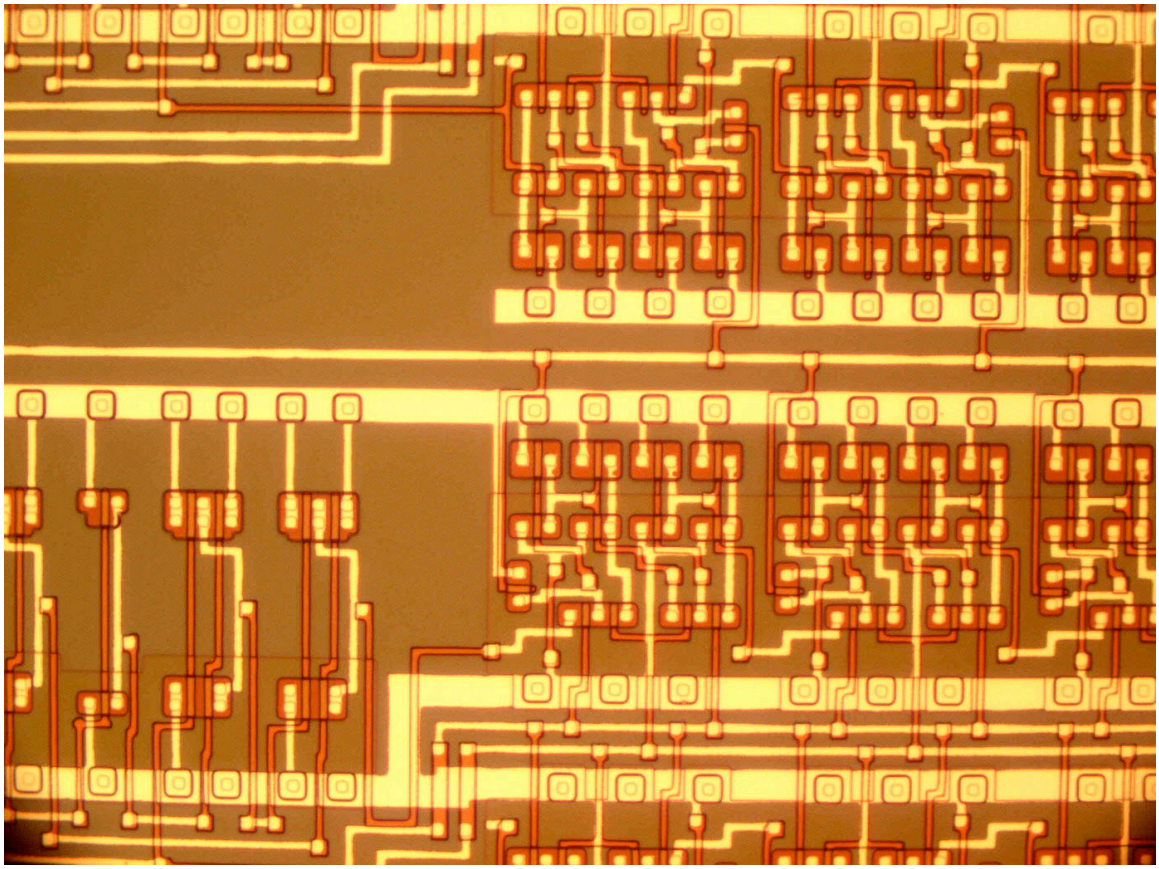
Integrated Circuit Fabrication

Lab Procedures



Instructor: Greg Snider

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THINGS TO REMEMBER

- HF can maim or kill you: Double glove
- Mixing acids and solvents makes rocket fuel

  (This is IC Fab, not beginning rocketry!)
- Sign-in when you enter the lab
- No shorts or open toed shoes in the lab
- No magazines or newspapers in the lab
- Gloves keep things off you, and you off things
- Aprons and face shields required when using hoods in 244
- Lab Hoods are “Laminar Flow” hoods, not fume hoods. Keep chemicals at the back of the hood!
- Clean up after yourself
- If you empty a bottle, triple rinse, deface the label, and throw in the trash (leave the cap off)
- Properly label chemicals that you dispense
- If bad things happen, tell the instructor
- Have fun!

SUMMARY OF CHEMICALS AND PROCEDURES

Acids. Use only in hoods marked "Acids".
Acids commonly used in this lab: HCl, HF, H_2SO_4,H_3PO_4, HNO_3
Disposal: All but HF go into the waste bottles marked "Acid" in the acid hoods. HF goes into dedicated waste bottles in the blue cabinets.

Bases. Use only in acid hoods. (Bases are not used a lot in this course).
Bases used in this lab: NH_4OH, H_2O_2 (call this a base), Developer (Developer can be used in solvent hoods).
Disposal: Pour into the waste bottles marked "Bases" in the hood.

Solvents. Use only in hoods marked "Solvents".
Solvents commonly used in this lab: Iso, Ace, Methanol, toluene, HMDS, resist stripper, photoresist
Disposal: Waste bottle in 247A (on floor).

Only water and rise water goes down the drain!!!!

Do not leave waste bottles uncapped. That's a $3,000 fine from OSHA!

PROCESS OVERVIEW

1. Wafer Characterization

Wafer resistivity measurement using four-point probe

2. Alignment Mark Etch

RCA clean if needed
Photolithography using reticle 0 (Layer 0), stepper program IC0
Etch mark using RIE

3. First Oxide

RCA clean
Oxidize wafers using the initial oxidation procedure

4. N-Well Implant Lithography

RCA clean if necessary
Photolithography using reticle 1 (N-well), stepper program IC0
Ion Implantation (send out) Species: P31, dose=$4x10^{12}$ cm^{-2} Energy=75kV

5. Well Drive-In

Strip resist
RCA clean
Well drive-in using the written procedure
Staff will deposit silicon nitride

6. Active Lithography, Etch and Channel Stop Implant

Photolithography using reticle 2 (Active), stepper program IC0
Etch nitride using RIE
Channel Stop implant. Species B11, dose=$4.0x10^{12}$ cm^{-2} Energy=25kV

7. Field oxidation

Strip resist
RCA clean
Oxidize wafers using the field oxidation procedure

8. Nitride Removal and Threshold Adjust

Remove nitride using phosphoric acid
Threshold adjust implant. Species B11, dose=$1.0x10^{12}$ cm^{-2} Energy=50kV

9. Gate Oxide

Remove pad oxide using BHF
RCA clean
Oxidize wafers using the gate oxidation procedure
Measure gate oxide thickness

10.Polysilicon Gate

Deposit Polysilicon, 300 nm undoped

Blanket Implant to dope polysilicon (send out) Species: P31, dose=$5x10^{15}$ cm^{-2} Energy=50kV
Photolithography using reticle 3 (Poly), stepper program IC2
Etch polysilicon using RIE

11. N-Channel Source-Drain

Strip resist
RCA clean
Photolithography using reticle 5 (P-Select) Image Reverse Process, stepper program IC2
Ion implantation (send out) Species: P31, dose=$3x10^{15}$ cm^{-2} Energy=20kV

12. P-Channel Source-Drain

Strip resist
RCA clean (if needed)
Photolithography using reticle 5 (P-select), stepper program IC2
Ion implantation (send out) Species: B11, dose=$2x10^{15}$ cm^{-2} Energy=20kV

13. Implant Activation

Strip resist
RCA Clean
Implant activation in furnace #2

14. Interlevel Dielectric

Deposit dielectric by PECVD
Photolithography using reticle 6 (Contact), stepper program IC3
Etch contact holes using RIE
Strip resist
RCA clean to remove resist residue

15. Metal Interconnects

Deposit aluminum (done by TAs)
Photolithography using reticle 7 (Metal), stepper program IC3
Dry etch aluminum using the RIE
Soak wafers for 20 min in DI to remove chlorine residue

16. Final Anneal

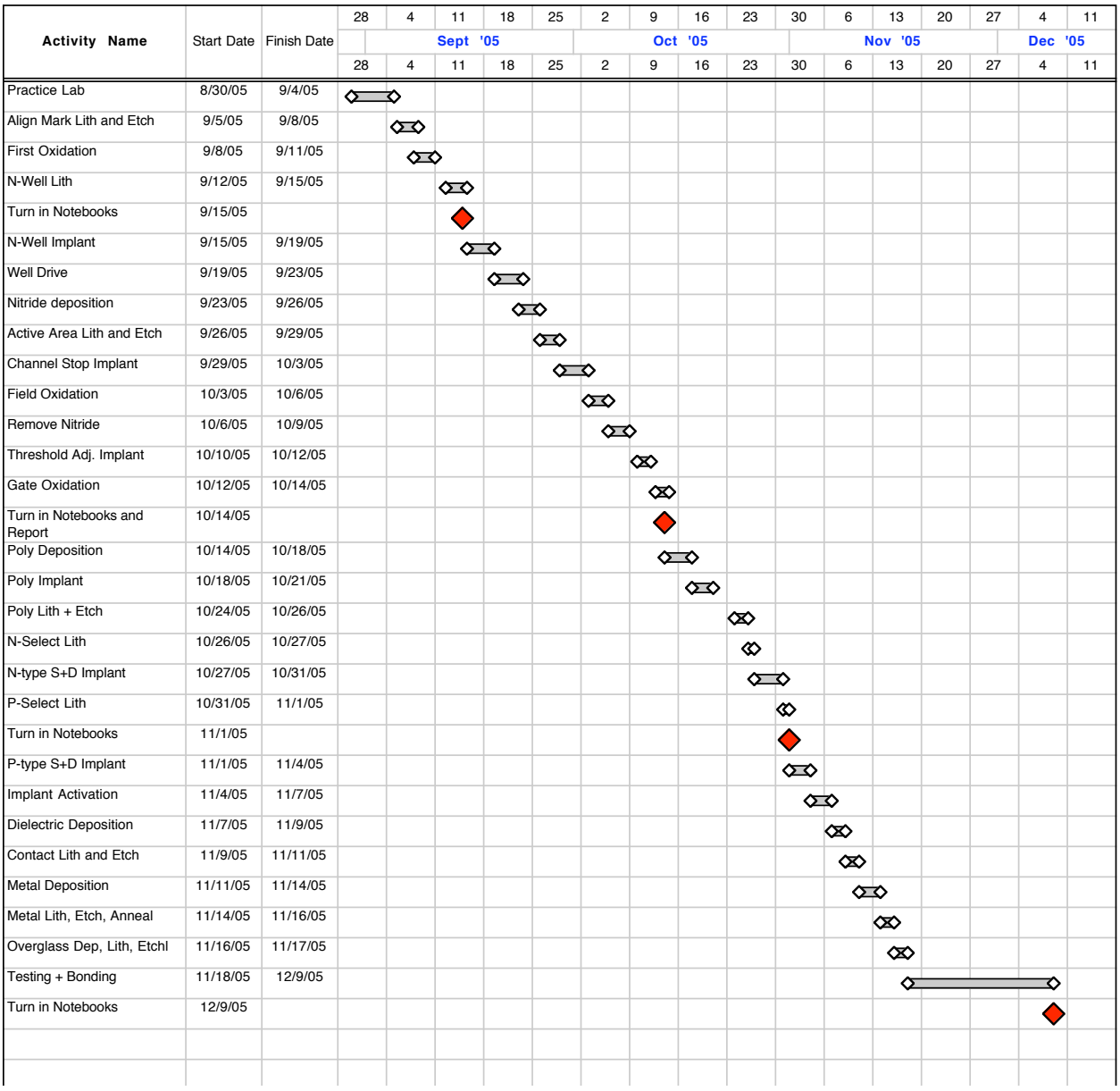
Strip resist
Anneal Contacts

17. Overlayer (Optional)

Deposit nitride in PECVD
Photolithography using reticle 8 (Overglass), stepper program IC3
Etch nitride in RIE
Strip resist

18. Test Devices

SCHEDULE

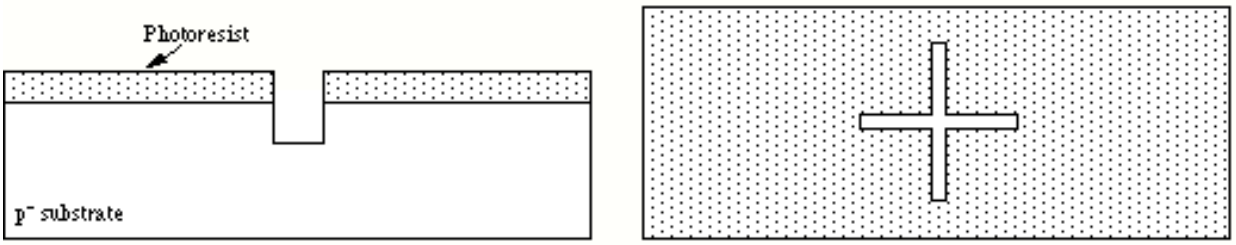


Activity Name	Start Date	Finish Date
Practice Lab	8/30/05	9/4/05
Align Mark Lith and Etch	9/5/05	9/8/05
First Oxidation	9/8/05	9/11/05
N-Well Lith	9/12/05	9/15/05
Turn in Notebooks	9/15/05	
N-Well Implant	9/15/05	9/19/05
Well Drive	9/19/05	9/23/05
Nitride deposition	9/23/05	9/26/05
Active Area Lith and Etch	9/26/05	9/29/05
Channel Stop Implant	9/29/05	10/3/05
Field Oxidation	10/3/05	10/6/05
Remove Nitride	10/6/05	10/9/05
Threshold Adj. Implant	10/10/05	10/12/05
Gate Oxidation	10/12/05	10/14/05
Turn in Notebooks and Report	10/14/05	
Poly Deposition	10/14/05	10/18/05
Poly Implant	10/18/05	10/21/05
Poly Lith + Etch	10/24/05	10/26/05
N-Select Lith	10/26/05	10/27/05
N-type S+D Implant	10/27/05	10/31/05
P-Select Lith	10/31/05	11/1/05
Turn in Notebooks	11/1/05	
P-type S+D Implant	11/1/05	11/4/05
Implant Activation	11/4/05	11/7/05
Dielectric Deposition	11/7/05	11/9/05
Contact Lith and Etch	11/9/05	11/11/05
Metal Deposition	11/11/05	11/14/05
Metal Lith, Etch, Anneal	11/14/05	11/16/05
Overglass Dep, Lith, Etchl	11/16/05	11/17/05
Testing + Bonding	11/18/05	12/9/05
Turn in Notebooks	12/9/05	

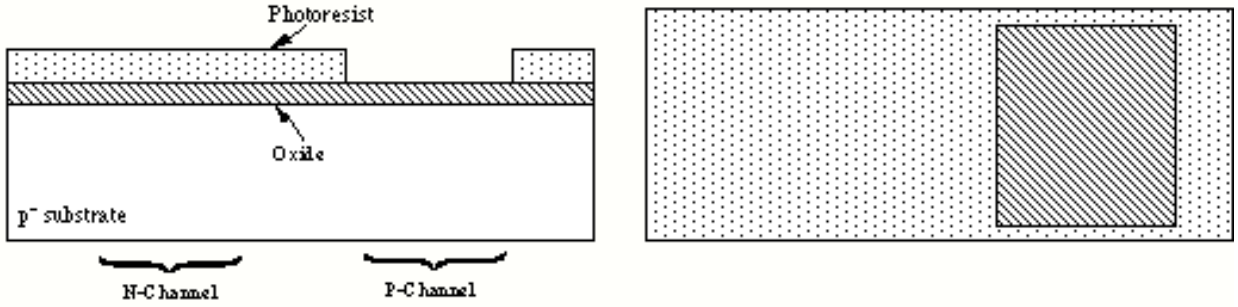
CMOS PROCESS FLOW

The figures below show a cross section and top view of the wafer as the fabrication process proceeds from bare silicon wafer to completed circuit.

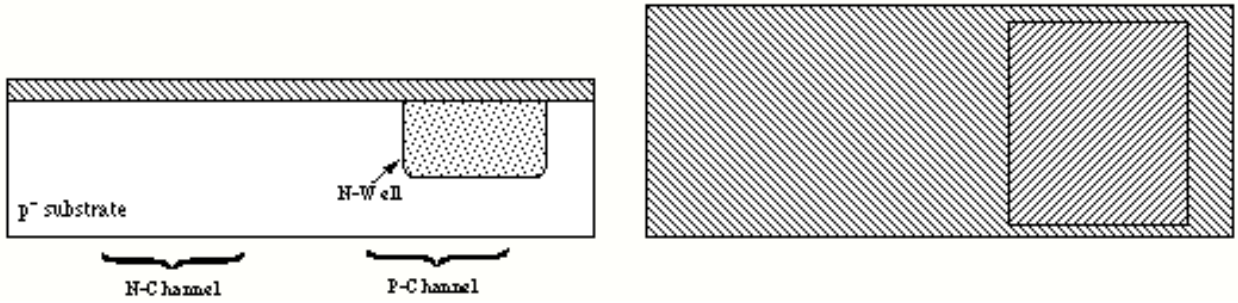
Alignment Mark Etch



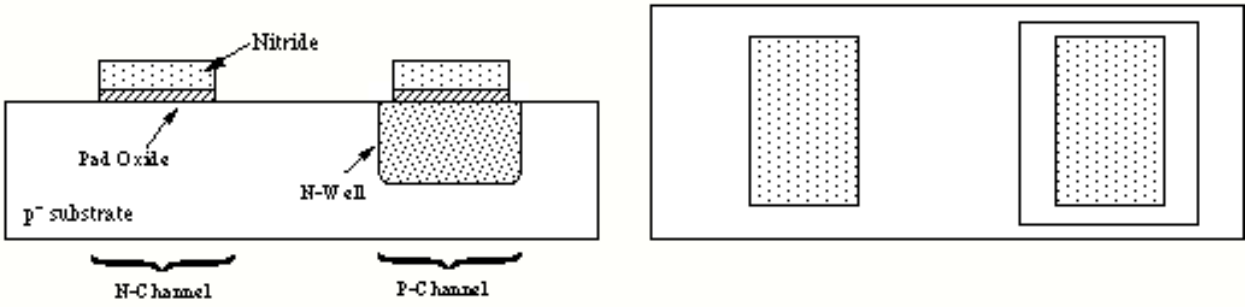
N-Well Lithography



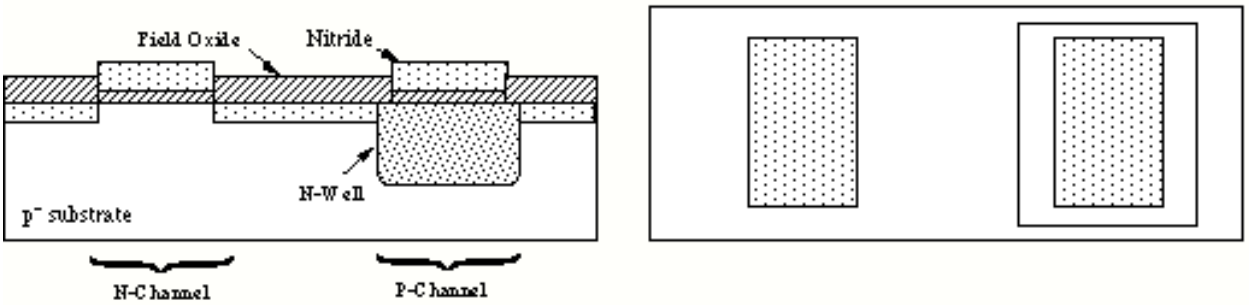
Well Drive-in



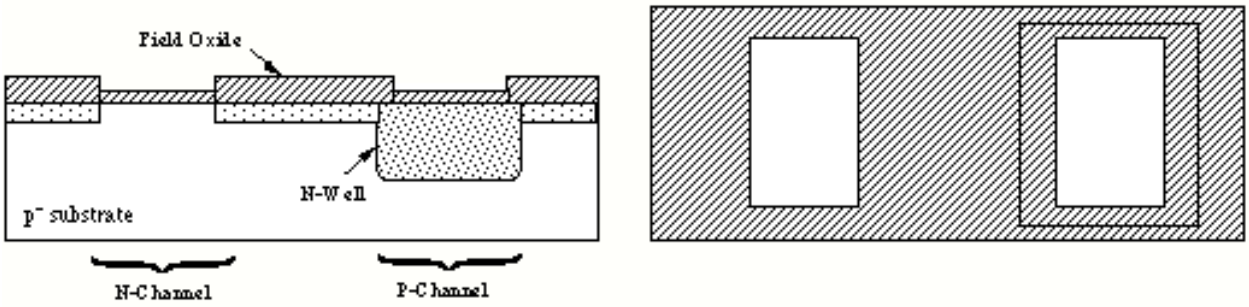
LOCOS Nitride, Active Area Lithography and Etch



