Chapter 1.3

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MOD 1

Standard Wafer Cleaning (Piranha Clean)

Purpose: To remove organic residues and complex heavy metal ions.

Equipment:

Sink 6: Sink6 consists of two temperature controlled baths in rear (piranha), two tanks in the middle (HF) and two rinse tanks on each front side of the sink.

Note: This is the pre-furnace clean sink for wafers with no metal on them. An additional sink8 cleaning prior to sink6 clean is required for wafers that have just had photoresist stripped from them. This extra sink8 clean is also required for non-MOS (MEMS) type process wafers. Please refer to Tystar/Tylan Furnace Overview Chapter 5.0 for more detailed information on MOS and non-MOS processing, and their required cleaning steps.

***Time of Execution*:** 20 minutes

***Summary*:**

(1) Add 100 ml of hydrogen peroxide to the 120ºC sulfuric acid bath just before cleaning wafers. This mixture is called 'piranha' and is sufficient to clean one 4" or 6" cassette filled with wafers at this sink.

(2) Wet wafers by immersing the cassette in the QDR (quick dump rinse, DI water tank) at the station.

(3) Immerse wafers in hot piranha for 10 minutes (standard pre-furnace clean).

(4) Dump rinse the wafers/cassette in QDR tank.

(5) Standard rinse/spin dry in SRD spinners.

Detailed Procedure:

(1) Put safety attire on (chemical-resistance gloves on top of surgical gloves, apron and face shield), while working at the acid sinks. Lab members need to also wear fresh poly gloves on top of other gloves to avoid cross contamination of the sink, transfer box/cassettes, and ultimately furnaces. This means you will need to have surgical gloves, chemical-resistant gloves and poly gloves on your hands while performing the pre-furnace cleaning step at sink6.

(2) Check that the temperature controllers of the piranha baths in the rear of Sink 6 are turned on and that the temperature setting is 120ºC. If not, turn on the heater by pressing the green TEMP CONT button. Temperature will be stabilized in about 30 minutes. The bath contains concentrated sulfuric acid.

(3) Move your wafers into one of the black STAT PRO 1000 Teflon® wafer cassettes marked as **sink6**.

(4) When the bath temperature is stable at 120ºC, and just prior to immersing the wafers into the bath, slowly add 100 ml of hydrogen peroxide to the bath. The piranha mixture should start bubbling immediately and should continue bubbling throughout the cleaning period.

Note: Perform an additional sink8 clean prior to sink6 cleaning, if wafers just had photoresist removed from them, and/or non-MOS process(es) are involved. Sink8 has white Teflon® wafer cassettes marked as sink8 available at that station.

(5) Wet wafers with DI water by immersing them in the QDR tank. This prevents bubbles from sticking to the wafer surface.

(6) Immerse cassette with wafers in the hot piranha bath for 10 minutes.

(7) Quick dump rinse your wafers followed by the spin rinse dry (SRD) as per MOD 2 instructions, following.

MOD 2
Standard Rinse – QDR & SRD

Purpose: To rinse to resistivity of 12 Mohm/square or higher prior to drying them.

Equipment: Fluorocarbon rinser/spinner (spindryer6) at sink6, for pre-furnace cleaning purpose, only.

Note: Additional clean in sink8 is required for a non-MOS process and/or post resist strip step for both non-MOS and MOS clean processes.

Time of Execution: ~ 10 minutes

Summary:

(1) Wearing new polyethylene gloves, move your wafers into the designated Teflon cassettes at the sink, and then place the cassette in the quick rump rinse (QDR) station.

(2) Press RESET (if status light is blinking) on the QDR station followed by START button to activate the dump rinse cycles.

(3) At sink6 only, monitor the resistivity by selecting the proper resistivity channel on the RESISTIVITY MONITOR control pad. This can be accomplished by pressing CHAN button (channel 1 for the QDR #1 on the left station, or channel #2 for the QDR #2 on the right station). Make sure that the Mohm-cm light is "on" when selecting this measurement mode. Water temperature or resistivity can be monitored on the same LED display by selecting/deselecting one or the other display mode via DSPLY button. Make sure your resistivity reading is 10 Mohm-cm or greater at the end of your dump rinse cycles, if necessary repeat the process to achieve proper reading.

(4) Remove the cassette from the QDR station and place it in the spin rinse dryer (SRD) station for the final rinse with the H-bar of the cassette facing in.

(5) Press start on the SRD station. The SRD will go through rinse and dry cycles. Final resistivity should be greater than 12 Mohm-cm for the SRD during its rinse cycles (applicable to pre-furnace clean, srdsink6, only)

Rinse Time:	3 minutes
Rinse Speed:	300 RPM
Dry Time:	4 minutes
Dry Speed:	2400 RPM

Take wafers out at the end of the SRD step, remove from the Teflon cassette into your cassette or transfer box at the station for furnace processing

MOD 3
Standard Oxide Dip

***Purpose*:** To remove thin oxide grown on Si during piranha clean.

***Equipment*:** Sink6.

Time of Execution: 10 minutes.

Summary:

(1) DI water rinse your wafers through one dump/rinse cycle (stop/reset after one rinse done)

(2) Dip wafers in HF (water:HF = 25:1 or water:HF = 10:1 at 25ºC, about 1 minute)

Please note some process sequence can not tolerate HF dip, in which case it can be skipped in the overall pre-furnace clean process, just receiving piranha in such cases.

Note: Etch rate of fresh chemicals = 200 A/minute (25:1); 500 A/minute (10:1); adjust etch time according to oxide thickness.

(3) Standard QDR & SRD (see MOD 2).

Detailed Procedure:

(1) Put proper safety attire on (chemical-resistance gloves on top of surgical gloves, apron and face shield), while working at the acid sinks. Poly gloves (clear gloves) must be worn on top of all the other gloves you are wearing at sink6.

(2) If necessary (contaminated solution or sink), aspirate the HF solution from the tank,.DI rinse ten times and replenish with fresh HF (5).

(3) Load wafers into a white Teflon® cassette in sink8 or black STATPro1000 cassettes at sink6.

(4) Quick dump Rinse your samples (wafers) at the QDR station (one dump/rinse cycle), before HF dip.

(5) For water:HF = 25:1, fill dip tank with 6000 ml DI water, add 240 ml HF. For water:HF = 10:1, fill dip tank with 6000 ml DI water, add 600 ml HF. ONLY VLSI Grade HF is allowed in sink6!

Note: Solution should be mixed ten minutes before use. These HF concentrations are usually prepared in advance by the process staff and are regularly replaced.

(6) Dip wafers into the HF bath for the total amount of time needed for your process.

Note: Etch rate = 200 A/minute (25:1) and 500 A/minute (10:1).

(7) Standard QDR followed by SRD as per MOD 2 instructions.

Note: If removing oxide after piranha clean, RINSE wafers for 1 minute in the QDR station, before dipping them in the HF tank. Failure to do so will contaminate the HF bath!

MOD 4
Standard Dehydration Bake

Purpose: To dehydrate wafers that cannot be HMDS vapor primed.

Equipment: VWR convection oven

***Time of Execution*:** 30 minutes (at least)

Summary:

(1) Temp = 120ºC

(2) Time = 30 minutes (at least)

Detailed Procedure:

(1) Below the convection oven are Teflon® cassettes for use in this oven. The cassettes are stamped with VWR to identify them. Do not use the sink cassettes for this process, and do not take the VWR cassettes into the VLSI area as this may lead to contamination. Load wafers into a VWR cassette and place a plastic insert in it that has been labeled with your name and the date (use the write-on tape).

(2) Put the cassette in the oven at 120ºC for at least 30 minutes. If the oven is unavailable and you have performed the standard pre-furnace clean on your wafers (MOD 1), then you can do a dehydration bake in Tystar3 (non-MOS processes) or Tystar2 (MOS processes) at 750ºC for 10 minutes.

Note: If wafers can be spun directly after a furnace step, this procedure an be precluded. When appropriate, it is always suggested that wafers be HMDS treated (MOD 6) and spun with PR directly out of the furnace.

MOD 5

Dehydration Bake or Anneal for Old Lab processed wafers

Purpose: To dehydrate old lab processed wafers that cannot receive HMDS or need an anneal step.

Note: Gold contaminated wafers from the old lab are not allowed in the VLSI area.

Equipment: YES vacuum oven.

Time of Execution: 40 minutes

Summary:

(1) Temp = 200ºC - 450ºC range depending on your process tolerance (recipes are available in vacoven).

(2) Time = 30 minutes bake time.

Detailed Procedure:

(1) Enable the YES vacuum oven on the wand. Read YES vacuum furnace chapter for more details regarding its operation.

(2) Check the chamber pressure on the convectron gauge.

Note: Make sure oven pressure is 760 Torr, so that you can open the chamber door (if not, dial thumb wheel to 2 and press Start. It will inject N2 into the chamber to vent the oven).

(3) Make sure the thumbwheel is set at 1. If not, change to 1.

(4) Load samples into oven.

Note: You may use a metal cassette, quartz or graphite boat, when loading wafers. Two 4" black anodized aluminum cassettes are provided. NEVER use a plastic (including Teflon™) cassettes nor put plastic in this oven. If you need to use other fixtures for your samples, get permission from Bill Flounders or Sia Parsa.

(5) Press **PROF** button until the desired program number is selected on the Partlow temperature controller.

(6) Press the **OPERATOR PANEL** button until the **PROCESS PARAMETER SELECT PANEL** page is displayed on the QUICKPANEL, touch screen panel. Indicate required process parameters. See YES vacuum oven manual for more details.

(7) Make sure the touch screen displays **READY TO PROCESS** before starting the process. If not, press the **OPERATOR PANEL** to return to the main status screen manual and the **READY TO PROCESS** will display.

(8) Press the big black **START** button on the system controller.

Note: To start the process, DO NOT press the **RUN/HOLD** button on the Partlow. Doing so will do nothing.

(9) When a message on the touch screen said that the process is complete, press the big red **RESET** button on the system controller.

Note: The wait time for the chamber to ramp down to set point, may take many hours. Therefore, you can vent the chamber when the temperature drops to 120°C on your cooling step (abort your process). You can vent the chamber by setting the thumbwheel to 2 and press the big black **START** button. Do not open the oven with temperature >150ºC. You can be seriously burned if the chamber is open when too hot.

Note: You may press the big red **RESET** button anytime to abort your process. Load your wafers in the boats using the MOS clean vacuum wand.

(10) Unload your wafers.

Note: Use the high temperature dedicated mitts to unload the anodized cassette when it is hot. Careful! You must have a good grip on the cassette when unloading it.

(11) Leave the oven pumped down when not in use. Set thumbwheel to 0 (pump down) and press **START** button

MOD 6
Standard Photoresist Coating Procedure

A. HMDS TREATMENT OF WAFER SURFACE

Purpose: To improve photoresist adhesion to the wafer surface especially for wafers coated with oxide.

Equipment: primeoven

Time of Execution: 35 minutes

Summary:

(1) Vacuum prime wafers with HMDS for 1 minute.

Detailed Procedure:

Place your wafers in a Teflon® cassette.

Place the cassette in the primeoven and close door securely.

(1) Verify that the thumbwheel switch is set to 0.

(2) Press the black START button.

(3) The system will now begin the automatic pump/purge/prime sequence followed by a prime sequence.

(4) When the cycle is complete, the COMPLETE light will light up and the system will alarm. Press the red RESET button to silence the alarm.

(5) Open the door, remove the cassette, and close door.

Note: The process dehydrates as well as vapor primes, so dehydrating the wafers first in the VWR oven is not necessary for the YES oven HMDS prime process. The wafers should NOT be put through more than one complete prime cycle; over priming will cause resist adhesion problems. The wafers can be left up to 3 weeks before coating with resist.

B. PHOTORESIST COATING ON THE AUTOMATED TRACKS

(See Section C below for information on manual coating of Photoresist)

***Purpose*:** To spin coat wafers with specific photoresist as per follows:

(1) To spin coat a 1.3 µm OCG 825 (G-line positive) photoresist layer onto 4" wafers.

(2) To spin coat a 1.1 µm of OiR 10i (I-line positive) photoresist layer onto 4" wafers.

(3) To spin coat 10 µm of thick resist, SPR 220-7.0 photoresist layer onto 4" wafers, See MOD 29.

Equipment: SVG Wafer Track

Time of Execution: 2 minutes/wafer (I-line & G-line resists), 7 minutes/wafer for thick resist (longer bake).

Summary:

Note: Wafers must first have been dehydrated and/or HMDS treated.

(1) For OiR 10i resist execute program #1, on svgcoat 1 and 2 (SVG coat tracks 1&2) :

(a) Dispense photoresist for 1.5 seconds dynamically at 500 rpm.

(b) Spread at 500 rpm for 1.5 seconds.

(c) Spin at 4100 rpm for 30 seconds.

(d) Soft bake at 90ºC for 60 seconds.

(e) Cool on cold chuck for 3 seconds.

(2) For OCG 825, G-line resist execute program #2, on svgcoat 1 and 2:

(a) Dispense photoresist for 1.5 seconds dynamically at 1000 rpm.

(b) Spread at 500 rpm for 1.5 seconds.

(c) Spin at 5000 rpm for 30 seconds.

(d) Soft bake at 90ºC for 90 seconds.

(e) Cool on cold chuck for 3 seconds.

(3) For Rohm Hass SPR 220–7.0 resist execute program #8, on svgcoat 1 and 2:

(a) Statics dispenses photoresist for 1.5 seconds.

(b) Spread at 300 rpm for 3.0 seconds.

(c) Spin at 1800 rpm for 30 seconds.

(d) Soft bake at 115ºC for 300 seconds.

(e) No cooling on cold chuck.

Detailed Procedure:

(1) Enable either svgcoat1 (Track #1) or svgcoat2 (Track #2).

(2) Verify that power to the system is ON.

(3) Adjust hot plate temperatures to desired set points.

(4) Verify that the track is in AUTO mode; the LED next to the word AUTO will be illuminated. If not, press this switch to toggle through the other options (SINGLE and MANUAL) until AUTO is selected.

(5) Select the desired dispense program (see coater program table, below).

Note: There are 2 separate display windows on the control panel: COATER and OVEN. To select the dispense program, the COATER display must be selected. When the COATER display is selected, an asterisk appears at the left of the COATER display and when the OVEN display is selected, a plus sign appears at the left of the OVEN display. You can toggle between the two using the STATION SELECT button on the control panel keyboard. With the COATER display active, press the PROGRAM SELECT button on the control panel keyboard to toggle through the available programs (1-9). Alternatively, you can press the desired program number key followed by the PROGRAM SELECT button to select the program.

(6) Verify that the correct oven program is selected for your desired resist (refer to bake program listed in the table below). As with the dispense program, the OVEN display must be active in order to select different programs.

(7) If necessary, press INDEX RESET button to bring indexers to their starting positions (fully up). Note that if you press the INDEX RESET button, you must lift the cassettes completely off the elevator and then replace them in order to proceed.

(8) Load an empty cassette onto the receive indexer (right side) and the cassette containing your wafers and 3 dummy wafers on the send indexer (left side). Make sure that the cassettes are properly seated on the indexers.

(9) Press the START button. The receive cassette will lower and the send cassette will lower until it senses a wafer. The wafer will then be transported to the spindle station for the dispense procedure, then to the bake station for soft baking, and finally to the chill plate and receive cassette.

Note: If the machine alarms at any point during the coating process, silence the alarm by depressing the CLEAR button. The machine state can be checked using the diagnostics feature as follows:

(10) Press the DIAGNOSTIC SELECT key on the control panel. The display will show the following prompt:

SELECT MODE 1 – 2

(11) Press 1 to display the present machine state. The machine state diagnostic messages for the upstream indexers and processing stations are displayed in the upper display window. Machine state messages for the downstream sensors are displayed in the lower display window.

(12) When all wafers have been coated and loaded into the receiving wafer cassette, depress the INDEX RESET button to bring the cassette up to its fully raised position.

(13) Remove all your wafers and replace the cassette back on the receiving platform.

Coater Programs

Program (#)	Resist Type	Spin Speed (RPM)	Refractive Index	Thickness (µm)
***1**	OiR 10i (I-Line)	4100	Default value ~1.631	~1.1
*2	OCG 825 (G-Line)	5000	Default value ~1.631	~1.3
3	OiR 10i (I-Line)	2000	Default value ~1.631	~1.6
4	OCG 825 (G-Line)	2200	Default value ~1.631	~2.0
5	OiR 10i (I-Line)	1300	Default value ~1.631	~2.0
6	OiR 10i (I-Line)	820	Default value ~1.631	~2.8
7	None			
**8	SPR 220 - 7.0 (Broadband)	1800	Default value ~1.631	~10.0
9	Edge Bead Removal (EBR)	600	Default value ~1.631	N/A

* Standard Programs
** Standard Thick Resist Program:

Note1: Must run EBR program #9 before softbake on coater 1.

Note2: If decided not to perform edge bead removal (EBR), then softbake must be done on hotplates in Y1 to prevent coater track's bake station contamination.

Oven (soft bake) programs

Program (#)	Bake Temp. (ºC)	Bake Time (sec.)	Chill Time (sec.)
*1	90	60	6
2	90	90	6
3	90	120	6
7	90	180	6
**8	115	300	0
9	No Bake	0	0

* Standard Program
** Standard Thick Resist Program

Note: For the thick resist process, users must adjust program #8 bake temperature to 115ºC manually and then return to 90ºC, after finishing the softbake process.

C. PHOTORESIST COATING USING MANUAL COATERS

***Purpose*:** To manually spin coat wafers with specific photoresist, as per follows:

(1) To spin coat a 1.3 µm OCG 825 (G-line positive) photoresist layer onto 4"/6" wafers.

(2) To spin coat a 1.1 µm of OiR 10i (I-line positive) photoresist layer onto 4"/6" wafers

(3) To spin coat 10 µm of thick resist, SPR 220-7.0 photoresist layer onto 4" wafers, See MOD 29.

Equipment: Headway1 and Headway2 machines (chapters 4.28 and 4.29, respectively)

Time of Execution: 4minutes/wafer (I-line & G-line resists), 7 minutes/wafer for thick resist (longer bake).

Summary:

Note: Wafers must first have been dehydrated and/or HMDS treated.

(1) For OiR 10i, I-line resist execute program #1 on Headway spinners or use similar parameters:

(a) Hand dispenses photoresist for one second during this 30 sec. waiting period.

(b) Spread at 500 rpm for one second (I-line) and 500rpm for 1.5 seconds longer at 10000 ramp rate.

(c) Spin at 4100 rpm for 30 seconds.

(d) Soft bake at 90ºC for 60 seconds (I-line) resists on (vauum) hotplate.

(2) For OCG 825, G-line resist execute program #2 on Headway1/Headway2 spinners or use similar parameters:

(a) Hand dispenses photoresist for one second with static dispense during this 30 sec. waiting period.

(b) Spread at 500 rpm for one second and 500 rpm for 1.5 seconds longer at 10000 ramp rate.

(c) Spin at 5000 rpm for 30 seconds.

(d) Soft bake at 90ºC for 60 seconds on (vacuum) hotplate.

(3) For SPR 220–7.0, thick resist execute program #5 on Headway spinners or use similar parameters:

(a) Static dispenses (zero rpm), hand dispense photoresist until it covers around 2/3 of the wafers.

(b) Spread at 300 rpm for 3.0 seconds.

(c) Spin at 1800 rpm for 30 seconds.

(d) Soft bake at 115ºC for 300 seconds.

Detailed Procedure:

A. Headway1 Spinner Operation (in msink3)

(1) Enable the System on the mercury and make sure the power is on to the control module. Lower the spinner cover when not in use. Remove the chuck after each use (and clean, if necessary). Never pour photoresist residue into msink3 drain; always use an organic waste bottle.

(2) Lift the cover by first pressing the black button. Line the bowl with a clean sheet of foil.

(3) Place the desired chuck in the spinner. There are several chucks located on the shelf next to the spinner. Make sure that the chuck is firmly seated on the spindle.

