# The TA Manual for EE143

**First Draft for Fall 2010**
**Version 8-26-2010**

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# Preface/Motivation of Documentation

Congratulations, you have been selected to TA EE143. TA'ing this course requires that the head TA and the other TA's work together in a seamless manner so that everything will run as smooth as possible during the semester. In order for this semester to be a success for you and your students, we have attempted to create a living document that will aid in the planning of the semester and inform you what is expected of you during the semester. In the following documentation we have described the roles and responsibilities of each TA as well as provide a checklist of items that should be done each week. We, as the TA's for the fall semester of 2002, have started this document so that it may be passed from semester to semester allowing the knowledge of each of the TA groups to accumulate. Therefore at the end of the semester you and your TA group will edit this document and add any insight that you deem necessary. It is our goal that this manual will, in the future, make TA'ing EE143 a great pleasure.

Good luck from the fall TA's of 2002.

# TA Roles and Responsibilities

## *Head TA's responsibilities:*

Your responsibilities can be divided into two main categories. First, you are responsible for carrying out all of the processing that is listed in the processing manual with the notation "done by TA." Now, this does not mean that you cannot enlist assistance from the lab TAs, but it is your responsibility to at least organize this processing. Second, you will be working **"ahead"** of the lab TAs on the remaining processing sections, meaning that you are responsible for thoroughly learning the operation of the lab equipment which will be used for a given week's lab well in advance, so that you can pass your knowledge along to the lab TAs efficiently, still in advance of the lab so that this information can be digested by the lab TAs. Remember, they spend many hours in lab working with students who expect things to go smoothly every time. Of course, snags will arise, and this leads to stressful situations for the lab TAs. By doing your job well, the occurrence of these situations can be minimized, and in general the lab will go more smoothly.

Specific responsibilities:

1) Ensure tool operation is satisfactory. Interface with Microlab staff in the event of equipment problems.
2) Learn tool operation well in advance (~3 weeks) or required lab use by students. Ask for Microlab assistance of help from previous semester's head TAs and lab TAs.
3) Hold an instructional session with current lab TAs well in advance (~2 weeks) of the required lab. Use this session to teach the TAs equipment operation, determine process parameters (etch rates, exposure times, develop times, length of furnace times, which may deviate slightly from the specified values in the manual) and to troubleshoot any problems which may arise with the processing—a second chance to catch equipment malfunction.
4) Take inventory of lab chemicals on Thursday before the following week's labs, and submit a request to the Microlab for the required chemicals so that they will be delivered on Friday, in plenty of time for Monday morning's (potential) lab session.
5) Complete all processing tasks that are to be "done by the TAs," namely the field oxidation, TCA clean before gate oxidation, poly-Si deposition, and $XeF_2$ etch. Also, procure all Microlab materials that will be needed for the furnace steps in the 143 lab (cleaned quartz boats, other quartz ware for the furnace steps).
6) After processing is complete, organize an evaluation of the lab manual and supporting documents by the lab TAs. Make necessary changes, additions.

## *Lab TA's responsibilities:*

Your main responsibility is to create an environment during lab sessions that essentially encourages the students to learn about the processing modules rather than just follow the recipes and go through the motions. Generally it seems as though when a lab session goes awry, usually due to difficulty with lab equipment, the students lose confidence that the lab sessions truly reflect any meaningful semiconductor processing flow, and quickly lose interest in learning about the processes in lab. Preventing this from happening more or less boils down to being **extremely well prepared** for your lab session. In particular, learning equipment operation, and ensuring that the equipment is functional, is a must. The head TA will do most of the heavy lifting in this regard (see head TA responsibilities), but it is up to you to be sure that you understand the equipment as well as you need to so that you can project a measure of confidence when showing the operation to the students in your lab sessions. Keep in mind that the head TA not only works ahead of you in terms of learning equipment operation and verifying functionality, but also will carry out the processing steps labeled in the manual as "done by TA." So make the head TA's job easier by trying to be well prepared for lab—you should be self-sufficient when you meet with students.

Specific responsibilities:

1) Attend head TA instructional meetings. Determine process parameters for lab two weeks in advance (so that if things go awry, there's an extra week to prepare), assist in troubleshooting equipment problems, and learn the proper operation of the equipment. Also, these sessions will be used to process the TA wafers (~2 per session), once correct process parameters have been determined. These TA wafers will be distributed to students in the event of a broken or misprocessed student wafer, and to assist in determining the process parameters, testing equipment, etc.
2) Provide an update to all TAs and the course instructor following each lab session, highlighting:
    a) problems encountered in the session
    b) potential process parameter adjustments
    c) control wafer measurements, if any
    d) chemical stock update
    e) anything else that would be valuable for other session TAs to know (processing hints, reminders, etc.)
3. After processing is complete, evaluate the lab manual and supporting documents, make necessary changes and/or additions.
4. Submit end-of-semester report, which will summarize difficulties encountered, advice for future TAs, and all documents that have been updated, added.