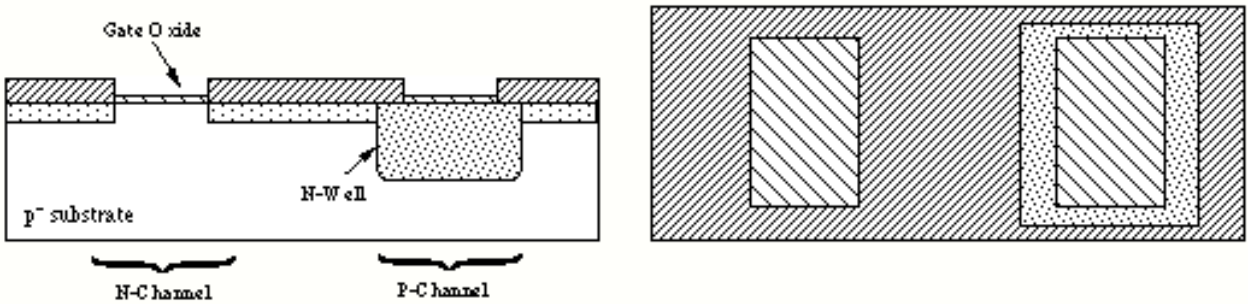
Channel Stop Implant and Field Oxidation



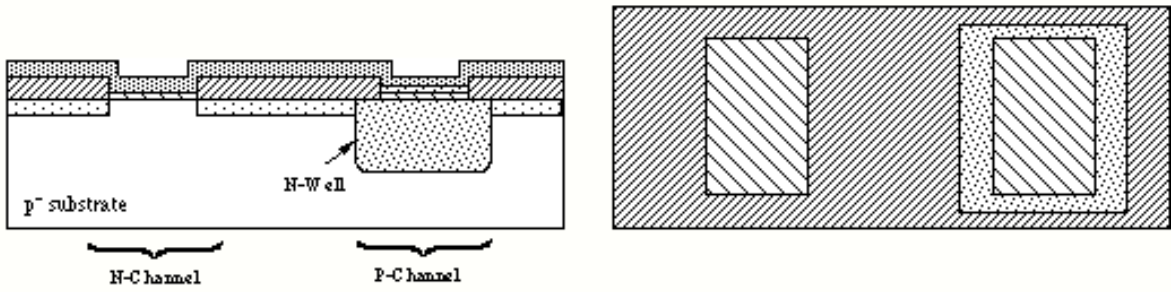
Nitride Removal and Threshold Adjust Implant



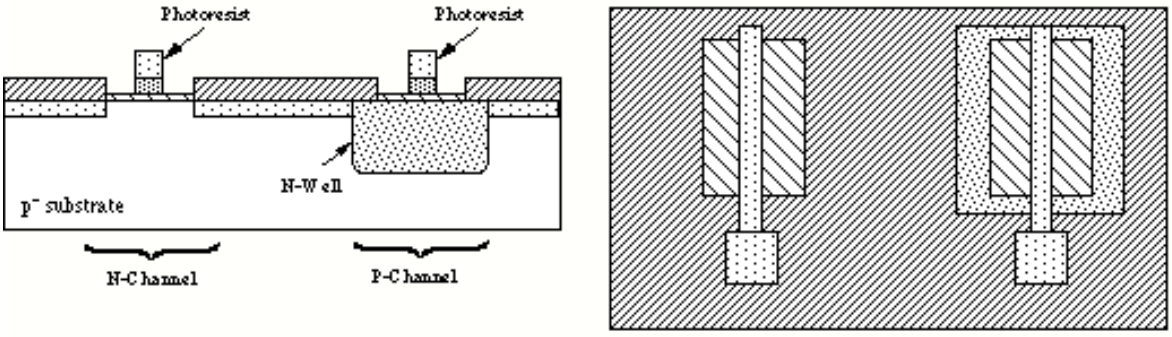
Gate Oxidation



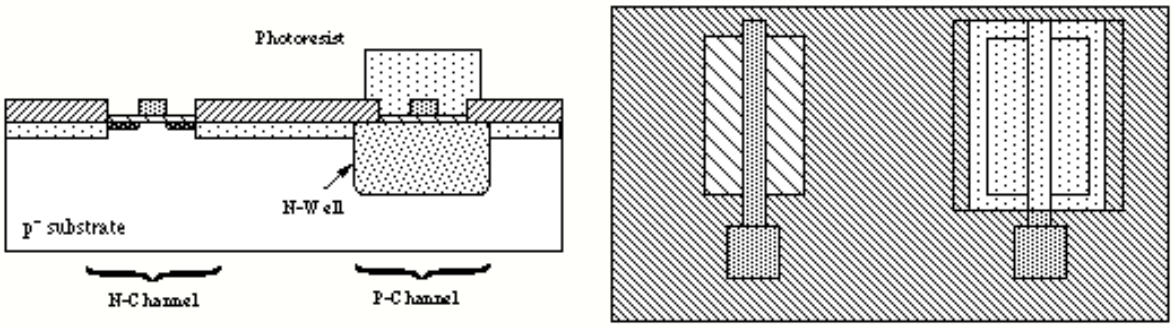
Polysilicon Deposition and Blanket Implant



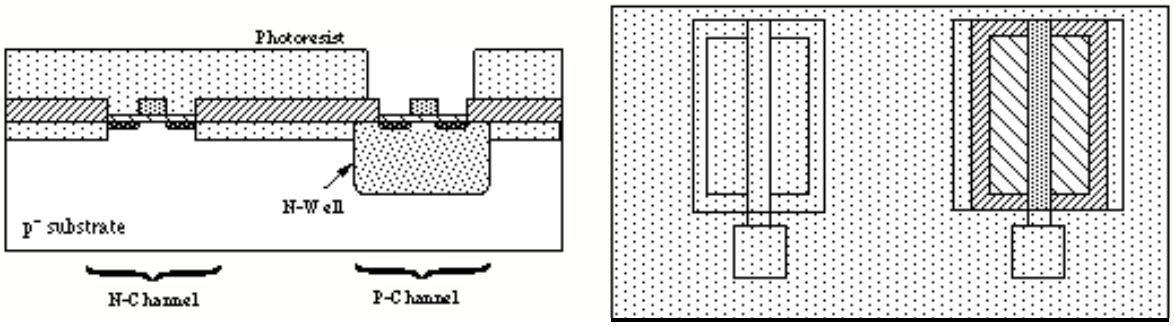
Polysilicon Gate Lithography and Etch



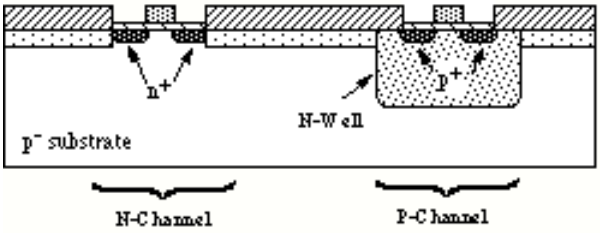
N-Select Lithography and Implant

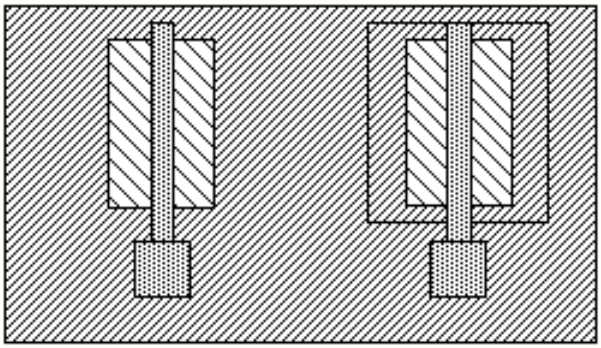


P-Select Lithography and Implant

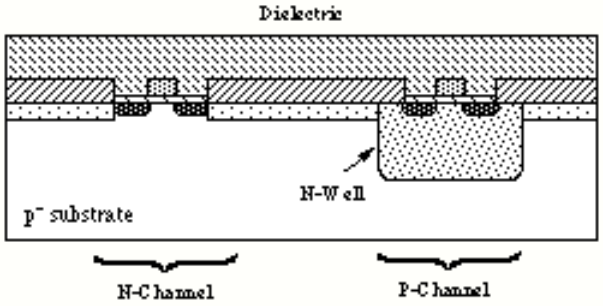


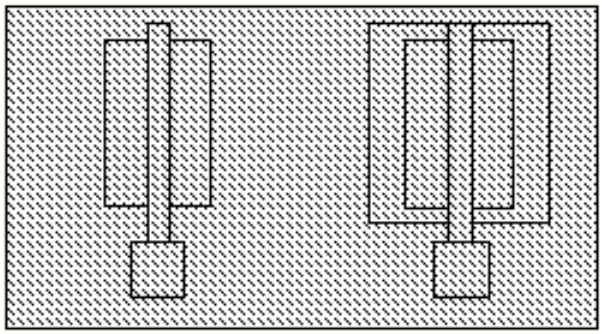
Implant Activation



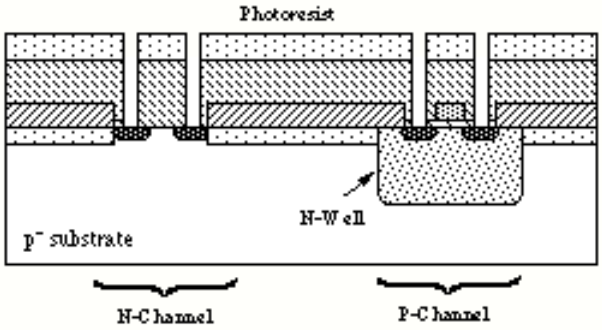


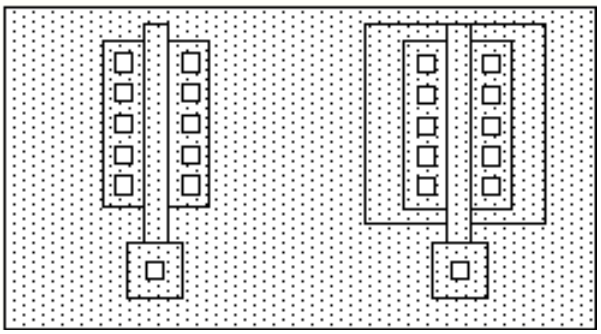
Interlevel Dielectric Deposition



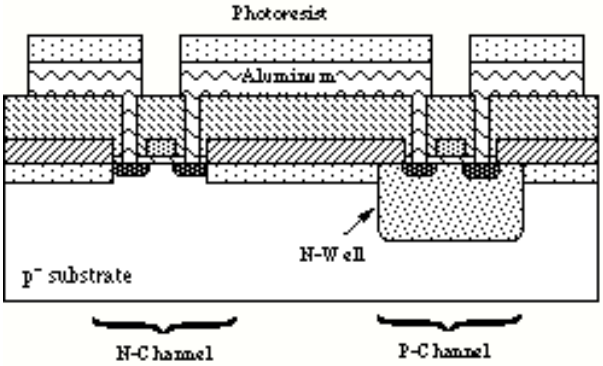


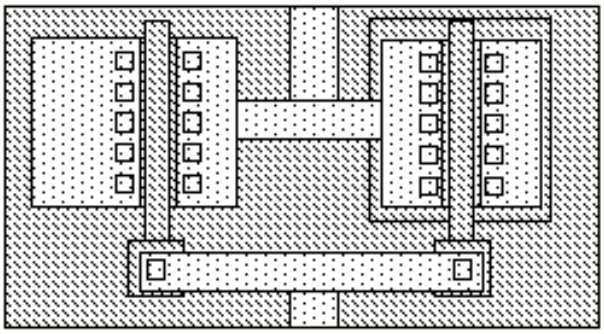
Contact Lithography and Etch



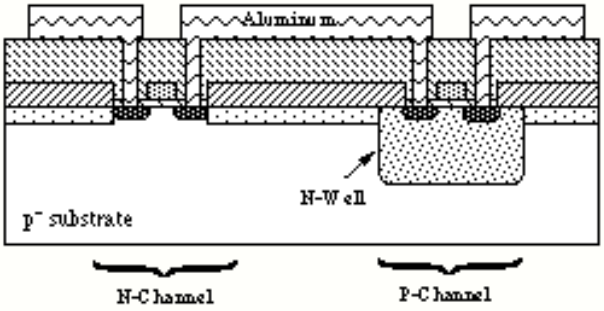


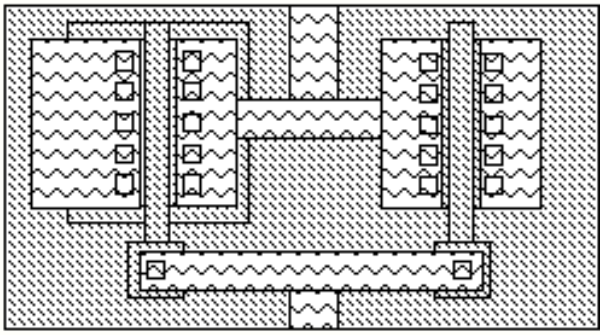
Metal Deposition, Lithography, and Etch



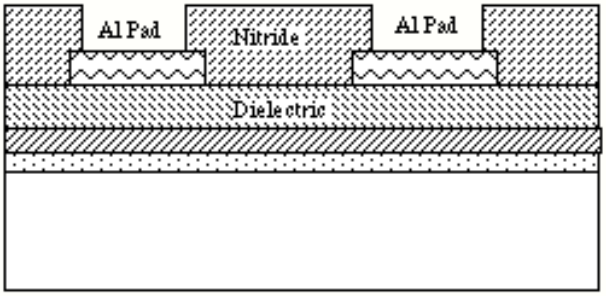


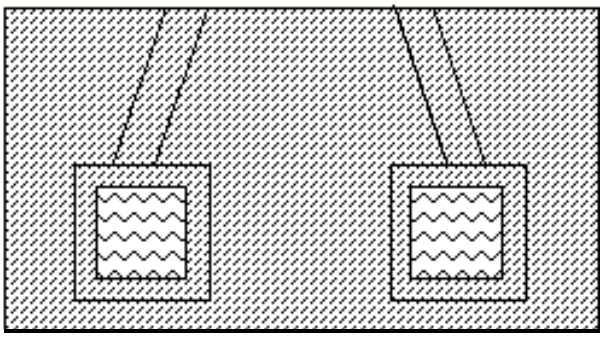
Finished Integrated Circuit





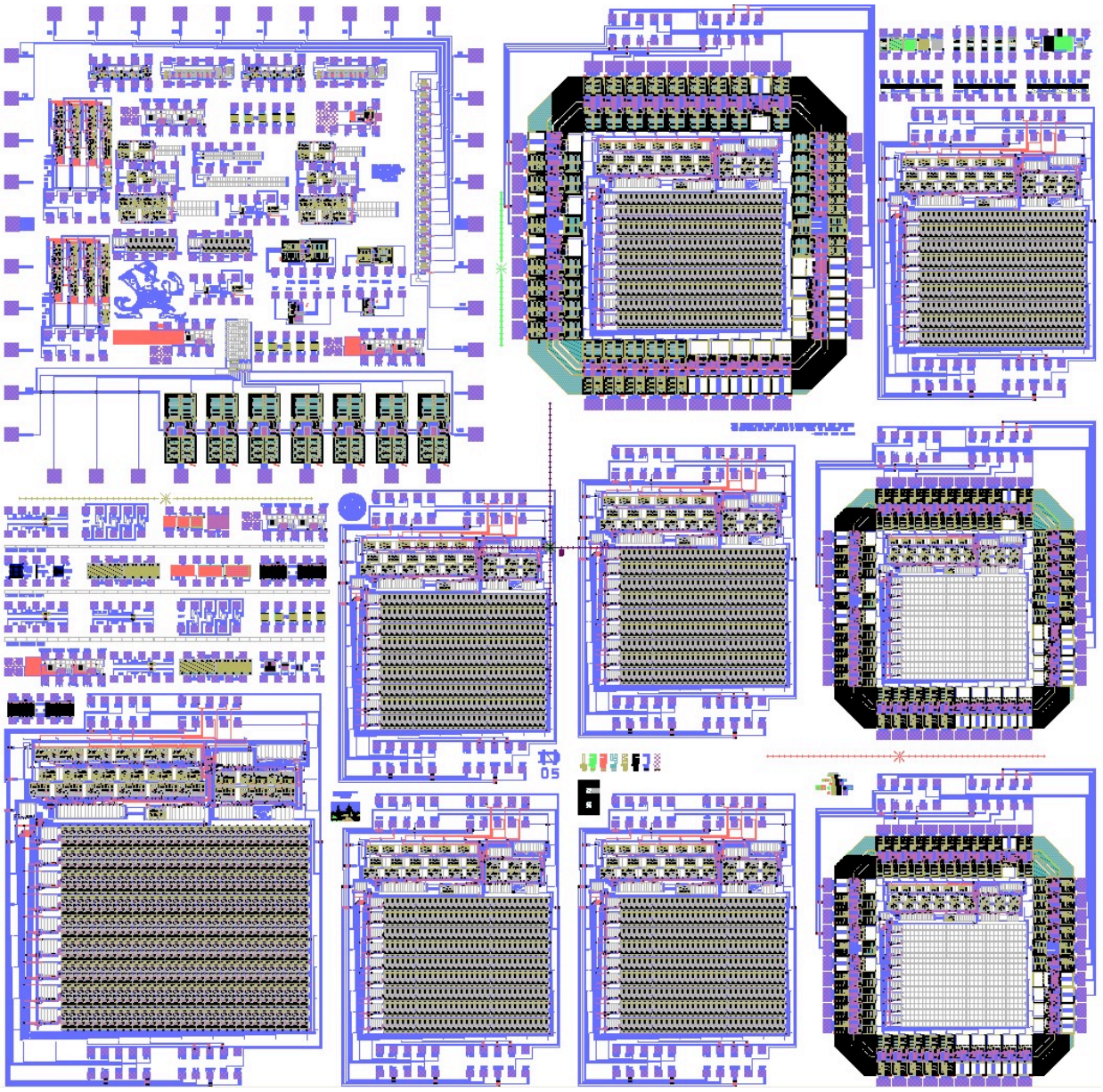
Overglass Deposition Lithography and Etch



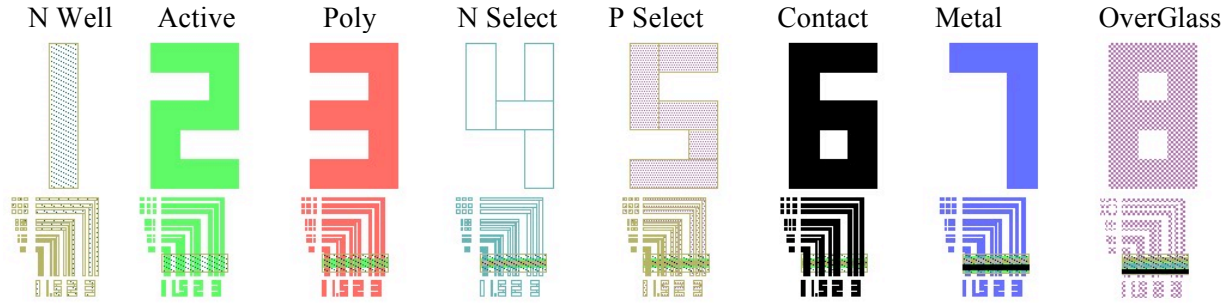


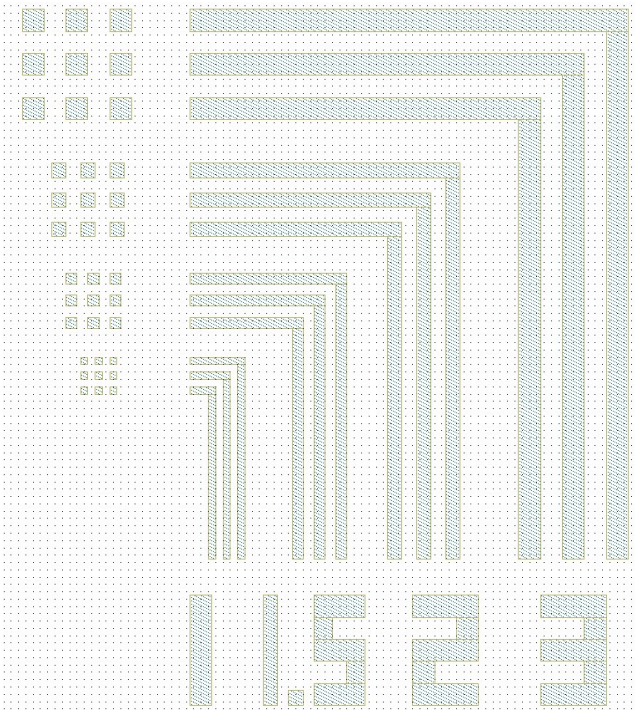
CHIP LAYOUTS

Full Reticle



Resolution Test Pattern





PRACTICE LAB

LAB EQUIPMENT AND MATERIALS

All personnel will wear blue labcoats, latex gloves, and eye protection while in the cleanroom. Full battle gear is required for the RCA cleaning step.