(4) Place a wafer on the chuck and press Vacuum on control module to secure the wafer. Display will show VACUUM ON. To turn on/off the vacuum, press VACUUM again. Lower the cover if the sample is ready.

(5) The spinner will not start if the vacuum level does not reach vacuum setpoint. The chuck will stop instantly during the operation, if the sample slips off the chuck. There is a chance of the sample slipping off on higher speeds, if it is not centered properly. Make sure to center the sample on the chuck.

(6) Double check that the lid is secured and the sample is centered on the chuck. The control unit has to be in READY (standby) mode, before starting a spin coat program. To exit reviewing or programming mode, press STEP followed by 0.

(7) Select your desired recipe by pressing RECIPE followed by entering the recipe number. Programs 1-6 are fixed and members are not allowed to modify them. Programs 7-9 are available for users to edit/change.

(8) Press the foot switch on the green side to start the spinner. The foot switch is located by the front left side of msink3 (floor). Pressing on the red side of the switch during the operation will stop the spinner motor, and an alarm message will display. To clear this alarm and return to standby mode, press the green side again.

(9) The current recipe and step number, spinning speed and step duration will be displayed while running a recipe. It is a good practice to double check steps, while running a spin coat program.

(10) Once the coater recipe started it will give you ample time to manually dispense photoresist on your wafer (second step in the recipe, low spin speed for dynamic dispense). The amount of resist you will need to apply depends on the wafer shape, resist type, final spin speed, substrate topography, etc. A good rule of thumb would be 1/3 of the sample surface initially covered by resist before spreading it over the rest of the wafer/sample. Photoresist is applied by pouring it slowly onto the sample using an eyedropper or syringe. DO NOT DISPENSE DIRECTLY FROM THE QUART BOTTLES OF PHOTORESIST!

(11) The spinner will spin for a set time/steps, then stops. Lift the cover, turn off the vacuum and remove your wafer for the next step in the process, i.e. soft bake. Remove the chuck, dispose excess amount of photoresist waste on aluminum foil in organic waste bottle, discard the foil in the exhaust vented waste can and clean the bowl if necessary. There should be no resist residue in the bowl when you are finished. Reline the bowl with fresh aluminum foil making sure not to obstruct the exhaust port around the spindle. Lower the cover.

Recipe Editing Notes (allowed on programs 7-9, only):

I. To open a recipe, press RECIPE followed by the number of the recipe. The control panel will turn to REVIEW mode. You can review and edit each step in the recipe by pressing STEP Key (top right corner on the keypad), followed by the desired step number. To return to READY (standby) mode, press STEP and 0. Once in a step, the step duration will be displayed by default. To change the duration of a step (step time), enter the desired value on the keypad and press enter. Data entered will be saved automatically.

II. To see the spin speed of a selected step, press SPEED/RAMP button and the speed will show up in RPM units. To change the speed, punch in your desired value, and then press enter.

III. You will need to also check the ramp up/down at a step (initial steps ramp up to next higher speed defined on the following steps and of course last steps will ramp down defined by the same key. The default value for a ramp up or ramp down is 1000 RPM/second. You can edit the ramp step by pressing the SPEED/RAMP button twice.

IV. To end recipe in a given step (defining the last step in the spin coat program), press STEP TERMINATE button twice and hit ENTER.

V. Press STEP and then 0 to return to standby mode, when you are done with editing or reviewing a recipe. Recipes can not start in the programming mode. The display should say READY and the number of the recipe selected.

B. Headway2 Spinner Operation (next to Headway1 Spinner)

(1) Enable the System on the mercury and make sure the power is on to the control module.

(2) Follow the instructions as Headway1 spinner, except using the START and STOP buttons the table top instead of the foot paddle controller on Headway1.

MOD 7

Standard Photoresist Development

A. POST EXPOSURE BAKE (PEB)

Purpose: To improve the photoresist profile following exposure on gcaws1 stepper (I-line resist).

Equipment: svgdev

Time of Execution: 1.5 minutes per wafer

Summary: 1 minute hotplate bake at 120ºC

Detailed Procedure:

(1) Load wafers in the send cassette on the SVG develop track (svgdev).

(2) Following the detailed procedure in section B, select dev program #8 and bake program #1.

(3) Press START. Wafers will be sent to the hotplate for a 1 minute bake at 120ºC (bypasses the coat).

(4) When process is complete, remove cassette and wafers.

Note: This process is strongly recommended whenever you use the I-line stepper to expose wafers; it will improve the photoresist sidewall profile and resist adhesion for submicron lines and spaces. It is not necessary when using the G-line stepper (gcaws2).

B. PHOTORESIST DEVELOPMENT

Purpose: To develop exposed OCG 825 coated wafers with OCG 934 developer 2:1 (premixed); to develop exposed OiR 10i coated wafers with OPD HPRD 4262 developer (premixed); to develop exposed thick resist (SPR22-7.0) coated wafers with Rohm Haas MF-26A developer (premixed).

Equipment: svgdev

Summary:

Note: There are total of 6 resist developer programs available on this track for I-line & G-line resists. No Developer program available for thick resist on this track. Perform post exposure bake (PEB), if necessary. Refer to general resist parameters chapter for more details on developer type, develop time needed for I-line, G-line and thick resists.

(1) Program 1 is the standard developer program for I-line (OiR 10i) resist.

(2) Program 2 is the standard developer program for G-line (OCG 825) resist.

(3) No developer program available for the thick resist (SPR-220-7.0), which can be manually developed at sink5.

Detailed Procedure for I-line & G-line Resist Developing:

(1) Enable the svgdev.

(2) Verify that the power to the system is ON.

(3) Verify that the SVG is in AUTO mode; the LED next to the word AUTO is illuminated.

(4) Select your desired developer program, as per resist type noted in the SVGDEV table, below.

(5) If necessary, press INDEX RESET button to bring indexes to their starting positions.

(6) Load an empty cassette onto the receive indexer and the cassette containing your wafers onto the send indexer.

(7) Press the START button. The send cassette will lower until it senses a wafer; the receive cassette will lower to wait for the wafers.

(8) When all wafers have been developed, press the INDEX button to return the receive cassette to its starting position.

(9) Remove your wafers and return the cassette to the platform.

(10) Disable the svgdev.

Detailed Procedure for Thick Resist Developing:

Note: For single wafer developing or very small group of wafers, use a shallow beaker instead of the recommended bath at sink5, and follow the instruction in steps 4-10, below.

(1) Enable the sink5.

(2) Remove the Teflon cassette currently in one of the spin rinse dryers station at sink5 (4" or 6").

(3) Place your wafers in the Teflon cassette.

(4) Place enough developer in the extra developer tank available at the front side of sink5 station. Make sure to DI rinse/drain the tank a few times, before filling it up with Rohm Haas MF-26A developer (developer for SPR-220-7.0 resist).

(5) Depending on the pattern density and the exposure used for your application, you may need to develop your exposed resist for 3-15 minutes. Agitate the solution (gently move your cassette/wafer/s up and down) to ensure uniform development.

(6) Once done with the develop step, immediately rinse your wafers (cassette) in the quick dump rinse (QDR) tank at the station.

(7) Place the cassette in the spin rinse dryer (SRD) next to sink5 for additional rinse followed by a dry step.

(8) Remove wafers from the SRD and out of the Teflon cassette.

(9) Return the Teflon cassette back into the SRD.

(10) Aspirate the developer and rinse/drain the tank.

(11) Disable sink5.

SVGDEV Programs

Developer Programs					
Programs	**Developer(s)**	**Resist(s) Developed**	**Puddle**	**Dev. Time** (sec)	**Comments**
*1	OPD 4262	OiR 10i	Single	60	Standard I-Line Develop
*2	OCG 934 2:1	OCG 825	Double	2 × 30	Standard G-Line Develop
3	OPD 4262	OiR 10i	Single	30	Half-Time I-Line Develop
4	OCG 934 2:1	OCG 825	Single	30	Half-Time G-Line Develop
5	OCG 934 2:1	OCG 825	Double	2 × 38	25% G-Line over-develop
6	Rinse	None	None	None	Rinse and Spin Dry
8 (PEB)	None	None	None	None Bake	Post-Exposure

*Standard Develop Programs

Bake Programs			
Program (#)	**Bake Temp.** (ºC)	**Bake Time** (sec)	**Chill Time** (sec)
1 (PEB)	120	60	6
2	120	90	6
3	120	120	6
*9	No Bake	0	0

Dispenser Assignments			
Developer	**Resist**	**Dispenser**	**Toggle Position**
OPD 4262	OiR 10i	Stream (DV-ST)	N. A.
OCG 934 2:1	OCG 825	Spray (DV-ST)	(not used)

C. INSPECTION

Purpose: To check for clear development and correct line width.

Equipment: Microscope and linewidth

Detailed Procedure:

(1) Inspect wafer under microscope for clear development and correct line width. Critical dimensions (CD) can be measured on linewidth. Be sure to use the yellow filter or your resist will be exposed!

(2) If development is satisfactory, go to the next step in your process flow path.

(3) If development is not satisfactory, develop again or carry out the following:

(a) Resist stripping, as per MOD 12 and/or MOD 11 instructions.

(b) Wafer Cleaning After Resist Removal, as per MOD13 instructions.

(c) Standard Dehydration Bake, as per MOD 4 instructions.

(d) Standard Photoresist Coating Procedure, as per MOD6 instructions.

(e) Resist Exposure.

(f) Standard Photoresist Development, as per MOD6 instructions.

MOD 8
Standard Hard Bake

Purpose: To drive out solvent in photoresist before etching or ion implantation.

Equipment: VWR convection oven

Time of Execution: at least 30 minutes

Summary: Bake wafers at 120ºC

Detailed Procedure:

(1) In a drawer underneath the VWR oven tabletop are Teflon® cassettes specifically for use in hard bake. Load the wafers into one of these cassettes. Label a plastic insert (using the write-on tape) with your name and date and insert in cassette.

(2) Put cassette with wafers in VWR oven for at least 30 minutes.

MOD 9
Standard De-Scum Procedure

Purpose: To remove resist residue in normally cleared areas

Time of Execution: 3 minutes per set of 4 wafers

Equipment: Technics-C

Summary:

(1) Vent the system and place wafers in chamber.

(2) Pump system down to base pressure (~35 mTorr).

(3) Introduce oxygen into chamber.

(4) Strike plasma by turning on power to 50 watts. Set time for 1 minute.

(5) Turn off power, then gas.

(6) Pump down chamber to remove reacted gases.

(7) Vent chamber and remove samples.

Detailed Procedure:

(1) The status of the machine should be as follows:

Mode:	Manual
SOL'N (Solenoid):	Closed
Vent:	Off
Power:	Toggle Off, Knob Pegged Counterclockwise
Gas #1:	Off
Gas #2:	Off

Occasionally the solenoid which controls the vacuum pump is left open. If this is the case, close it before enabling the system.

(2) Once you are ready to introduce your sample, vent the chamber by toggling the VENT switch. Be sure that the SOL'N is closed when you do this. It will take about 15 seconds for the chamber to fill. Once at atmospheric pressure, open it carefully - the top is very heavy - and place your wafers on the plate. Close the top carefully, being sure not to allow it to fall.

(3) Oxygen for photoresist descum is connected through GAS #1.

(4) To start the vacuum pump, leave the vent ON, and toggle the solenoid (vacuum pump) switch open. After 2 or 3 seconds, close the vent switch to allow the pump to lower the pressure of the chamber.

(5) You can watch the pressure drop as the system comes under vacuum. When the system reaches base pressure, introduce oxygen into the chamber by toggling the GAS #1 switch (be sure the O switch on the PD module is up). The pressure in the chamber will rise as gas flows in, and then stabilize.

(6) Once gas flow into the chamber is stable and at the desired pressure, (~300 mTorr - this is preset) strike a plasma by switching the POWER toggle on and turning the dial clockwise until 50 Watts is reached. The plasma is visible through the window on the front of the chamber. Begin timing your run for 1 minute.

(7) Once the run is complete, turn off the power, then the gas. Always turn off the power before turning off the gas.

(8) Allow the chamber to pump down to base pressure to sweep all potentially harmful gases out of the chamber.

(9) Turn off the vacuum pump by switching the SOL'N toggle to closed position. Now you may vent the chamber. Again, remember not to vent the chamber until the SOL'N has been closed.

(10) The chamber will now come up to atmosphere and sample can be removed.

(11) Once the sample has been removed, close the chamber and start the vacuum with the vent open. After a couple of seconds, close the vent and allow the chamber to pump down to base pressure. Close the SOL'N. Be sure that gas switches and power are off.

MOD 10
Photoresist Removal

Purpose: To remove photoresist on wafers, the following cases are considered:

A: Removing soft photoresist from wafers with NO metal layer on them after any etch step OR reworking such wafers at any photolithography step (stripping resist from non-metalized wafers).

B: Removing soft photoresist on wafers with metal layers on them (metalized wafers).

C: Removing hardened (long hard baked or implanted or etched) photoresist on wafers with NO metal on them.

D: Removing hardened (long hard baked or implanted or etched) photoresist from wafers with metal on them.

CASE A

Purpose: To remove soft photoresist on resist coated wafers with no metal on them.

Equipment: Sink5 (PRS-3000 baths) or plasma ash followed by sink8 (piranha bath)

Summary:

(1) Do MOD 11 PRS-3000 bath and/or MOD 12 Plasma Ashing of Photoresist (technics-c and matrix) to remove all of the resist from your sample.

(2) Do MOD 13 piranha clean after resist removal is done.

Detailed Procedure:

Explained in MOD 11, MOD 12, and MOD 13.

CASE B

Purpose: To remove soft photoresist on wafers coated with aluminum or refractory metals. Please note, other metals including; noble metals (Gold, silver) and copper are not allowed in the VLSI sinks or in sink5, as well as any of the process equipment in the VLSI section of the lab.

Note1: Most metals can get attacked by piranha, therefore ARE NOT allowed in sink6 or sink8. Wafers with aluminum and refractory metals should be cleaned in the PRS-3000 solution or get ashed (O2 plasma cleaned) in the matrix or technics-c machines.

Note2: Refractory metals are metals with melting points above 1500ºC (Molybdenum**,** Tungsten, Tantalum, Rhenium and niobium)

Note3: Noble metals do not easily get corroded by oxygen: Some are highly diffusive in Si, therefore, can negatively impact fabricated MOS device performance. This means noble metals (Ag, Au, Ir, Os, Pd, Pt, Rh, Ru), especially gold are not allowed in the VLSI area/sinks (sink6 - sink9). Gold is also not allowed in Sink5.

Equipment: Sink5 (PRS-3000 bath), matrix or technics-c asher.

Summary:

(1) Do MOD 12 plasma ashing of the photoresist to adequately remove all this material from your wafers.

and/or

(2) Do MOD 12 PRS-3000 Resist Stripping. Please be aware that aluminum surface may get impacted (pitted) by the PRS-3000 solution, cases have been reported in the past!

Detailed Procedure:

Explained in MOD 11 and MOD 12.

CASE C

Purpose: To remove the photoresist from wafers with NO metal on them that have been hardened by plasma etching or by implantation or because the baking time has been too long.

Equipment: Technics-c or matrix, sink8

Summary:

(1) Do MOD 12 Plasma ashing of photoresist in technics-c or matrix asher, and if necessary increase the ash time to ensure complete resist removal (Max. 10 minutes).

(2) Do MOD 13 wafer cleaning of wafer with no metal on them in sink8 for 10 minutes, after the resist has completely been removed from the wafers (non-metalized wafers only).

Detailed Procedure:

Explained in MOD 12 and MOD 13**,** if needed additional MOD 14.

CASE D

Purpose: To remove the photoresist on wafers with metal on them that have been hardened by plasma etching or by implantation or because the resist baking time may have been too long.

Equipment: Technics-c or matrix, Sink5 (PRS-3000),

Summary:

(1) Do MOD 12 plasma ashing of photoresist in technics-c or matrix asher, and if necessary increase the ash time to ensure complete photoresist removal (Max. 10 minutes) .

(2) Do MOD 11 wafer cleaning after the resist removal in sink5 PRS-3000 solution.

Detailed Procedure:

Explained in MOD 12 and MOD 11.

Note: If resist is somehow hardened beyond the point that the above MOD 12 procedure cannot strip it, then perform an additional MOD 14 to remove such hardened photoresist. You may also increase the ash time for the ash step, if necessary (Max. 10 minutes).

MOD 11
PRS-3000 Resist Stripping

Purpose: To remove soft photoresist from wafers.

Equipment: Sink5, srdsink5

Summary:

(1) Strip resist in sink5 PRS-3000.

(2) Spin dry wafers in srdsink5.

(3) Do MOD 13 wafer cleaning after resist removal for wafers with no metal on them.

Detailed Procedure:

(1) Enable sink5 and srdsink5 on the wand.

(2) Lift cover off the PRS-3000 bath and put it aside.

(3) Load wafers to be cleaned into a Teflon® cassette; use appropriate cassette handle for the cassette you choose.

(4) Put wafers in 80ºC PRS-3000 photoresist stripper quick soak bath or long soak bath. Leave the handle on the cassette to prevent accidental breakage of your wafers by the next user, who may not clearly see if there is a cassette in the bath (PRS-3000 with dissolved resist in it looks murky, therefore it is hard to see objects inside it).

Note: Quick soak bath is for stripping resist up to 20 minutes assigned to the task of stripping soft baked resist. Long soak bath is for stripping resist from 20 minutes to 8 hours. Long soak bath can be used for stripping resist on resist bonded wafers, hard baked resist wafers, and resist etched in a plasma chamber.

(5) Pull cassette out of PRS-3000 photoresist stripper bath when you are finished with stripping the resist, and put it in the water filled QDR tank.

(6) Replace cover on the PRS-3000 bath.

(7) Press the STOP/RESET button on the QDR, and then press the START button.

(8) When the water rinse is finished, press the STOP/RESET button.

(9) Take the cassette handle off. Blow dry (N2 gun) the wafers, if you use the 1/2 size Teflon® cassette, otherwise, transfer the 4" full Teflon® cassette in the top spin dryer or for your 6" wafers use the bottom spin dryer of srdsink5. Make sure the H-bar is facing in.

(10) Press the START button on the appropriate unit on srdsink5. This recipe will rinse and spin dry the wafers.

(11) At the end of the cycle, the spin dryer will stop.

(12) Remove the cassette when the spin dryer stops completely and then unload the wafers.

(13) Disable sink5 and srdsink5 on the wand.

(14) Do MOD 13 wafer cleaning procedure to remove resist residues, if necessary (non-metal wafers).

Note: Only staff are allowed to drain and change sink5 PRS-3000 baths.

MOD 12
Plasma Ashing of Photoresist

Purpose: To remove hardened photoresist post etch or implantation step, using the oxygen plasma.

Equipment: Technics-C or matrix asher

Summary:

Note: Please refer to technics-C and Matrix asher manual for details on recipes and the etch rate to be used.

A – Technics-C Plasma Asher

(1) Vent the system and place wafers in chamber.

(2) Pump system down to base pressure (~35 mTorr).

(3) Introduce oxygen into the chamber.

(4) Strike plasma by turning on power to 300 watts. Set process time, as needed for complete photoresist stripping, then run the process.

(5) Turn off power, then gas.

(6) Pump down chamber to remove reacted gases.

(7) Vent chamber and remove samples.

B – Matrix Plasma Asher

(1) Vent the system.

(2) Place your wafers in the cassette.

(3) Load the cassette on the stage.

(4) Run the standard ashing recipe.

(5) Remove the cassette and unload your wafers.

(6) Put system back in standby mode.

Detailed Procedure:

Technics-C Operation in Auto Mode

(1) Start with the machine in manual mode. All valves should be closed.

(2) Vent the chamber by toggling the VENT switch up. It will take ~15 sec for the chamber to fill. Once it is at atmospheric pressure, lift/open the chamber door carefully, and place your wafers on the plate. Close the chamber lid. Toggle the VENT switch off.

(3) Toggle the mode switch to auto mode (up).

