ENSC 495/851Introductory Notes

Version 3 Jan. 18, 2012

1.0 Description of lab portion of course

1.1 Process: Guided by the instructor and lab staff, ENSC 495 (undergraduate) and ENSC 851 (graduate) students fabricate a 4 mask semiconductor test device, containing resistors, diodes, transistors, photo cells, etc. Students participate in thermal oxidation, lithography, oxide etch, boron and phosphorus diffusion, metal deposition, etch and anneal processes and electrical probe testing. The lab is basic, but students can form an appreciation of semiconductor processing.

1.2 Projects: ENSC 851 students may be given optional projects. The nature of these projects will be decided with the instructor. Projects may be in addition to, or in place of, some of the course work. Work may have to be done outside of normal lab time to complete projects (see also 2.4 below). *Note that ENSC 495 students do not have this option; they will complete the prescribed processing and testing.* Note also that ENSC 851 students doing a project must return any equipment, manuals, etc. borrowed for the project *before the report will be marked.*

1.3 Marking: The instructor will specify details of marking. Note that specific lab knowledge, including such things as the purpose of processes, the order of processes, the time and temperature of processes, is testable at any time at the discretion of the instructor. The lab mark is, however, not based on yield or performance of the finished devices. Mind you, it might be a little hard to demonstrate your knowledge if you smash all your wafers on the second day.

2.0 Lab schedule

2.1. Time of labs: *This lab cannot be run as an open lab*. There will be specific lab times, which may be during the day or evening. Evening labs usual start at 16:30 or daytime at 14:30.

2.2. Start time: Scheduled lab start times will be determined according to the needs of students, staff, instructor and other lab users.

Actual start times are also important. Most labs cannot start unless almost everyone is present. Therefore, the sooner we all arrive and are ready, the sooner we can start the process steps that must be completed. Lab completion is delayed if we are still waiting for 2/3 of the students to arrive 20 minutes after the lab is supposed to have started. Useful information may also be missed if announcements and instructions have to be repeated for each late arrival. Therefore, please be gowned and inside the lab at the appointed start time. Note that gowning can take a few minutes when several people are trying to gown up at the same time.

2.3. Length of labs: Labs comprise particular process steps and take as long as it takes to complete those steps. Typical length of lab is about 4 hours. Be prepared to stay in the lab for this time. It is only occasionally practical to have people coming and going from the lab, and this cannot be done individually. Don’t complain about being hungry, tired, etc.; you aren’t alone.

2.4 Lab access: No student will be permitted unaccompanied access to the lab and the lab door code will not be given to course students; therefore extra access for projects, if needed, will be permitted only during normal working hours *whenever lab staff can be available*. Any grad students who may have lab access are not allowed to bring in other students.

3.0 Student participation

3.1 Attendance: This is a lab course and attendance during the scheduled lab is expected. If you plan on missing labs to do work for other courses, go skiing, etc., please consider dropping the course now; the lab will be less cluttered and safety and process pointers will not be missed.

3.2. Participation: This is a "hands on" lab; everybody is expected to try everything at some point. This should be fairly easy, because most activities are repeated several times during the term as the process continues. Please don't hide around a corner doing homework from another course; merely being in the same room or an adjacent room doesn't quite count as active participation. There will be times in the lab when you are waiting for a process or waiting for a piece of equipment. We will not always be able to fill that time for you. However, when there is a process happening, you are expected to be doing it or observing it.

3.3. Groups: Students will form lab groups. It's not a commitment for life. Please cooperate and form groups when asked. Depending on the size of the class, lab groups will typically be 2-3 people and will stick together for the semester. The idea is not one of proportional representation; having one member of your group show up for the labs is not really good form.

4.0 Lab support

4.1 Instructor and/or TA: The instructor will be involved in the labs. The instructor gives Lab Report assignments, and has all information regarding meaning, due dates, marking, etc. Assignments may be individual or group assignments. Most information on theory and calculations will come from the instructor and/or TA.

4.2 Lab staff: Lab staff will oversee most of the process operations and give other support as required. Any extra support for projects, etc., beyond the scheduled lab times, will usually be available only during normal working hours. Students will require lab staff supervision, even for those process steps they have covered in the course labs.

5.0 Facility

The gowning area is a softwall cleanroom, nominally about Class 100. The larger area is about a Class 1000 random flow area. Normal entrance to this area is from the softwall gowning area. The photoresist area is a Class 100 laminar flow area, which is normally entered only through the airlock from the Class 1000 area.

This is not only a teaching facility, but also a shared research facility. Some of the equipment used in the course is research equipment. Some of the other equipment in the lab may be important to

someone’s research. Respect this situation.

6.0 Clothing

6.1 Gowning area entry: Gowning area is the softwall clean module immediately outside the cleanroom entrance. Use shoe cleaner before entering gowning area, especially if you have just come from outside the building. Enter the area properly, using the slit door only. Long panels are “IN” and short panels are “OUT”. Be sure they are sitting properly after you go through. Do not lift or move the main panels. These precautions help to avoid excessive wear and damage to this relatively fragile structure.