Objective

Many of the problems in IC Fab happen early in the process. For this reason, we will do a quick practice run on junk wafers so that you have a chance to make mistakes (and learn) and not ruin the real wafers. Photolithography and etching are the most important skills that you will need in processing the wafers. This lab will give you experience with wafer cleaning, photoresist processing, a first look at the wafer stepper. You will be given four bare wafers to process.

Advice:

Use this lab to learn as much as you can about processing before starting on your real wafers.

Detailed procedure:

1. Clean the wafers using the RCA Cleaning procedure (see appendix).
2. **Clean-Up.** Whenever you use the HF or BHF tanks, you should clean up the hood surface to ensure that there are no HF drops on the surface. Wearing your double gloves, take a cleanroom wipe and wipe dry the surface of the hood around the HF tank. Rinse this wipe thoroughly, and throw in the trash.
3. You will run two different photoresist processes. To two of the wafers apply 1813 photoresist (see appendix) and expose the wafers using the wafer stepper. On the other two wafers you should apply 5214 photoresist and expose them using the stepper. You will need to make an appointment with the TAs to use the wafer stepper. Be sure to tell them which wafers have which photoresist (the exposure times are different).
4. Develop the 1813 wafers using the procedure in the appendix.
5. Process the 5214 wafers using the image reversal process detailed in the appendix.
6. Examine the wafers closely in the microscope. Look at the very small patterns. Are the corners nice and sharp?
7. Descum the wafers for 30 sec. using the DryTek plasma etcher (see appendix).
8. Etch the wafers two at a time in the Plasma Therm RIE using the IC_L0 recipe (see appendix). Etch two wafers (one of each photoresist type) for 2 minutes, and the other two for 4 minutes.
9. Remove the resist using the DryTek. Examine the wafers again using a microscope. Look at the very small patterns. Are the corners nice and sharp?
10. Measure the step height of the patterns on the wafers using the Alpha-Step. Are the results the same for the 1813 and 5214 wafers? If not, why not? Calculate an etch rate in nm/min. Are the results from the 2 min etch consistent with the 4 min etch?
11. Be sure to good records of the processing in your notebooks. Take appropriate pictures of the wafers and attach them in your notebook. Remember, what you learn and write down now could save your wafers later on.

WAFER RESISTIVITY CHARACTERIZATION

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue labcoats, latex gloves, and eye protection while in the cleanroom.

Objective

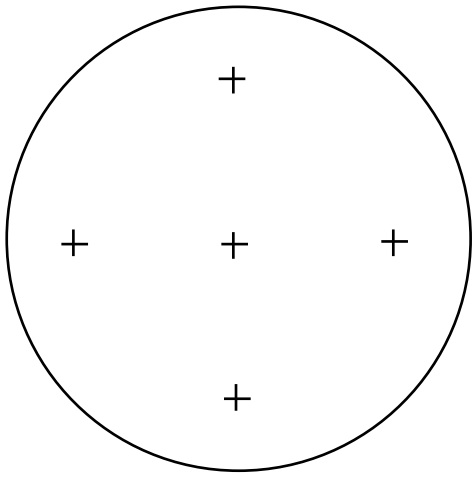
The first step in IC fabrication is to determine what kind of wafers you have, doping type and concentration. You will use the Veeco FPP 5000 four-point probe to determine the resistivity of the wafers. Using graphs in the book, you can use the resistivity to find the doping concentration in the wafer. The doping concentration is extremely important because it is a strong factor in the threshold voltage of the p-channel transistors.

Advice:

You will be placing your wafers face-down on the platen of the FPP 5000. This is very scary since any dirt on the platen can damage your wafer. Be sure to wipe the platen with a cleanroom cloth before you put your wafers down.

Procedure

1. Set the FPP 5000 for resistivity measurement, and type. The led for these buttons should be lit.
2. Check the wafer thickness setting of the FPP 5000 (see appendix) for the resistivity program. Your wafers are 620 μm thick.
3. Place your wafer face down on the platen, and place the appropriate wafer support fixture on the wafer. These fixtures are found in the black box near the FPP.
4. Measure the resistivity of the wafer at several locations and record this information in your notebook. Be sure to include the wafer identification number on the back of the wafer. Suggested measurement locations are shown below. Don't stress over exact placement, just measure the resistivity at several locations around the wafer. It should be pretty uniform.
5. Measure the rest of your wafers.
6. From graphs given in the book, determine the doping concentration of your wafers.
7. Before you start the RCA clean, check that your wafers have not picked up dust from the platen. Blow off the wafers with nitrogen if necessary.



ALIGNMENT MARK ETCH

LAB EQUIPMENT AND MATERIALS

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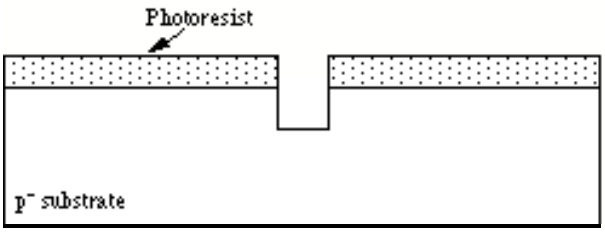
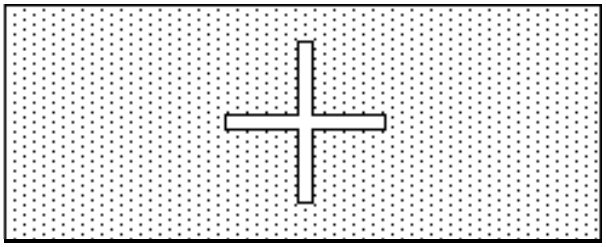




Procedure

1. Unless the wafers are dirty, you do not need to RCA clean your wafers.
2. Apply the 1813 photoresist.
3. Arrange with the TAs to expose your wafers using the Alignment layer reticle (reticle #0). Use the stepper program IC0 for this exposure. Your wafers have a notch to indicate crystal orientation. When placing the wafer on the stepper stage, place this notch against the pin at the back of the chuck, and then bank the wafer against the pin on the left of the chuck. If the wafer is not placed on the stage properly, all subsequent alignments will **be EXTREMELY** difficult!
4. After developing, inspect the wafers carefully to ensure that all of the alignment mark patterns are fully developed. You'll need to look carefully in the microscope, since the patterns are sparse. Put the wafer on the microscope stage with the notch away from you. Find the notch in the microscope and move down. You should find the marks. No post bake is necessary.
5. Prepare to etch the alignment mark into the wafer with the RIE using the ICLayer0 process (refer to the appendix on RIE etching). Be sure that the RIE is set for CF4 gas (not CHF3). If it is not, have the instructor or TAs set it up for you.
6. Check the RIE log book. Unless the user before you did a CF_4 etch, you will need to "season" the chamber. Seasoning the chamber brings the chamber into equilibrium so that each etch behaves the same as the others. If you don't season the chamber your first sample will etch differently than the second and third. The first step in seasoning the camber is to clean the chamber. If the last etch done by the previous user was not an oxygen etch, you must first clean the chamber using the o2clean process. Next run the ICLayer0 process without a sample in the chamber. The process has a variable time for the etch step. When you press run, the program asks you for the desired time. Click on the etch step line on the left side of the dialog box, and enter the time on the right side. To season the chamber, enter 10 minutes. Press run.
7. You're now ready to run your wafers. The nominal time needed to etch two wafers at a time 1min 30 s. There will be an announcement if there is a change in the etch time. The etch depth is not critical for this step, so don't stress too much!
8. Etch all of your wafers two at a time.
9. Remove the photoresist using the DryTek.

FIRST OXIDE

GENERAL FURNACE RULES

1. Immediately before any wafers go into an oxidation furnace, they must be given an RCA clean!
2. No metal in the furnace tube, EVER!
3. No photoresist or other organics in any furnace.
4. Sign the log book before starting.
5. Open a furnace tube only when a LOAD or UNLOAD step is running in the control program.
6. Return boat to the proper furnace when finished! Do not mix quartzware between tubes.

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue labcoats, latex gloves, and eye protection while in the cleanroom. Full battle gear is required for the RCA cleaning.

Special Safety Equipment:

High Temperature Gloves for handling the hot quartz furnace tube cap and pig.

Safety Notes:

The furnaces are hot and require appropriate care to avoid severe burns
The quartz boat retains heat for a long time.
Wafers and quartzware may be hot.

Lab Equipment Required:

Furnace #2 Refer to the appendix for detailed instructions for furnace operation.

Advice: To save time in this procedure, you should merge it with the RCA Clean. When you come into the lab start all the heaters at once, furnace, and RCA baths. By the time you've finished the RCA clean, the furnace will be at temperature, ready for you wafers.

Do not touch any of the quartz ware with your bare hands!! If you do, it must be cleaned with HF, and everybody hates HF!

PROCEDURE:

1. RCA clean the wafers. Be sure that the photoresist has already been removed.
2. Refer to the appendix on furnace operating instructions. Press the "Tube 2 Recipe" button and select the furnace program "IC_FirstOxide", which contains the following steps:
    a. Temp: 1000 degrees Celsius.
    b. Time: 20 min. Dry O2
    c. Time: 30 min. High N2 (anneal)
3. Open the oxygen valve above the jungle. If the O2 regulator does not show a pressure of about 10 psi, showing zero instead, contact Mike Thomas or a TA. Start the furnace program by pressing the "Load Tube" button. This will begin heating the furnace and start the high flow of nitrogen so that you can remove the furnace cap. Remove the wafer boat from the mouth of the furnace.
4. When the RCA clean is done, load the wafers into the boat. Carry the wafers back to the furnace. Check to be sure that the loading portion of the program is still running. If not, restart it.
5. Load the wafers slowly into the #2 furnace, taking 3-5 minutes to transition into the hot zone. Press "Start Program" to begin the final heating of the tube and the timed steps. Leave the pig on the tube.

6. After the N2 anneal step is done, let the furnace cool to below 750 ˚C before unloading the wafers from the furnace. Remember to pull them slowly from the furnace.
7. Take the pig off the furnace tube, and recap the pig and the tube. **DO NOT PLACE THE END CAP TIGHTLY INTO THE PIG!!!** Leave about 1 cm of the ground-glass joint of the cap showing. Let the wafers cool (approximately 30 minutes) before taking the pig to the MOS Cleaning bench to unload the boat.
8. Place the quartz boat back into the mouth of the furnace. Be sure that the "Unload" step is still running in the program!
9. Close the Oxygen valve above the jungle, and stop the furnace control program by pressing "Abort Tube 2.

Be sure to fill in your lab notebook. Be complete. Things that you must include are:
Date
Time for the various elements of the system to come to the proper temperature.
Color of wafers. Has it changed from the silver of the unoxidized wafers?

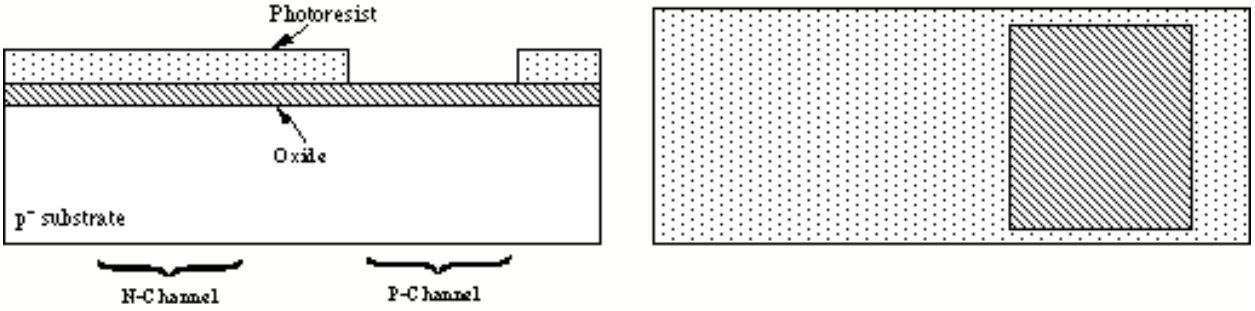
N-WELL IMPLANT LITHOGRAPHY

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue lab coats, latex gloves, and eye protection while in the cleanroom. Full battle gear is required for the RCA cleaning step.

Chemicals Required:

RCA Cleaning baths (if wafers are not clean. Use your judgement)
Photoresist
Developer



Procedure:

1. RCA clean. (If the wafers are fresh out of the oxidation furnace,or still look clean, you can skip this).
2. Photolithography (see appendices on Applying Photoresist, GCA 6300 Stepper Instructions, and Developing Photoresist) using 1813 photoresist and the N-Well reticle. Use the stepper program IC0.
3. Descum the wafers for 30 sec. in the DryTek.
4. Send Email to the instructor and TAs telling that your wafers are done, and be sure to fill out the status table on the ICFAB cabinet. When all the groups are done, the wafers will be sent out for the N-Well implant. Notice that the photoresist will mask the implant, which goes through the thin oxide.

WELL DRIVE-IN

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue labcoats, latex gloves, and eye protection while in the cleanroom. High Temperature Gloves for handling the hot quartz furnace tube cap. Full battle gear for the RCA clean.

Safety Notes:

The furnaces are hot and require appropriate care to avoid severe burns
The quartz boat retains heat for a long time.

Lab Equipment Required:

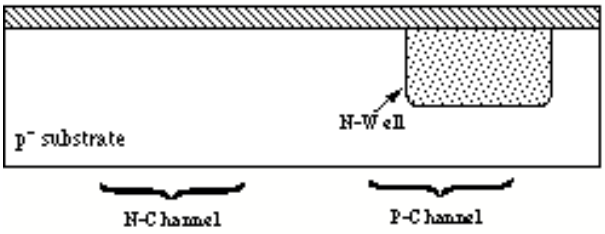
Furnace #2. Pig (or Elephant), Oxidation boat, Push rods.

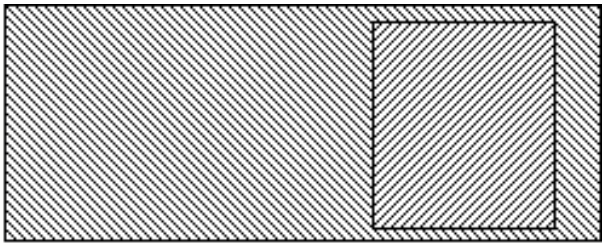
Observations:

The temperature of the tube is 1200 ˚C. At this temperature the color of the hot zone will be near white with a little yellow. Very white with no yellow indicates a possible over-temperature condition. Check the furnace temperature profile posted on the furnace to determine where to place the boat. When inserting or removing the boats, be mindful of this. The part of the push rod inserted into the furnace will be very hot and the part of the push rod that remains out of the furnace will be cool. The overall time of the procedure is about 4-5 hours, including RCA clean.

Do not touch any of the quartzware with your bare hands!! If you do, it must be cleaned with HF, and everybody hates HF!

Advice: To save time in this procedure, you should merge it with the RCA Clean. When you come into the lab start all the heaters at once, furnace, steam generator, RCA baths. By the time you've finished the RCA clean, the furnace and steam generator will be at temperature, ready for you wafers.





PROCEDURE

1. Remove the resist left from the P-well implant using the Dry Tek.
2. RCA clean the wafers.
3. Refer to the furnace operating instructions in the appendix. Press the "Tube 2 Recipe" button and select the furnace #2 recipe "IC_Nwell". The program is as follows:
   Temp: 1200 degrees Celsius.
   Time: 5 min. Dry O2
   Time: 120 min. High N2 (Drive the dopants in)

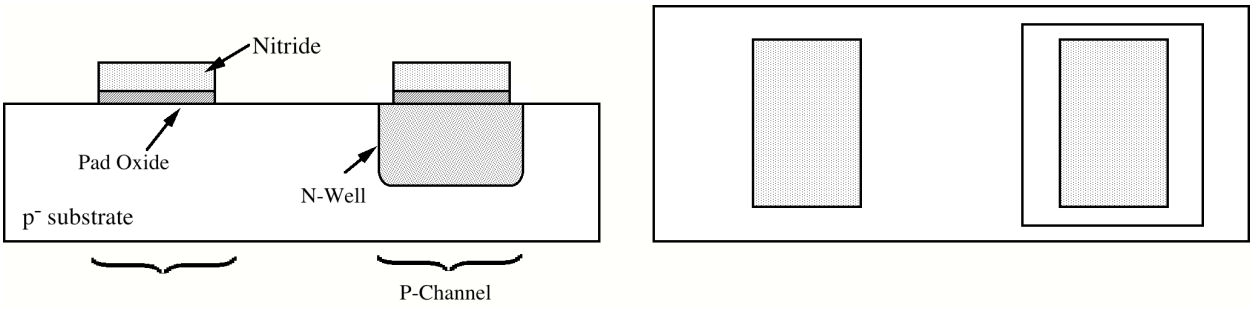
4. Turn on the oxygen valve above the jungle. If the O2 regulator does not show a pressure of about 10 psi, showing zero instead, contact Mike Thomas or a TA. Start the furnace control program by pressing the "Load Tube" button. Remove the wafer boat from the mouth of the furnace.
5. When the RCA clean is complete, load the wafers into the boat. Carry the boat (in the pig) back to the furnace. Check to be sure that the loading portion of the program is still running. If not, restart it.
6. Load the wafers into the # 2 furnace, taking three to five minutes to load the wafers to the flat zone of the furnace (refer to the posted furnace profile). Leave the pig on the furnace. Start the final tube heating and timed program steps by pressing "Start Program".
7. The selected recipe will activate and diffuse the implanted phosphorus with a short oxidation at the beginning.
8. After the furnace cools below 750˚ C, remove the wafers slowly from the furnace.
9. Be sure that the unload portion of the program is running so that High N2 is flowing while the furnace tube is uncapped.Take the pig off the furnace tube, and recap the pig and the tube. **DO NOT PLACE THE END CAP TIGHTLY INTO THE PIG!!!** Leave about 1 cm of the ground-glass joint of the cap showing. Let the wafers cool (approximately 30 minutes) before taking the pig to the MOS Cleaning bench to unload the boat.
10. Shut off the Oxygen valve above the jungle.
11. Place the quartz boat back into the mouth of the furnace. Be sure that the unload portion of the program is running so that High N2 is flowing!
12. Stop the furnace programming by pressing the "Abort Tube 2" button.
13. Let the instructor and TAs know that your wafers are ready for nitride deposition.

Be sure to fill in your lab notebook. Be complete.

ACTIVE LAYER LITHOGRAPHY, ETCH, AND CHANNEL STOP IMPLANT

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue lab coats, latex gloves, and eye protection while in the cleanroom.



PROCEDURE

1. When the TAs return your wafers, they will be coated with an additional layer of about 80 nm of silicon nitride.
2. Apply the AZ 1813 photoresist. Align and expose the wafers on the stepper using the Active layer reticle (reticle #2). Use the stepper program IC0 and align to the marks on the wafer.
3. No post bake is necessary. Descum the wafers for 30 sec. in the DryTek.
4. Be sure that the RIE is set for CF4 gas (not CHF3). If it is not, have the instructor or TAs set it up for you.
5. Check the RIE log book. Unless the user before you did a CF4 etch, you will need to "season" the chamber. Seasoning the chamber brings the chamber into equilibrium so that each etch behaves the same as the others and you get repeatable results. If you don't season the chamber your first sample will etch differently than the second and third. The first step in seasoning the camber is to clean the chamber. If the last etch done by the previous user was not an oxygen etch, you must first clean the chamber using the o2clean process. Next run the ICnitrd process twice without a sample in the chamber. The ICnitrd process has a fixed time for the etch step.
6. You're now ready to run your wafers. Etch the silicon nitride and into the silicon using the RIE with the ICnitrd process (refer to the appendix on RIE etching). The etch depth is not very critical here, so we'll etch for the time set in the program. Etch your wafers two at a time.
7. **Be sure to leave the photoresist on.** Tell the instructor and TAs that your wafers are ready for implant.

LOCOS FIELD OXIDATION

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue labcoats, latex gloves, and eye protection while in the cleanroom.
High Temperature Gloves for handling the hot quartz furnace tube cap and pig. Full battle gear is required for the RCA cleaning step.

Safety Notes:

The furnaces are hot and require appropriate care to avoid severe burns
The quartz boat retains heat for a long time.
Wafers and quartzware may be hot.

Lab Equipment Required:

Furnace #2 Refer to the appendix for detailed instructions for oxidation.

Advice: To save time in this procedure, you should merge it with the RCA Clean. When you come into the lab start all the heaters at once, furnace, steam generator (bubbler), RCA baths.