(4) Toggle the SOL'N and VENT switches ON (up).

(5) You can watch the pressure drop as the system comes under vacuum. When the system reaches ~30 mtorr, you can introduce the gas you wish to use into the chamber by toggling the appropriate gas switches as follows.

(6) Turn on the gas1 switch (up) on the PD module and toggle GAS #1 (O2) on the PE module

(7) Toggle the switch power ON and turn the dial clockwise six turns from the eleven o'clock position. Each turn is 50 Watts for the total power needed (300 Watt).

(8) Set the desired time. Standard time is five minutes.

(9) Press **Start/Stop** switch to start.

(10) Once the cycle is completed, the machine will **beep**, and the **Start/Stop** button will light up. Press **Start/Stop** again to silence the **beep**.

(11) If loading more wafers, wait until the system is vented to continue.

(12) Once the cycle is completed, after unloading the last wafers, turn all switches off, starting with the power switch. Bring the power dial to zero.

(13) Bring the system to **Manual** mode.

(14) Toggle the SOL'N switch and pump the system down to base pressure.

(15) Close the SOL'N, and disable the technics-c.

Technics-C Operation in Manual Mode

(1) The status of the machine should be as follows:

Mode:	Manual
SOL'N (Solenoid):	Closed
Vent:	Off
Power:	Toggle Off, Knob Pegged Counterclockwise
Gas #1:	Off
Gas #2	Off

Occasionally the solenoid which controls the vacuum pump is left open. If this is the case, close it before enabling the system.

(2) Once you are ready to load your sample, vent the chamber by toggling the VENT switch. Be sure that the SOL'N is closed when you do this. It will take about 15 seconds for the chamber to fill. Once it is at atmospheric pressure, open it carefully (the top is very heavy), and place your wafers on the plate. Close the top carefully, being sure not to allow it to fall.

(3) Oxygen for photoresist ashing is connected through Gas #1.

(4) You are now ready to start the vacuum pump. Leaving the vent ON, toggle the solenoid (vacuum pump) switch open. After 2 or 3 seconds, close the vent switch to allow the pump to lower the pressure of the chamber.

(5) You can watch the pressure drop as the system comes under vacuum. When the system reaches base pressure, introduce oxygen into the chamber by toggling the GAS #1 switch. The pressure in the chamber will rise as gas flows in, and then stabilize.

(6) Once gas flow into the chamber is stable and at the desired pressure, (270-280 mTorr - this is preset) strike a plasma by switching the POWER toggle on and turning the dial clockwise until

300 Watts is reached. The plasma is visible through the window on the front of the chamber. Begin timing your run.

(7) Once the run is complete, turn off the power, then the gas. Always turn off the power before turning off the gas.

(8) Allow the chamber to pump down to base pressure to be sure all potentially harmful gases have been swept out of the chamber.

(9) Turn off the vacuum pump by switching the SOL'N toggle to closed position. Now you may vent the chamber. Again, remember not to vent the chamber until the SOL'N has been closed.

(10) The chamber will now come up to atmosphere and you may remove your sample.

(11) Once your sample has been removed, close the chamber and start the vacuum with the vent open. After a couple of seconds, close the vent and allow the chamber to pump down to base pressure. Close the SOL'N. Be sure that gas switches and power are off.

(12) Disable Technics-C.

C – Matrix

(1) Enable the Matrix asher.

(2) Check the operator console and see if it is in standby mode, then exit by pressing the **EXIT** key. Wait until chamber is vented and main operating page is displayed.

(3) Load your wafers in the designated input cassettes, available at the station (4" or 6").

(4) Adjust the cassette receiver (stage) to accept your desired wafers size (4" or 6") by placing the input cassette on the stage and adjusting the knobs on the stage.

(5) Press **RUN** in the run option screen (standard recipe), and it will take you to the next screen.

(6) Press **HOME** to reset the cassette on this screen or use the Up and Down key under the move cassette option submenu to position your first wafer in front of the pick and place wafer transport, starting with the lowest desirable wafer slot in the cassette.

(7) Press **AUTO** or **SINGLE** to start the ash process. This will automatically process your wafers or one wafer at a time depending on your selected mode of operation.

(8) After you are done ashing, remove the wafer cassette.

(9) Press the **STANDBY** key to leave the machine in the standby mode with chamber isolated from the atmosphere.

Note: The Matrix standard recipe ashes for 1.5 minutes. Repeat the process if the wafers are not clean after the first ash. Please refer to **Matrix 106 Resist Removal System** chapter manual for more detailed information.

MOD 13

Wafer Cleaning After Resist Removal

Purpose: To clean wafers of resist residue after resist has been stripped by PRS-3000 stripper, plasma ashing, or hardened photoresist stripping (MODs 11, 12, 14) on wafers with no metal layer on them.

Equipment: Sink 8 and Fluorocarbon, QDR and spin/dry (srdsink8) for wafers with no metal layer on them.

(1) Sink8 cleaning can be performed on wafers with no metal layer on them (non-MOS and MOS) that have gone through PRS-3000 photoresist stripping and/or plasma ash processes (photoresist removal). Sink 8 piranha bath is reserved specifically for cleaning resist residue that may have been left behind by the ash process.

Note: All wafers going into the furnace must be cleaned again in Sink 6 (pre-furnace clean), MOD 1.

(2) Be sure to use the cassettes and handles numbered for the appropriate sink. Do not mix cassettes and handles between sinks 6, 7 and 8 or other sinks.

Detailed Procedure:

Please refer to sink8 operation manual.

MOD 14
Photoresist Stripping of Hardened Resist

Purpose: To remove hardened photoresist on wafer after high energy implant or plasma etch.

Note: Photoresist can normally be removed using plasma ashing (MOD 12). Only in cases of abnormally high implant doses or harsh plasma etches does the resist become hard enough to warrant this treatment.

Equipment: The ultrasonic bath and the sink432C (Chem Room).

Resist Strippers: The lab currently has the following standard resist stripper available: PRS-3000 (J.T. Baker). Processing parameters are detailed in Table 1.

Note: Any resist stripping should be done under an operational fume hood and protective clothing should be worn at all times.

Summary:

(1) Heat up two 1000 ml beakers filled with resist stripper to desired temperature (65ºC max.) in the ultrasonic bath (be sure to fill bath with water).

(2) Immerse wafer in first beaker for 5 minutes. Transfer to second beaker and immerse for 5 minutes.

(3) Rinse thoroughly in DI water.

(4) Do MOD 12 plasma ashing of photoresist in technics-c or matrix asher, if necessary.

(5) Do MOD 13 wafer cleaning procedure after resist removal on wafers with no metal layer on them.

Detailed Procedure:

(1) Turn on the temperature controller to the ultrasonic bath, which is at the left of sink432C to your desired temperature (Max. 65ºC).

(2) Check that the temperature setting is correct. It will take 30-60 minutes to stabilize at this temperature.

(3) Transfer your wafer to a single white Teflon® wafer holder.

(4) Turn on the ultrasonic agitation and immerse holder and wafer in the first beaker for 5 minutes when the temperature is stabilized. Transfer the wafer to the second beaker and immerse for 5 minutes. The first bath should remove the bulk of the resist, while the second bath cleans up any remaining traces of photoresist.

(5) Remove the wafer from the bath. Inspect your wafers visually for resist residue. Repeat step 4 if necessary.

(6) Rinse wafer thoroughly with flowing DI water.

(7) Turn off temperature controller if you do not expect anyone to use it within the next hour.

(8) Do MOD 12 Plasma Ashing of Photoresist in technics-c or matrix asher, if necessary.

(9) Do MOD 13 wafer cleaning procedure after resist removal only for those wafers which do not have any metal layers on them (skip piranha clean on wafers with metal layers on them).

Disposal:

Please Note PRS-3000 can be used many times over, however, once ready for disposal, you should pour it in a marked plastic bottle, logged in as PRS-3000 in the chemical disposal cabinet in the old lab for pick up. Please do not aspirate this chemical.

Table 1 - Resist Strippers

Stripper	Substrates	Bath Temp Type	Agitation	DI water Rinse
PRS-3000	All	Positive	25-65ºC	Yes
Microposit 1165	All	Positive	25-80ºC (Max.)	

Note1: PRS-3000 is the standard photoresist stripper currently available in sink5.

Note2: Required temperature will depend on previous resist processing conditions. Very **hard** resist will require the higher temperatures for successful removal. Please ask process engineering staff for permission, and do not exceed flash point temperature of the stripper (refer to MSDS spec sheets in the lobby).

MOD 15

Standard Wet Oxide Etching

Purpose: To etch oxide films in buffered oxide etch

Equipment: Wet process stations or fume hood

Summary:

(1) Being sure any photoresist on wafers has been hard baked, wet wafers in DI H2O to prevent bubbles sticking to film surface.

(2) Dip wafers in buffered HF (BHF) for required amount of time.

(3) Rinse/dry wafers per MOD 2.

Detailed Procedure:

(1) Wet wafers in DI H2O in tank 1 or 4.

(2) Immerse wafers in buffered HF for required amount of time based on etch rate (see below).

Etch rates (approximate/when the solution is fresh):

BHF 10/1 ~500 A/minute
BHF 5/1 ~1000 A/minute

(3) Follow with rinse/spin (MOD 2).

MOD 16

Plasma Etching in Technics-C

Purpose: Plasma etching of nitride and oxide films

Equipment: Technics-C

Note: The lam1 plasma etcher is the system dedicated to nitride etching and Lam2 is dedicated to oxide etch. Prefer to use these two systems for clean standard processes, which provide better uniformity in etching.

Summary:

(1) Carry out an O2 scourge to clean chamber.

(2) Vent the system and place wafers in chamber.

(3) Pump system down to base pressure (~35 mTorr).

(4) Introduce desired gases into chamber.

(5) Strike plasma by turning on power to desired wattage and time.

(6) Turn off power and gas.

(7) Pump down chamber to remove reacted gases.

(8) Vent chamber and remove samples.

Detailed Procedure:

(1) The status of the machine should be as follows:

Mode:	Manual
SOL'N (Solenoid):	Closed
Vent: Off	
Power:	Toggle Off, Knob Pegged Counterclockwise
Gas #1:	Off
Gas #2:	Off

Occasionally, the solenoid , which controls the vacuum pump, is left open. If this is the case, close it before enabling the system.

(2) Carry out an O2 scourge to clean the system with O2 at 300 Watts for 10 minutes, following the outline given below for system operation (from Step (4)).

(3) Once you are ready to introduce the samples, vent the chamber by toggling the VENT switch. Be sure that the SOL'N is closed when you do this. It will take about 15 seconds for the chamber to fill. Once it is at atmospheric pressure, open it carefully -- the top is very heavy -- and place your wafers on the plate. Close the top carefully, being sure not to allow it to fall.

(4) Oxygen for photoresist descum/ashing and cleaning the system (scourge) is connected through Gas #1. The Gas #1 switch will flow (1) SF6; (2) He; and (3) O2. Check correction factors on the PD module and set points for the particular gas you are going to use.

(5) You are now ready to start the vacuum pump. Leaving the vent ON, toggle the solenoid (vacuum pump) switch open. After 2 or 3 seconds, close the vent switch to allow the pump to lower the pressure of the chamber.

(6) You can watch the pressure drop as the system comes under vacuum. When the system reaches base pressure, introduce the gases you need into the chamber by toggling the appropriate gas switches on the PD and PE modules. The pressure in the chamber will rise as gas flows in, and then stabilize. (See below for specific recipes for nitride and oxide etching.)

(7) Once gas flow into the chamber is stable and at the desired pressure strike a plasma by switching the POWER toggle on and turning the dial clockwise until desired wattage is reached. The plasma is visible through the window on the front of the chamber. Begin timing your run as required based on etch rate.

(8) Once the run is complete, turn off the power, then the gas. Always turn off the power before turning off the gas.

(9) Allow the chamber to pump down to base pressure to be sure all potentially harmful gases have been swept out of the chamber.

(10) Turn off the vacuum pump by switching the SOL'N toggle to closed position. Now you may vent the chamber. Again, remember not to vent the chamber until the SOL'N has been closed.

(11) The chamber will now come up to atmosphere and you may remove your sample.

(12) Once your sample has been removed, close the chamber and start the vacuum with the vent open. After a couple of seconds, close the vent and allow the chamber to pump down to base pressure mtorr. Close the SOL'N. Be sure that gas switches and power are off.

(13) Carry out an O2 scourge to leave the system clean. Use O_2 at 300 Watts for 15 minutes, following the outline given in steps (5) through (12).

A. Nitride Etch

Set Points:	SF6 - 13.0
	He - 21.0
Power:	100 Watts
Nitride Etch Rate:	~500 A/minute
Oxide Etch Rate:	~250 A/minute
Silicon Etch Rate:	~8000 A/min

Beware: This process etches single crystal silicon at about 8000 A/min!

It is suggested that you conservatively approximate the time you will need to etch through your nitride film, run your sample for half the total time, open the chamber and rotate your wafers around their central axes by 180 degrees, and then etch again. This provides better uniformity in etching.

MOD 17
Standard Furnace Cleaning

Purpose: To remove heavy metal ions from the furnace tube

Equipment: Tylan furnaces

Summary:

(1) Run STCA recipe: Standard TCA clean. The recipe has the following steps:

a) a) Ramp up to 1100ºC.

b) b) Oxygen flow: 2 minutes ($0_2 = 4$, $N_2 = 0$)

c) c) TCA clean: 5 minutes (TCA = on, $0_2 = 2.0$) 60 cycles of (b) and (c).

Note: The TCA flow rate can not be specified in the recipe.

1. Post-ox: 5 minutes ($0_2 = 4$, TCA = off)
2. Ramp down to 750ºC. This process takes about 8 hours.(The sixty cycles, loop alone, is seven hours.)

(2) Run MAIN recipe: Temperature calibration in 50 steps from 750ººC to 1100C, plus standard TCA clean. The recipe has the following steps:

(a) (a) Temperature calibration up to 1100ºC.

(b) (b) Oxygen flow: 2 minutes (0_2 = 4, N_2 = 0)

(c) (c) TCA clean: 5 minutes (0_2 = 4.0, TCA = ON)

(d) (d) 60 cycles of (b) and (c).

(e) (e) Ramp down to 750ºC. This process takes about 10 hours.

Note: This calibration recipe has a tolerance of three degrees as opposed to the two degrees that the standard calibration recipe "SCAL" has. The "MAIN" program has this quick calibration that should only be used in case of a problem with the temperature is suspected. Normally, the "STCA" recipe should be chosen for cleaning.

Detailed Procedure:

(1) Put the Standard Recipes floppy disc in the disc drive.

(2) Load STCA or MAINtenance (if needed) program into required tube.

(3) When the computer asks for delay time, type in requested time such that the process ends around 8AM, or at the time you are starting your run in the morning.

(4) If the loading is completed, a GOOD LOAD response will appear on the screen.

(5) Go to the tube and press RUN on the ROP (remote operation panel), or type RUN tube#.

(6) After the cleaning is done, the alarm will sound. Press the ALARM ACK button on the ROP.

(7) For best results, use tube soon after cleaning.

Notes:

1. These programs can only be aborted in an oxygen flow step.
2. The TCA clean cannot be run in two adjacent tubes at the same time!
3. It is preferable to run a TCA clean during the night, so the temperature will not interfere with other processes.

MOD 18

Lift-Off Process

***Purpose*:**

Lift-off is a process that enables the patterning of a thin layer metal film. It begins with the patterning of a thin layer(s) material, typically photoresist, followed by a directional metal deposition, usually via evaporation. After the metal has been deposited, the initial patterned layer is dissolved in solvent leaving behind a patterned metal film. It is critical that step coverage does not occur during the deposition of the metal. Step coverage disallows a clean “lift-off.” The process recipes described hereafter are specifically designed to achieve a sacrificial layer profile that disallows metal step coverage. This enables the likelihood of success for the final lift-off step.

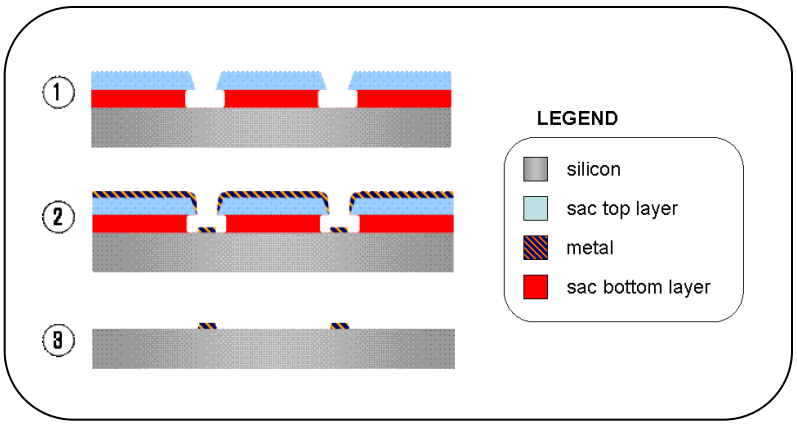


Figure 18.1 - Basic Lift-Off Process Flow

(1) Sacrificial layer is patterned. Note profile disallows metal step coverage.

(2) Metal deposition, and

(3) Lift-off in solvent. Metal pattern remains.

I. G & I-Line Bi-Layer Method

This bi -layer method is a simple yet effective way to achieve a good undercut profile that disallows step coverage. The process uses standard resists, stocked by the Microlab. Automated spincoat and development tracks with standard recipes can also facilitate processing.

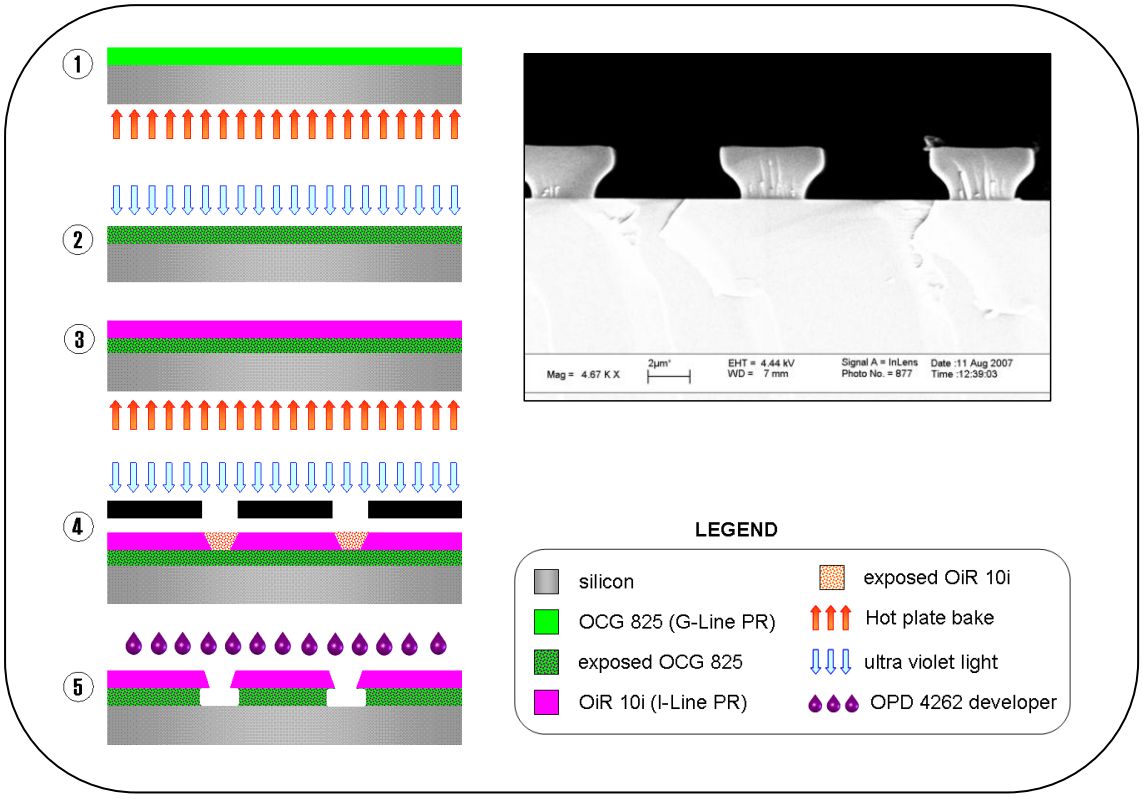


Figure 18.2 - G-line I-line Bilayer Method Process Flow

The acquired cross- sectional profile is shown in SEM image.