# TA Weekly Checklist

## *TA Checklist*

The TA checklist entails running the student process a week ahead of time using processing parameters that are due to a characterization effort made by the head TA. Each TA section should entail verifying the process on a single TA wafer and then running the rest of the TA wafers after the processing parameters are deemed sufficient.

An example of the NMOS process flow for the TA's is listed below.

Week 0: Meet, Greet and Organize - Starting Materials
Week 1: Initial Oxidation - 5200Å
Week 2: Active Area Photolithography
Week 3: Gate Oxidation - 800Å
Week 4: Poly-Si Deposition – In Microlab
Week 5: Gate Photolithography
Week 6: Source-Drain Deposition and Drive (N+)
Week 7: Contact Cut
Week 8: Metalization
Week 9: Metal Definition
Week 10: Check Characterization Equipment
Week 11: Prepare Answer Sheets for Report #1
Week 12: Grade Report #1
Week 13: Prepare Answer Sheets for Report #2
Week 14: …..

## *Head TA Weekly Checklist*

The Head TA will work 1 week in front of the TA's and 2 weeks in front of the students. This time is necessary so that problems have sufficient time to be worked out. It is imperative that you stay on schedule, even when machines need to be fixed, as to ensure the proper execution of the lab.

Week -1: Meet, Greet and Organize - Starting Materials
Week 0: Initial Oxidation - 5200Å
Week 1: Active Area Photolithography
Week 2: Gate Oxidation - 800Å
Week 3: Poly-Si Deposition – In Microlab
Week 4: Gate Photolithography
Week 5: Source-Drain Deposition and Drive (N+)
Week 6: Contact Cut
Week 7: Metalization
Week 8: Metal Definition
Etc..

## Week 0:

All TA's

1. Set up meeting with Prof., pertinent Microlab Staff (contact K. Voros to determine who should be contacted) and whoever is in charge of characterization equipment. Important to set up paths of communication with each associated
2. party so that semester will run smooth
3. Decide on day of the week to meet and run the next week's lab. The lab will take at least 3-4hr as characterization must be performed (you must run a lab 1 week prior with as many wafers as the largest section has so that any problems that you will run into during the week will be ironed out).
4. Uniquely label each of the substrates
5. Organize Each Section: Each lab section should have (and also the TA section should have):
    a. Wafers
        1 TA wafer
        1 wafer per each 2 students (max of 6 wafers or 12 students)
        1 Control wafer (to be process in any of the high temp processes with student wafers so that dopant diffusion may be monitored via 4-point probe measurements)
        Rest of wafers set aside for TA section (head TA needs ~5 and TA's need ~ 10). As semester goes on many wafers will fall out as characterization tests are performed.
    b. Notebooks:
        1 TA clean room notebook
        1 notebook per each 2 students
    c. Lab section box for storing notebooks and wafers week to week
6. Verify required supplies for semester are present
    a. I.e. tweezers, beakers, masks, etc…

TA's ~ Running week 1 of processing

1. Assist head TA

Head TA ~ Preparing for week 2 of processing

1. Confirm cleanliness requirements with Microlab so that field oxide may be grown there.
2. Grow Field Ox.

## Week 1:

TA's ~ Running week 2 of student processing

1. Follow procedure delineated in the Detailed Process Flow
2. Measure Oxide many wafers to ensure it is ~5200Å.
3. Read Manual on Quintel & watch video regarding operation of this equipment.

4. Each TA must prepare resist bottles for their sections for the following week (See Appendix)

Head TA ~ Preparing for week 3 of student processing

1. Have Cory218 gate oxidation furnace RCA cleaned for week 3, and get training on operation and characterization of that furnace tube.
2. Have gate oxidation tube turned on for thermal stabilization.
3. Characterize Quintel for exposure times and develop time (See appendix).
4. Perform Oxide Etching characterization with the 5:1 BHF (See Appendix).

Notes on any problems for week 1:
None

## Week 2:

TA's ~ Running Week 3 of student process

1. Prepare PR bottles (Se Appendix)
2. Verify Quintel exposure time to and develop time reported by head TA(See Appendix)
3. Verify oxide etching times with the 5:1 BHF (See Appendix)
4. Run Process module for week 3, i.e. the detailed NMOS process flow, with at least 10 wafers to define active area.

Head TA ~ Preparing for week 4 of student process

1. Characterize gas flow rates and time with respect to temperature to attain ~800Å oxide in gate region for week 3.
2. Learn how to operate 4-pt probe in 218Cory and make measurements.