6.2 Clothing: You will wear a hood, lab coat and shoe covers over your street clothes. These cleanroom clothes must be worn everywhere, and at all times, in the cleanroom. You should not be reaching inside the clothing for pens, etc. Do not leave the cleanroom or clean gowning area with any part of your cleanroom clothing on.

These clothes will be stored in the correct place in the gowning clean area. If the class is small, you will be assigned a set of clothing for the term. Your name will be on the hanger and the storage spot for the hood and shoes. You will use these clothes and only these clothes. If the group is larger, there will be clothing labelled “ENSC 495/851" and “Visitor” on the racks. The positions will also be numbered. Use these after *first putting on a disposable bouffant cap*. Do not use any other clothing. Return your clothing to the same hanger and storage spots from which you obtained it. This is necessary in order to keep track of the clothing for laundry purposes.

6.3 Donning clothing: Put on bouffant cap, if required. Put on hood and do it up tightly, using all front snaps, so that it covers all hair; if necessary use adjustment snaps at back of hood. Put on coat, covering the cape portion of the hood; do up all snaps, including those on sleeves. Sit down on the bench and put on the boot covers; note that the boot covers must not touch the floor in this area. They may touch only on the side of the bench covered in the green mat.

6.4 Cleanroom gloves: Cleanroom gloves (unpowdered latex or nitrile) are provided inside the cleanroom and must be worn at all times to avoid transferring hand soils to product and equipment. These are also your SECOND line of defence against chemical burns; chemical gloves will be worn over the cleanroom gloves, as required. If anyone has a latex allergy, please let us know and we will see that nitrile gloves are available.

6.5 Miscellaneous clothing related points:
6.5.1. Do not wear clothing from a hanger with the instructor’s name on it (or anybody else’s name, for that matter).
6.5.2. Please note that the hoods go on the top shelf, the shoe covers on the bottom shelf, and the coats on the hangers in between. Please don’t put them anywhere else. Creative combinations are not appreciated or encouraged.
6.5.3. Have a little respect for the clothing. Put it on and take it off carefully. Be especially careful with the elastic in the shoe covers and the snaps on the coats. We’d like the clothing to last a while.
6.5.4. Please do not steal the clothing or the coat hangers.
6.5.5. Do not hang street clothing on the cleanroom clothing rack.

6.5.6. Do not bring packs, coats, food, etc. into the cleanroom.

7.0 Additional personal equipment, etc.

Bring as little as possible into the room with you; leave extra books, notes, clothing, etc. outside the cleanroom. Do not bring any food or drink into the cleanroom or gowning area. Use only ball point pens for writing; do not use pencils. We will, however, use ordinary paper because of the cost of cleanroom paper.

8.0 Safety

8.1 Personal preparation: Know what the lab is about before coming in. Be in physical condition for lab. Anyone obviously coming straight from the pub, etc. will have to leave, for their own safety and the safety of others. There will be no makeup labs.

8.2 Behaviour: Participate in the lab. Do not engage in any form of horseplay.

8.3 Clothing: In addition to the required cleanroom clothing, wear the designated chemical safety gear when working with chemicals.

8.4 Exhaust systems: The lab has several self contained exhaust systems. You will be using one on the furnace, one on the Class 100 fume hood, and one on the Class 100 wet deck.

8.5 Safety Equipment: There is an eyewash just inside the main entrance to the Class 1000 area. There is a portable eyewash next to the fume hood in the Class 100 room. There is a safety shower situated with the eyewash in the Class 1000 area. There is a portable safety spray near the silicon etch bench in the Class 1000 area. There is a CO2 fire extinguisher in the Class 100 area and two more in the Class 1000 area.

8.6 Escape Routes: The single door next to the microscope in the Class 1000 area is to be opened only in an emergency. This provides access to the hallway as an escape route to the outside of the building.

The double doors at the north end of the Class 100 room are to be opened only in an emergency. These doors provide access to the gowning area and thereby to the hallway and the outside of the building.

The main door to the Class 1000 area provides access to the gowning area and thereby to the hallway and the outside of the building.

8.7 Chemical inventory: The following are the most common chemicals used in this course:
DI H_2O: deionized water
NH_4OH: ammonium hydroxide
H_2O_2: hydrogen peroxide, 50%
HF: hydrofluoric acid. 50%

HCl: hydrochloric acid
Photoresist: Shipley SPR2FX-1.3L or equivalent
Developer: Shipley MF-319 or equivalent (mild base)
BOE: buffered oxide etchant, Transene or equivalent (HF and ammonium fluoride mix)
Acetone
Boron solid diffusion source
Phosphorus solid diffusion source
O_2: gaseous oxygen
N_2: gaseous nitrogen
LN_2: liquid nitrogen
Aluminum etch: Transene A1 or equivalent (phosphoric, nitric and acetic acid mix)

8.8 Material safety data sheets: There are Material Safety Data Sheets available for all lab materials in the binder in the gowning area.

8.9 General chemical comments: You will be using some potentially dangerous chemicals during the course. When these materials are used with proper care and equipment, however, risk is reduced considerably.