Equipment:

Primeoven, Svgcoat1 or 2, Ksaligner, Svgdev,

Procedure:

1. HMDS prime wafer at Primeoven. Spincoat (svgcoat2) 1.3 micron G-line resist (5000 RPM). Soft bake hot plate 60 sec at 90ºC. Chill plate 6 sec.
2. Flood expose (ksalinger) 0.14 joule/cm^2 (non-critical, use clear field dummy mask).
3. Spincoat (svgcoat2) 1.1 micron I-line resist (4100 RPM). Soft bake hot plate 60 sec at 90ºC. Chill plate 6 sec.
4. Expose (ksaligner - soft contact mode). The optimal dose for a 5-inch chrome mask with a clear field pattern area between 5% and 10% is 0.06 joule/cm^2.
5. I-line develop. Although the automated track developer may also be used for this step, a timed tank develop allows for more precise undercut. The track develop will not necessarily yield optimal results for all applications. Optional: hotplate hardbake - 60 sec at 90ºC (see notes below).
6. Deposit metal. Keep substrate temp as low as possible so as to prevent profile degradation.
7. Lift-off in acetone.

Notes:

a. The exposure dose in STEP 4 is critical. Overexposing or underexposing the resist will ultimately effect the profile of the bilayer undercut.

b. The amount of undercut may be controlled with more precision by performing a timed tank develop.

c. GCAWS may be used with this method. Perform a focus exposure test, and a series of timed tank develops to determine the optimal exposure and develop time.

d. Depending on the feature size, an aggressive hardbake can cause critical dimension disruption due to rapid solvent release. If necessary, perform a low temp hardbake. If at all possible though eliminate the hardbake step altogether. This helps to ensure critical dimension integrity and makes the acetone liftoff step easier.

e. The amount of undercut can usually be observed with optical microscope inspection. For smaller features, a mask with a test structure array of incremental lines and spaces works well - the obliterated (100% undercut) lines vs. standing lines help pin-point the amount of undercut.

II. AZ5214

AZ5214 E is a positive resist that has the capacity for image reversal. The image reversal component is used to obtain a negative profile that prevents step coverage during metal deposition. A negative mask pattern must be used with this method.

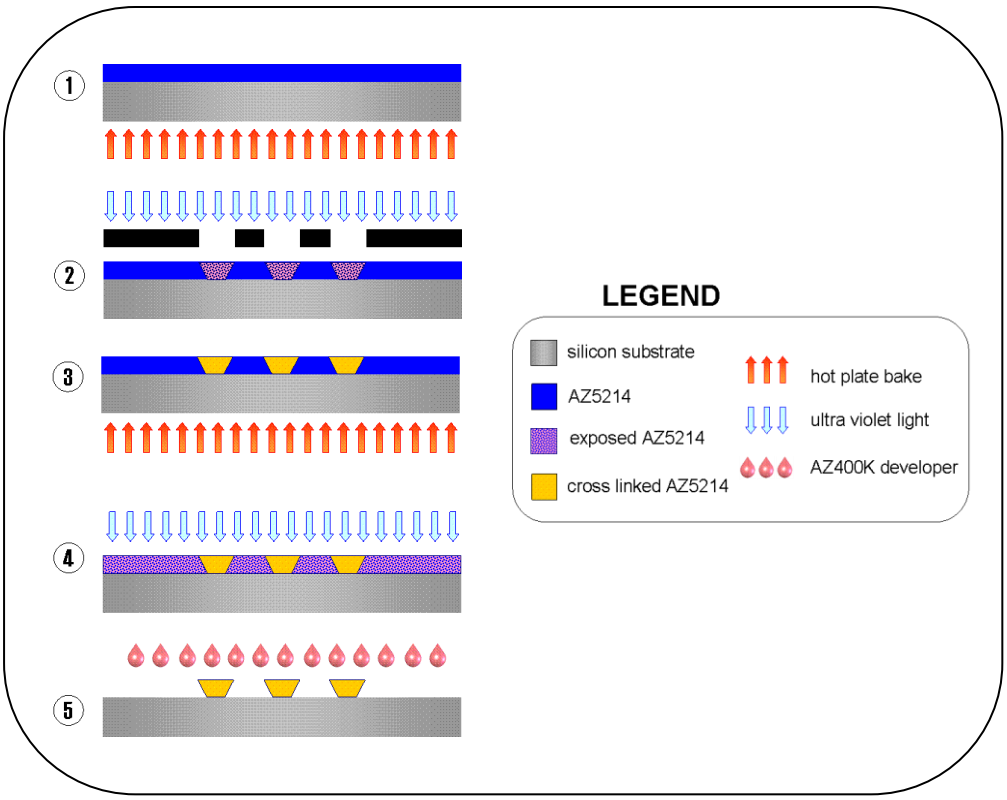


Figure 18.3 - AZ5214 Single Layer Method Process Flow

Equipment: Primeoven, Spinner1, Sink4 or 5, Ksaligner

Procedure:

1. Spincoat (spinner1) 1.5 micron AZ5214 resist (4000 RPM). Soft bake hot plate 90 sec at 90ºC.
2. Expose (ksaligner) 0.08 joule/cm^2.
3. Image reversal bake: hot plate 2 min at 120ºC. This step is the most critical of the process.
4. Flood expose (ksaligner) 0.2 joule/cm^2.
5. Tank develop. AZ400K:H20 1:5 ratio; 30 sec.
6. Deposit metal. Keep substrate temp as low as possible so as to prevent profile degradation.
7. Lift-off in acetone.

Notes:

a. Negative resist will provide the same type profile, but can be more difficult to remove during the liftoff step. AZ5214 is a positive resist, and thus better suited for lift-off.

b. Double layer thickness of AZ5214 may be spun for thicker metal film deposition. Adjust bakes and exposure times accordingly.

c. AZ5214 may also be used as a normal positive resist.

III. LOR10B

LOR10B is a spin-on coating underlayer that selectively undercuts for lift-off. Here it is processed with Shipley 1818 resist.

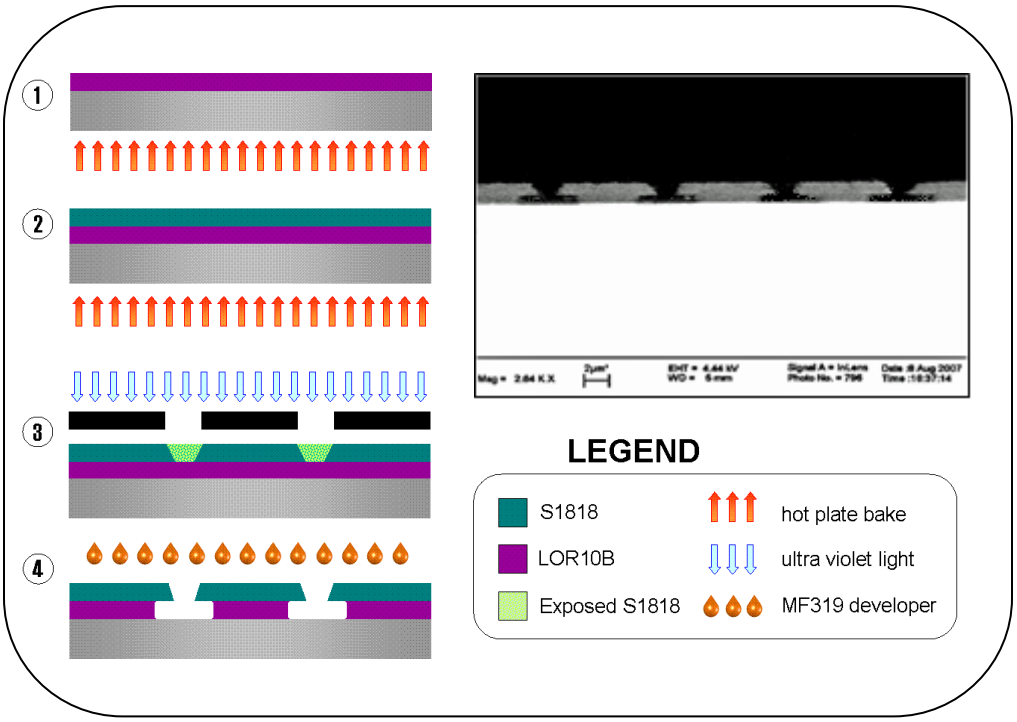


Figure 18.4 - LOR10B Process Flow

SEM cross-sectional result is shown.

Equipment: Primeoven, Spinner1, Sink4 or 5, Ksaligner

Procedure:

a. Spincoat (spinner1) 1 micron LOR10B (3000 RPM). Soft bake hot plate 5 min at 150ºC.
b. Spincoat (spinner1) 1.1 micron S1818 (4000 RPM). Soft bake hot plate 1 min at 120ºC.
c. Expose (ksaligner – soft contact mode) 0.04 joule/cm^2.
d. Tank develop MF319 60 sec.
e. Deposit metal. Keep substrate temp as low as possible so as to prevent profile degradation.
f. Lift-off in acetone.

Spray Gun Manual for Enhanced Liftoff

MOD 19

Spin-On SiO_2 Glass (SOG) for Inter-Metal Dielectric

Purpose: To provide inter-metal dielectric for double metallization.

Equipment: Headway spinner, convection bake oven, and Tystar 4.

Summary:

(1) After defining the Al pattern (0.6Mm thick), bake wafers at 120ºC for thirty minutes.

(2) Coat wafer with SOG.

(3) Bake the wafers for one hour total time.

(4) Anneal the wafers per MOD 18, using recipe SOGN2 or SOGO2.

Detailed Procedure:

(1) Wafer Preparation: Dry the wafer in convection oven at 120ºC for 30 minutes. (MOD 4)

(2) SOG Coating:

(a) Enable spinner1

(b) Place wafer on the Headway spinner.

(d) Adjust speed to 3000 rpm.

(d) Set spinning time to 20 seconds.

(e) Use a dropper to dispense 3 cc of Futurex IC1-200 SiO_2 SOG on the wafer. Start spinning.

(3) Baking:

(a) Place wafer in 120ºC oven for 30 minutes. (MOD 8)

(b) Increase temperature of oven to 200ºC and bake wafer for an additional 30 minutes.

(4) Annealing: Anneal wafer in Tystar 4 using either SOGN2 or SOGO2 program (400ºC for 30 minutes.) (MOD 18)

MOD 20

Standard Wet Nitride Etching

Purpose: To etch nitride films in hot phosphoric acid

Equipment: Sink 7

Summary:

(1) Remove all photoresist.

(2) Dip wafers in oxide etch to remove any oxide from nitride film. The presence of even a very thin layer of oxide will prevent the acid from etching the nitride.

(3) Wet wafers in DI water to prevent bubbles sticking to film surface.

(4) Dip wafers in hot phosphoric acid for required amount of time.

(5) Rinse/dry wafers per MOD 2.

Detailed Procedure:

(1) Etch oxide from nitride by dipping in 10:1 HF for approximately 1 minute.

(2) Turn on hot phosphoric acid bath (right heated bath of sink7) by pushing the green TEMP CONTROL button on the right half of the sink. Set the controller to the desired temperature (the standard is 150ºC). Wait for temperature to stabilize. Acid will reach a rolling boil.

(3) Immerse wafers in hot phosphoric acid. The time required to etch the film will vary because small amounts of water are added to the bath as the level goes down, thus diluting the acid. For a 1000 A film, check the wafers after an hour. You should be able to tell visually when the film has been etched away.

(4) Follow with rinse/spin (MOD 2).

MOD 21

Wet Etching Single-Crystal Silicon

Purpose: To anisotropically wet etch single crystal silicon.

Equipment:

For EDP etchant: Sink 3, reflux system, left side.

For KOH etchant: Sink 3, pyrex beaker, right side.

Special Note:

Do not use wax at sink3 since it may contaminate other user's processes. The use of wax should be done elsewhere in the lab. Also, make sure all wax contaminated cassettes are completely separated from sink3 cassettes.

Summary:

(1) Clean the work area (this will take 30 minutes to 1 hour for the reflux system).

(2) Mix etchant (recipes in Chapter 1.10).

(3) Calculate etch time based on etch rate for the specific etchant.

(4) Etch silicon as required.

(5) Rinse/dry wafers per MOD 2(sink3). Clean work area.

Detailed Procedure:

A. EDP ETCHANT

Etch recipes and pertinent information are given in Chapter 1.10.

****** EDP IS DANGEROUS!!!**
IT IS IMPERATIVE THAT YOU WEAR
****** GREEN GLOVES, APRON, FACE SHIELD, AND A RESPIRATOR.**
****** A RESPIRATOR FITTING SHOULD BE SCHEDULED THROUGH EH&S**
****** RESPIRATORY PROTECTION AT 642-3073.**
ALL OF THIS SAFETY
****** EQUIPMENT SHOULD BE WORN AT ALL TIMES**
WHEN HANDLING THE
****** EDP APPARATUS WHICH INCLUDES CLEANING, WEIGHING AND**
****** AND ADDING CHEMICALS, ADDING WAFERS, ETC.**

(1) EDP does not etch silicon dioxide. Therefore, be sure to HF dip your wafer to remove native oxide from the silicon surface to be etched before proceeding. A 10 second 10:1 HF dip should be sufficient. Either silicon dioxide or silicon nitride is an acceptable masking material.

(2) Make sure the reflux system is clean. The top of the ring on the tank and the watchglass must be clean and dry when you begin to prevent noxious vapors from escaping into the room. Check the watch glass cover and the top ring of the tank for white crystalline material. If you find any, clean it off with plenty of DI water and techni-cloths. An RCA clean (Chapter 2.1 of the lab manual) of the tank is recommended prior to use.

(3) If you do not wish to carry out an RCA clean, proceed as follows to ensure that the tank is at least nominally clean before proceeding with your etch.

(4) Fill the reflux tank with DI water, and let it sit for 30 minutes to 1 hour to dissolve any chemical residues in the tank.

(5) Aspirate the water, which may be very discolored. Rinse the interior of the tank with DI water and aspirate, several times, until you are satisfied that the tank is clean.

(6) Before preparing the etchant, note that the amounts of chemical listed in the recipes of Chapter 1.10 are enough to cover 2" wafer cassettes. All volumes/weights must be doubled for use with 4" wafers! Also, see the reference listed at the end of this manual for further information. Obtain ethylenediamine, pyrazine and pyrocatechol from the Microlab office. There is a portable, battery operated scale in GL2 upon which the solid chemicals except pyrazine can be weighed. This should be done inside sink3. Plastic weighing boats are provided in the C-locker next to the sink and more can be found in the old lab. Remove the scale from the sink when you are finished using it. The pyrazine should be weighed in the enclosed scale across from sink3. The reagents are mixed in the following order:

   (a) Weigh pyrocatechol and place in the reflux tank.

   (b) Weigh pyrazine (if necessary - not all recipes call for it) and add it to the tank. Cover the tank with the watchglass - pyrazine is very volatile.

   (c) Add the required amount of DI water.

   (d) Add the required amount of ethylenediamine.

   A commonly used recipe in the Microlab is the 'F' etch with 6 g of pyrazine, which is:

   320 g pyrocatechol
   6 g pyrazine
   320 ml DI water
   1000 ml Ethylenediamine
   at 110ºC

   This leads to an approximate etch rate of 55 um/hr.

(7) Turn on the heater by pressing the left side Temp. Control button, and set it to the desired temperature. Wait 30 min for the bath temperature to stabilize.

(8) Place the wafers to be etched in the cassettes or holders provided in the tray labeled EDP located on the table in the center of GL2. EDP cassettes are readily identified because they are discolored. **DO NOT USE THE KOH CASSETTES IN THE EDP TANK**.

(9) Keep a pile of techni-cloths near to the sink so that after inserting or removing wafers from the tank and rinsing off your gloves in the glove wash, you can dry your gloves to reduce the possibility of getting EDP on your skin. Using the glass rod hook, carefully lower the cassette with wafers into the reflux tank. Start timing the etch.

(10) When the etch is complete, lift the cassette, using the glass rod, and allow the etchant to drip off the wafers and cassette. If any etchant drips on the wet process station surface, rinse it off immediately with copious amounts of water, as EDP stains the plastic. Place the cassette in the rinse tank filled with 1 cm of DI water. The water prevents EDP from collecting in the bottom

of the rinse tank. Allow the wafers to cool slightly, to prevent the wafer (and membranes, where applicable) from suffering temperature shock and possible breakage.

(11) Once the wafers have cooled, fill the rinse tank and proceed with the rinse cycle. If you notice a white precipitate on your wafers, this indicates that the solution has been depleted. Making a new batch of EDP should be considered.

(12) If you are not going to use the etchant again within 24 hours, shut off the temperature controller, aspirate the etchant and fill the tank with DI water. Allow the water to sit in the tank for 30 minutes at@ 80ºC. Then turn off the temperature controller, aspirate the water and disable the sink. Wipe off the outside of the tank using damp techni-cloths to remove any residue and dry using dry techni-cloths.

B. KOH ETCHANT

Etch recipes and pertinent information are given in Chapter 1.10. KOH etches silicon dioxide, so it is not a suitable masking material for long etches. Silicon nitride is the preferred masking material.

(1) Rinse the beaker thoroughly and aspirate to make sure it is clean before processing. Always take care not to spray water outside of the beaker since it may ruin the hot plate. Also, make certain that the spin bar and Teflon® bottom screen are inside of the beaker.

(2) With the cassette out of the beaker, add 2 liters of DI water by looking at the 2 liter mark on the beaker. For Critical runs, the DI water may be measured using the graduated cylinder located near the sink.

(3) Turn on the spinner, which is accomplished by pressing the right Megason button, and adjusting the speed using the knob under the heat lamp timer. Typically, the speed is set to 6. If the speed is too high, the spin bar will move away from the center of the beaker and stop. This can be fixed by turning the speed knob to zero, allowing the spin bar to return to the center, and then slowly increasing the speed to the appropriate setting.

(4) Add 1 kg of KOH by simply adding the contents of two 500 mg bottles of KOH (or one 1 kg bottle, if available). For critical runs, the KOH should be weighed on the portable balance inside the sink. Also, other ratios of KOH to water produce different results so see the reference at the end of this manual for more information.

(5) Turn on the hot plate by pressing the right Temp Control button. Typically, the hot plate should be set to 80 deg. The KOH will temperature stabilize at 80 deg between 30 minutes to 1 hour. During the temperature stabilization phase, a visible interface may form between the hot and cold (KOH and water) liquids. Using the cassette handle as a stirrer, this interface may be broken allowing the mixture to temperature stabilize faster.

(6) Load the wafers to be etched in the cassette and place in the beaker. Take care when removing the lid since the KOH solution condenses on it, so tap it a few times to shake off most of the drops and place on a techni-cloth. For critical runs, the cassette can be left in the beaker during the temperature stabilization period, lifted out of the KOH solution so that the wafers can be loaded, and then dropped back into the solution.

(7) Replace the lid and start timing the etch. For critical runs, since the etch rate of KOH is extremely temperature sensitive (a factor of 2 to 3 times for every 10 degrees), the wafer can be rotated half way through the etch. This time can be approximated by assuming that the etch rate of silicon is approximately 1 um/min using the suggested temperature and KOH to water ratio.

(8) Once the etch has been completed, carefully remove the lid and remove the cassette. Let the wafers cool briefly before rinsing by partially dipping the wafers in the rinse tank to avoid breaking membranes. Initiate the rinse cycle.

