab**, a new *Web-based Microelectronics Device Characterization Test Station* that is being developed in Prof. del Alamo's lab. 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 <sup>1</sup>. A tentative manual for the use of this system is enclosed.

In this problem, a Si Schottky diode is connected to a HP4155B Semiconductor Parameter Analyzer. This tool is basically a fancy curve tracer. Using this tool, you can easily obtain the I-V characteristics of the device. How to use the software interface to the HP4155B is described in the manual.

You have to do the following:

1. (*10 points*) Obtain I-V characteristics of the Schottky diode through the Web. The device connection is available on-line. Take measurements between -1.5 and 1.5 V. When you are happy with the result (as judged by the characteristics displayed through the web), download the data to your local machine and port them into your favorite spreadsheet program for graphing and analysis. 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. Think about the distribution of measurement points so that sufficient measurements are taken in all regions of interest.
2. (*15 points*) 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

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<sup>1</sup>To know more about this new educational initiative, look at <http://www-mtl.mit.edu/alamo/weblab/index.html>

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. Assume the measurement temperature is 22 C.

3. (10 points) Compare the experimental characteristics with simple theoretical models. To do this, graph together the experimental measurements and the predictions of the following simple models (in both linear and semilog scales):
  - model 1: I-V characteristics obtained using the extracted values of  $I_S$  and  $n$ , and setting  $R_s = 0$ ;
  - model 2: 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?

4. (5 points) Give us feedback on this web-based homework. Tell us about what works and what doesn't. Make suggestions on how to improve it.

Additional information and assorted advice:

- The parameter extraction of part 2 above should not demand fancy numerical analysis. There is no need to do regressions or least-squares fits. The graphs you have to turn in need not be too fancy, just correct. They must have proper tickmarks, axis labels and units. When there are several lines, each one should be properly identified.
- Remote access to the set-up is provided 24 hours a day, 7 days a week. In spite of this, you should try to do the experimental portion of this homework problem early. If everybody waits until the last minute, problems with the system or the device might occur. If you encounter difficulties, please e-mail Fatih or Prof. del Alamo. If the diode characteristics look funny, let the course staff know. The diode is real and it can be damaged if improperly measured. The diode might be changed from time to time, so do not expect identical results everytime you access the test station.
- The login page uses your Athena username (as provided by the Registrar) as username and your MIT ID as password. You should login as soon as you can to confirm that you have access to the system.
- The HP4155B can only support a current of 100 mA. This will be the maximum current you will be able to measure.
- The system records all logins and the scripts that each user executes.

Please give us all kinds of feedback on this experience.