The RCA clean uses a strong base (ammonium hydroxide), a strong oxidizer (50% hydrogen peroxide), and two strong acids (hydrochloric acid and hydrofluoric acid). You will know immediately if any of these, except hydrofluoric acid, attack your bare skin. While the others may cause a burning sensation and immediate pain, the hydrofluoric acid may cause no immediate discomfort. The problem may become apparent hours later. HF can penetrate unbroken skin and has an affinity for calcium (bone). There are special first aid requirements for hydrofluoric acid; we have some special cream in the lab. The oxide etch uses a solution of hydrofluoric acid and ammonium fluoride (buffered oxide etch or BOE). This should also be treated with the same respect as HF. Aluminum etchant is a mixture of phosphoric, nitric and acetic acids. This must also be handled carefully. Developers and photoresists are not corrosive, but should not be allowed to contact skin and must not be inhaled any more than necessary. Organic solvents, such as acetone, must not be allowed to touch the skin for extended periods, and must be used with fume exhaust to minimize inhalation.

8.10 General chemical handling precautions:
8.10.1 When handling the large chemical containers, always use the finger hole to support them to minimize the chances of a slip and subsequent messy, dangerous landing.
8.10.2 Always wear the appropriate gloves, but continue to handle the chemicals as though your hands were unprotected. Keep your fingers out of the beaker.
8.10.3 Check chemical gloves for cracks, holes or other damage, especially between fingers and at the ends of fingers.
8.10.4 Do not mix organic and inorganic chemicals in this lab. Clean out graduated cylinders with DI water before using them to measure another material.
8.10.5 Add acid to water, NOT water to acid. A possible exothermic reaction can cause acid spattering.
8.10.6 Always start work with the fume hood deck clean and dry. Keep it that way. Treat any liquid drops or unknown containers on the deck as dangerous; check with pH paper.

8.11 Spills: We have spill kits available in the lab to deal with small spills.

8.12 Chemical storage: Most chemicals of interest to this course are stored in the chemical storage cabinet under the right hand side of the fume hood in which we perform cleaning, developing and etching.

8.13 Chemical Disposal: Inorganic chemicals, such as RCA clean solutions, etc., can be disposed of down the drain with copious amounts of cold running water after solutions have cooled and/or been diluted or neutralized if required.

Organic chemicals must not be disposed of down the drain. These are collected in containers under the left hand side of the fume hood and are taken to Science Stores for proper disposal. The left container is for acetone, alcohol, etc., while the right hand container is for halogenated solvents, such as trichloroethylene.

9.0 Process batch sheets

9.1 Nature and use: We will give you process batch sheets as a guide to the processes used in each lab. These list each step of the process and give some detail on process parameters. *Use these sheets to keep track of your place in the process, by initialling each process step as it is completed. These are also your lab notebooks; keep notes of your process settings and observations.* Continue on to the back of the sheet if necessary.

9.2 Limitations: Batch sheets are not cookbooks; they do not contain all details. You must be aware of what you want the process to do. *You should especially note the difference between a timed process, such as RCA clean or thermal oxidation, and an endpoint process, such etching.* For an endpoint process, a time is only a guideline; process completion is determined by inspection, and may vary from wafer to wafer within the same process batch. You will have to know that you etched until the oxide was removed, for example, not that you etched for the same time that someone else did. Note that some standard processes, such as an RCA clean, may be completely detailed, whereas a variable process, such as a diffusion, may specify only the mechanics, leaving the user to determine and record times and temperatures.

Batch sheets are generic, and are not specifically geared to give all required instructional details for the processes as used in ENSC 495/851. There are process parameters that are only blanks to be filled in on the batch sheet. There may also be optional steps on some sheets that may not be used in the ENSC 495/851 process.

9.3 Batch sheets vs, course requirements: The instructor will specify the details of procedures and results required for reports. They are not detailed on the batch sheets. For example, an “Inspection” step on a batch sheet might suggest an inspection and/or measurement at that point in the process; it will not, however, tell you whether there are measurements to be recorded for your report, nor will it tell you what to measure. The instructor will specify such information.

Copies of completed process sheets will probably be required to support lab reports

10.0 Wafers

10.1 Number of wafers

The maximum number of wafers that we can handle per lab is eight. Each group will be assigned 2-3 wafers for processing. Wafers are identified by numerical or other codes.

10.2 Handling of wafers

Wafers should be handled with clean tweezers, held by careful, gloved hands. Contact the wafer only at the major flat. No hands, gloved or otherwise, to touch wafers. As much as possible, transport wafers in clean wafer containers, held in gloved hands. Otherwise, hold with tweezers over a clean wipe supported by other hand.

10.3 Disposition of wafers

At the end of the course, wafers normally remain the property of the school. There are not enough left over to give everyone a souvenir wafer. Usually a chip can be made available to everyone.

11.0 Breakage

If you break a wafer, we can make accommodations. We are more concerned with equipment breakage. We have a pretty good record for minimal problems in this class. Should something be broken, please let us know as soon as possible. You will not be charged or marked down (at least not the first time). We need to get it fixed for the next lab.

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