(9) If you are finished etching, shut off the heater by pressing the Temp. Control button and stop the spinner by pressing the Megason button. Aspirate the KOH, and rinse the tank with DI water and aspirate three times. Disassemble the beaker and plastic collar, wipe down using damp techni-cloths and dry using dry techni-cloths. Disable the sink.

For more information of anisotropic etching a good reference is:

H. Seidel, L. Csepregi, A. Heuberger, and H. Baumgartel, "Anisotropic etching of crystalline silicon in alkaline solutions, I. Orientation dependence and behavior of passivation layers, " J. Electrochem. Soc., vol. 137, no. 11, pp. 3612-3626, Nov. 1990. and

H. Seidel, L. Csepregi, A. Heuberger, and H. Baumgartel, "Anisotropic etching of crystalline silicon in alkaline solutions, II. Influence of dopants, " J. Electrochem. Soc., vol. 137, no. 11, pp. 3626-3632, Nov. 1990.

MOD 22

Plasma Etching of Trenches in Single-Crystal Silicon

Purpose: To etch deep trenches in single crystal silicon using plasma.

Note: This is to etch trenches in single crystal Si, deeper than 3 Mm; when no photoresist mask can be used. For trenches that are less than 3 Mm deep, use the standard procedure for Poly-Si etch in lam4 (Chapter 7.4).

Equipment: lam4

Summary:

(1) Mask your sample with oxide.

(2) Program the recipe into the lam (see Chapter 7.4 for details).

(3) Etch the desired length of time.

Detailed Procedure: See lab manual Chapter 7.4 for lam4 operating procedures.

(1) Deposit the required thickness of oxide onto the wafers. The etch selectivity of Si to oxide, using recipe #400 in lam4 (given here), is 20:1.

(2) Coat the wafers with photoresist, expose with the desired mask and hard bake at 120ºC for thirty minutes before the oxide etch.

(3) Etch the oxide in lam2. See Chapter 7.2 for lam2 operating procedures.

(4) Strip the remaining photoresist, after the oxide etch, using standard procedures (MOD 10).

(5) Load the polysilicon etch recipe #400 into lam4.

(6) Delete the overetch step by copying steps seven to six, eight to seven, and nine to eight.

(7) Change the following parameters on the corresponding recipe steps:

RF Top W: 300 (in step 5)

He lamp t: 0 (in all steps)

Time: 60 seconds (in the new step 6)

(8) In step #5, change the "completion" parameter from [TIME & ENDPOINT] to [TIME], by moving the cursor to completion with the arrow keys and entering 1 from the available options.

(9) Program in the desired amount of time based on an etch rate of approximately 6700 A/minute.

(10) The final recipe should look like this:

Single Crystal Silicon Trench Etch					
Parameter	**#01**	**#02**	**#03**	**#04**	**#05**
PRESSURE (mT)	400	400	425	425	400
RF TOP (W)	0	200	0	300	0
GAP (cm)	1.00	1.00	0.80	0.80	1.00
Cl2 (ccm)	0	0	180	180	0
O2 (ccm)	0	0	0	0	0
He (ccm)	0	0	400	400	400
HBr (ccm)	0	0	0	0	0
SF6 (ccm)	100	100	0	0	0
He clamp t	0	0	0	0	0
COMPL	STBL	TIME	STBL	TIME	TIME
TIME	60 sec.	7 sec.	30 sec.	ET sec.	60 sec.

(11) Program in the desired amount of time based on an etch rate of approximately 6700 A/minute.

(12) Run a test sample, patterned with some mask you are using, to check the etch rate.

Note: This procedure works fine for trenches up to 4.5 µm deep.

MOD 23

Plasma Etching of Thick PSG

Purpose: To etch thick films of PSG using plasma.

Equipment: lam2

Summary:

(1) Mask your sample with a double layer of photoresist, hard baking at 120ºC for at least 60 minutes before etching.

(2) Clean the lam chamber using the clean recipe, and one dummy wafer.

(3) Program the recipe into the lam (see Chapter 7.2 for details).

(4) Etch the desired length of time.

(5) Clean the lam chamber again using the clean recipe, and one dummy wafer.

Detailed Procedure:

See lab manual Chapter 7.2 for lam2 operating procedures.

(1) Coat your wafers with a double layer of photoresist (MOD 6), using program #4 on the svgcoat.

(2) Expose your wafer, using 1.5 times the standard exposure time.

(3) Hardbake the wafers at 120ºC for at least sixty minutes before etching (MOD 8)

(4) Load the CLEAN recipe into lam2 and run the recipe using a dummy wafer.

(5) Load the standard oxide etch recipe into lam2.

(6) The following should be the parameters in the etch step of the standard recipe:

Pressure: 2.8 Torr
RF Top: 850 Watts
Gap: 0.38 cm
He: 120 sccm
CHF3: 30 sccm
CF8 = 90 sccm
Etch Time: 01:00

(7) After each etch step, a cool down period is required to minimize resist burning and erosion. Program the step subsequent to each etch step as follows:

Pressure: 2.8 Torr
RF Top: 0 Watts
Gap: 0.38 cm
He: 120 sccm
CHF3: 30 sccm
CF4: 90 sccm
Time: 01:00

(8) Program in the required number of etch/rest cycles necessary to etch your film, based on an etch rate of approximately 6000 A/min (for densified PSG). It is recommended that you etch a test wafer for one minute, with the same pattern, to measure the etch rate for your own process.

(9) Following the final etch step, program the subsequent step as follows (to bring the gap to the nominal value of 1.35 cm):

Pressure: 0.0 Torr
RF Top: 0 Watts
Gap: 1.35 cm
He: 0 sccm
CHF3: 0 sccm
CF4: 0 sccm
Time: 00:10

The final recipe should look like this:

Thick PSG Etch					
Parameter	**#01**	**#02**	**#03**	**#04**	**#05**
PRESSURE (TORR)	2.8	2.8	2.8	2.8	0
RF TOP (W)	0	850	0	850	0
GAP (cm)	0.38	0.38	0.38	0.38	1.35
C2F6 (ccm)	0	0	0	0	0
O2 (ccm)	0	0	0	0	0

He (ccm)	120	120	120	120	120
CHF3 (ccm)	30	30	30	30	30
CF4 (ccm)	90	90	90	90	90
COMPL	stbl or time	time	time	time	time
MAX	30 sec.	60 sec.	60 sec.		10 sec.

Thick PSG Etch					
Parameter	**#01**	**#02**	**#03**	**#04**	**#05**
PRESSURE (TORR)	2.8	2.8	2.8	2.8	0
RF TOP (W)	0	850	0	850	0
GAP (cm)	0.38	0.38	0.38	0.38	1.35
C2F6 (ccm)	0	0	0	0	0
O2 (ccm)	0	0	0	0	0
He (ccm)	120	120	120	120	120
CHF3 (ccm)	30	30	30	30	30
CF4 (ccm)	90	90	90	90	90
COMPL	stbl or time	time	time	time	time
MAX	30 sec.	60 sec.	60 sec.		10 sec.

Notes:

(1) Steps 2 and 3 should be copied for as many times as necessary to etch your particular film.

(2) If you need to end point your process at the final step, set the "End Point Menu" accordingly. See Chapter 7.2 of the Microlab manual for details.

(10) Run the wafer.

MOD 24

Contact Etching

Purpose: To etch contact openings prior to metallization.

Equipment: lam2, sink8

Summary:

(1) Define the contact openings using standard photolithography processes. Be sure to descum and hard bake at least 30 minutes before etching.

(2) Measure the initial oxide thickness in the contact openings using the nanospec (you'll probably have to use the 100X lens for this measurement - see Chapter 8.33 for details). Add 2000A to this value to compensate for the extra oxide thickness over the polysilicon gate region.

(3) Clean the lam chamber using the clean recipe.

(4) Program the recipe into the lam (see Chapter 7.2 for details).

(5) Etch the desired length of time.

(6) Wet etch to remove remaining oxide.

(7) Clean the lam chamber using the clean recipe.

Detailed Procedure:

See lab manual Chapter 7.2 for lam2 operating procedures.

(1) Load the CLEAN recipe into lam2 and run it using one of the clean dummy wafers for lam2.

Note: DO NOT have the loading cassette ready when loading the recipe, if you are going to modify the recipe. The etch process will start as soon as the recipe is loaded, if the loading cassette is ready.

(2) Load the standard oxide etch recipe into lam2.

(3) Calculate the etch time required to etch through your film based on an average etch rate value of the last process monitor test posted on the lam2 comments. If your film thickness exceeds 1 Mm, see Error! Unknown switch argument. for instructions.

(4) Enter the calculated etch time into the L/S (low selectivity) etch step of the standard recipe:

Pressure: 2.8 Torr
RF Top: 850 Watts
Gap: 0.38 cm
He: 120 sccm
CHF : 30 sccm
CF 3= 90 sccm
Etch Time: Variable

(5) After the L/S etch step, a 50% H/S (high selectivity) overetch is required to guarantee that the contacts are clear. Program this etch step as follows:

Pressure: 3.0 Torr
RF Top: 700 Watts
Gap: 0.40 cm
He: 110 sccm
CHF : 35 sccm
CF : 30 sccm
Time: 50% Overetch

(6) Run the wafer.

(7) Measure remaining oxide thickness in contact openings. It should be less than 200A. If it is more, plasma etch again for time required to clear remaining oxide. The color in the contact area will be highly reflective (white) if you've cleared the oxide. Other colors indicate the presence of oxide or other films.

(8) Without removing the photoresist, wet etch the wafers in 5:1 BOE (sink8) until contact openings enlarge to within 1Mm of the edge.

MOD 25

"Show" Wafer Process

Purpose: To make 4-inch or 6-inch "show wafers" for special occasions.

Equipment: sink6, tystar2, 3, or 4, primeoven, svgcoat6, svgcoat1 or 2, ksaligner, svgdev, svgdev6, oven-vwr, sink8, sink5, matrix, technics-c, cpa

Summary:

4" wafers:

(1) Grow thermal oxide on bare Si wafer.

(2) Make a transparency to use as a mask.

(3) Prime wafers in primeoven.

(4) Spin coat wafers with 1 - 2 microns photoresist using standard coat programs at svgcoat1 or svgcoat2.

(5) Expose wafers at the ksaligner.

(6) Do a post-exposure bake on the svgdev.

(7) Develop wafers on the svgdev.

(8) HF etch in sink8.

(9) Strip off photoresist.

6" Wafers:

(1) Grow thermal oxide on bare Si wafer.

(2) Make a transparency to use as a mask.

(3) Prime and spin coat wafers with 12000A I-line resist on the svgcoat6.

(4) Expose wafers at the ksaligner.

(5) At svgdev6, do a post-exposure bake and develop the wafers.

(6) HF etch in sink8.

(7) Strip off photoresist.

Detailed Procedure:

(1) Decide what color you would like for the background. Royal blue is nice and you can use the 1000 A oxide wafers as the substrate. Purple is also nice-this can be done with ~5000A of thermal oxide. You can check the oxide color chart in the Tylan notebook (VLSI area) for other color/thickness ideas.

(2) Perform a standard pre-furnace clean of the wafers (MOD 1)

(3) Grow thermal oxide on the bare silicon wafers in one of the tystar wet oxidation furnaces (tystar2, 3, or 4). Use a wet oxidation recipe, as it is quicker. To find time required for desired oxide thickness, see an oxide growth chart (in Tylan notebook, VLSI area) or use an oxide growth calculation program (several are available through the internet).

(4) Use computer software such as Word, Powerpoint, or Photoshop to create a document with the desired words and/or images. If possible, images should be converted to black-and-white. Half-tone conversion is best if available, but good results have also been obtained with grayscale.

(5) Print the document onto a transparency, which will be used as a mask. For this standard process module, with positive resist over dark blue 1000A oxide on lighter silver-gray silicon, your transparency should be a positive mask, not a negative one. You can use a laser printer to print directly on the transparency, but be sure that the printer and transparency are compatible or the transparency could melt. An inkjet printer has also been used successfully.

(6) Dehydrate and prime the wafers. For 4" wafers, use primeoven. 6" wafers are primed as part of the svgcoat6 track.

(7) Coat 4" wafers with G-line resist (OCG 825, program #2, svgcoat1 or 2). 6" wafers on svgcoat6 can be primed and then coated with 12000A I-line (OiR 897 10i, program #3). Include a 90 C soft bake after coating.

(8) Obtain two clear glass mask plates larger than the wafer size. (The idea is that you will create a "sandwich," with the transparency resting directly on top of the coated wafer and with both these two in between the two glass mask plates, in other words: plate--wafer--transparency--plate.)

(9) Cut the transparency to fit the mask plate, and tape it tightly to the top plate at the corners. The transparency should be affixed such that it will not print backwards on the wafer.

(10) At the ksaligner, install the mask holder frame appropriate to the mask plate size you are using. Leave a dummy mask in the ksaligner mask frame, so that it doesn't get vacuum errors. Do **not** load your masks in the frame, and do **not** load any wafers into the ksaligner.

(11) Take the mask plate which does not have the transparency affixed, and place it carefully into the recessed area on top of the mask frame. The vacuum leaking from below will probably hold the plate somewhat firmly to the frame, this is normal.

(12) Place a resist-coated wafer on top of this plate.

(13) Place the mask with the transparency on top of the wafer, transparency side down.

(14) Center the mask plate over the wafer so that the image and/or text is centered over the wafer (make sure that the transparency side is in contact with the wafer). Be careful not to scratch the resist while centering the transparency, try to keep it lifted it a bit while moving it.

(15) Before exposing, take a moment to make absolutely certain that there is enough clearance for the exposure assembly to slide out without hitting anything on the mask frame. If it crashes, it could damage the ksaligner.

(16)

(17) Take note of the seconds on a watch or clock, and press the button "lamp test". This causes the exposure assembly to slide out and flood the mask frame with UV light, but without moving the wafer chuck.

(18) Exposure should be about 10-20 seconds. The ksaligner does not run the timer during a lamp test, so you will need to count the seconds yourself with a watch or wall clock. If you are printing a grayscale image, you may need to do a test to find the optimal exposure time for bringing out the grayscale.

(19) Press "lamp test" again to stop UV exposure. The exposure assembly will slide back in.

(20) Do a post-exposure bake and then develop. For 4" wafers use the svgdev, for 6" wafers use svgdev6.

(21) Optional: Hard bake the wafers in a 120ºC oven (oven-vwr in Y2) for 30 minutes.

(22) Etch the wafers in the buffered HF bath at sink8, until the solution readily beads off of any areas not coated with resist (about a minute or less). Rinse in QDR, and dry in spindryer.

(23) Strip the photoresist in sink5 PRS-3000, matrix, or technics-c (MOD 13). Voilà! You now have a beautiful work of art!

Optional: This process can be modified for other films, for example 1000A – 2000A Aluminum sputtered on top of 1000A oxide in cpa can be etched in aluminum wet etch at sink8 without attacking the oxide, yielding bright white-silver positive areas on dark blue negative areas (this requires a negative mask if any images are present.)

MOD 26

LAM Monitors

General Operation and & Procedures

Measurements:

- Measure in following positions: T(1,4); C(4,4): F(8.4); L(4,1); R(8,1). (Pick position in the die closest to the center of wafer.)
- Measure in the same spot before and after etching.

Calculations:

- For Lams 1, 2 and 4:

  Etch Rate: (PreEtch - PostEtch) / 0.5 A/min

  For Lam3:

  Etch rate = Step Height / 0.5
- %Unif: (Max - Min) / (Max - Min)

PC Screen resetting on Lam 1 and 2:

- **ctrl-alt-delete** (may need to do it twice)
- **F1**
- password: **lam1-pc**

  Y → **enter**

  choose Lam1 in small window → **enter**
- esc (proper screen should appear)
-

Purpose: Nitride etch Monitor Test

Equipment: LAM 1

Time of Execution: 30 seconds per wafer

Detailed Procedure:

(1) Measure nitride thickness on Nanospec, Program#6, Lens:10X, Tox:1000A

(2) On PC key board hit

- ctrl-esc → choose Lam1 → **esc**

(3) Load: O2clean.RCP (program4) and load 1 bare Si wafer. → Press **START**.

(4) Load NITSTN1.RCP (recipe #3) and edit as follows:

NITSTN1.RCP (recipe #3)		
Recipe	**Step #1**	**Step #2**
PRESSURE	375	375
RD POWER (W)	0	150
GAP	1.35	1.35
He (sccn)		50
SF6 (sccm)	175	175
TIME	20 sec.	30 sec.
COMPL	TIME	TIME & ENDPT

(a) Eliminate overetch step.
Copy step #5 → #3 go to copy press field select.
Copy step #6 → #4 go to copy press field select.

(b) Go to Parameters: [MACHINE] should be flashing and press field select.
Change endpoint #1. Set normalize to 10 sec. and trigger to 25%.

(5) Press STATUS --> go to monitor hit esc --> enter to see the plot come up on the screen.

(6) Load 3 dummies + 3 test wafers with CMOS active pattern on nitride (tylan9) over 1000A of oxide.

(7) Press START (on first 3 dummy wafers press field select once power becomes stable - make sure manual endpoint is flashing).
Watch RF Power < 10.
Then run 3 work wafers.

Specification:

Etch rate: 1000 A/min+/-10%
w/in W Unif: 10%
W-W Unif: 10%

Note: Nitride with lower stress (tylan 18) will have lower etch rate.

Purpose: Oxide etch Monitor Test

Equipment: LAM 2

Time of Execution: 30 seconds per wafer

Detailed Procedure:

(1) Measure oxide thickness on Nanospec, Prgram#1, Lens:10 x

(2) On PC key board hit

- ctrl-esc → choose **Lam2** → **esc**

(3) Load: Clean recipe and load 1 wafer with oxide. → Press **START**

(4) Load Recipe #b (SIO2ET) and edit as follows:

SIO2ET (Recipe b)	
Recipe	**Step #2**
PRESSURE (TORR)	2.8
RD POWER (W)	850
GAP	0.38
He (sccn)	120
CHF3 (sccm)	30
CF4	90
TIME	30 sec.
COMPL	TIME & ENDPT

(a) Step#1 change [COMPL] to [time only] time = 00:20 min:sec

(b) Edit recipe to eliminate overetch step.
Copy step #5 → #3 go to copy press field select
Copy step #6 → #4 go to copy press field select.

(c) Go to Parameters: [MACHINE] should be flashing and press field select.
Notify endpoint #1. Set normalize to 10 sec and trigger to 25%.

(5) Press **STATUS** → go to monitor hit esc → enter to see plot come up on the screen.

(6) Load 3 dummies + 3 test wafers with resolution mask pattern on 6000 A of thermal oxide.

(7) Press **START** (on first 3 dummy wafers press field select once power becomes stable - make sure manual endpoint is flashing).
Check Pressure: 2.8 mT
Temp < 20

Specification:

Etch rate: 5800 A/min ± 10%
w/in W Unif: 20%
W-W Unif: 20%

Note: For better uniformity use Press: 2.9T, Gap: 0.42, RF: 750, He: 110, CF4: 95 sccm, CH3: 30

Purpose: Aluminum etch Monitor Test

Equipment: Lam 3

Time of Execution: 30 seconds per wafer

Detailed Procedure:

(1) Make sure Lam4 is not in use when using recipe w/ CL2.

(2) Load 3 dummies + 3 test wafers with resolution mask pattern on 7000 A of Al over 1000 A of thermal oxide.

(3) Put module in → Press load

(4) Modify recipe:

Parameters	Step #1	Step #2	Step #3
PRESSURE (MTORR)	250	250	0
RF POWER (W)	0	250	0
BCl3 (sccm)	50	50	0
N2	50	50	100
Cl2	30	30	0
CHF3 (sccm)	20	20	0
CF3 (sccm)	0	0	0
COMPL	time	time	Recipe
MAX	20 sec.	30 sec..	10 sec.

(a) Step#1 change [COMPL] to [time only].
time = 00:20 min:sec

(b) Step #2 change time to 30 sec.

(c) Edit recipe to eliminate overetch step.
Copy step #4 → #3 go to copy press field select
Copy step #5 → #4 go to copy press field select.