Do not touch any of the quartz ware with your bare hands!! If you do, it must be cleaned with HF, and everybody hates HF!

PROCEDURE:

1. Remove the photoresist using the DryTek..
2. RCA clean the wafers.
3. Refer to the furnace operating instructions in the appendix on oxidation. Press the "Tube 2 Recipe" button and select the furnace recipe "IC_FieldOxide. Program summary:
   Temp: 1100 degrees Celsius.
   Time: 30 min. Dry O2
   Time: 70 min. Wet
   Time: 30 min. Dry O2
4. Open the oxygen valve above the jungle. If the O2 regulator does not show a pressure of about 10 psi, showing zero instead, contact Mike Thomas or a TA. Check the water level in the bubbler and add DI water if needed. Turn on the bubbler heater. Start the furnace program by pressing the "Load Tube" button. Remove the wafer boat from the mouth of the furnace.
5. When the RCA clean is done, load the wafers into the wafer boat. Carry the wafers back to the furnace. Check to be sure that the load portion of the program is still running. If not, restart it.
6. Load the wafers slowly into the #2 furnace and press "Run Program" to start final tube heating and the timed program steps. Leave the pig on the furnace.
7. At the end of the program, when the furnace temperature has dropped below 800˚ C, slowly remove the wafers from the furnace.
8. Be sure that the unload portion of the furnace program is running. Remove the pig from the furnace tube and recap the pig and furnace. **DO NOT PLACE THE END CAP TIGHTLY INTO THE PIG!!!** Leave about 1 cm of the ground-glass joint of the cap showing. Let the wafers cool (approximately 30 minutes) before taking the pig to the MOS Cleaning bench to unload the boat.
9. Turn off the bubbler heater.
10. Place the quartz boat back into the mouth of the furnace. Be sure that unload portion of the program is running!
11. Close the Oxygen valve above the jungle, and stop the furnace program by pressing "Abort Tube 2".

NITRIDE REMOVAL

LAB EQUIPMENT AND MATERIALS

Full battle gear is required for this procedure.

Safety Notes:

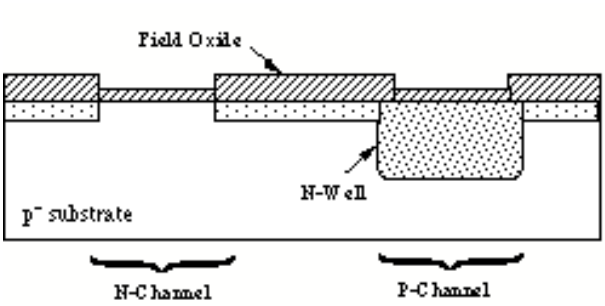
You will be working with hot acids. Be careful
The quartz boat retains heat for a long time.
Wafers and quartzware may be hot.

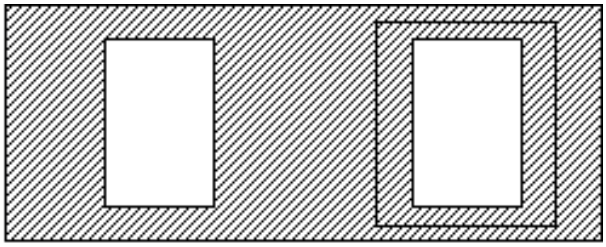
Chemicals Required:

Phosphoric Acid (H_3PO_4)

Lab Equipment Required:

Hotplate and temperature controller (built into acid hood).





PROCEDURE:

1. Check the level of phosphoric acid in the beaker. Add more if necessary.
2. Check that the hotplate and thermocouple are connected to the controller in the acid hood (room 244).
3. Turn on the cooling water for the refluxer (cover for the beaker). **Turn the water on just enough that the indicator just barely turns. No Higher!!**
4. Set the temperature to 180 ˚C, place the thermocouple in the beaker, and begin heating the acid. Be sure that the cover is on the beaker.
5. Place your wafers in the wafer carrier and put them in the phosphoric acid.
6. Let the wafers etch until all the nitride is gone. This can take 2-3 hours.
7. Remove the wafers from the acid and rinse for two cycles in the dump rinser (in the acid hood).
8. Turn off the hotplate.
9. Measure the final field oxide thickness using the Filmetrics thickness measurement system in the photoresist room.
10. Do not remove the pad oxide. Notify the instructor and TAs that your wafers are ready for the threshold adjust implant.

GATE OXIDATION

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue labcoats, latex gloves, and eye protection while in the cleanroom.

Safety Procedures and Equipment:

High Temperature Gloves for handling the hot quartz furnace tube cap and pig.

Safety Notes:

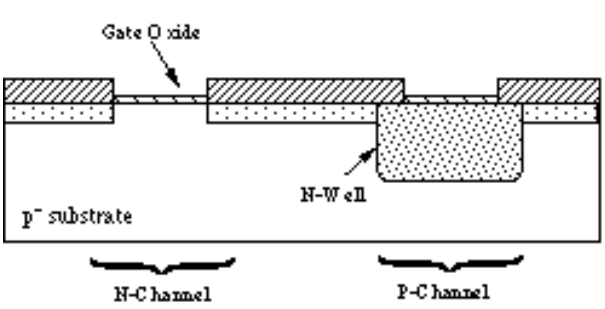
The furnaces are hot and require appropriate care to avoid severe burns
The quartz boat retains heat for a long time.
Wafers and quartzware may be hot.

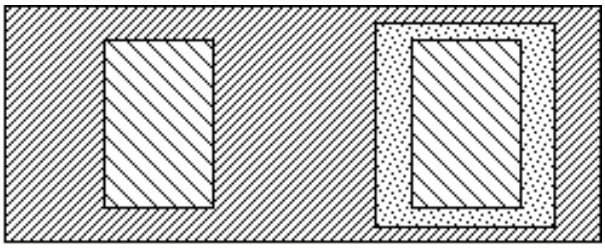
Lab Equipment Required:

Furnace #1. This tube is dedicated to the growth of high quality oxides with chlorine added to reduce the effect of sodium ions. It is your responsibility to follow this procedure closely to ensure that the furnace is not contaminated.

Advice: To save time in this procedure, you should merge it with the RCA Clean. When you come into the lab start the furnace and RCA baths.

Do not touch any of the quartz ware with your bare hands!! If you do, it must be cleaned with HF, and everybody hates HF!





PROCEDURE:

1. You will be given a p-type bare wafer. This will be your test wafer to check the gate oxide thickness. Clean and grow the oxide on this wafer along with your real wafers.
2. Etch the wafers for 60 sec. in the 10:1 buffered HF (in the acid hood) to remove the pad oxide from the active areas
3. RCA clean the wafers.
4. Refer to the furnace operating instructions in the appendix on Furnace Operation. Press the "Tube 1 Recipe" button and select the recipe IC_GateOxide. Start the Trans LC temperature controller. Program summary:
   Furnace temperature: 950˚ C
   Time: 3 min. Dry O2
   Time: 20 min. Trans LC
   Time: 3 min. Dry O2
   Time: 20 min. High N2 (Anneal)

3. Open the O2 valve above the back of the jungle. If the O2 regulator does not show a pressure of about 10 psi, showing zero instead, contact Mike Thomas or a TA.
4. Start the furnace program by pressing the "Load Tube" button. Remove the wafer boat from the mouth of the furnace.
5. When the RCA clean is finished, load the wafers into the boat. Carry the wafers (in the pig) to the furnace. Check to be sure that the load portion of the program is still running.
6. Load the wafers slowly into the #1 furnace (put the test wafer on the boat in the in the middle of your wafers) and press "Run Program" to start final tube heating and the timed program steps. Leave the pig on the furnace.
7. When the program is finished and the temperature falls below 800 ˚C, slowly remove the wafers from the furnace.
8. Be sure that the unload portion of the furnace program is running. Remove the pig from the furnace tube and recap the pig and furnace. **DO NOT PLACE THE END CAP TIGHTLY INTO THE PIG!!!** Leave about 1 cm of the ground-glass joint of the cap showing. Let the wafers cool (approximately 30 minutes) before taking the pig to the MOS Cleaning bench to unload the boat.
9. Turn off the oxygen by closing the valve above the back of the jungle. Turn off the Trans LC temperature controller.
10. Place the quartz boat back into the mouth of the furnace. Be sure that the load portion of the program is running
11. Stop the furnace control program by pressing the "Abort Tube 1" button.
12. Email the instructor and TAs that your wafers are ready for polysilicon deposition.
13. Measure the oxide thickness on your test wafer using the ellipsometer (see appendix).

Be sure to fill in your lab notebook. Be complete.

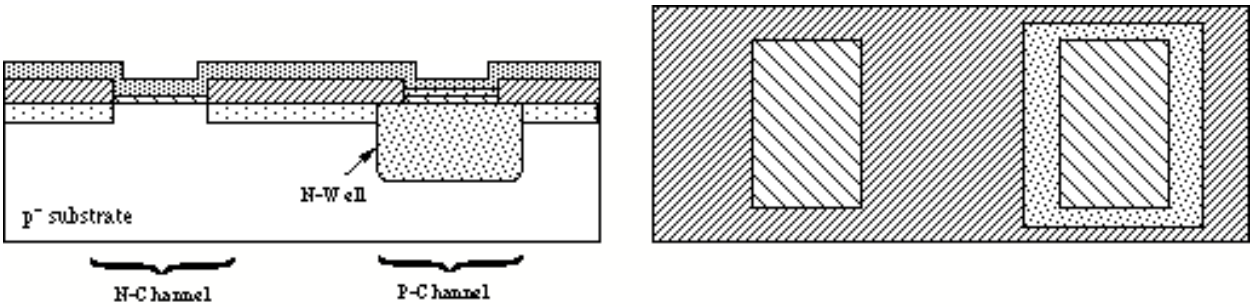
POLY LITHOGRAPHY AND ETCH

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue lab coats, latex gloves, and eye protection while in the cleanroom.

Advice:

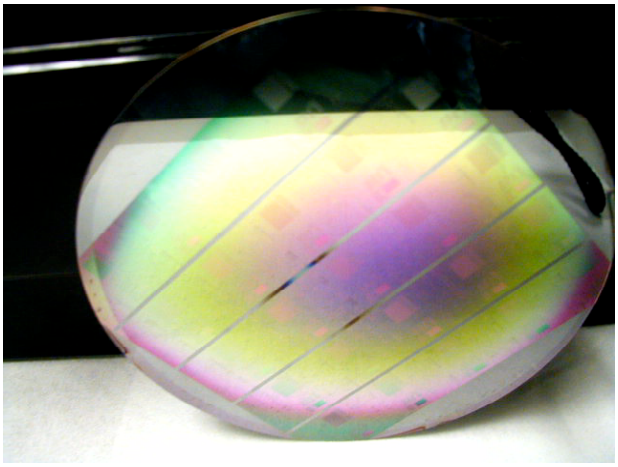
This is one of the trickiest steps in the process since you need to etch far enough to remove all the poly, but not so far that you etch deeply into the substrate.



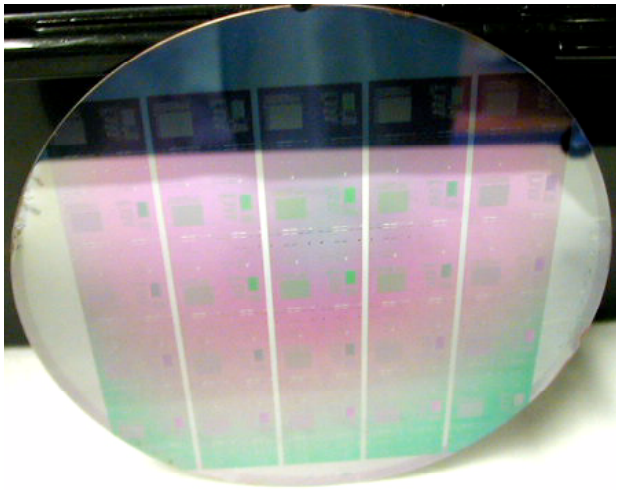
Procedure

1. Unless the wafers are dirty, you do not need to RCA clean your wafers.
2. Apply the 1813 photoresist.
3. Align and expose the wafers on the stepper using the Poly layer reticle (reticle #3). Use the stepper program IC2. This will align to marks formed by the Active layer (on the screen, you should see a small number "2" below the alignment mark).
4. After developing, inspect the wafers carefully to ensure that all of the gate patterns are on the surface (If there are any adhesion problems the gates will float away in the developer). No post bake is necessary.
5. **VERY IMPORTANT!!** Measure the thickness of the photoresist using the Alpha-Step 500. The resist must be at least 1.2 microns thick. If it is not, you must re-do the lithography. Inform the instructor and the TAs.
6. Prepare to etch the polysilicon in the RIE using the ICpoly process (refer to the appendix on RIE etching).
7. Be sure that the RIE is set for CF4 gas (not CHF3). If it is not, have the instructor or TAs set it up for you.
8. Check the RIE log book. Unless the user before you did a CF4 etch, you will need to "season" the chamber. Seasoning the chamber brings the chamber into equilibrium so that each etch behaves the same as the others. If you don't season the chamber your first sample will etch differently than the second and third. The first step in seasoning the camber is to clean the chamber. If the last etch done by the previous user was not an oxygen etch, you must first clean the chamber using the o2clean process. Next run the ICpoly process without a sample in the chamber. The ICpoly process has a variable time for the etch step. When you press run, the program asks you for the desired time. Click on the etch step line on the left side of the dialog box, and enter the time on the right side. To season the chamber, enter 10 minutes. Press run.
9. You're now ready to run your wafers. The recommended time to etch the poly on two wafers etched at once will be posted on the RIE. Remember that beneath the poly is your thin gate oxide. Ideally we want to etch through the poly and stop before etching through the gate oxide.

10. Etch your first two wafers to be sure that you are etching the correct amount. Inspect the wafer carefully. Be sure that the polysilicon is completely etched at the edges of the active area openings. When you are confident that the etch time is correct, etch the other wafers, two at a time.



Not Done Yet!

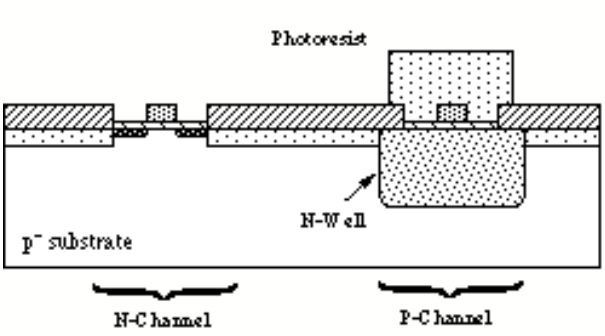


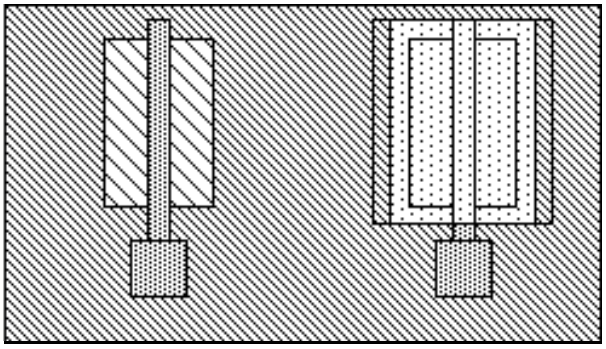
Done!

N–SELECT LITHOGRAPHY

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue lab coats, latex gloves, and eye protection while in the cleanroom.





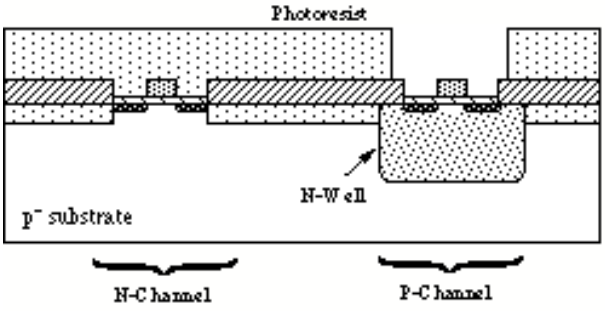
Procedure

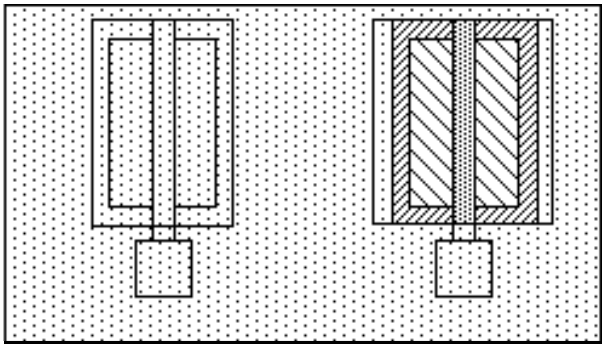
1. Remove the photoresist in the DryTek. Since the wafers received a high-dose implant the resist will take longer than usual to remove. RCA clean your wafers if necessary.
2. Apply the **5214** photoresist. Use the image reverse process.
3. Expose the wafers on the stepper using the P-select reticle (reticle #5). Use the stepper program IC2, but change the exposure time to 5 sec. (check the whiteboard on the stepper for the exact time).
4. **Be sure to use the Image Reversal Procedure!** This involves an image reversal bake after exposure, and a flood exposure before developing.
5. De-scum the wafers for 30 sec. in the DryTek.
6. Notify the instructor and TAs that your wafers are ready for implant.

P–SELECT LITHOGRAPHY

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue lab coats, latex gloves, and eye protection while in the cleanroom.





Procedure

1. Remove the photoresist using the DryTek. Since the wafers received a high-dose implant the resist will take longer than usual to remove. RCA clean your wafers if necessary.
2. Apply the **1813** photoresist.
3. Expose the wafers on the stepper using the P-Select reticle again (reticle #5). Use the stepper program IC2. Develop the wafers.
4. De-scum the wafers for 30 sec. in the DryTek.
5. Notify the instructor and TAs that your wafers are ready for implant.

SOURCE–DRAIN IMPLANT ACTIVATION

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue labcoats, latex gloves, and eye protection while in the cleanroom.

Safety Procedures and Equipment:

High Temperature Gloves for handling the hot quartz furnace tube cap and pig.

Safety Notes:

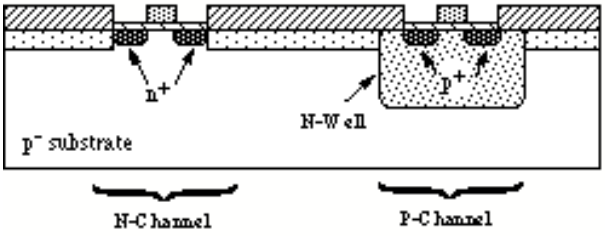
The furnaces are hot and require appropriate care to avoid severe burns
The quartz boat retains heat for a long time.
Wafers and quartzware may be hot.

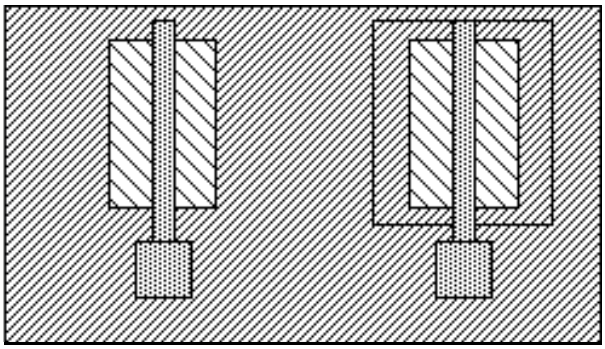
Lab Equipment Required:

Furnace #2

Advice: This step will activate two implants simultaneously (n-select, and p-select). To save time in this procedure, you should merge it with the RCA Clean. When you come into the lab start the furnace and RCA baths. Refer to the posted furnace temperature profile to determine where in the tube to place your wafers.

Do not touch any of the quartz ware with your bare hands!! If you do, it must be cleaned with HF, and everybody hates HF!





PROCEDURE:

1. Remove the photoresist using the DryTek. Since the wafers received a high-dose implant, removal of the resist will take longer than normal.
2. Refer to the furnace operating instructions in the appendix on Furnace Operation. Press the "Tube 2 Recipe" button and select the recipe "IC_Activation". Program Summary:
   Temp: 950˚ C
   Time: 10 min. Dry O2
   Time: 5 min. High N2 (anneal)
3. RCA clean the wafers.
4. Open the oxygen valve above the jungle. If the O2 regulator does not show a pressure of about 10 psi, showing zero instead, contact Mike Thomas or a TA. Start the furnace control program by pressing the "Load Tube" button. Remove the wafer boat from the mouth of the furnace. Start the furnace gas program.