Notes on any problems for week 2:

This will be a long lab for your students. Let them know that it is difficult to finish in 3hrs.
Improper cleaning of PR bottles will result in HORRIBLE resist spinning with lots of "bugs" in the resist. → Clean Bottles Properly
Over etching of the oxide (the 15% in lab manual) should be done this week to ensure all of the oxide is removed from the active area.

## Week 3:

TA's ~ Running week 4 of student processing

1. Watch video on operation of furnaces
2. At beginning of TA section Head TA should teach TA's how to operate furnaces and discuss contamination issues.
3. Run week 4 of student processing

Head TA ~ Preparation of week 5 of student processing

1. Check that Poly Si tube in Microlab is working and not scheduled for maintenance during time when EE143 will need to use.

## Week 4:

TA's ~ Running week 5 of student processing

1. Take the TA lab section off ~ Poly Si deposited by head TA in Microlab at end of week 4.

Head TA ~ Preparation of week 6

1. At end of week 4 deposit poly on all of the EE143 wafers in the Microlab
2. After poly deposition run lithography characterization on Quintel (will need longer exposure time than in week 3 due to decreased reflectivity)
3. Characterize develop time (in fall 2002 found an increase in develop time needed and developer must be changed out about every 3 wafers)
4. Characterized poly etch. (See appendix for characterization of etch rate)
5. Have drive in tube cleaned and turned on.
6. Make sure Spin on glass is available and not expired.

Notes on any problems for week 4:

- ✓ Exposing and Developing time must be extended this week (relative to week 3) as the reflectivity of the polysilicon is less that that of the substrate & there exists topology). The other effect of the topology is that over developing must be done to remove all exposed PR stringers. You MUST check each of the wafers (specifically around the edges) for undeveloped PR in the active area regions; otherwise if hard-baking is performed wafers may be lost.

## Week 5:

TA's ~ Running week 6 of student processing

1. Prepare PR Bottles (See Appendix)
2. Verify Exposure Time, PR Develop time, and Poly Etch Rate prescribed by head TA
3. Run week 6 of student processing

Head TA ~ Preparing for week 7

1. Characterize wet oxidation in furnace tube 2, specifically time, temperature and gas flow rates to obtain ~1500Å of oxide for interlayer dielectric. In fall of 2002, we had many problems with this.
2. Run week 7 of student processing with TA wafers

## Week 6:

TA's ~ Running week 7 of student processing

1. Verify with dummies the time, temperature , and gas flow settings delineated by the head TA for proper ILD thickness
2. Run week 7 of student processing

Head TA ~ Preparing for week 8 of student processing

1. Characterize exposure times and developing times for photo resist (see appendix)
2. Characterize etch rate for 5:1 BHF
3. Order liquid nitrogen canister to be filled by Microlab for metalization.

## Week 7:

TA's ~ Running week 8 of student processing

1. Verify processing parameters given by head TA by running process on one wafer
2. Run process for week 8 of student processing on the rest of the TA wafers.

Head TA ~ Preparing for week 9 of student processing

1. Learn operation method of evaporator (manual and video)
2. Deposit metal on test wafers
3. Do pattern and etch to determine thickness of aluminum

## Week 8:

TA's ~ Run week 9 process

1. Run evaporator with dummies to verify process given by head TA
2. Run week 9 of student processing for all of TA wafers.

Head TA ~ Prepare for week 10 of student processing

1. Characterize exposure and developing times on Al surface.
2. Characterize Al etch rate by etching away unprotected Al area.
3. Verify sintering tube operation
4. Done with Processing!

## Week 9:

TA's ~ Run week 10 of student process

1. Verify exposure, develop, and etch times reported by head TA.
2. Run week 10 of student processing → Done with processing!

Head TA ~ Prepare for Characterization

1. Have staff involved with the characterization equipment give a short display of how software works
2. Check all probe stations to ensure working properly for MOSFET devices.

## Week 10:

TA's ~ Learn how to use characterization equipment

1. Test TA wafers on all stations to ensure devices working properly and report any necessary problems.
2. Decide who will be grading each section of Report #1

Head TA

1. Use simulation or calculations to determine appropriate theoretical calculations for the values that are to be reported in lab report #1

## Week 11: Prepare Answer Sheets for Report #1

TA's

1. Verify values reported by head TA
2. Assemble grading criteria for Report 1
3. Measure characteristic responses for report #2