(5) Press STATUS

(6) Press START (on first 3 dummy wafers press field select once power becomes stable - make sure manual endpoint is flashing).

(7) To go to [Air Lock] go to recipe press field select when [Reactor] is flashing.

Specification:

Etch rate: 5000 A/min ± 10%

w/in W Unif: 20%

W-W Unif: 20%

Measurements:

► Strip PR in PRS2000 and measure step height in AS200

Purpose: Polysilicon etch Monitor Test

Equipment: LAM 4

Time of Execution: 30 seconds per wafer

Detailed Procedure:

(1) Measure poly thickness on Nanospec (Program#4), RI = 3.7, Tox:1000 A and Lens:10 x.

(2) Make sure Lam3 is not in use when using recipe w/CL2.

(3) Load 3 dummies + 3 test wafers with CMOS-Poly mask pattern on Polysilicon over 1000A of thermal oxide.

(4) Status - Check for idle condition.

(5) Check alarm and clear them.

(6) Load Recipe: Select 1) Recipe then press LDNEW → 400 → load

(7) Modify recipe as follows:
Select recipe and press copy to insert step between 4 and 5 by going to
COPY 5 to 6 → **ENTER**
COPY 4 to 5 → **ENTER**

Modified Polysilicon Etch Recipe 400		
Parameter	**Step #5**	**Step #6**
PRESSURE (MTORR)	425	425
RF TOP (W)	0	0
GAP (cm)	0.80	0.80
Cl2 (sccm)	0	180
He (sccm)	400	400
SF6 (sccm)	0	0
HE CLAMPT	8.0	8.0
COMPL	[STABL]	[ENDPT]
TIME	15 sec.	30 sec.
CHANNEL		C
DELAY		15
NORM SEC		10
NORM VALUE		5000
TRIGGER %		50%

(8) Go back to Menu, press **STATUS**
To see graphics press **PLOT** → Trend

Specifications:

Etch rate: 4900 A/min ± 10%

w/in W Unif: 5%

W-W Unif: 10%

Note: When using endpoint copy start by 11 → 12, 10 → 11, 4 → 5

Change step #5 Cl2 = 0

Step #6 Trigger = 90%

Time = 90 sec It will endpoint by itself.

MOD 27

OCG 825 Reversal Image Process

(1) Standard clean wafers.

(2) Spin dry.

(3) Standard dehydration bake wafers in furnace tube for 10 minutes.

(4) Standard HMDS treatment.

(5) Standard spin coat wafers with OCG 825 Photoresist.

(6) Expose 1st level at best focus and best exposure.

(7) Do not develop.

(8) **All the lights in the Technics-B and adjacent rooms must be turned off to prevent exposure of the photoresist on the wafers.

(9) Turn heater power on Technics-B and set temperature to 60ºC. Pump down Technics-B with usual procedure and set the NH3 dial to maximum. Turn on gas #1 valve on PDII-A and switch flowmeter from off to auto. When temperature reaches 60ºC, turn off gas #1 valve and pump down as usual.

(10) Vent Technics-B and load wafers. Pump down system. Open gas #1 valve. Turn off vacuum. Reset temperature to 95ºC immediately. Time for 45 minutes. The NH3 flowmeter valve will automatically shut off, because the gas flow is too high. Set temperature back to 60ºC after 45 minutes. Close gas #1 valve. Pump down and vent as usual.

(11) Unload wafers.

(12) Flood-expose wafers (2nd exposure) with a clear mask using the best focus and best exposure.

(13) Develop 90 seconds with standard developer.

MOD 28

Polyimide Technology

Polyimide is a spin-on organic insulator, which is typically used as an interlayer dielectric. Once it is fully cured, it is very tough mechanically and its electrical properties are almost identical to those of thermal oxide. Since it is a spin-on coating, it planarizes the surface of the wafer, and thus virtually eliminates step coverage problems.

Polyimide in its partially cured state is easily etched off with alkaline solutions such as photoresist developer. This property was utilized in developing the Polyimide Insulator Technology described below.

Polyimide Process:

(1) Dry wafers in oven for 30 minutes @at120.

(2) Obtain the heat lamp from GL2.

(3) Place the lamp over the spinner, about 8 to 10 inches from the spin head, pointing near but not directly at the spinner. This is to increase the uniformity of the polyimide. Leave the lamp off for now.

(4) Obtain polyimide (PIX L110). Prepare wafer on spindle as in standard PR spinning. Dispense Polyimide insuring that it spreads to at least quarter size (for good coverage).

(5) Start spinner and immediately turn on the lamp. When spinner stops, turn off lamp immediately. 4000 rpm will yield ~16,000-19,000 A.

(6) Bake at 90ºC for 10 minutes and then 120ºC for 5 minutes (all oven bake). These bakes drive various solvent vapors from the polyimide. Please insure proper ventilation.

(7) Spin and expose standard PR process.

(8) Standard develop for 90 seconds.

(9) Inspect. Should look like developed photoresist (Polyimide also developed.)

(10) Strip resist with acetone.

(11) Descum 3 minutes at 50 watts. More may be necessary to get good looking polyimide.

(12) Bake 100ºC for 30 minutes and 200ºC for 30 minutes and 330ºC for 1 hour. The last step is down in a furnace.

(13) Put back heat lamp where you found it.

MOD 29

Standard Thick Resist Process

(Shipley's SPR-220 thick resist)

Purpose: To spin coat, expose, develop, and hardbake 10μm of SPR 220 thick photoresist. SPR-220 exhibits a much higher selectivity than STR-1075 resist. It is the preferred resist for deep silicon DRIE etch.

Equipment: SVGCOAT2, hotplate, ksaligner, and wet sink.

Time of Execution: Approximately 1 – 1.5 hours process total.

Summary:

1. HMDS
2. SVGCOAT 2 PROGRAM 8

   Or SPINNER1
3. Softbake 115°C Hot plate for 5 minutes
4. Exposure
5. Wait 30 minutes (hold time)
6. OPTIONAL: Post Exposure Bake 115 hotplate for 6.5 minutes
7. LD26W Tank Develop
8. Hardbake 80°C hotplate for 120 minutes

Detailed Procedure:

1. HMDS the wafer in PrimeOven.
2. Immediately following HMDS step:
   a. Automatic spin coat SPR 220 using SVGCOAT2 - coating Program 8. This should spin 10 microns of thick resist onto wafer.
   b. Alternative to SVGCOAT2: manual Spinner1:
      i. Engage the vacuum on Spinner 1, set the speed to 0 RPM
      ii. Pour a quarter bottle of SPR220 from dropper bottle
      iii. Ramp the speed to 0.5 Krpm in 10 seconds
      iv. Hold it at 0.5 Krpm for 10 seconds

v. Ramp the speed to 1.8 Krpm in 10 seconds

vi. Hold it at 1.8 Krpm for 30 seconds. The result should be ~10 microns of thick resist on wafer.

3. Softbake

   a. Softbake on 115°C hotplate for 5 minutes. Use either the SVG hotplate or manual hotplate. If the softbake is performed on the SVG hotplate, the User must first manually set the temperature to 115°C (default temp is usually 90°C). Users must likewise ensure that the SVG hotplate is set back to the default when finished. A 300-second softbake is included by default in the SVGCOAT2 Program 8.

   b. After the wafer is removed from the hot plate, ***it is important to avoid thermal shock***. This means avoiding an instant cool down step using a cooling-block. Thermal shock will induce cracking in the SPR-220 thick resist. Always allow the wafer to cool down slowly (note that there is no cooling block step in SVGCOAT2 Program 8).

4. Exposure

   a. Lithography may be performed using either Ksaligner or GCAWS2.

   b. The KSaligner low vac contact program has been found to give the best resolution for SPR 220 thick resist. Wafer-mask “sticking” is infrequent using this type of exposure.

   c. Exposure time should be between 13 – 18 seconds on Ksaligner. This of course depends on the lamp intensity, as well as your mask pattern and feature size.

5. Hold Time

   Wait at least 30 minutes prior to performing the post exposure bake (PEB). This “hold time” is crucial, as it allows the PAC (Photo Active Compound) to breakdown in the relatively thick resist.

6. Post Exposure Bake

   a. This step is optional. It may actually contribute to thermal shock and cracking of the resist if the wafer is not allowed to cool down sufficiently before developing.

   b. Place wafer on 115°C hotplate for 6.5 minutes.

   c. Again, allow the wafer cool to room temperature slowly. Do not induce thermal shock.

7. Tank Develop

   The wafer must be now be tank developed. Note that spin development track does not work well with thick resist. Ensure that the wafer is at room temperature then immerse the wafer in a beaker of LD26W developer. The duration of the development will vary depending on the density and the smallest feature size of your pattern. Duration in tank can range from 2 to 10 minutes.

8. Rinse the wafer with DI water thoroughly and gently hand dry with N2 gun.

9. Hardbake

   Place wafer on 80°C hotplate for 120 minutes for best results. It has been shown that a hotplate hardbake helps to maintain critical dimensions and sidewall profiles of the thick resist much better than a convection oven hardbake.

MOD 29

Standard Thick Resist Process

(Shipley's SPR-220 Thick Resist)

Purpose: To spin coat, expose, develop, and hardbake 10μm of SPR 220 thick photoresist. SPR-220 exhibits a much higher selectivity than STR-1075 resist. It is the preferred resist for deep silicon DRIE etch.

Equipment: SVGCOAT2, hotplate, ksaligner, and wet sink.

Time of Execution: Approximately 1 – 1.5 hours process total.

Summary:

1. HMDS
2. SVGCOAT 2 PROGRAM 8

   Or SPINNER1
3. Softbake 115°C Hot plate for 5 minutes
4. Exposure
5. Wait 30 minutes (hold time)
6. OPTIONAL: Post Exposure Bake 115 hotplate for 6.5 minutes
7. LD26W Tank Develop
8. Hardbake 80°C hotplate for 120 minutes

Detailed Procedure:

1. HMDS the wafer in PrimeOven.
2. Immediately following HMDS step.
   a. Automatic spin coat SPR 220 using SVGCOAT2 - coating Program 8. This should spin 10 microns of thick resist onto wafer.
   b. Alternative to SVGCOAT2: manual Spinner1:
      i. Engage the vacuum on Spinner 1, set the speed to 0 RPM.
      ii. Pour a quarter bottle of SPR220 from dropper bottle.
      iii. Ramp the speed to 0.5 Krpm in 10 seconds.
      iv. Hold it at 0.5 Krpm for 10 seconds.
      v. Ramp the speed to 1.8 Krpm in 10 seconds.
      vi. Hold it at 1.8 Krpm for 30 seconds. The result should be ~10 microns of thick resist on wafer.
3. Softbake
   a. Softbake on 115°C hotplate for 5 minutes. Use either the SVG hotplate or manual hotplate. If the softbake is performed on the SVG hotplate, the User must first manually set the temperature to 115°C (default temp is usually 90°C). Users must likewise ensure that the SVG hotplate is set back to the default when finished. A 300-second softbake is included by default in the SVGCOAT2 Program 8.

b. After the wafer is removed from the hot plate, ***it is important to avoid thermal shock***. This means avoiding an instant cool down step using a cooling-block. Thermal shock will induce cracking in the SPR-220 thick resist. Always allow the wafer to cool down slowly (note that there is no cooling block step in SVGCOAT2 Program 8).

4. Exposure

   b. Lithography may be performed using either Ksaligner or GCAWS2.

   c. The KSaligner low vac contact program has been found to give the best resolution for SPR 220 thick resist. Wafer-mask “sticking” is infrequent using this type of exposure.

   d. Exposure time should be between 13 – 18 seconds on Ksaligner. This of course depends on the lamp intensity, as well as your mask pattern and feature size.

5. Hold Time

   Wait at least 30 minutes prior to performing the post exposure bake (PEB). This “hold time” is crucial, as it allows the PAC (Photo Active Compound) to breakdown in the relatively thick resist.

6. Post Exposure Bake

   a. This step is optional. It may actually contribute to thermal shock and cracking of the resist if the wafer is not allowed to cool down sufficiently before developing.

   b. Place wafer on 115°C hotplate for 6.5 minutes.

   c. Again, allow the wafer cool to room temperature slowly. Do not induce thermal shock.

7. Tank Develop

   The wafer must be now be tank developed. Note that spin development track does not work well with thick resist. Ensure that the wafer is at room temperature then immerse the wafer in a beaker of LD26W developer. The duration of the development will vary depending on the density and the smallest feature size of your pattern. Duration in tank can range from 2 to 10 minutes.

8. Rinse the wafer with DI water thoroughly and gently hand dry with N2 gun.

9. Hardbake

   Place wafer on 80°C hotplate for 120 minutes for best results. It has been shown that a hotplate hardbake helps to maintain critical dimensions and sidewall profiles of the thick resist much better than a convection oven hardbake.

MOD 30

Standard Aluminum Wet Etch

Purpose: Tto remove Aluminum using a wet etch process

Equipment: Sink 8

Time of Execution: 10 minutes

Summary:

(1) DI water, 15 seconds in rinse tank #1, #2 or #3.

(2) Dip premixed Al Etchant, (Type A, by Transene Co.: phosphoric and acetic acids) at 50°C bath temp.

Note: Etch rate of fresh chemicals = 6000 A/minute; adjust etch time according to oxide thickness.

(3) Standard rinse-spin procedure noted in MOD 2, but use sink8 only.

Detailed Procedure:

(1) If necessary, aspirate Aluminum Etchant from tank.

(2) Rinse with DI water, aspirate. Repeat three times.

(3) Fill dip tank with 3500 ml of Aluminum Etchant. The liquid level should be about 1 inch below top.

Note: Etch baths are usually prepared in advance by the process staff and are regularly replaced. They are maintained at the required temperature (50ºC for Al etch).

(4) Fill rinse tanks. Be sure tank fill lights are on and tank drain lights are off. Turn the tank fill buttons off once the tanks are full (to conserve DI water).

(5) Load wafers into a white Teflon® cassette and dip into DI water tank #1 to wet.

(6) Dip wafers into Al etch bath. Etch rate = 6000 A/min or 100 A/sec. Please note etch rate significantly decreases with use. You may consider running a test wafer to determine exact etch rate.

(7) Standard rinse-spin procedure noted in MOD 2, but use sink8 only.

Note: After the Al etch, the wafer still contains metallic contaminants that will ruin IC devices.

DO NOT PUT WAFERS IN SINK6 OR A MOS CLEAN FURNACE AFTER AL ETCH!

MOD 31

Processing Glass Wafers in the Microlab

(This Module is intended to provide information/guidelines on glass processing in the Microlab.)

I. Types of Glass

A) Introduction/Background

A very large variety of glasses are available, and are differentiated by their metal-oxide content. For example, fused silica is almost entirely SiO_2, with other components as trace contaminants. Here is a table of readily-available glasses, and their makeup by percentage weight.

Glass Name	Compounds and their Appoximate Composition Percentages by Weight								
	SiO_2	B_2O_3	Al_2O_3	Na_2O	K_2O	CaO	MgO	ZnO	BaO
Glass Wafers Stocked in the Microlab									
Pyrex® 7740	80.6	13.0	2.3	4	0.1	-	-	-	-
Fused Silica	~100	-	-	-	-	-	-	-	-
Other Glass TypeSubstrates									
Borofloat® 33	81	13	2	(4 total, Na_2O+K_2O)		-	-	-	-
LE Borosilicate	60	5	15	1	1	18	-	-	-
Non-alkaline (NA)	55	14	-	-	-	31			
Soda Lime	62	-	2	17	1	14	2		
BK7 Borosilicate	68	15	-	6	5	-	-	-	6
SD2	58.8	1.5	22.3	10	-	-	4.9	2.5	-

This presentation of glass composition data makes it very clear why glass etching/cleaning in the Microlab is restricted – most of the constituents of most of the glasses listed can easily contribute unwanted dopants or even catastrophic impurities to the baths or the etch tools!

B) Microlab Stock

Name	Stock No.	Wafer Description
Waferpy	1142	4-inch diameter Pyrex® 7740
Wafer	999	4-inch diameter fused silica (amorphous)

C) Glass Properties

Properties of Glass Wafers Stocked in the Microlab						
Glass Name	**Young's Modulus** 10^9 Pa	**Poisson's Ratio** -	**Knoop Hardness** Kg/mm^2	**Coefficient of Thermal Expansion** 10^{-6} K	**Thermal Conductivity at 300K** W/m-K	**Specific Heat** J/Kg-K
Pyrex® 7740	64	0.2	418	3.25	1.13	726
Fused Silica	73	0.2	635	0.56	1.38	746
Borofloat® 33	63	0.2	480	3.25	1.12	830

II. Restriction on Processing Glass Wafers

DO NOT attempt to **ETCH** Pyrex® 7740, nor any other metal-oxide-containing glass substrates in any of the sinks or plasma etchers in the VLSI area (see Table in Section B-2). Pyrex® 7740 can however be cleaned for amorphous poly deposition (tystar16) purposes in sink8. This is the only exception made for the VLSI sinks in regards to Pyrex© glass substrate processing in the VLSI area. Please refer to Tystar16 chapter for more information on Pyrex® 7740 processing in Tystar16, as well as material and process compatibility policy chapter.

III. Photolithography

A) **Spin Coating**: Pyrex® 7740 and other glass wafers can be coated on manual spinner1 in Y1. Do not spin coat wafers on SVGCOAT1 & 2 as these automated tracks cannot detect glass wafers unless the glass wafer has an unetched opaque film cover on it (e.g., an aluminum layer). Consult with the process supervisor if you absolutely have to use SVG tracks on clear glass wafers, he/she might be able to help you.

- **Resist Exposure:** Pyrex® 7740 and other glass wafers can be exposed on our 1X contact aligners (KS aligner, quintel and canon aligners). Do not use gcaws steppers on the 0.7 mm and 1 mm thick glass wafers as the usable depth of focus cannot compensate for these thicknesses. You may however align 0.5 mm thick glass wafers, which have similar thicknesses to STD 4" Si wafers currently used in the Microlab.

B) **Resist Development:** Pyrex® 7740 and other glass wafers should be tank developed. Do not process clear glass on SVGDEV track developer, as it will not be able to detect the glass wafer and breakage may occur. Glass wafers covered by an opaque film however may be processed on this track.

IV. Deposition of Thin Films

Amorphous Poly Deposition on Pyrex® 7740 Wafers (Tystar 16)

There are three techniques available to deposit a-poly on Pyrex® 7740 wafers, most importantly Tystar 16, which is outlined below.

1) Tystar 16 LPCVD technique (a-poly deposition at temperatures <= 550ºC)
2) technics-b plasma-enhanced deposition
3) pqecr (GL2) Plasma Quest ECR PECVD, a-silicon film (a-Si:H) deposition at room temperature.

Undoped amorphous poly can be deposited on Pyrex® 7740 substrates in Tystar 16. The deposition temperature should never exceed 550ºC when depositing a-poly on Pyrex® 7740 substrates. Although the loading temperature is often set at the same value as the deposition temperature, note that the furnace can easily overshoot the set point by 20-30ºC during the loading step. Use the dedicated borofloat glass boat at the station to process your wafers. Replace one of the boats in the tube with the designated borofloat boat for your process.

Suggested Recipe for Amorphous poly Silicon Deposition in Tystar 16				
Temperature	**SiH2 Flow**	**Pressure**	**Deposition Time**	**Expected Layer Thickness**
525ºC	100 sccm	300 mTorr	02:20:00	1800-2000 Angstrom

Please refer to general operational and safety guidelines in Chapter 5.0 (Tystar/Tylan Furncaces Overview) of the lab manual for more detailed information.

V. Etching

A) Wet Etching

1) Glass Etching

Wet etching of glass, because of the amorphous nature of most glasses, is almost entirely isotropic, making it an inappropriate choice for narrow, deep trenches or through-wafer vias, but which also makes it *ideal* for making shallow surface channels with cylindrical cross-sections: “surface micromachining”. A popular application for this technique is micro-fluidic channels.