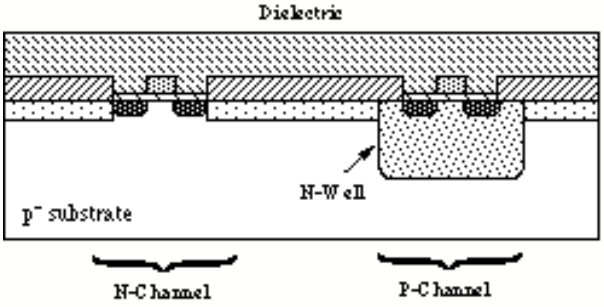
5. Load the wafers into the #2 furnace and press press “Start Program” to start the final tube heating and the timed program steps. Leave the pig on the furnace.
6. The program will activate the implants, and also oxidize the wafers.
7. When the program is finished and the temperature falls below 750 ˚C, slowly remove the wafers from the furnace.
8. Be sure that the unload portion of the furnace program is running. Remove the pig from the furnace tube and recap the pig and furnace. **DO NOT PLACE THE END CAP TIGHTLY INTO THE PIG!!!** Leave about 1 cm of the ground-glass joint of the cap showing. Let the wafers cool (approximately 30 minutes) before taking the pig to the MOS Cleaning bench to unload the boat.
9. Stop the furnace gas program. Close the Oxygen valve above the jungle, and reset the furnace to the standby temperature.
10. Place the quartz boat back into the mouth of the furnace. Be sure that the unload portion of the program is still running.
11. Stop the program by pressing the “Abort Furnace 2” button.

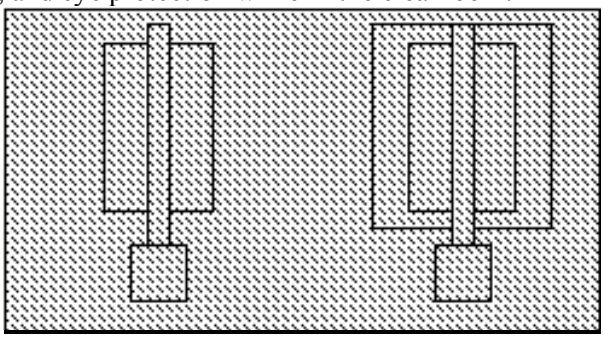
Be sure to fill in your lab notebook. Be complete.

INTERLEVEL DIELECTRIC AND CONTACT ETCH

LAB EQUIPMENT AND MATERIALS

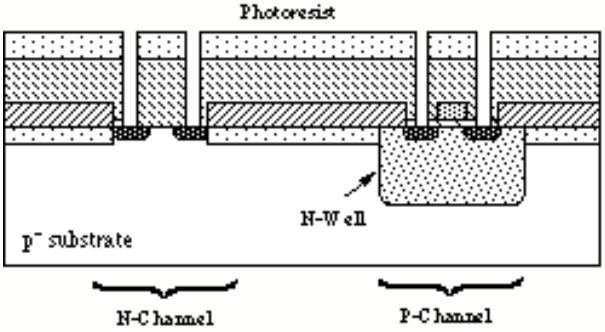
All personnel will wear the blue lab coats, latex gloves, and eye protection while in the cleanroom.

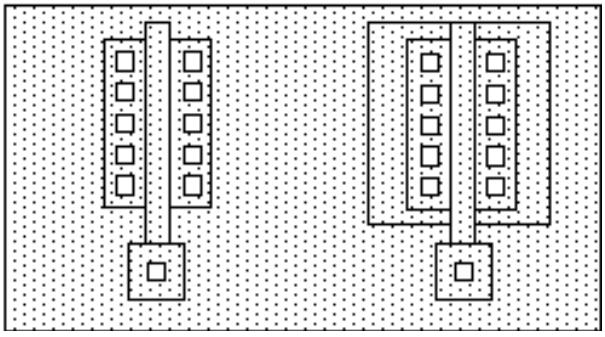




Delectric Deposition

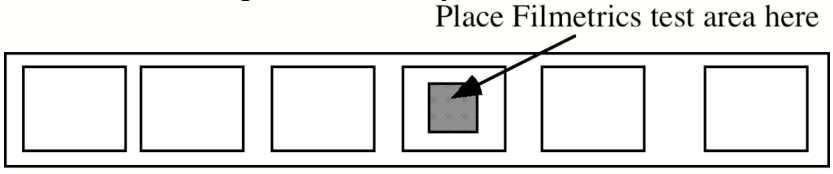
1. You will deposit the interlevel dielectric (silicon dioxide) of 300 nm in the Unaxis PECVD system. See appendix for details.





Contact Lithography Procedure

1. Apply the 1813 photoresist.
2. Expose the wafers on the stepper using the Contact reticle (reticle #6). Use the stepper program IC3. Develop.
3. De-scum the wafers for 30 sec. in the DryTek.
4. Etch the contact vias in the RIE until the vias and contacts clear. Use the recipe ICvia. The nominal etch time will be posted on the RIE. Check that CHF3 (not CF4) is set in the RIE. If not, contact the TAs to change the configuration.
5. Etch the wafers two at a time. Inspect them carefully. In particular look at the TLM structure. The TLMs are the horizontal bars in the second row of the test chip. Use either the n-TLM or p-TLM (refer to the chip layouts). The TLMs should be etched all the way down to bare silicon, and are big enough that you can measure using the Filmetrics system.



TLM test pattern

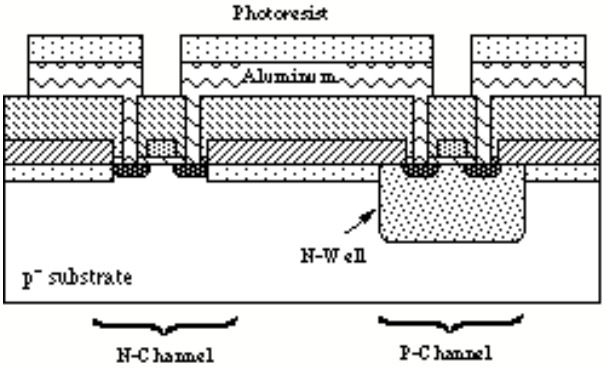
6. Remove the resist using the DryTek.
7. Important: Do an RCA clean of the wafers. This removes photoresist residue from the surface of the wafers.

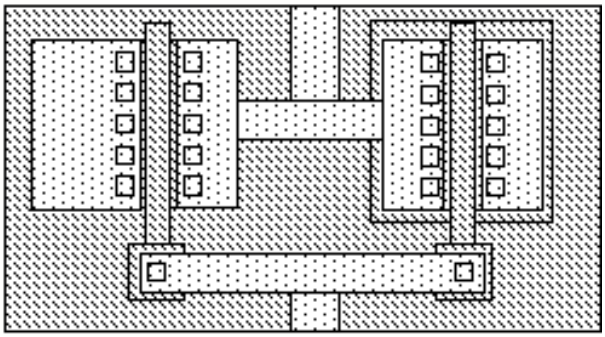
8. Send email to the instructor and TAs to tell them that your wafers are ready. Be sure to also fill out the chart on the ICFAB cabinet.

METAL LITHOGRAPHY AND ETCH

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue lab coats, latex gloves, and eye protection while in the cleanroom.





Procedure

1. Aluminum (200 nm thick, with 2% Si) will be deposited on you wafer by the lab staff. No more RCA cleans after this step: it will destroy the aluminum.
2. Apply the 1813 photoresist.
3. Expose the wafers on the stepper using the Metal reticle (reticle #7). Use the stepper program IC3.
4. Bring a crystalization dish (big, flat-bottomed glass container found in the IC FAB cabinet near the photoreisist cabinet in 247A) with about 1 cm of DI water to the RIE. Label it properly. This water will be used for the immediate rinse of your etched wafers.
5. Etch the wafers using the RIE. The aluminum etch recipe is named “ICAlEtch”. This recipe uses chlorine, a hazardous and corrosive gas. When you are ready to etch your wafers, please contact the instructor to set up the gases for you. Etch your wafers two at a time. The nominal etch time is 6:45, and any change will be posted.
6. VERY IMPORTANT!! Immediately after removing the etched wafers from the RIE, put them into the DI water, and leave them for at least 10 min. If you omit this step the chlorine residue on the wafer will corrode the aluminum lines. When all of you wafers have been etched and rinsed, do a final rinse for two cycles in the dump rinser in the acid hood in room 244.

FINAL ANNEAL

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue labcoats, latex gloves, and eye protection while in the cleanroom.

Safety Procedures and Equipment:

High Temperature Gloves for handling the hot quartz furnace tube cap and pig.

Safety Notes:

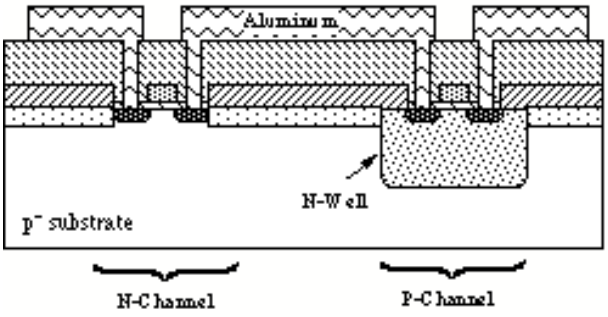
The furnaces are hot and require appropriate care to avoid severe burns
Wafers and quartzware may be hot.

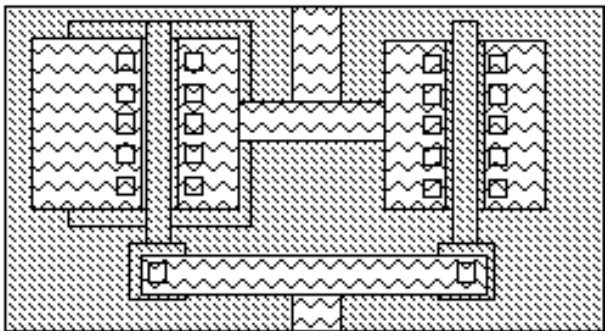
Lab Equipment Required:

Furnace #3

Advice: This is the last required step in the fabrication. This step will anneal the metal-semiconductor contacts to make them ohmic, and tie up the dangling bonds at the Si-SiO2 interface with hydrogen.

Do not touch any of the quartzware with your bare hands!! If you do, it must be cleaned with HF, and everybody hates HF!





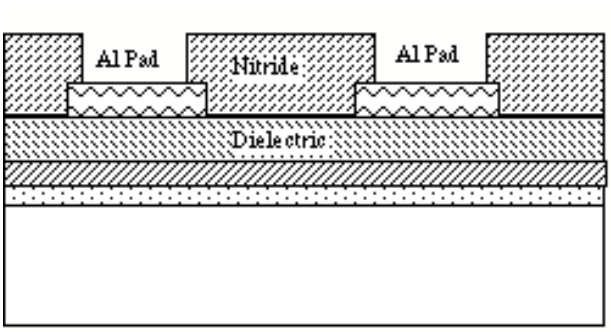
PROCEDURE

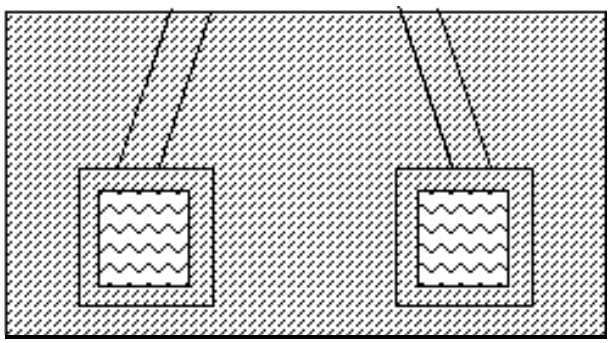
1. Remove the photoresist using the DryTek.
2. Turn on the forming gas (big tank located on the wall behind the furnaces).
3. Press the "Tube 3 Recipe" button and select the recipe "IC_Anneal". Program summary:
   Temp: 450˚ C
   Time: 30 min. Forming gas
4. Start the furnace program by pressing the "Load Tube" button, and remove the boat from furnace #3.
5. Transfer the wafers from the storage carrier to the wafer boat.
6. Load the wafers into the #3 furnace and press "Run Program" to start the timed program step. Leave the pig on the furnace.
7. Anneal the wafers for 30 minutes.
8. Remove the wafers from the furnace. Be sure that the unload portion of the furnace program is running. Remove the pig from the furnace tube and recap the pig and furnace. **DO NOT PLACE THE END CAP TIGHTLY INTO THE PIG!!!** Leave about 1 cm of the ground-glass joint of the cap showing. Let the wafers cool before taking the pig to the MOS Cleaning bench to unload the boat.
9. Shut off the forming gas.
10. Place the quartz boat back into the mouth of the furnace. Stop the furnace program by pressing "Abort Tube 3".

OVERGLASS LITHOGRAPHY AND ETCH

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue lab coats, latex gloves, and eye protection while in the cleanroom.





You will deposit the silicon nitride overglass of 300 nm in the Unaxis PECVD system. See appendix for details.

Overglass Lithography Procedure

1. Apply the 1813 photoresist.
2. Expose the wafers on the stepper using the Overglass reticle (reticle #8). Use the stepper program IC3. Develop.
3. De-scum the wafers for 30 sec. in the DryTek.
4. Etch the pad openings in the RIE until they clear. Use the recipe ICnitrd. The nominal etch time will be posted on the RIE. Check that CF4 (not CHF3) is set in the RIE. If not, contact the TAs to change the configuration.
5. Etch the wafers two at a time. Inspect them carefully to be sure that you have etched all the way to the aluminum pads.
6. Remove the resist using the DryTek.
7. Your wafers are now ready for dicing. **Congratulations! Your wafers are finished!!**

APPENDICES: EQUIPMENT OPERATING INSTRUCTIONS

FPP 5000 OPERATING INSTRUCTIONS

Comments:

The FPP 5000 is extremely easy to use. The simplified instructions are: select the program you want, put the wafer in the support fixture, then put it on the platen and close the lid. The measurement runs automatically when you close the lid.

Procedure

1. Select the program that you want to run by pressing the appropriate button on the lower right of the machine. If you want to measure the resistivity press "SLICE," and also press the "TYPE" button. This will determine the wafer type when the measurement is done. If you want to measure the sheet resistance, press "SHEET".
2. For Slice and Sheet, you must enter the thickness of the wafer (slice) or doped layer (Sheet). Enter the thickness used by the FPP program. Press the "PRGM" button. Let's use Slice as the example. The display will now show the wafer thickness. If the display does not show "0.620E3", then you must enter your wafer thickness of 620 μm. Enter "620" to get "0.620" on the display, then press "3" to enter the exponent. Press "Store" to store your wafer thickness in the program. Press "PRGM" again to return to the measurement mode.
3. Select the appropriate wafer fixture from the black box near the FPP and place the wafer in the ring face down with the backing block behind it.
4. Lift the lid and place your wafer and fixture face down on the platen.
5. Move the wafer so that the probes will measure the desired area.
6. Close, press, and hold the lid. The measurement takes place automatically and the results are displayed.
7. When finished, remove the wafer fixture and wafer and close the lid. Remove your wafer from the fixture, and replace the fixture in the black box.

MOS CLEANING PROCESS (RCA Clean)

IMPORTANT

No metal allowed in the MOS cleaning hood! This includes metal tweezers!

LAB EQUIPMENT AND MATERIALS:

All personnel will wear the blue labcoats, latex gloves, and eye protection while in the cleanroom. In addition, while at the cleaning bench **"Full Battle Gear" is required: Apron, face-shield, and nitrile gauntlet gloves (green)**.

Safety Notes:

Always clean your work area when you leave it. If you don't, you are leaving a hazard for the next group of students using the area.

Chemicals Required:

De-ionized Water (H_20) (Resistivity > 12 MΩ)
Ammonia hydroxide (NH_40H)
Hydrogen peroxide (H_20_2)
Hydrochloric Acid (HCl)
Hydrofluoric acid:DI 1:50 (Don't worry, you don't have to mix this)

Lab Equipment Required:

Timer (watch)
Wafer cassette (A dedicated cassette is kept in the MOS clean hood)
Controlled temperature baths
Dump rinser
Spin rinse dryer

Advice: You can inspect your wafers using the high intensity lamp located on the left side of the MOS cleaning bench. Especially in later processing steps, this lamp is very useful in determining how clean (or dirty) you wafers are. The high intensity lamp needs several minutes to produce maximum output, and of course the brighter the lamp the easier it will be to detect particles on the surface of your wafers.

SIMPLIFIED PROCEDURE:

1. Clean the wafers in a base solution (RCA 1) 40-50 : 1 : 1 DI : NH_4OH : H_2O_2.
2. Clean the wafers in an acid solution (RCA 2) 40-50 : 1 : 1 DI : HCl : H_2O_2.
3. HF dip.
4. Dry the wafers.

DETAILED PROCEDURE:

1. Remember that cleanliness is right next to Godliness in IC processing!
2. Prepare a pair of "MOS Clean" gloves by putting on a pair of green nitrile gloves and scrubbing them thoroughly under the DI gooseneck tap. You will see soap bubbles on the surface of the gloves that are from the mold-release compound. Scrub the gloves together and rinse until the bubbles go away. These are now your MOS Clean gloves. They should touch nothing other than things in the MOS clean hood and furnace quartzware.
3. If you need the inspection lamp, turn the switch in the upper left comer of the MOS cleaning bench to the on position to start the lamp.

4. RCA baths. Turn on power to the baths by turning on the breaker on the far left side of the hood, and the switch labeled "Power". Next, press the green button beneath each of the temperature controllers. This gives you 90 minutes of power to the bath heaters. If you need more time, press the green button again at any time and you get another 90 minutes of power. Check the temperature setting of the baths. Set the temperature to 70˚ C. It takes about 10-20 minutes for the baths to come to temperature.
5. Check the clipboard for the RCA clean bath. The RCA baths is perishable, since the H_2O_2 breaks down in about 1 hour in RCA1 and RCA 2. If you are incredibly lucky, someone added peroxide less that an hour ago and you can begin cleaning your wafers. Otherwise, you will have to prepare the solution. Check the sign-up list on the clipboard. If the bath is more than a three days old, you must mix a fresh batch for both baths, as detailed below. If the bath is below the maximum level (about to spill out of the tank) add 100 ml of H_2O_2 to RCA 1, and 100 ml H_2O_2 to RCA 2 if it has been more than 1 hour since the last peroxide addition. If the bath is at its maximum level, prepare a fresh bath as detailed below. If the liquid level is too low to cover your wafers (this sometimes happens) prepare a fresh bath.
6. Attach a handle to the cassette holding your wafers, turn on the bubbler, and place the cassette into the RCA 1 bath. Place the teflon tweezers in the bath too. After 10 minutes (no more than 30 min.) remove the cassette and tweezers and place them in the dump rinser. Turn off the bubbler, replace the bath cover, and turn down the temperature to 20 ˚C.
7. Rinse the wafers and tweezers for two rinse cycles in the dump rinser.
8. Place the wafers and tweezers in the RCA 2 bath (HCl: H_2O_2) for 10 min. (no more than 30), turn on the bubbler. Remove the cassette and tweezers and place in the dump rinser. Turn off the bubbler, replace the bath cover, and lower the temperature to 20 ˚C. Turn off the heater power on the left side of the hood.
9. Rinse for two cycles in the dump rinser.
10. Place the cassette in the 50 : 1 HF solution for 20 seconds. Remove the cassette and let it drain for a 10 seconds (dripping back into the HF bin) before placing the cassette in the dump rinser. **Do not put the tweezers in the HF!**
11. Rinse for two cycles in the dump rinser.
12. Place the cassette into the spin rinse dryer. The cassette's H-bar should go in first. Close the door and press the green start button. The dryer will cycle through a pre-programmed sequence then stop.
13. Remove your cassette and proceed with the next process.

Preparing Fresh RCA Baths

First, turn off power to the baths, and drain the tanks using the switch above the bench. Rinse the tanks thoroughly with DI water from the DI gun. Turn off the drain switch. Fill each of the tanks with DI water from the DI gun to the top of the marker visible in each tank (black mark on the back of the tank). Add 100 ml of HCl to the RCA 2 tank. Add 100 ml of NH_4OH to the RCA 1 tank. Turn the bath power on and set the temperature to 70˚ C. Once the baths are at temperature, add 100 ml of H_2O_2 to RCA 1, and 100 ml of H_2O_2 to RCA 2, and you're in business.

APPLYING PHOTORESIST

LAB EQUIPMENT AND MATERIALS:

All personnel will wear the blue lab coats, latex gloves, and eye protection while in the cleanroom.

Safety Procedures and Equipment:

The solvents you will be using are flammable and should be handled with care. If solvent fumes are excessive close the solvent containers and leave the room until the fumes dissipate. Dispose of any unused solvents. Be sure you do not leave unmarked containers in the labs. If you see any unmarked containers, get help and dispose of them.