## Week 12: Grade Report #1

TA's and Head TA ~ Grade Report #1

Head TA

1. Do calculations for values to be reported in Report #2 using measurements done by TA's in week 11.

## Week 13: Prepare Answer Sheets for Report #2

TA's and Head TA ~ Prepare to Grade Report #2

## Week 14:

TA's and Head TA ~ Grade Report #2

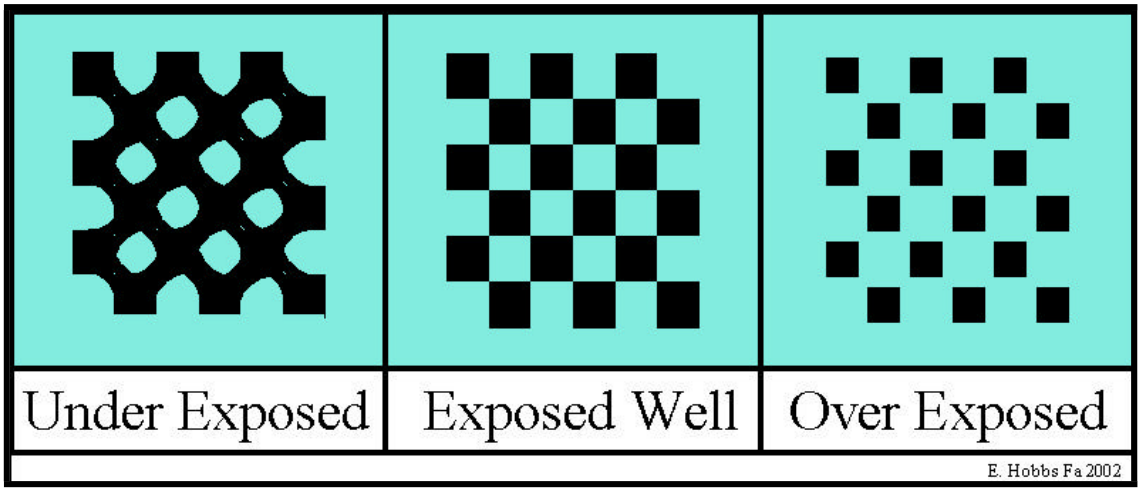
## Week 15:

TA's and Head TA ~ Clean Lab and do end of semester reports

# Appendix

## *Characterization of Exposure and Develop Times*

The sensitive parameter in the game of selecting the appropriate exposure and develop times is typically (in Cory 218) the UV exposure time. Once exposure time is determined, a good method of selecting the developing time is to develop until the red residue emitting from the resist film is no longer present (then usually 10-20 seconds after the last sight of that it is determined developing is done). Below is a diagram of the resolution patterns depicting the under exposed, over exposed, and a perfect exposure. If under exposed then increase time and if over exposed then decrease time.



## *Cleaning Process for PR Bottles*

The following process was adopted from Frank Zendejas of the spring 2002 TA group. Without cleaning the photoresist bottles properly the films will look terrible.

Process

1. Obtain dropper bottles from Microlab.
2. Rinse 2x with Acetone. Make sure to suck acetone up into syringe bladder.
3. Rinse 2x with Isopropanol. Make sure to suck acetone up into syringe bladder.
4. Rinse 2x with Methane. Make sure to suck acetone up into syringe bladder.
5. Remove rubber bladder and glass pipet and bake the bottles for 10min @ 90oC.
6. While bottles are baking, remove glass pipet from black rubber bladder (just pull it off). Blow both dry with N2 gun (good idea to use poly gloves here to avoid contamination).
7. After bottles done baking, pull them from the oven and let cool to room temp.
8. Obtain funnel and bottle of OCG 825 from service chase behind primeoven. Fill ~1 bottle for each 2 sections.
9. Place Bottles in refrigerator in EE143 Lab.

## *Etch Rate Characterization*

This method of etch rate characterization is not exact but will give average value of what etch rate may be. This method also only works for films that can be measured using the Nanospec.

Process:

1. Measure the film thickness at a minimum of 5 points on the wafer using the Nanospec and then compute the average.
2. Using K. Williams Etch rate table calculate the exact time that it would take to etch through the entire film. Divide that time by 2.
3. Etch for the time calculated in step 2
4. Re-measure the film thickness at approximately the same points as measured in step 1 and also compute the average.
5. Subtract the average final thickness from the average initial thickness and then divide by the time to determine the approximate etch rate.

## *Mask Cleaning Process*

1. Douse the chrome side of the mask with Acetone. If necessary, lightly use a mask scrubber to assist in the removal of any solidified photoresist on the mask. If you choose to use the mask scrubber exercise extreme caution as damage to the mask may occur. DO NOT LET THE ACETONE DRY ON THE MASK → STREAKING WILL OCCUR
2. While Acetone is still pooled on mask, spray the acetone off with IPA. Continue to rinse with IPA until you are sure all of the acetone has been removed. DO NOT RINSE WITH WATER (you will just induce water droplet marks).
3. Blow-dry with $N_2$ gun.