One of the biggest issues with HF/BHF etching of glass is the performance of photoresist as an etch mask. If the desired etch depth is significant compared to the resist thickness, we frequently observe a destructive undercut of the resist at the edge of features, causing a loss of pattern fidelity. A common alternative is to use the resist to pattern an underlying *hard mask*. The requirements for the hard mask are: reasonably low stress, good adhesion to the glass, non-reactivity to HF, and the ability to either leave the mask on the sample, or to remove it without affecting the glass. Common choices are a-poly, chromium (can be evaporated or sputtered), and nickel (can be sputtered, evaporated, or electroplated).

A standard glass wet etch process flow is as follows:

(i) After depositing a-poly Si layer, silanize with HMDS.

(ii) Spincoat photoresist and pattern.

(iii) Etch a-poly Si with Ptherm (SF6 at 200 W).

(iv) Etch glass with 49% HF. Strip resist.

(v) Remove a-poly Si with silicon etch solution: 1890 ml nitric acid, 960 ml DI water, 75 ml ammonium fluoride at room temperature, etch rate: ~0.20 µm/min

To first order, etch rates in HF solutions will vary with the non-SiO_2 composition of the glass. It has been observed that glasses with higher percentages of metal ions etch faster than fused silica. The nature of the chemical reactions that take place in the etching of glass, or even SiO_2, is not straightforward, and becomes more complex as other oxides are added to the mix. Thus, the researcher is cautioned to perform etch-rate experiments using material of the same makeup as the sample of interest.

Please aspirate the silicon etchant after you are done etching your glass wafers. This will protect others from possible contamination.

B) Dry Etching

There exist dry (plasma) etch techniques which are appropriate for deep, narrow, high-aspect-ratio, bulk micromachining of glass. **No LAM etching of any type of glass wafers are allowed in the Microlab**. Pyrex® 7740 as a substrate is allowed, see table below. This table also defines the Microlab rules for etching Pyrex® 7740 (glass) and quartz substrates in our currently available plasma etch chambers. This will be repeated at the end of the module for emphasis.

1) CF_4/CHF_3

The use of these two etch gases to etch various glasses has been reported . The system used was not dissimilar to our "ptherm" RIE reactor. The conditions were: 50 mtorr chamber pressure, 350 watts RF input at 13.56 MHz, and a 500 v self-bias to the substrate. Using 100% CHF_3, the observed etch rate was 60 nm/min for highest-purity fused silica, and considerably lower for multicomponent glasses. This is not a practical rate for obtaining trenches of several microns depth.

2) SF_6

The use of SF_6 to etch glass substrates in a reaction chamber not unlike our STS deep trench silicon etching system has also been reported. A low-pressure, inductively-coupled plasma was employed, along with a strong DC magnetic field to "densify" the plasma in the volume of the chamber directly above the sample. Removal rates of 0.5 - 0.6 microns/minute were demonstrated at a 0.2 Pa chamber pressure, 7 sccm gas flow rate, 150 watt (13.56 MHz) coil power, and 140 watt stage power. Observed sidewall taper depended on the concentration of glass components that yielded nonvolatile etch products; these etch products tended to redeposit on the trench sidewalls and increase the sidewall taper. Hence, high purity fused silica yielded the steepest sidewalls. Electroplated nickel was used as an etch mask, and selectivity of 14 to 20 was reported, relative to the glass removal rate.

Note: The Centura DPS-DT is an ICP etcher that employs all of the etch gases listed above. Processing applications for glass etch will be taken on a case-by-case basis. Please contact Matthew Wasilik for details (mwasilik at @eecs.berkeley.edusilicon).

Do not attempt etching Borofloat/Pyrex® wafers in **any** of the lam etchers or technics-c (VLSI area). **No LAM etching of any type of glass wafers are allowed in the Microlab**, regardless of what film it is that you are trying to etch on your glass substrate. Since we've repeated this warning, the reader is led to think, "Gee, this must be important". **It is**. So don't do it.

Pyrex® 7740 and Quartz Wafer Processing in Microlab Plasma Etch Tools

	Pyrex® 7740 Etching	Pyrex® 7740 as substrate*	Quartz Etching	Quartz as substrate°
Lam1	No	Yes[1]	No	Yes[1]
Lam2	No	Yes[1]	Yes[1]	Yes[1]
Lam3	No	Yes[1]	No	Yes[1]
Lam4	No	No	No	Yes[1]
Lam5	No	No	No	Yes[1]
STS	No	Yes[2]	No	Yes[2]
Technics-C	No	No	No	Yes
Centura MxP+	No	No	Yes[1, 2]	Yes[1, 2]

Centura DPS-DT	No	Yes[1,2]	No	Yes[1, 2]
Semi	No	No	No	Yes
Oxford	No	No	No	Yes
Ptherm	Yes	Yes	Yes	Yes
AMST	No	Yes	No	Yes
Xetch	No	Yes	No	Yes
IonMill	Yes	Yes	Yes	Yes

[1] Lam1-5 and Centura use LED sensors at the indexer and edge detector units that cannot detect transparent substrates such as Pyrex® 7740 or Quartz. The sensors on Lam1-3 require thick film stacks to successfully handle Pyrex® or quartz substrates. The sensors on Lam4-5 and Centura can usually handle transparent wafers with thinner layer(s) of opaque films.

[2] Equipment employs electrostatic chuck: additional conductive handle substrate necessary.

Note: Ptherm and Ionmill are the ONLY Microlab tools in which members may attempt Pyrex® 7740 plasma etching.

- ► Pyrex® 7740 as substrate = there will be no exposed Pyrex® during plasma etch of some other material that has been deposited on a Pyrex® wafer.
- ► Quartz as substrate = there will be no exposed quartz during plasma etch of some other material that has been deposited on a quartz wafer.

VI. Dicing

Glass Wafers and Microscope Sliding Glass can be cut on the wafersaw dicing machine, as per manual Chapter 9.6 - Esec 8003 Dicing Saw.

Following blade type and recommended blade speed of 0.5 mm/sec shall be used to cut (dice) glass wafers or sliding glass at an inappropriate depth relative to their thicknesses.

Blade Specification

- **Blade Type:** Dicing Technology, PN CX-010-600-060 J with kerf of .010", 22-36 micron abrasive, 1.5 mm or .060" exposure
- **Recommended cutting speed, best cut:** 0.5 mm/sec
- **Maximum depth of cut:** 0.7 mm or 0.04" Maximum cutting speed: 1 mm/sec.

MOD 32

Edge Bead Removal (EBR)

Purpose: To remove edge-bead from resist coated wafers (1/16" ring at edges of wafer).

Equipment: SVGCOAT 1&2 and coat program 9 (no hot plate bake).

Time of Execution: 1 minute, includes two 10 second EBR dispense cycles.

Detailed Procedure:

(1) Load resist coated wafers on the send cassette of the spin track.

(2) Select program 9 on the coat module and program 9 on hot plate to bypass the bake.

(3) Press START. Wafers will be send through two EBR dispense cycles (AZ EBR 70/30 solvent) and 15 seconds of dry spin.

(4) When process is complete, remove wafers from the out cassette.

Note: EBR program is optimized to remove edge-bead on our standard I-line & G-line programs (1.0 - 1.2 micron thick). Multiple runs through track may be necessary to remove thicker coats. EBR process will clear out the edges of wafer void of resist, is not be desirable for backside etching and STS handle wafer used for through silicon etch process. The EBR program is highly recommended for Lam 5 plasma etching, where incidents of resist reflow and wafer sticking to chuck has been reported.

MOD 33

Pocket Wafer Fabrication for 6" Wwafers

Purpose: Pocket wafers are 6" wafers with a 300 micron deep recessed area that is fabricated to fit a 4" wafer. 4" wafers can be mounted on pocket wafers and processed in various 6" tools, including sputterers and etchers.

Equipment: Wet oxidation furnace, KSAligner, Matrix, svgcoat6, svgdev6, centura-mxp, Sink 3.

***Summary*:**

1. Wet Oxidation
2. Lithography
3. Oxide Etch
4. TMAH Silicon etch
5. Trilogy silicon etch
6. Wet Oxidation

***Detailed Procedure*:**

1. Furnace pre-clean in sink 6.

2. Wet Oxidation
   Recipe 2WETOXA: 1050ºC, 3 hrs
3. Nanospec and record oxide thickness
4. PR Coat at Svgcoat = 6
   a. I-line PR – program 7 (no EBR). Need to add extra PR using a dropper bottle at the dispense step.
   b. Prebake at 90C (need to lower hotplate setpoint).
   c. **DO NOT** use tweezers to handle wafers. Tweezers promote the formation of poc marks in the wafer during latter stages of the process (TMAH etch). Use the vacuum wand to handle all wafers.
   d. Return hotplate to normal setpoint.
5. Lithography in KSAligner
   a. Use the standard pocket wafer transparency (later to be replaced with a mask). The transparency is taped to a clear mask.
   b. Soft contact exposure.
   c. Avoid using tweezers. Use the vacuum wand for wafer handling.
6. PR Develop at Svgdev6
   a. I-line develop, Recipe 3.
   b. PEB at 90C (need to lower hotplate setpoint).
   c. **DO NOT** use tweezers to handle wafers. Use the vacuum wand instead.
   d. Return hotplate to normal setpoint.
7. Hard Bake
   VWR oven for 2 hrs.
8. Centura MxP Oxide etch
   Recipe: “OXIDE MXP T2 EP” to endpoint.
9. Matrix PR Ashing
   Strip all resist.
10. TMAH etch at Sink 3.
    a. Set TMAH bath to 90ºC.
    b. For 4000 ml of etchant, mix 2400 ml of 25% TMAH with 1600 ml DI water. Probably need about 8000-9000 ml of etchant to cover a 6” wafer cassette.
    c. Etch rate estimated at 50 microns per hour. For removal of 300 microns, this means a ~6 hour etch.
    d. Do a HF dip for the wafers before putting them in TMAH. This removes the native oxide on the Si surface and results in a shiny, smooth etch surface afterwards.
    e. Check occasionally to ensure the liquid level has not depleted noticeably; use the deck hose to bring it back up if necessary.
    f. Rinse in DI water and dry with the N2 gun.
    g. Measure the etch profile using the ASIQ.

11. Silicon trilogy etch – immerse wafer for one minute. This will to help smoothen edges.

12. Furnace pre-clean, followed by final wet oxidation:
    Recipe 2WETOXA: 1050ºC, 1 hr

MOD 34

Anodic Bonding

Purpose:

Glass wafers (Pyrex® 7740) can be anodically bonded to silicon wafers at a relative low bonding temperature (450ºC) by applying a large voltage potential across the glass-silicon interface. This generates an electric field that drives Na+ ions in the glass wafer away from the Si/glass interface. An Na+ depletion zone is formed and oxygen molecules at the interface diffuse into the silicon to form an interstitial layer of amorphous SiO_2 to bond the pair together.

Equipment:

KS Bonder with the "unitool" (chuck configured with one set of electrodes) or the anodic bonding tool (chuck configured with an annular, dual set of electrodes) installed. The anodic bonding tool with its dual set of electrodes has been determined to provide a better quality bond.

Summary:

1. Bond pair alignment can be done in the KSBA6. Following this procedure, the wafer pair is mechanically clamped in transport fixture for anodic bonding in the SB6 chamber.
2. Load fixture with wafer pair into the KS Bonder.
3. Bond with appropriate anodic bonding recipe.
4. Remove bonded pair from the chamber.

Detailed Procedure:

Fixture Substrate Pair Clamping:

1. Perform alignment in KSBA6 if necessary. Refer to Chapter 9.1 (Karl Suss Bond Aligner) for this procedure. If no alignment is necessary, the wafer pair may be manually clamped together in the SB6 fixture. The "flags" are typically not used, as they tend to trigger misalignment between the wafer pairs.

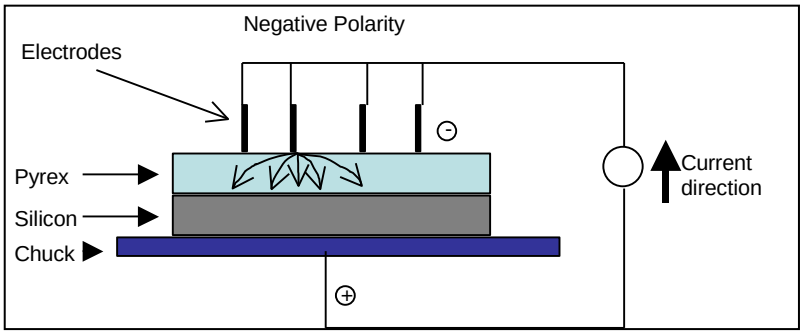


Figure 1

2. If the wafer pair requires alignment (using KSBA6), then the wafer pair will be configured as shown in Figure 1: silicon on bottom, glass on top, and negative polarity.

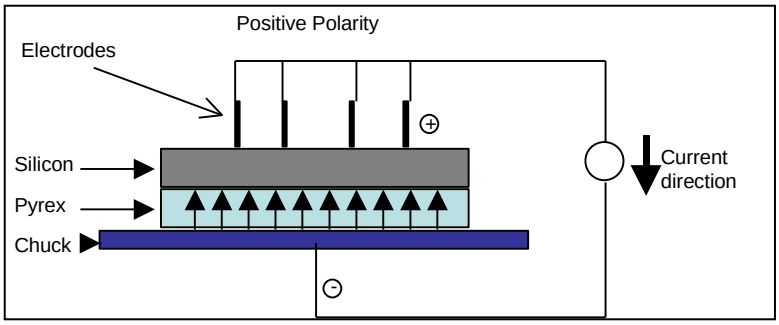


Figure 2

3. Figure 2 shows the preferred configuration for wafer pairs that do not have the requirement of alignment. This configuration will bond faster than that of Figure 1. The silicon on top, glass on bottom, and positive polarity effectively provides a larger electrode (electrode = silicon wafer). Thus the electric field lines are shortened and the bond happens faster.
4. A design of experiment was performed by Ning Chen to find optimized recipe parameters for anodic bonding. Refer to the Anodic Bonding Research Report for more information.

Anodic Bonding:

1. The computer monitor for the KS Bonder should be turned on when the tool is enabled.
2. Turn on gas flows (Compressed Air and N_2 gas) to the marked pressure position.
3. Login to the Windows NT environment. Click on SB6 Start icon to get the SB6 Main Menu.
4. Login with your own account name and password.
5. Click on the CONTROL CENTER icon.
6. Click on DOWNLOAD RECIPE. The standard anodic bonding recipe's parameters are: -1500 V, 450ºC, and atmospheric process pressure. Verify the recipe parameters prior to loading.
7. Position the fixture on the loading arm.
8. Click on LOAD in the control center window. When the chamber door opens, push the load arm smoothly into the chamber.
9. Click on MOVE and wait until the stage moves up and the wafer pair is unloaded from the fixture.
10. Pull out the loading arm and click FINISH.
11. Click START to run the recipe.
12. The process can be monitored from the Status Screen. After the recipe is completed, wait for the chamber to cool down to 200ºC.
13. Click UNLOAD. Once the chamber door opens, push the load arm into the chamber.
14. Click MOVE to set the bonding pair fixture on the load arm.
15. Move the load arm out of the chamber when prompted.
16. Click FINISH to close the chamber. The machine will return to idle and the temperature will automatically drop to 100ºC.
17. The bonded pair can now be removed from the fixture.
18. Logout of the SB6 software, and logout of Windows NT.

19. Shut off the compressed air and N2 lines.

MOD 35

Handle Bonding (Reversible Bonding)

Purpose:

Handle bonding is a necessary procedure for through-wafer etches (DRIE) and the etching of dies and substrates smaller than 6inch diameter. It is also necessary to perform a handle bond for deep trench etching of features that either (1) exceed a depth of 250 microns, or (2) exceed a depth 60% of the original thickness of the wafer. Handle bonding serves to protect the DRIE chuck from damage, ensure uptime of the DRIE equipment, and also keep intact the device being etched. There are several recommended approaches to handle bonding included in this module. Click here to view a graphical reference flow chart on reversible bonding.

I. Cool Grease™ as a Bonding Agent

Cool Grease™ is a thermally conductive paste suitable for bonding wafer-wafer and die-wafer substrates in DRIE processing. Cool Grease™ may be ordered from: www.aitechnology.com. Be aware that there are several different "flavors" of Cool Grease™ available, and importantly that some types are NOT compatible with VLSI equipment in The Microlab. The preferred type for handle bond processing in The Microlab has a boron-nitride filler (should be white in color), and the correct part number is CGR7016. Cool Grease™ (CGR7016) may be used for both wafer-to-wafer bonding or die-to-wafer bonding, and is generally the preferred means of handle bonding for DRIE processes.

ADVANTAGES: Good thermal conductivity to device substrate.

DISADVANTAGES: Particulates generated from debond step. Not recommended for use with features 2 micron or smaller. Depending on feature layout and type, debonding step may take some time.

Equipment:

Sink6, Tystar12, Hotplate, Cool Grease™

Summary:

1. Pre-furnace clean.
2. LPCVD 1-2 µm SiO_2.
3. Apply Cool Grease™ on the oxide handle wafer.
4. Bond the device wafer to the handle wafer.
5. Soak in acetone to remove the handle wafer once done etching.

Detailed Procedure:

Handle Wafer Preparation:

1. Sink 6 piranha clean for 10 minutes.
2. Rinse and dry the wafers.
3. Deposition of LTO on the handle wafer using Tystar12 is generally recommended, but mandatory for etches deeper than 200 microns. The recipe to use is **12SDLTOA** and the duration should be 2 hours (~1.5 to 2 µm).
4. Use a clean glass slide to spread Cool Grease™ on the handle wafer. The thickness of the Cool Grease™ after spreading should be about 300 µm to 600 µm.
5. Place LTO handle wafer onto a hotplate with temperature of 50ºC. This will soften the cool grease and make it slightly easier to bond device substrate.

For die level bonding, use just enough cool grease to bond the die to the handle wafer (i.e. it is not necessary to cover the entire handle wafer with Cool Grease™).

Bonding:

1. Taking the handle wafer off the hotplate, try to align the device wafer to the handle wafer and bond together as quickly as possible. Firmly press the two together.
2. Place the aluminum cooling block on the bonded pair for 5 minutes. Or alternatively press with wafer tweezers at select spots on wafer.
3. Bake pair on 50ºC hotplate or oven for ~10 minutes.
4. Inspect the bonded pair; remove any excess cool grease near the edge of device substrate with a clean room techniwipe. Cool Grease™ should never be exposed in the etch chamber.
5. Place the bonded pair under vacuum (e.g. Centura load lock, Technics-C) for 15 minutes first. Remove and inspect wafer pair, ensure all is well.

Debonding:

After etching, place the bonded pair in acetone to separate the device from the handle. If your devices will allow, use clean room paper soaked with acetone to gently pry apart the wafer pair. Be patient! Excessive force used in the debonding of pair not recommended

II. Photoresist as a Bonding Agent

Photoresist may be used for wafer-to-wafer or die-wafer bonding. Although the thermal conductivity of photoresist is much less than that of Cool Grease™, it is generally easier to work with.

ADVANTAGES: Easy to work with. Release step does not generate particles.

DISADVANTAGES: Poor thermal conductivity - not recommended for use with critical etch applications.

***Equipment*:** Sink6, Tystar12, SVGCOAT, prime oven, VWR oven, Technics-C

***Summary*:**

1. Pre furnace Clean.
2. LPCVD 1-2 µm SiO_2.
3. Spin coat 2 µm G-line resist.
4. Bond the device wafer to the handle wafer.

5. Primeoven → VWR oven.
6. PRS3000 or acetone for removing the device wafer from handle wafer after etching

***Detailed Procedure*:**

Handle Wafer Preparation:

1. Sink 6 piranha clean for 10 minutes.
2. Rinse and dry the wafers.
3. Deposition of LTO on the handle wafer using Tystar12 is generally recommended, but mandatory for etches deeper than 200 microns. The recipe to use is **12SDLTOA** and the duration should be 2 hours (~1.5 to 2 µm).
4. Spin coat 2 µm G-line using SVGCOAT2 – coating program 4 and no softbake.