Chemicals Required:

HMDS
Photoresist (1813 or 5214)

Lab Equipment Required:

Photoresist Spinner
Hot plate set at 100 °C (For image reversal)
Hot plate set at 90 °C (For soft-bake)

Advice: When the photoresist is spun on, you will see a varying set of concentric color rings form. The wafer should be uniform in color at the end of the spinning operation. If there is evidence of particulates or excessive color banding, remove the photoresist with solvents and re-apply the photoresist.

SIMPLIFIED PROCEDURE:

1. Dehydration Bake of the wafers to remove traces of moisture. (Only if having adhesion problems).
2. Vacuum deposit adhesion promoter.
3. Apply and spin photoresist.
4. Pre-bake the photoresist film using the 90˚ C hot plate.
5. **Clean the resist spinner!!**

DETAILED PROCEDURE:

1. Check the temperature of the hot plates. If you are having trouble with photoresist adhesion, place your wafers on a 120 °C hot plate for 5 minutes or so. This step is only necessary if you are having trouble with resist adhesion. Normally the HMDS treatment is enough.
2. Set up the photoresist spinner, and hot plates. You will use program “P” on the spinner. If program “P” is not already selected, select it by pressing the “Program Select” button until program “B” appears. The spinner is programmed to initially spin at 1000 RPM for 3 seconds then spin at 2500 RPM for 30 seconds. The pre-bake hot plate temperature should be set to 90 ˚C.
3. From the yellow cabinet, get the 250 ml bottles containing the HMDS adhesion promoter, and 1813 photoresist, and place them next to the spinner (on a cleanroom cloth. Get a transfer pipette from the box beneath the spinner bench.
4. Take the top off the HMDS vapor deposition chamber. Remove the wafer holder and sample plate to check the amount of HMDS in the container at the bottom. If the HMDS is more than a day old (or of unknown age) dump the HMDS in the solvent waste and put in just enough new HMDS to cover the bottom of the container. Replace the sample plate.
5. Place your wafers in the wafer holder, place them in the chamber, and replace the chamber top.

6. Open the chamber valve to pull a vacuum in the chamber (check the little diagram on the 3-way valve. The base of the "T" points to the chamber to pull a vacuum, and straight up to vent the chamber). Hold at vacuum for 2 minutes. Close the valve to vent the chamber. (Be sure that the valve is in the correct position otherwise you'll try to pump out the room).
7. Remove one wafer and spray it with the nitrogen gun to remove any dust particles.
8. Place the wafer onto the wafer chuck, checking that it is properly centered. Press the vacuum button
9. Dispense photoresist (cover approximately 2/3 of the wafer) onto the wafer, close the cover, and start the spinner.
10. After the spinner stops, turn off the vacuum to the chuck. Open the cover and transfer the wafer to the 90 ˚C hotplate (transfer pins up).
11. Lower the wafer onto the hotplate (switch on control box), and bake the wafer for one minute. Raise the transfer pins. Using tweezers place it into your wafer cassette. Repeat the process until you have coated all of your wafers.

Be sure to record the following information in your notebooks each time that you apply photoresist. Operators, date, photoresist type, dehydration bake temp and time, spin speeds, bake times and temperaures.

GCA 6300 STEPPER INSTRUCTIONS

Adapted from instructions written by Gary Bordonaro, Cornell University

General information:

Our stepper is located in Room 247B, and is a g-line 5:1 reduction tool. The wavelength of g-line emission is 436 nm, and the stepper has a lens with a numerical aperture NA=0.3, giving a resolution of 0.9 μm and a depth of focus of ±2.4 μm. A 5" reticle is used, and the largest area that can be exposed on the wafer is a square 20 mm on a side.

OPERATING PROCEDURE:

IMPORTANT: The stepper is a very delicate and expensive piece of equipment. It sometimes malfunctions (especially at reticle loading). Follow the procedure given below, and if something doesn't seem correct, or it gives you an error message, then the machine has probably malfunctioned. DO NOT try to fix anything, contact Mike Thomas.

1. Be sure that the proper reticle has been loaded into the reticle handling system. Check the whiteboard on the stepper to determine the floor number (1-10) of your reticle. Only Mike Thomas can load reticles into the reticle handling system. Check with Mike if the reticle that you need is not in the system.
2. Sign in the logbook.
3. On the switches on the extreme left side, turn off the switch for θ-stage vacuum. Carefully pull out the wafer chuck from the stage. Place your wafer onto the chuck with the wafer notch against the banking pin at the back of the chuck, and be sure that the wafer is snug against the banking pin at the left side of the chuck. Turn on the chuck vacuum switch. Carefully place the chuck back on the stage (**avoid hitting the microscope objectives**). Be sure that the chuck is seated properly. Turn on the q-stage vacuum. Close the doors on the stepper enclosure.
4. Before exposing your first wafer you must log in by typing: **LOG IN ICDX0**, and when asked for the password type: EE446. - to log into the stepper. Check for files by typing **LISTF**. There should be only a few files, including IC0, IC1,IC2, and IC3.
5. To execute the exposure job, type **EXEC JOBNAME, PASS1**. The job name will be IC0 or one of the other ICx jobs, depending on which layer is being processed. The computer then asks you a series of questions. The questions and your response are shown below. If the response already shows up on the screen, you can just hit return. If not, type what is in BOLD, then hit (return).
   Expose: **0.54** (return) The time is changed for Image Reversal
   Focus **251** (return)
   Reticle Bar code: (return)
   Floor #: **{type your reticle position, 1-10}** (return)
   Alignment Mark Phase: **N** (return)
6. The system will load the requested mask. Wait for the display to show "PRESS RESET AND START AWH". It can take a few seconds. Note: this is where most system errors occur. If the display does not show "PRESS RESET AND START AWH", the system has not loaded the reticle correctly, and you must contact Mike Thomas.
7. Now you start the exposure execution. Press the **RES** button above the keyboard. Wait 10 sec. (Do the little dance. It doesn't work if you don't do the dance! :-)). Press the **MAN** and **S/C** buttons together. Wait 10 sec. (Do the little dance again). Press the **MAN** button. You should hear a tone lasting 2-3 sec. If it's shorter than that, repeat this step, starting with pressing the **RES** button.
8. If you are doing an alignment, the alignment marks should show in the two windows on the screen. If this is your first lithography step there are no marks on the wafer, and you can skip this step. Using

the two joy sticks you will move the alignment marks to match the marks on the screen. To change the speed of the stage motion, press **CTRL-O**, but be sure to be at low speed for the final alignment. If you don't see the marks, you probably didn't load the wafer properly against the banking pins. Start the alignment procedure with the right side alignment mark. Move the horizontal and vertical marks on the wafer inside the Cross Hair Pattern using the X-Y joystick. Now, working with the left side alignment mark, move the horizontal alignment marks inside the horizontal Cross Hair Pattern using the "theta" control. If necessary, switch back and forth between x-y and theta adjustment several times as they interact with each other.

9. NOTE: There may be a slight offset in the x direction in the alignment between the marks on the left and right screen. If so, align the wafer in x and y using the marks on the right side, and use the marks on the left side only to adjust the rotation (theta). There is a limit range Theta motion (±1˚). If the alignment marks do not appear on the video screen then you must repeat the mechanical alignment of the wafer against the 2 pins on the chuck. Turn off the wafer vacuum and gently reseat it against the 2 pins. Turn the vacuum back on and check the video screen. If problems persist call the TAs or Mike Thomas.
10. When the x-y and theta alignments are correct, press the **EXP** button. The system will now expose your wafer.
11. When the wafer is finished, the stage will move to the load position. Turn off the θ-stage vacuum. and remove the chuck. Turn off the chuck vacuum and remove your wafer. If you have more wafers, carefully place the next wafer on the chuck and turn on the chuck vacuum. Replace the chuck and turn on the θ-stage vacuum. Press the **MAN** button to move this wafer into alignment position. Repeat steps 8-9 to expose the rest of your wafers.
12. When all of your wafers have been exposed, quit the program by pressing **CTRL-Q**.
13. Send the reticle back to the elevator by typing: **RMSRET**.
14. Log out by typing: **LOG OUT**.

DEVELOPING PHOTORESIST

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue labcoats, latex gloves, and eye protection while in the cleanroom.

Safety Procedures and Equipment:

The solvents you will be using are flammable and should be handled with care. If solvent fumes are excessive close the solvent containers and leave the room until the fumes dissipate. Dispose of any unused solvents. Be sure you do not leave unmarked containers in the labs. If you see any unmarked containers, get help and dispose of them.

The chemicals we will be using are in closed containers inside a fume hood. Keep the containers closed, except when in use, to prevent contamination from the environment. This will reduce the fume buildup and will help keep a pleasant environment for all those using the facility.

Chemicals Required:

AZ 327 MIF positive photoresist developer

Lab Equipment Required:

Hotplates for "Post Bake". Containers for developer (located in the Lithography Room, 247A, developer bench). Ensure that the developer is fresh. Pour new chemicals for your group's wafers, and replace when needed (no more than 10 or so wafers with one batch of developer). Cleanroom wipes, and nitrogen gun for blow drying the wafers

Advice: You can often see the patterns as they develop. Use your eyes as well as the timer to determine development times. When blow drying the wafers, you can either place them flat on a lab wipe, or hold them with tweezers. In either case, keep the nitrogen gun from touching the wafers. Make sure the chemicals are fresh. If you see debris on your wafers it could be a sign of contaminated developer. When inspecting the developed and dried wafer pattern, look at the overall wafer at low magnification first to look for complete development and no photoresist scum or debris. Then make sure the smallest features are clear of photoresist, since these are the last to develop. You should see and note two colors in the microscope field of view, corresponding to areas with photoresist and without. Sometimes there are even more colors due to patterns already on the wafer. You should learn to tell which areas have photoresist and which do not.

OVERVIEW

Develop the resist using the positive photoresist developer.
Rinse the wafers in DI water and dry with nitrogen.

PROCEDURE

1. Develop the wafers one at a time. You will need to develop the patterns, dry each wafer, and inspect each one to insure all features of the pattern show up and no photoresist scum or debris remains on the wafers. You might need to modify exposure or developing times based on what comes out. Remember that all photoresist processing is sensitive to temperature and humidity changes. These are not well controlled in Fitzpatrick Hall. Don't assume that everything works with the nominal process. Check it for yourself!!
2. To prepare the developer, take the container out of the benchtop and dump the old chemical into the base waste container in the hood. Rinse with DI. Pour fresh AZ 327 MIF into the developer container, and place it back in the benchtop.

3. Using the handy-dandy plastic wafer holder marked “DEV”, submerse one of your wafers in the photoresist developer for 40 seconds. Gentle agitation will help remove the development products from the smaller features of the pattern.
4. Remove the wafer from the developer, place the wafer holder in the sink and immediately turn on the DI water. Let the excess developer drip back into the developer container for a second, and rinse for approximately 60 seconds. Be sure to rinse the back of the wafers.
5. Remove the wafer from the wafer holder and dry each wafer using the nitrogen gun.
6. Dry each wafer by placing the edge of the wafer (held by tweezers) on a cleanroom wipe and gently dry both sides from the top to the bottom. Use the cleanroom wipe to adsorb the excess water. If you do not remove all of the water from the back of the wafer it will stick to the microscope sample holder.
7. Inspect each wafer. Using the lower magnification, check for overall photoresist removal and for scum or debris. Using the higher magnifications carefully inspect the smaller features for photoresist, scum, or debris. Figure 1 shows a wafer at various stages of development, from severely under-developed to fully developed.

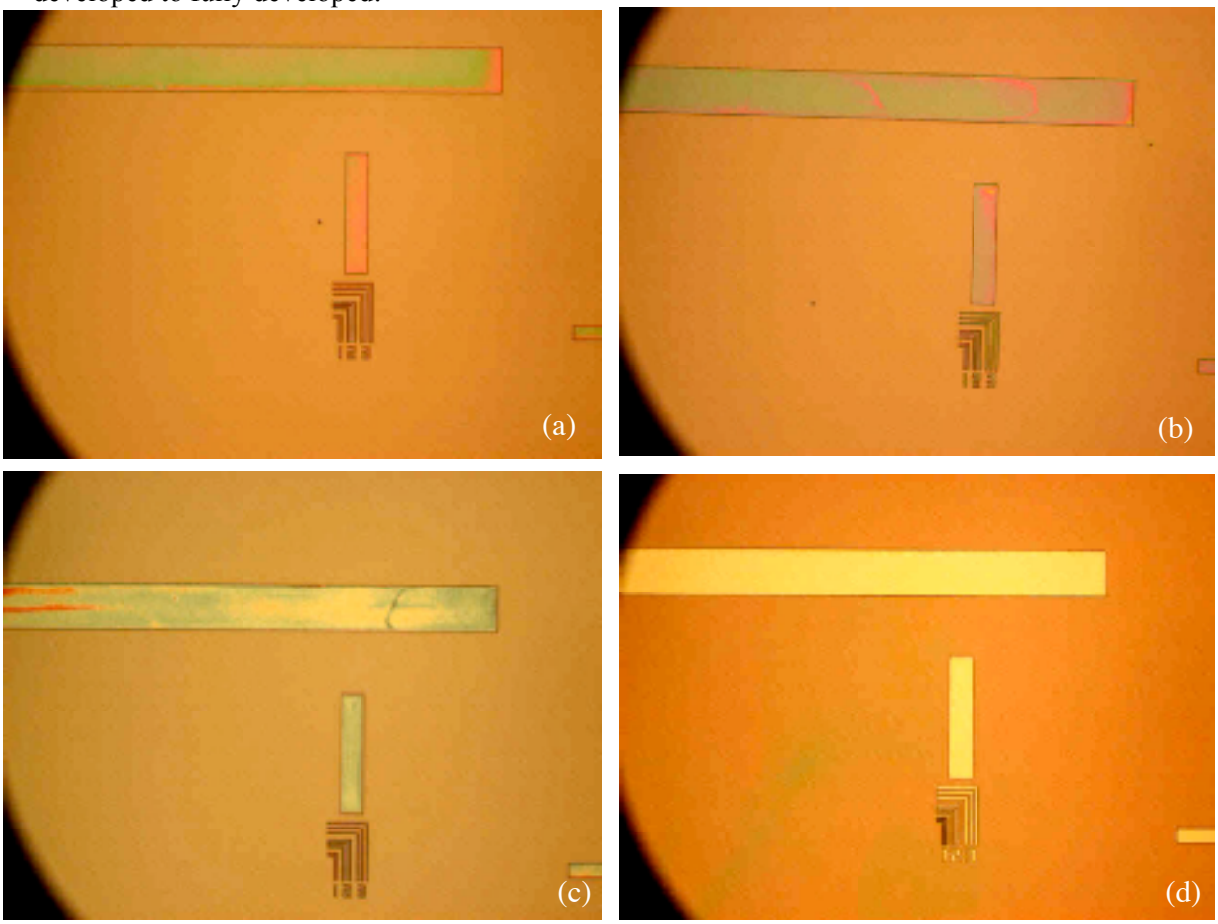


Figure 1. Wafer after developing times from shortest (a) to longest (d). Only at (d) is the wafer fully developed. Actual time to full development can vary due to resist thickness and exposure time.

8. If you find an excessive amount of junk or defects on a wafer, remove the photoresist from that wafer and repeat the photoresist cycle. If you go on from here with a bad pattern you will ruin the wafer. To remove the resist using acetone and methanol (2 min. each), then re-spin the resist and start over with the exposure and developing procedures.

IMAGE REVERSAL PROCEDURE

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue lab coats, latex gloves, and eye protection while in the cleanroom.

Lab Equipment Required:

Cobilt Contact Mask Aligner (Two are located in the Photolithography Room, 247A)

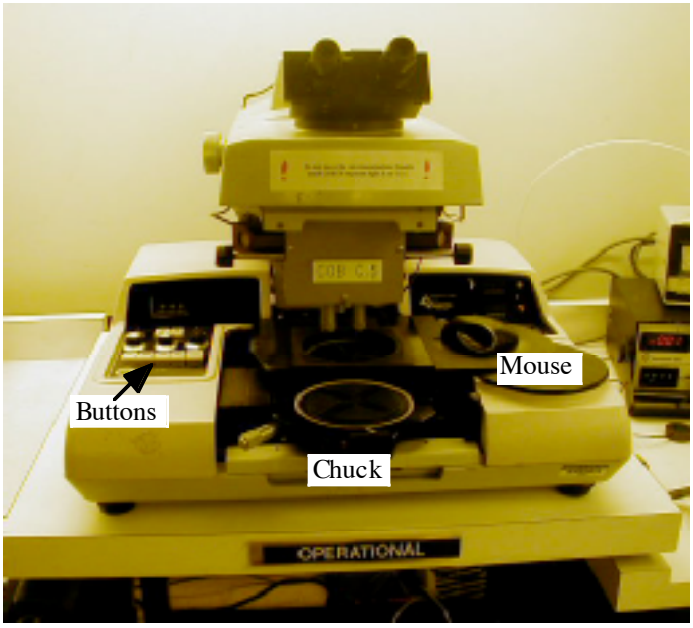
OVERVIEW

5214 is a "magic" resist. It is a positive resist, but can become a negative resist with proper processing. For a negative resist, perform the following steps:

1. After exposure on the wafer stepper, bake the resist on the 100˚ C hotplate for 60 seconds
2. Flood expose the wafer for 60 seconds on the Cobilt mask aligner.
3. Develop using the normal procedure.

DETAILED PROCEDURE:

1. Check the temperature of the left hotplate in the photoresist hood. If it is not at 100 ˚C, change the temperature setpoint to 100 by pressing and holding the "Set" button on the controller, and using the up and down buttons to change the setpoint. Allow time for the hotplate to stabilize at the 100 ˚C.
2. Apply 5214 photoresist to your wafers using the normal procedure. Expose your wafers on the wafer stepper. For 5214 resist the exposure time is approximately 5 seconds. Check the whiteboard on the stepper for the exact exposure time.
3. Bake the wafers for 1 min. at 100 ˚C on the left hotplate in the photoresist hood.
4. The flood exposure will be done using the Cobilt aligners using no photomask. There are two aligners in room 247A. Use the one on the right (its lamp should be left on all the time). When the lamp is on, you will see a bluish light reflected off the wall behind the aligner. If the lamp is off on both aligners, notify the TA or instructor.



Cobilt Aligner

5. Set the exposure time to 60 sec. on the thumbwheel switches.

6. Place a wafer on the chuck. Since there is no mask, the orientation of the wafer is unimportant. Just be sure that the wafer is centered on the chuck.
7. Press the “TURNTABLE” button to rotate the wafer to the exposure position. Even though there is no mask, the wafer must be in the “Contact” position before it can be exposed. Press the red button on the mouse (right side) to raise the chuck and wafer into momentary “Contact” then lower to the “Separate” position.
8. There is no mask or alignment. Simply bring the wafer into the “contact” position by pressing the red button on the mouse again.
9. Press the “EXPOSE” button.
10. When the exposure cycle is completed, press the “RESET” button (if needed) to return the wafer and chuck to the lowered position.
11. Load another wafer (if needed) onto the second wafer chuck.
12. Press the “TURNTABLE” button.
13. Remove the exposed wafer.
14. Develop using the normal procedure.

FURNACE OPERATION

GENERAL FURNACE RULES

Immediately before any wafers go into a furnace, they must be given an RCA clean!
No metal in any tube (other than #3) EVER!
No photoresist or other organics in any furnace.
Sign the log book before starting.
Open a furnace tube only when a "High N2" step is running in the gas program.
Return boat to the proper furnace when finished! Do not mix quartzware between tubes.

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue labcoats, latex gloves, and eye protection while in the cleanroom. Full battle gear is required for the RCA cleaning step and HF etch step. High Temperature Gloves needed for handling the hot quartz furnace tube cap.

Safety Notes:

The furnaces are hot and require appropriate care to avoid severe burns.
Keep the bubbler and water bottle away from the end of the furnace tube as they can be damaged by heat.
The quartz boat retains heat for a long time. Be careful!
Wafers are to be transferred to the oxidation boat and the transport vehicle (called a Pig or Elephant) to minimize exposure to the lesser quality environment in the open areas of the lab. These items may be hot.

Chemicals Required:

Deionized Water (DI) (Resistivity > 12 MΩ)
Oxygen
Nitrogen

Advice:

1. To save time in this procedure, you should merge it with the RCA Clean. When you come into the lab start all the heaters at once, furnace, steam generator (if needed), RCA baths. By the time you've finished the RCA clean, the furnace and steam generator will be at temperature, ready for you wafers.
2. Check the posted furnace profile for the location of the "flat zone". When inserting your wafers, be sure that the boat lands in the middle of flat zone.
3. The part of the push rod inserted into the furnace will be very hot, while the end that remains out of the furnace will remain cool to the touch. Watch out for the hot end!