Bonding:

1. Align the device wafer to the handle wafer. Firmly press the two together.
2. Place the wafer pair in a proper cassette holder and load into Prime oven. Run standard HMDS coating program (about 30 minutes). This performs two things for the wafer pair: (1) rids solvent and trapped air bubbles in the PR; (2) hardbakes the resist. Alternatively, place the bonded pair in VWR oven at 120ºC for 2 hours of hard bake, or a lower temp oven (80ºC) for 4-5 hours. Note SPR-220 patterned wafers prefer the latter, lower temperature hard bake.
3. Place the bonded pair under vacuum (e.g. Centura load lock, Technics-C) for 15 minutes first. Remove and inspect wafer pair, ensure all is well. Repeat bake step if necessary.

Debonding:

After etching, place the bonded pair in acetone, or PRS300 to separate the device wafer from the handle wafer. This process can take a few hours, so be patient! Excessive force used in the debonding of pair not recommended.

III. Thermally Conductive Double-Sided Tape

Thermally conductive double--sided tape (3M™ 9882) may be used to bond dies to a handle wafer. This is a quick and easy way to perform die-level DRIE etching.

ADVANTAGES: Good thermal conductivity.

DISADVANTAGES: Release step may take long time. Cannot be used with wafer size substrates. Only for use with small dies.

***Equipment*:** Sink6, Tystar12, 3M™ 9882 double- sided Tape

***Summary*:**

1. Pre furnace Clean.
2. LPCVD 1-2 µm SiO_2.
3. Bond dies to handle wafer using 3M tape
4. Acetone or sulfuric acid for debonding

***Detailed Procedure*:**

Handle Wafer Preparation:

1. Sink 6 piranha clean for 10 minutes.
2. Rinse and dry the wafers.
3. Deposition of LTO on the handle wafer using Tystar12 is generally recommended, but mandatory for etches deeper than 200 microns. The recipe to use is **12SDLTOA** and the duration should be 2 hours (~1.5 to 2 µm).

Bonding:

1. Cut a small piece of 3M™ tape, big enough to cover the entire backside of the die
2. Remove one side of the tape cover and gently lay the tape onto the handle wafer
3. Make sure that there's a good adhesion between the wafer and the tape
4. Remove the top cover of the tape
5. Align the die with the exposed tape; bond the two together with gentle pressure.
6. Place the bonded pair in techincs-c or centura loadlock under vacuum condition for 15 minutes just prior to your etching. Remove and inspect bonded die on the handle wafer. Ensure all is well.

Debonding:

After etching, place the bonded pair in acetone, or make a sulfuric acid bath to separate the die from the handle wafer. This process can take up to an hour. Excessive force used in the debonding of pair is not recommended.

IV. Thermal Release Tape

Thermal release tape (**Revalpha** by Nitto Denko, or **Rexpan** by Haeun Chemtec) is a unique adhesive tape that may be used to temporarily bond a die to a silicon handle for etch processing. The device substrate may then later be separated from the handle by simply applying heat. In this way devices are less susceptible to damage during the debonding step. Double-sided heat release tape consists of an acrylic adhesive layer, a polyester base layer, and a heat sensitive acrylic adhesive layer. The heat sensitive layer is available in several select temperatures for heat release, however only the 170°C variety is allowed for use with STS and Centura DRIE processing. Note deep silicon etches at Centura and STS can actually produce enough heat to debond the tape. This tape is therefore not recommended for long etches.

ADVANTAGES: Easy bond and release.

DISADVANTAGES: Not for use with long etches. Thermal conductivity poor. Cannot be used with wafer size substrates. Only for use with small dies.

***Equipment*:** Sink6, Tystar12, scissors, razor blade, Technics-C, hotplate, oven

***Summary*:**

1. Pre furnace Clean.
2. LPCVD 1-2 µm SiO_2 on handle wafer
3. Apply Revalpha double-sided tape to handle wafer
4. Bond the device wafer to the handle wafer.
5. Pump down in a vacuum check for bonding integrity
6. Hotplate for removing the device wafer from handle wafer after etching

***Detailed Procedure*:**

Handle Wafer Preparation:

1. Sink 6 piranha clean for 10 minutes.
2. Rinse and dry the wafers.
3. Deposition of LTO on the handle wafer using Tystar12. The recipe to use is **12SDLTOA** and the duration should be 2 hours (~ 1.5 to 2 µm).
4. Revalpha double- sided tape should be applied only in the center of the handle. This guards against the possibility of the die debonding and falling off the handle during processing.

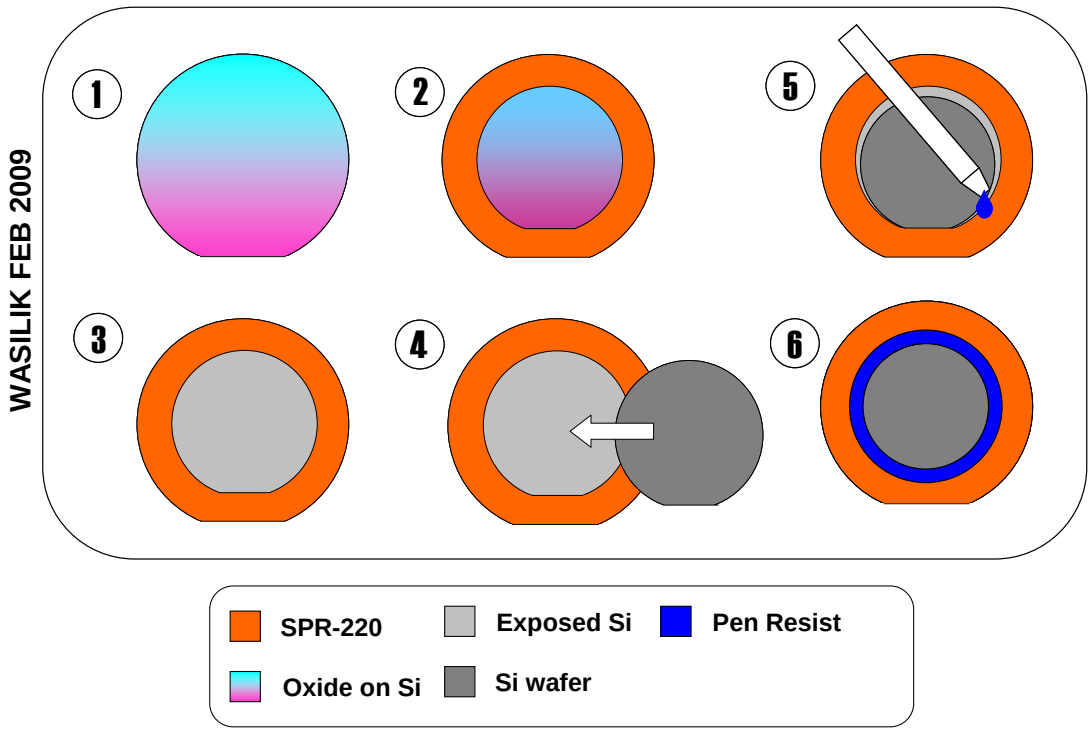
Bonding:

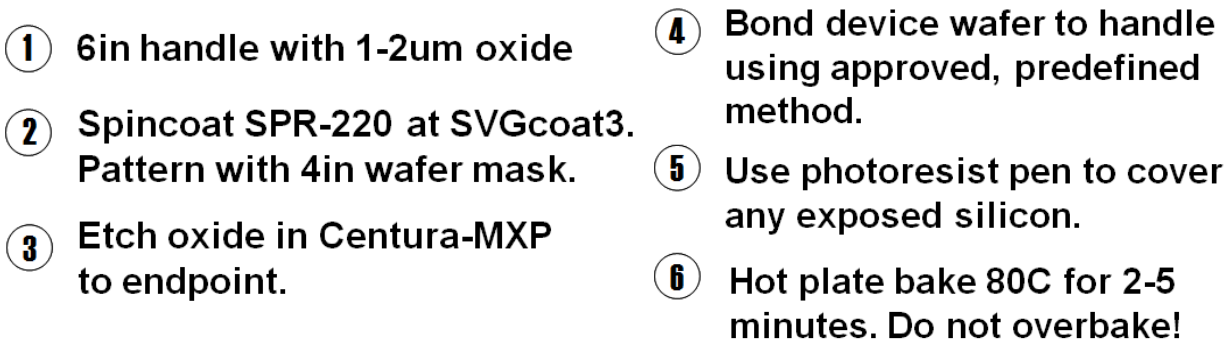
1. Align the device wafer to the tape at center of handle wafer. Firmly press the two together. Ensure no heat release tape will be directly exposed to plasma during the subsequent etch. Trim with razor blade around device as necessary. Exposed tape is not allowed in etch chamber.
2. Place the bonded pair into a vacuum chamber for 15 minutes (e.g. Technics-c). This helps to ensure that the bond is tight, and allows any trapped air bubbles to escape from the interface. Verify that the bond looks okay before proceeding with processing.

Debonding:

1. After processing, place the bonded pair onto a hot plate or into an oven with the specified temp of the release layer. Allow time for uniform heating. The device substrate should debond from the handle with relative ease.
2. The non-heat release acrylic adhesive layer side will still be stuck to the handle. Note that the exposed acrylic adhesive should never be placed into any etch chamber. At this point clean or discard the handle if necessary.

V. 4-inch Wafer Handle Bond for 6-inch Through-Etch Processing





The schematic above illustrates standard method of bonding a 4 inch wafer to a 6 inch handle for a etch-through-wafer application. Removal of oxide in step 3 promotes better thermal conductivity to the device wafer. Ensure that all exposed silicon on handle is covered before etching. *Failure to do this may result in handle being etched!* A resist pen works well to quickly cover any exposed silicon. Simply draw resist on exposed areas, then perform quick hot plate bake to remove solvent - 80°C for 2-5 minutes. Excessive baking of the pen resist will make it difficult to strip later.

MOD 36

Fusion Bonding

***Purpose*:**

Two silicon wafers can be bonded by allowing primary hydrogen bonds to form between their surfaces when brought into contact, and then by annealing the bonded pair at high temperature to create Si-O-Si bonds. Oxidized silicon wafer can also be bonded in this way. See Si-Si Fusion Bonding Process Flow Chart .

***Equipment*:**

KSBA6 for alignment and pre-bond. Tystar4 for nitrogen anneal.

***Summary*:**

1. Clean wafers in piranha bath and HF dip.
2. Bond pair alignment and pre-bond can be done in the KSBA6. Make sure the Si fusion upper chuck, and the bottom vacuum bond chuck with rubber seal is properly loaded. The alignment gap, pre-vacuum, vacuum and purge times need to be entered in the silicon fusion pre-bond program.
3. Anneal bonded pair in Tystar4: 1050ºC for 1 hour.

MOD 37

Standard Anti-Reflective Coating for DUV Process

Rohm Hass AR3-600 DUV Bottom Anti-Reflective Coating (BARC)

***Purpose*:** To minimize DUV light reflection from a highly reflective layers such as: aluminum or poly-Si by applying the AR3-600 material under the UV resist layer. This particular Bottom Anti-Reflective Coating (BARC) manufactured by Rohm Hass Company is compatible with our standard UV-210-0.6 resist, and can enable submicron lithography on a highly reflective layer for our DUV process.

Equipment: SVGCOAT6, SVGDEV6

Time of Execution: 2 minutes per wafer

Summary:

1. Dispense 600Å of AR3-600 bottom anti-reflective coating (BARC) on the wafer.
2. Spin coat the BARC material at 3750 R.P.M. for 30 seconds on SVGCOAT6 track, as per equipment manual, Chapter 4.24 (BARC recipe, program4).
3. Bake the AR3-600 bottom Anti-reflective coating at 205ºC for 1 minute to cure it, before the application of UV-210-0.6 resist on top.
4. DO NOT use adhesion promoter such as HMDS between the BARC and photoresist.

Detailed Procedure:

1. Obtain small 50 ml. bottle of AR3-600 DUV BARC material from the refrigerator and allow it to warm up to room temperature.
2. Enable SVGCOAT6 and SVGDEV6.
3. Verify system powers are on for both the coater and the developer tracks.
4. Adjust temperature of the second hot plate (farthest on the left) on SVGDEV6, the developer track to 213ºC (an 8ºC offset is currently needed to correct for required bake temperature of 205ºC for the AR3-600 BARC material on this particular bake station).

   Note: Temperature can be adjusted/set by pressing the black square button and turning the dial knob on the temperature controller unit (farthest one to the right in front of the SVG8800 machine). Releasing the button will display the actual temperature on the hot plate.
5. Press the CLEAR button to silence the alarm on control panel 4 on the SVGDEV6 track, while the temperature is ramping to the set point of 213ºC. You can now start coating the AR3-600 BARC material on the coater side of the SVG8800 machine.
6. Verify the SVGCOAT6 track is in AUTO mode.
7. Press INDEX RESET buttons on SVGCOAT6 track until the cassettes are all up.
8. Lift all cassettes and replace them.
9. Lift coater cover off on SVGCOAT6 and put it aside.
10. Skip HMDS prime program by selecting program#9 on control panel 1 of the SVGCOAT6 track.

    Note: HMDS is not needed for coating AR3-600 BARC on substrates, as well as under the resist layer that will later be applied on the BARC layer.
11. Skip soft bake station by selecting program 9 on control panel 2 of the SVGCOAT6 track.
12. Choose Program #4 coat program on the control panel 2 of the SVGCOAT6 track.

    Note: Program 4 allows for manual dispensing of the BARC material (hand dispense out of the bottle, static mode) at the first step of the program with no arm programs involved.
13. Load clean dry wafers in the send cassette indexer of SVGCOAT6.
14. Press the START button on control panels 1and 2.
15. Draw 1 full pipette (use a 7 ml. disposable pipettes from our lab supplies) of the AR3-600 DUV BARC material, and when the wafer gets on the wafer chuck and consequently drops down into the catch cup, immediately dispense the full pipette of AR3-600 DUV BARC material onto the center of the wafer (squeeze the pipette reservoir gently to avoid bubbles). Draw another full pipette of the AR3-600 DUV BARC and dispense it onto the wafer before the wafer starts the spin coat.

Note: The BARC solution should cover about 2/3 of the wafer, and you have 15 seconds to dispense about 7 ml. solution without major bubbles.

16. Put the coater cover back on, immediately after dispensing the BARC.

    Note: AR3-600 should go to a spread cycle and then spun at 3750 R.P.M. for 30 seconds.

17. Repeat steps 15 and 16 on the consequent wafers coming into the coater module (wafer on the chuck), until all wafers are all coated with 600Å of the AR3-600 BARC.

    Clean the bottle neck with a texwipe to make sure there is no AR3-600 BARC on it. Put the cap back on and put the bottle back in the refrigerator. Dispose the unwanted/used plastics pipette in the trash can which has a cover in the room.

    Note: If bottle neck is not cleaned and when AR3-600 Anti-Reflectant dries up; it will turn into particles. These particles can migrate into the solution and cause defects on your wafers during consequent BARC coating.

18. After wafers transfer to the receive cassette, press the INDEX RESET button. You are now ready to bake (cure) the BARC layer.

19. Transfer the BARC coated wafers to the send cassette of the SVGDEV6 (develop track).

20. Skip the PEB (first bake) station by selecting program 9 on control panel 3 (SVGDEV6).

21. Skip the develop module by selecting program 9 on control panel 4 (SVGDEV6).

22. Choose program #4 on the hard bake oven, second bake plate on SVGDEV6 track.

    Note: The program should be 60 seconds contact bake and temperature at 213ºC on the display.

23. Press the START button on control panel 4, when the temperature reaches the set point of 213ºC on the display (SVGDEV6).

24. After wafer transfers to the receive cassette, press the INDEX RESET button to bring the cassette up.

25. Unload all the wafers and replace the cassette on the indexer.

26. Set all the programs back to default programs on SVGCOAT6 and SVGDEV6.

27. Set the temperature back to 120ºC on the hard bake oven on SVGDEV6 (default value).

28. Press the CLEAR button to silence the alarm on control panel 4 on SVGDEV6.

29. Follow Chapter Manual 4.24 - SVG 8800 Coat Track (6"), the SVGCOAT6 instructions to coat the Rohm Haas UV210-0.6 DUV Positive Photoresist on top of the BARC.

    Note: Allow BARC coated wafers cool down to room temperature before coating resist. HMDS treatment is not needed before coating the UV210-0.6 DUV Positive Photoresist.

30. Follow Chapter Manual 7.6 - Centura® MxP+ Chamber instructions to etch away the BARC from open areas of the exposed resist, if needed (MXP-BARC-ETCH recipe). Most etch recipe, however can cut through the thin BARC layer, as well as their target material with a very little penalty on the resist selectivity (~1000 resist loss due to BARC layer etching). This is true for standard poly, aluminum and oxide etch recipes in the Lams etchers and the Centura machine.

31. Follow Chapter Manual 4.28 - Matrix 106 Resist Removal System (asher) instructions to strip AR3-600 anti-reflective coating. It can be stripped with the standard ash recipe in one minute.

MOD 38

ITO Deposition by Reactive Thermal Evaporation

Purpose:

High quality Indium tin oxide films can be prepared by reactive thermal evaporation of In-Sn metallic source material in the presence of a partial pressure of oxygen gas and elevated substrate temperature. These films have transmission as high as 98% in the visible spectrum and resistivity 2×10^{-4} Ω·cm. A detailed report is available on the Microlab web page.

Equipment:

The nrc thermal evaporator is used with the heated sample plate installed and a partial pressure of oxygen gas controlled by the piezo leak valve.

Summary:

1. Load a fresh charge of In-Sn (10 at. wt. %) into a boron nitride (BN) crucible and place in a tungsten basket heater.
2. Install the heated sample plate in the nrc.
3. Set the oxygen partial pressure to 0.25 mTorr.
4. Evaporate film.
5. Remove the heated sample plate from nrc.

Detailed Procedure:

Prepare the Chamber:

1. Load the tungsten basket heater (R.D. Mathis P/N B8A-3X.030W) into the nrc electrodes.
2. Place ~1 g of In-Sn (10 at. wt. %) source material (ESPI Metals P/N KNC6069) into a BN crucible (R.D. Mathis P/N: C1-BN).
3. Replace the chimney and locate the heated sample plate in the cabinet near the nrc.
4. Attach the molex connector on the sample plate to the connector on the feed-through on the left side of the chamber.
5. Attach the thermocouple wires to the thermo couple feed-through at the front of the chamber. The marked wire on the thermocouple should be connected to the positive lead.
6. Place a wafer on the sample plate. Partial or broken wafers should not be used as they will lead to contamination of the halogen bulb. Report any contamination of the bulb as a fault on the wand.
7. Place the thermocouple in firm contact with the back side of the wafer.
8. Seal the chamber and begin pumping.

Deposit Film:

1. Press SEL once on the temperature controller to enter the programming mode.
2. Use the up arrow to set the temperature setpoint to 347°F (175°C).
3. Press SEL again to enter the setpoint and begin ramping the temperature.
4. Allow the chamber to reach the desired base pressure.
5. Move the Gas Select valve to the O2 position.
6. Open the Gas Delivery Valve.
7. Turn on the DC power supply and adjust the voltage until the pressure reaches 0.25 mTorr.
8. Configure the crystal thickness monitor with the nominal ITO values: density = 7.1 g/cm^3 and Z-factor = 0.439.

9. Turn on the filament and slowly ramp the current to 48-50A.
10. Open the shutter and deposit a film of the desired thickness.
11. Close the shutter.
12. Turn off the DC power supply.
13. Close the Gas Delivery Valve.
14. Turn the Gas Select valve to OFF.
15. Press SEL on the temperature controller.
16. Change the setpoint to the minimum value.
17. Press SEL on the temperature controller.
18. Allow the system to cool below 95°F (35°C).
19. Remove wafer and return the heated sample plate to the cabinet.