Do not touch any of the quartz-ware with your bare hands!! If you do, it must be cleaned with HF, and everybody hates HF!

OVERVIEW:

1. Sign the log book.
2. Load your recipe (click "Tube Recipe," then "Load Recipe." Select your recipe, and click "Close Programmer."
3. Press "Load Tube" to begin heating the tube and flowing high N2. High N2 must be flowing whenever the endcap is removed from the tube.
4. If doing a wet oxidation, add DI water to the steam generator if needed, and turn on its temperature controller.
5. Turn on O2 valve above the back of the jungle.

6. Transfer the wafers from the cassette (after the RCA clean) to the oxidation boat.
7. Transfer the boat containing the wafers into the appropriate furnace.
8. Click “Start Program.”
9. When complete, transfer the boat containing the wafers from the furnace back into the Pig. (High N2 should be running)
10. Turn off bubbler.
11. Let wafers cool at furnace station (at least 20 minutes).
12. Transport pig containing wafers to MOS Cleaning station.
13. Transfer wafers from the boat to cassette after wafers have cooled.
14. Turn off O2 valve above the back of the jungle.
15. Place boat back in the mouth of the tube. Be sure high N2 is running!
16. Click “Abort Tube” to return tube to standby.

DETAILED PROCEDURE:

1. Sign the log book
2. Activate the furnace control computer (wake it up from sleep). Log into the “Student” account. There is no password.
3. The main control panel is displayed on the screen. Click the “Tube X Recipe” button for the tube you plan to use.
4. The recipe programmer will appear. Click the “Load Recipe” button on the top-left of the panel. Select your recipe from the list that appears.
5. Press the “Close Programmer” button.
6. Click the “Load Tube” button for your selected tube. This will activate high nitrogen, and will raise the temperature to 750º C. The “Load Tube” button will disappear and be replaced with a “Start Program” button. At this point, you should perform your RCA clean of your wafers. If you do not complete the cleaning and lading within two hours, the furnace will return to idle, and you will need to click “Load Tube” again to reactivate the furnace.
7. Remove the end caps from the furnace tube and pig, and place the pig on the mouth of the furnace tube. Pull the oxidation boat from the mouth of furnace into the pig. Carefully remove the pig from the furnace tube and replace both end caps. **DO NOT PLACE THE END CAP TIGHTLY INTO THE PIG!!! Leave about 1 cm of the ground-glass joint of the cap showing.** Whenever the pig has been on the furnace tube, it can get hot. If you put the end cap tightly into a hot pig, when the pig cools and contracts it will fuse to the cap. A $1,000 mistake! If it will be more than two hours before the wafers are ready to load, stop the loading sequence by clicking on the “Abort Tube” button (You started it so that high N2 would flow when the tube was open).
8. If doing a wet oxidation, prepare the steam generator. Open the top Plexiglas doors at the back of the furnaces (this area is called the jungle). The steam generator (sometimes called a bubbler) is the three-headed quartz vessel setting in a heater. The center opening is for gas inlet and outlet, another is for the thermocouple, and the last for adding DI water. Be sure that the vessel is more than half full, since if it goes dry there is no safeguard to keep the heater from burning up. There is a labeled bottle that is convenient for adding solution to the bubbler. Remove the stopper from the quartz vessel. Add DI water into the quartz vessel using bottle, and recap the opening. Be sure that the quartz cap is on firmly, as it can pop off when gas begins to flow. Close the Plexiglas doors. Turn on the power of the steam generator for the appropriate furnace, located behind the lower Plexiglas doors. The controller will already be set to 95 °C. It will take around 45 minutes to stabilize at 95 °C. **Keep the bubbler and water bottle as far as possible from the end of the furnace tube! They can be damaged by the heat!**
9. Open the O2 valve above the back of the jungle. If the O2 regulator does not show a pressure of about 10 psi, notify the TAs and Mike Thomas.
10. When the RCA clean of the wafers is done, carry the pig to the cleaning bench and transfer your clean and dry wafers to the boat with the front side of the wafers away from the pushrod loop. Put the

wafers as far from the pushrod loop as possible, leaving a couple of open slots between wafers, if possible. Put the boat back in the pig with the front side of the wafers facing the open end of the pig. Replace the end cap on the pig.

11. Carry the wafers to the furnace. Remove the end caps from the furnace and the pig, and put the pig on the mouth of the furnace tube ensuring that the pig is stable. Leave the wafers in the pig for 2 min. so that the foreign atmosphere is replaced by the furnace tube atmosphere.
12. Push the boat into the mouth of the furnace. Be careful, as it can be a little tricky to get the boat over the lip of the furnace mouth. Slowly push the boat to the center of the tube. Take about 3-5 min. to traverse the transition zone from the mouth of the furnace to the "flat zone" of the tube. Refer to the furnace profile to determine the location of the flat zone, and use the provided meter stick to measure the position of the boat in the tube.
13. Take the pig off the tube and recap both the pig and the furnace tube. Put the pig back on the furnace station. (**BE CAREFUL: Never cap the tube or pig too tightly or the cap will be unremovable when the quartz cools.**).
14. Click the "Start Program" button for your tube.
15. Following completion of the program, the furnace temperature will be set to 400, and high nitrogen will be activated. Remove the end cap and place the pig on the furnace mouth. (Note: High N2 must be flowing when you take off the furnace end cap. If the program has finished and N2 has stopped flowing, press the "Load Tube" button to reactivate the flow). Pull the boat out of the center of the furnace taking about 5 min. to traverse from the hot zone to the mouth of the furnace. Leave the boat at the mouth for 2 min. Then leave it in the pig for 2 min.
16. Take the pig off the tube and place on the furnace station (metal shelf at furnace). Recap the tube and the pig. (**BE CAREFUL: Never cap the tube or pig too tightly or the cap will be unremovable when the quartz cools.**).
17. Let the pig and wafers cool for 20 minutes before moving the pig to the MOS cleaning hood. Remove the wafers from the boat.
18. Ensure that N2 is flowing (click "Load Tube" if needed), and return the boat to the mouth of the tube.
19. Click "Abort Tube" to reset the tube to standby. Shut down the bubbler temperature controller if it was used.

Prepared by Aaron Prager.

DRYTEK - MEGA STRIP 5

Note!

Always wear gloves when handling anything that goes inside the chamber.
The wafers and sample holder can become hot, handle them with care!

STANDBY CONDITIONS

1. The main circuit breaker should left in its on condition.
2. The "Machine On" button should be lit (indicating a standby status).
3. The power switch on the RF Power Supply should be off.
4. The light for the "System-On" status should be off.
5. The light for the "Mechanical Pump-On" status should be off.
6. The chamber should be vented.
7. The oxygen tank should be shut off.

OPERATION

1. Fill in the logbook.
2. Open the door of the chamber using both of the handles on the door. Place your samples inside using one of the quartz boats. Close the chamber door, again using both handles.
3. Open the door on the front lower half of the Drytek:
    a. Turn on the power switch to the RF Power Supply (Drytek PE 1650 AC Plasma Source), the display should light up
    b. Press the "Mechanical Pump-On", the button should light up
    c. Press the "System-On" button, the button should light up
4. On the upper control panel push the "Micro Reset" button. This will reset the microprocessor to the desired starting conditions of the machine. (If pressed during the middle of a cycle, the cycle will end immediately.)
5. Turn on the oxygen cylinder valve and checks its pressure setting. The regulator's output gauge should have a 20-PSI delivery pressure.
6. Check the machine settings:
    a. Pressure Controller (252A Exhaust Valve Controller)
        i. Power On
        ii. Set Point Int. / 200
        iii. Phase 8
        iv. Gain 75
        v. 10-1-0.1 1
        vi. Mode Select Auto
    b. Pressure Monitor (PDR-C-1B Power Supply Readout)
        i. Power On
    c. Time/RF Level
        i. Time Select See Note 1
    d. Flow Controller Gas1 Gas 2
        i. Auto/Off Auto Off
        ii. Set Point 20 N/A
    e. Optical (End Point) Detector
        i. Zero 890
        ii. Rec. Suppr. N/A

7. At this point the “Cycle Start” Button should be flashing. Press the “Cycle Start” button to start your process. The “Cycle Start” light should come on and stay on during the process. To stop the process, press the “Process Reset” button. (See Note 2)
8. After the plasma has started, check the RF power level. Nominal setting is 1500 W.
9. When the Drytek has completed a process operation, the process will stop and the chamber will begin to vent.
10. Once this is completed the “Cycle Start” light will go out and the “Process Complete” light will blink on and off and an audible beeping will occur. It usually takes a couple of minutes for the camber to come up to atmosphere.
11. The wafers and boat can be hot so be careful! Open the chamber door and remove your samples from the quartz boats. Place the boats back inside of the Drytek. Don’t close the door; closing the door will initiate another process sequence of the machine.
12. Press the “System-Off” button; the button light should turn off.
13. Press the “Mechanical Pump-Off” button; the button light should turn off.
14. Turn on the power switch to the RF Power Supply (Drytek PE 1650 AC Plasma Source).
15. Close the oxygen tank valve.
16. Ensure the machine is in its standby condition before leaving.
17. Log out of the logbook.

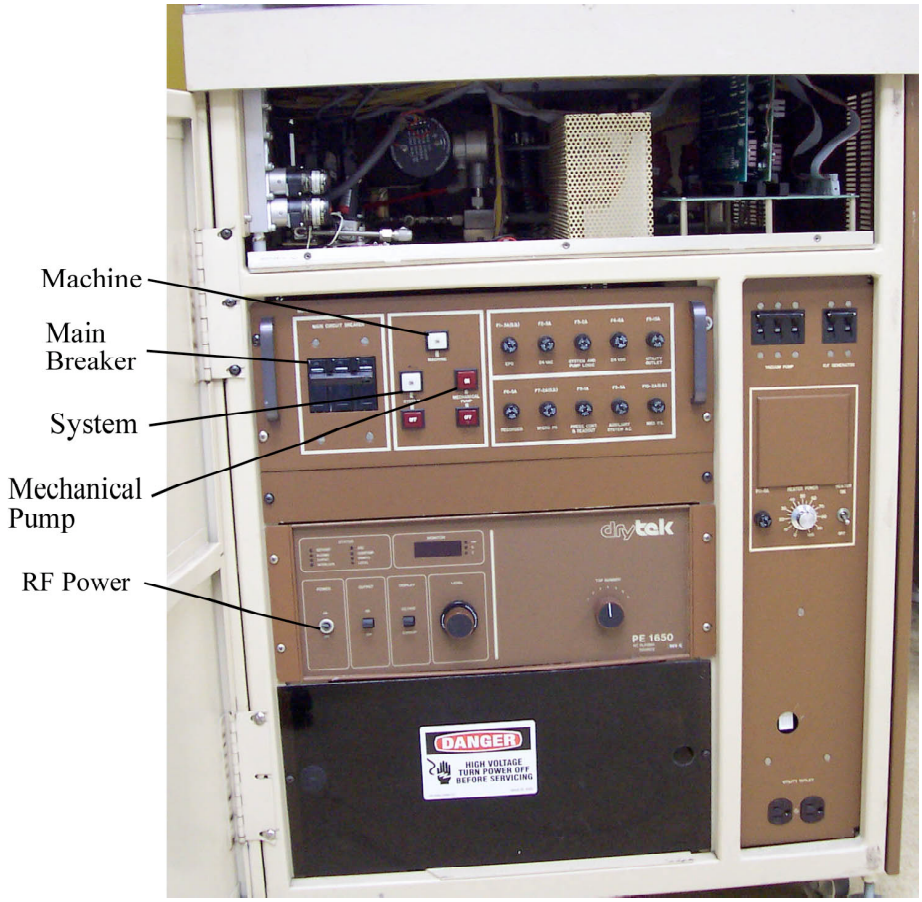
Note1:
The two left thumbwheel switches are used to set the number of minutes and the third thumbwheel switch from the left is used to set tens of seconds. The right most thumbwheel is used for controlling gas #2, which in this machine is not used and should always be set to zero.

For a descum process the time is about 30 seconds. To strip resist the normal time is about 15 minutes, but can be longer if you are doing a number of wafers or if the resist has been severely baked. The time will be process dependent.

Note 2:
If it is desired to stop a process, pressing the “Process Reset” button will immediately stop the machine cycle and begin to vent the chamber.

Prepared by Mark Richmond.


Pressure Controller
Pressure Monitor
RF Level
Time
Flow Controller
Optical End Point
Cycle Start
Micro Reset
Process Reset
Process Complete
drytek
use both hands to handle the door


Machine
Main Breaker
System
Mechanical Pump
RF Power
drytek
PE 1650
DANGER
HIGH VOLTAGE
TURN POWER OFF
BEFORE SERVICING

PLASMA THERM 790 RIE OPERATING INSTRUCTIONS

Emergency Procedures

Power Failure: No immediate action required. When power is restored, restart system as detailed below.

Water Leak: Push big red button on front of system to cut power. If leak is cooling water (green), close valves on the wall behind system. If heat exchanger is leaking, it has already been turned off with the system.

Starting The Machine From Power Up. (Not usually necessary)

1. Open the door on the front of the machine and push the green buttons marked "Machine" and "Mechanical Pump" (located on the lower right side).
2. When the computer has booted-up, log in using the appropriate operator name and password. Start the turbo pump by selecting the item "Turbo Pump On" under the "Utilities" menu. When the turbo pump is up to speed, its icon on the vacuum diagram will turn from red to green. Click the softkey "Standby" at the bottom of the screen.
3. To begin pumping the chamber, select the item "Pump Chamber (Turbo)" under the "Utilities" menu.

Notes:
If an alarm is sounding, click the "Alarm Silence" softkey at the bottom of the screen. This will stop the infernal beeping of the alarm. Check the "Alarm" text box on the screen to see if it is something obvious such as "Above atmospheric pressure in chamber", meaning that you didn't hold down the camber lid when you started pumpdown. To clear the alarm, click "Hold", which rechecks the alarm condition and removes it if it no longer exists. If the alarm persists or you don't understand the alarm message, contact a senior user or Prof. Snider.

Normal Log-in (You usually start here)

Choose the "logout" item under the "Utilities" menu. I know this is stupid when you are logging in, but we didn't write the software! Enter the operator name "icfab" and password "icfab". **Sign in on the log sheet in the log book.** Be sure to write the time that your wafers go into the chamber, and also the time you finish. This lets others know that your wafers are in the chamber.

Loading a Sample

To open the chamber, select the item "Vent" under the "Utilities" menu. The computer will automatically control the sequence to vent the chamber. When venting is complete the chamber icon on the vacuum diagram will turn blue and say 'Atmosphere'. You can then open the chamber lid and place your sample on the platen. You should be able to fit several wafers at once. Wear gloves whenever your hands go inside the chamber. The chamber can be pumped in manual mode, or as part of running a process. The manual method is as follows: Close the lid, and select the "Pump Chamber (Turbo)" item under the "Utilities" menu, and press down on the chamber lid. The computer automatically executes the pumpdown sequence. Be sure to press down on the chamber lid, or the mechanical pump will try to rough out the room! You don't have to lean on it hard, just enough pressure that the o-ring seals. (It takes about 30 sec. before the pump starts. When the o-ring seals the crack under the chamber "disappears")

Selecting a Process

The processes specific to IC Fab all begin with the letters IC. You may also need to use the recipe o2clean to clean the chamber. To choose a recipe the machine should be in "Standby" mode. Select the desired recipe by selecting the item "Load" under the "Process" menu. This brings up a dialog box listing the available recipes. Select the desired recipe.

Running a recipe

Click on the "Ready" button at the bottom of the screen. Next, click on the "Run" button. If you haven't already pumped out the chamber, the pumping sequence will begin now. Be sure to press down on the chamber lid. When the recipe is finished, you can vent the camber (menu item "Vent" under "Utilities") and remove your sample.

When You're Finished

Remove your last sample and click on the "Standby" button. Pump down the chamber (menu item "Pump Chamber (Turbo)" under "Utilities"). Fill out the log sheet to let others know you are finished with the machine. Log out by choosing the "Logout" menu item, then hit "OK" without entering anything. Close the appropriate gas bottles.

Process Notes

O2clean: A high-power oxygen plasma recipe intended to clean the chamber. Check the logbook. If the last user of the system did a process other than oxygen or your process, you should run this recipe to clean the chamber.

ICnitrd: A CF4 based plasma to etch the nitride for Locos oxidation.

ICpoly: A CF4 plasma used to pattern the polysilicon for the gates.

ICLayer0: A CF4 plasma used to etch the initial alignment marks into the wafer.

ICvia: A CHF3 plasma used to etch the interlevel dielectric.

ICAlEtch: Aluminum etch using chlorine.

UNAXIS PECVD OPERATING INSTRUCTIONS (IC FAB)

Before starting your work be sure to make an entry into the log sheet. Write the time-in, first name and last name, the film you are depositing, process conditions and the cumulative thickness.

Loading a Sample

To open the chamber, select the item "Vent" under the "Utilities" menu. The computer will automatically control the sequence to vent the chamber. When venting is complete the chamber icon on the vacuum diagram will turn blue and say 'Atmosphere'. You can open the chamber lid and place your sample on the platen. Wear gloves whenever your hands go inside the chamber. Close the lid, and select the "Pump Chamber (Lo Vac)" item under the "Utilities" menu, and press down on the chamber lid. The computer automatically executes the pumpdown sequence. Be sure to press down on the chamber lid, or the mechanical pump will try to rough out the room! Just apply enough pressure on the lid to seal the o-ring for 8-10 seconds.

Running a Process

Auto Mode
This mode is used to run preset recipes. To load a process select "Load" under "Process" menu and select the recipe you want.

Silicon nitride - sinx.prc
Silicon dioxide - sio2dep.prc
Clean and season chamber - cl-seas.prc

After loading your recipe click READY softkey at the bottom of the screen and then click RUN. Clicking OK in the dialog box that appears runs your process. If you are depositing a film you will have to enter the deposition time (you can determine that from the required thickness of your film and its growth rate).

Note: The system will sound an alarm when your process is over. Make sure that you are near the system before that happens.

The time that you set when starting the recipe will determine the thickness of the deposited film. For the interlevel dielectric you want 300 nm of oxide, so set the time of the recipe sio2dep.prc to 6 minutes. For the overglass you want 200 nm of nitride so set the time of recipe sinx.prc to 13.5 minutes.

When you are finished

Remove your sample and pump down the chamber. Fill out the 'Time Out' and 'Cumulative Thickness' column in the log sheet. Make sure that you leave the system in STANDBY mode by pressing the STANDBY key located at the bottom of the screen.

Cleaning and Seasoning of Chamber

When the cumulative thickness reaches 10,000Å the chamber has to be cleaned. Run the process "cl-seas.prc" to clean the chamber. This will clean the chamber then deposit 1000Å of oxide to season the chamber.

System Status Softkeys

ON: This is EQUIPMENT ON mode. The system enters this mode immediately after power up. During this mode the chamber(s) are isolated from the pump(s) by closing of the gate valves. Once the system is in this mode, all modes become accessible.

STANDBY: This button serves two purposes: it leaves the system in a vacuum state under temperature control or it performs STANDBY menu sequences.

READY: This button also serves two purposes: it prepares the system for processing of wafers and it performs the ready menu sequences. Select the READY button to enter the READY mode.

The system is always in one of the above three modes. The ON button is used to return to the EQUIPMENT-ON mode from STANDBY and READY modes. When the button is lit it indicates that the system is trying to attain that status. When a legend is illuminated it has attained or completed the mode.

Process Softkeys

RUN: When this button is selected during a READY state, the system enters the RUN mode.

ABORT: This key is used to exit the RUN mode regardless of what is presently occurring. The system will normally return to the READY mode or the EQUIPMENT-ON mode if aborting under error conditions.

HOLD (User Activated): Pressing the HOLD button requests the machine to HOLD (all gases, RF and pressure control are turned off).

HOLD (Machine Activated): The system is always put in a HOLD condition when an error is detected. After analyzing the problem, press the HOLD button to deactivate it and the machine will try to continue from the point at which an error occurred.

END STEP: By activating this key, the operator activates the termination of the current step and the system proceeds to the next step.

ALARM SILENCE: Press this key when you have to silence the Alarm. You will have to press HOLD key to activate the system again.

Typical PECVD Process Sequence

Step 1: Initial
Setup the process & chamber wall temperature
Pressure = 1.0×10^{-2} Torr
Hold Time = 30 secs
Step 2: N_2 Flush of Chamber
500 sccm Nitrogen Process Gas
Pressure = 200 mTorr
Time = 1 min
Step 3: Process Gas Stabilization
Setup process gas flow rates
Setup process pressure
Time = 30 sec
Step 4: Deposition Step
Same as Step 3 except with RF power and deposition time set
Step 5: N_2 Flush Following Deposition
500 sccm Nitrogen Process Gas
Pressure = 200 mTorr
Time = 1 min
Step 6: Final Pumpdown
Pressure = 1.0×10^{-2} Torr
Hold Time = 1 min

Notes:

1. The typical deposition temperature is 100 to 350 °C.
2. The chamber wall temperature is normally set at 60 °C.

ALPHA STEP 500 OPERATING INSTRUCTIONS

Cautions:

Stage should be all the way lowered before and after your use.
Raise the Stylus before loading and unloading your sample.
Do not move the stage when the Stylus is on the stage.
Be sure your sample is clean, Dust accumulates on the stylus.

Procedure:

1. Make sure the stylus is up and away from the contact surfaces.
2. Open plastic door.
3. Insert your sample onto the stage.
4. Close plastic door.
5. Press “Menu Key” (Escape) until you get to the recipe menu.
6. Press the “↓” (down arrow) to get to “Catalog”.
7. Press “Enter Key” to continue into the catalog menu.
8. Press “↑” (up arrow) and “↓” (down arrow) to find the process “ICFAB” or your own process.
9. Press “Enter Key” to load the process.
10. Press “Z-θ key” (F5) to enable stylus motion.
11. Lower the stylus until it lands on the substrate. Pressing “↑” (up arrow) and “↓” (down arrow) toggles the stylus between contact and separation. Make sure the stylus is in the up state.
12. Using the knobs on the lower left of the machine, move the stage to the area you want to measure. The stage can also rotate.
13. Press the “Start” key(F8) to start your scan.
14. After the scan stops, press the “Level” key (F10) if needed.
15. Position the cursors to the points that you want to level to. “Select” (space bar) switches between cursors. “←” (left arrow) and “→” (right arrow) moves the cursors.
16. Press the “Level Key” (F10) again to re-plot the data using the leveling.
17. Step thickness is measured by using the cursors. Cursors move as per above.
18. Printing can be done by pressing the “Print Screen Key”.
19. Repeat steps 11 – 18 for as many measurements as you wish to make.
20. Press “Z- θ Key” (F10) to enable motion on the stage and the stylus.
21. Make sure the stylus is up.
22. Lower the stage to remove your sample by pressing the “↑” (up arrow).
23. Open the plastic door.
24. Remove your sample.
25. Close the plastic door.

Prepared by Mark Richmond

GAERTNER ELLIPSOMETER

Operation:

Use Figures 1 - 5 during this procedure.

1. Turn the “Power on/off Keyswitch” until the “Power” light on the front illuminates.
2. Start the “GEMP” program on the computer.
3. Turn over the table and remove the foam sheet.
4. Pull to open the “Shutter”.
5. Set sample wafer on top of table.
6. Looking thru eyepiece adjust the two “Tilt knobs” on the bottom of the table until the “+” and the “X” are overlapping. See Figures 3 and 4.
7. In the “GEMP” program:
    a. Click on the “Ellipsometer” menu.
    b. Click on the “Measurement and Calculation” option.
    c. Load a setup by clicking the “Thin Oxide” button in the lower left section of the dialog box. If you need more complicated structures, refer to the more detail operator’s manual.
    d. Depress the button “Table Height Adjustment”.
        i. Adjust the black “Table Height Knob” on the bottom of the table until you reach the maximum power available. If 10 is reached the display wraps back down to 5 to allow for more adjustment.
        ii. A small Bar on the right of the diagram shows the Max Power you have reached therefore making it easy to see when you have maximized the power.
9. Perform the measurement.
    a. Click the “Measure” button in the lower left portion of the dialog box.
    b. Click the “Calculate” button.
    c. Read the measured film thickness an refactive index at the lower right of the dialog box.
10. Remove your sample.
11. Repeat steps #5 thru #9 for as many samples as you have.
12. Close the “GEMP” program.
13. Push to close the “Shutter”.
14. Turn off the “Power on/off Keyswitch”.
15. Place the table upside down on the foam piece.

Prepared by Mark Richmond

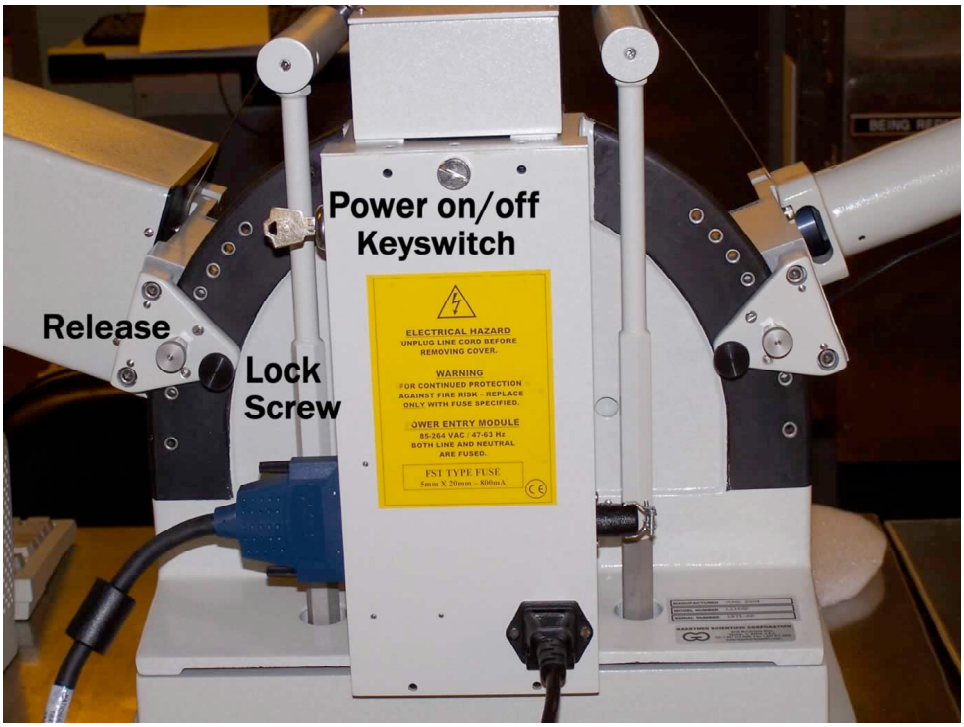


Figure 1: View of rear of machine.

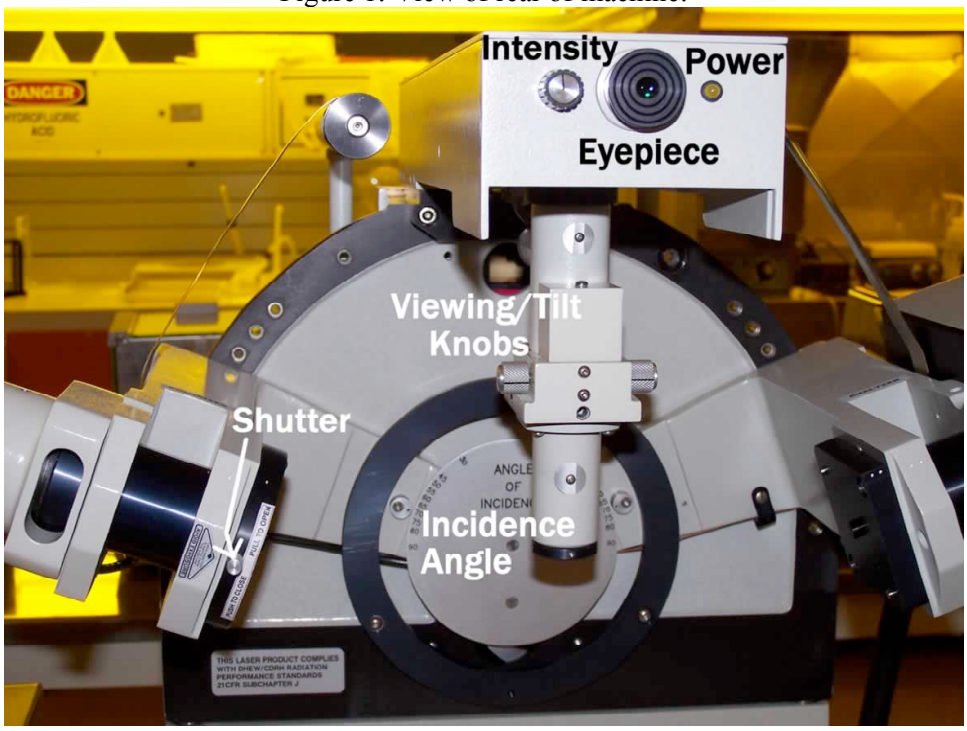


Figure 2: View of front of the machine.

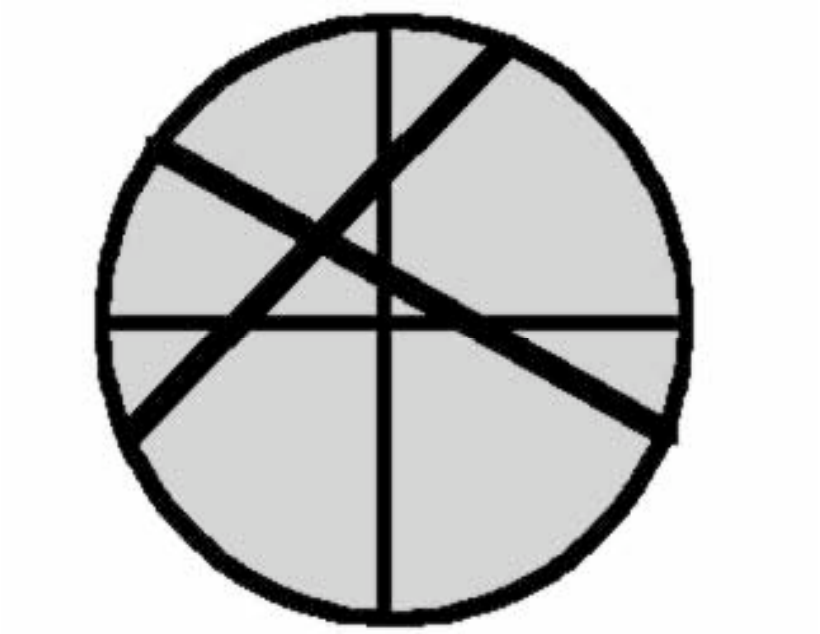


Figure 3: Looking thru view port before table is aligned.

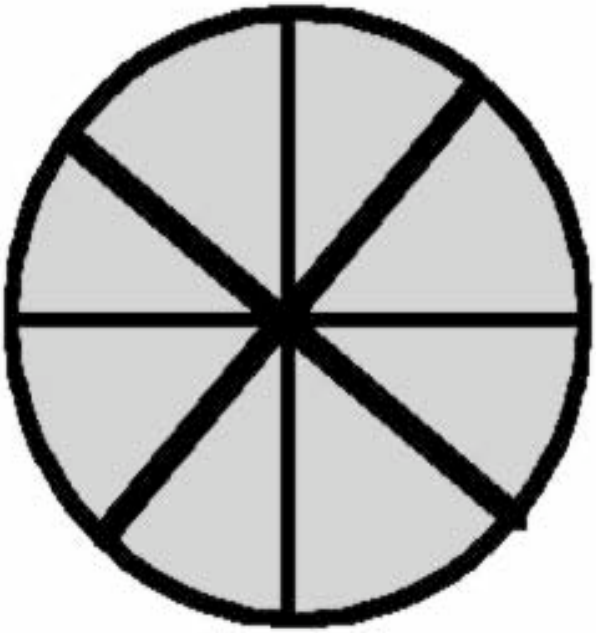


Figure 4: Looking thru the view port onto an aligned table.

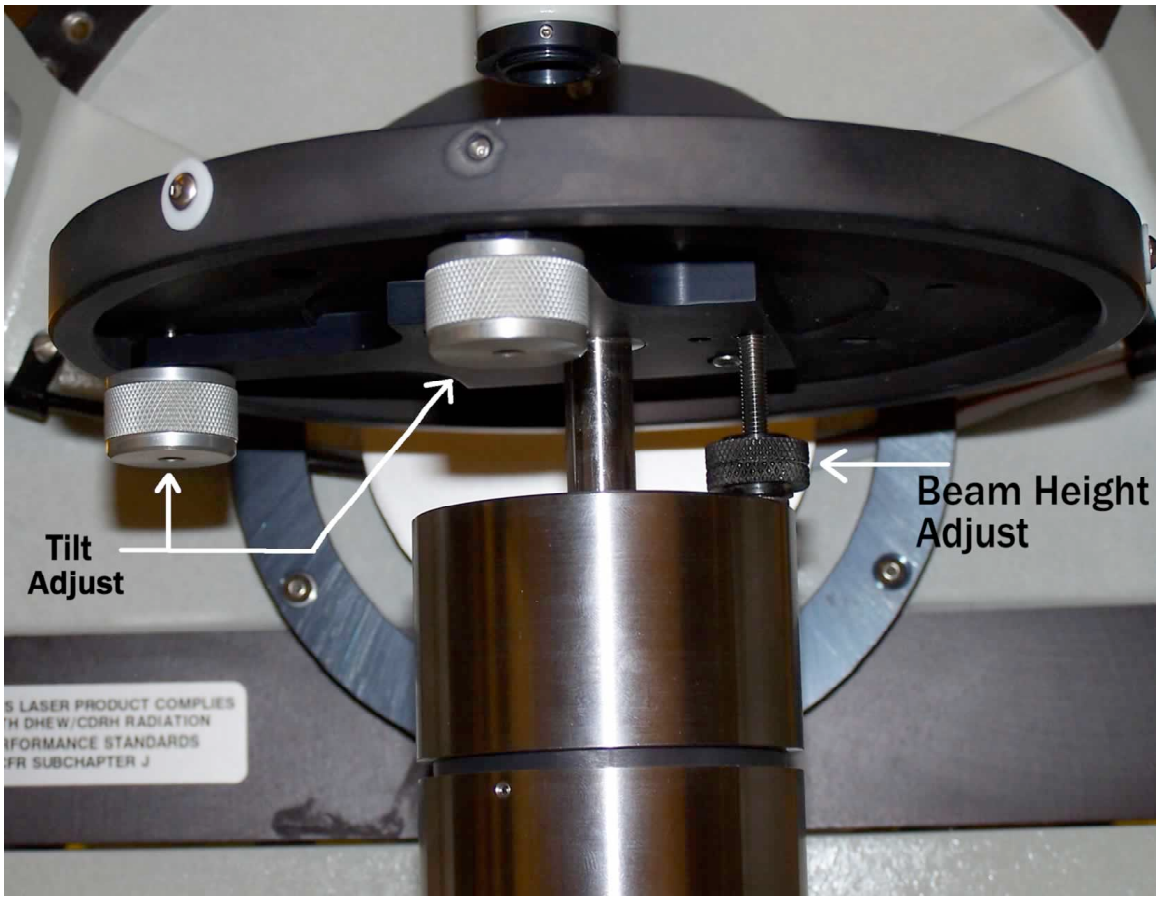


Figure 5: Bottom of table.

ZEISS AXIOTRON MICROSCOPE OPERATING PROCEDURES

General Precautions

1. Raise table slowly to avoid contact between optics and wafer. This contact can cause damage to your wafer and to the microscope objectives.
2. Change objectives slowly by only increasing 1 power at a time. (i.e. Go from 2.5X to 5X and not 2.5X to 50X.)
3. Make sure all samples are clean and dry before putting on microscope table.
4. When finished with the microscope make sure you leave the table in a low position to remove your sample and to leave for next person.
5. Always clean up after yourself. Don't leave a mess for the next person to use the microscope.
6. The specifics of operation described here apply to the Axiotron with the motorized stage, but the operation of the manual Axiotron is similar.

Operation

1. Turn on light source power. This is the LEP Ltd. DC Power Supply located to the left of the Microscope.
2. Allow 5 minutes for light to warm up and stabilize. This is very important if you are using the Filmetrics system.
3. Verify stage is in a down position.
4. Place wafer on table.
5. Adjust eyepiece spacing so you can see in microscope easily.
6. Using Joystick to the right of the microscope, move stage under objective. NOTE: the button on the joystick tells the stage to move at a faster speed.
7. Starting with the lowest (2.5X) objective, bring the sample into focus using the course focus rocker switches on the back of the hand unit.
8. Using the fine focus wheel on the hand unit to finish bringing the sample into focus.
9. Change objective lenses if necessary on the hand unit by using the objective rocker switches.
10. Bring each lens into focus as needed until required objective lens is reached using both the course and fine focus controls.
11. The rod on the top right of the microscope will change the view from the eyepieces to the thickness monitor and camera. Note: The rod on the left is for darkfield/lightfield illumination.
12. When done using microscope, lower the stage down and move it out with the joystick to remove sample.

Prepared by Mark Richmond

FILMETRICS THICKNESS MONITOR

General Precautions

1. Be familiar with use of Axiotron Microscope and how to use it.
2. Software will need a baseline before the first use, anytime the light intensity has been adjusted, and anytime the magnification is changed.

Baseline

1. Set the magnification and illumination to the values you will be using. This may require you to examine your real sample before performing the baseline.
2. To start the baseline procedure, follow the Axiotron operating procedures to focus the microscope on a bare wafer. A bare silicon wafer should be in a wafer box next to the microscope. Focusing on a bare wafer is difficult, so you may want to start by focusing on the edge and moving in. The microscope should be in lightfield mode.
3. Start Filmetrics software. "FILMeasure" Icon is located on desktop or in "Start Menu/Programs/Filmetrics/Filmeasure".
4. After software is started and running. Make sure microscope is allowing light to the thickness monitor and camera.
5. Set "Numerical Aperture" if necessary. This number is from the microscope objective, 2.5X–0.075, 5X–0.15, 20X–0.5, 100X–0.9.
6. Set the microscope to a clean area of the wafer. For films on silicon, this will be a bare silicon wafer. For other substrates.
7. On the right side of the screen, click Baseline.
8. The "Take Reflectance Reference" dialog box will pop up on screen.
    a. Step #1 is "Set Parameters". This is your substrate material (select Si for films on silicon).
    b. Step #2 is "Take Reference". Click "OK".
9. "Take Reflectance Dark". Pull out the selector bar until the light comes out the eyepieces. This keeps any light from hitting the detector. (Do not touch the focus).
10. Click "OK".
11. This concludes the baseline steps and you should now be able to measure your sample.

Measure

1. Put your real sample on the microscope and locate the area that you wish to measure. The area to be measured is the dark square on the video monitor. Be sure that the microscope is focused properly. Remember that if you change the magnification of illumination you must repeat the base line.
2. On the right side of the screen is the "Structure" text box. Using the pull-down menu, select the film program that matches the film structure that you wish to measure.
3. Click "Edit Structure". Enter your guess of the thickness of the layers to be measured. This does not have to accurate, it just gives the computer a starting point.
4. To perform the measurement, click "Measure". This reading should be accurate but always verify that it is a reasonable number that you are seeing. Remember that this system will always output a number, and it is up to you to decide if it is correct. Look at the spectrum to ensure that your measured thickness is the result of a good fit. If the fit is bad you can try editing the structure to give an initial guess closer to the real layer thickness. If your readings start acting up or you change the light level, you will need to redo the baseline measurements.

Prepared by Mark Richmond

VISION GAUGE LINE WIDTH MEASUREMENT SYSTEM

To Begin

1. Double-click the "VisionGauge" icon on the desktop to start image program.
2. Place the wafer under the microscope.
3. The upper camera selector must be pushed in. (This is the black knob on top of microscope)
4. Pull out the aluminum rod to view object on monitor (Located above and to the right of the eyepieces.)
5. On the screen select "Live Video".
6. Adjust the light intensity as necessary. (The analog CCD camera does not have and automatic gain control.)
7. Bring the object into view and focus as necessary.

To Measure

1. When you are ready to measure, left click anywhere on the screen with the mouse. (This will freeze the image for measurement.)
2. Select from the Tools menu "Calibration Toolbox"
3. Select the microscope objective you wish to use from the "Calibration Toolbox".
4. Go to the Settings menu, choose "Units", and select the desired measurement units.
5. Select "Measure" from the right side of the screen.
6. To measure the object move the pointer over the beginning point and left click the mouse. Then move the pointer to the desired location and read the results at the bottom right of the screen.

Saving to Disk

1. Choose the "File" command
2. Select "Image"
3. Select "Save As" and save the file as you normally would. Each group should have a folder in the Users directory, in the ICFAB_05
4. Vision Gauge can support Windows Bitmap (.bmp), Targa (.tga), JPEG (.jpg), and TIFF (.tif) graphics file formats
5. To read a saved file from disk, Choose "File"
6. Select "Image"
7. Select "Open" and choose the file you wish to read

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