# PROCEDURE OVERVIEW

1. Log in to Mendix
2. Prepare, clean, and check sample and dummy wafer
3. Vent Loadlock, load dummy wafer & quartz cover ring
4. Run conditioning process, 20-50 cycles (incl. pump, transfers, and vent)
5. Load desired sample & quartz cover ring
6. Modify loop count of recipe as needed
7. Run recipe (incl. pump, transfers, and vent)
8. Unload sample, place cover ring back in container
9. Pump loadlock, run appropriate cleaning recipe

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## CRITICAL PRECAUTIONS AND COMMON MISTAKES

- Mendix login restricts chamber venting
- **MATERIALS restrictions:**
  - **No exposed metal:** There has not been an exception to this in recent memory. Cr is not an acceptable mask material for this tool in its current configuration. Sputtering of these metals can result in redeposition on other users’ samples, and cause micromasking during their processes.
- **SAMPLE restrictions:**
  - Samples must be 100mm **non-insulating** wafers, or must be mounted on a 100mm non-insulating wafer
  - Sample height at edge of 4” wafer must be <1.2mm
- **Procedure restrictions**
  - **Recipe modifications:** Do not modify recipes: any parameters of recipe 1-4 (standard processes) aside from loop count, or of cleaning recipes 94/98/99 other than the time of step 2
  - **Double-Glove:** When loading/unloading samples, don an additional set of gloves immediately before touching the wafer or cover ring. Grease/electrolytes on your gloves (from your phone screen?) will transfer into the chamber, and contaminate other users’ samples
  - **Wafer Edges:** If processing whole wafers, remove the edge bead **within 3mm of the wafer edges**; if processing piece-parts, make sure no part of the sample is within 3mm of the edge of the carrier.
  - **Wafer Backside:** backsides of wafers must be clean of resist, and must be particulate-free. Particulates can damage the electrostatic chuck, and prevent your sample from being clamped correctly during your process
- **Processing:**
  - **Each new process must be approved by the MNFL staff**
  - Many parameters will affect your etch rate in addition to the recipe parameters themselves:
    - feature size, proximity to other features, global % of wafer exposed, local % of wafer exposed, use of a carrier wafer, degree of contact to carrier wafer, and others
  - **Cover Ring:** Handle the cover ring extremely delicately! Roughly closing the lid of its enclosure, loading it upside-down, and dropping it onto the transfer arm have destroyed them in the past. They are $1200 apiece, and have replacement lead times of 6 weeks...

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### Before you start

- Your Mendix reservation should take length of conditioning & cleaning processes into account
- Your wafer edges (outer 3mm) and backside should be clean of resist and particles
- LLC should be pumped down
- Previous user’s cleaning process should have been completed
### Tool condition for the next user:
- LLC pumped down, cleaning process started with plasma lit
- Logbook filled out, logbook back on logbook table

### Metrology you SHOULD be doing. We cannot help debug processes without this
- Resist thickness measurements pre/post-etch, at center & 2cm from center (use reflectometer; ellipsometer dead zones may be problematic). Measure near critical features, use same spots before/after. Use same reflectometer objective lenses before/after
- Etch depth of critical features (profilometer), near the 2 spots you performed optical measurements
TOOL OVERVIEW

The SAMCO 800iPB DRIE is designed to perform deep, high-aspect-ratio of Si using Bosch processes. It has also been used for shallow etching of Si through user-generated custom processes.

The tool has 2 RF generators, a 3kW ICP generator, and a 500W (?) bias generator. It is plumbed with SF6, C4F8, Ar, O2, and CF4, can run processes between 0.5-40Pa (~4-300mTorr), is equipped with an electrostatic clamp, and a He backside cooling system. The system is loadlocked, and is capable of accommodating 100mm wafers, as well as smaller samples (mounted on 100mm wafers).

The system is controlled via touchscreen, with a physical ‘jog wheel’ and ‘set button’ for changing parameters. Data logging is accomplished by serial communication to an external laptop PC.

FULL PROCEDURE

A) Start up and Login

Log in Via Mendix

a. The loadlock will not vent if you’re not logged in.

NOTE: There is no visible indication on the tool that you’re logged in

Check Tool Condition

1) Check for messages and status indicators on main screen
   a. Check for blinking status indicators, at the bottom of the main screen
   b. Check for messages in the MsgBox, at the top of the main screen

2) Check the chamber pressure on main screen
   a. DG1 [Pa] indicator in upper-center of main screen (bottom number should be 0.00)

3) Check Loadlock pressure on main screen
   a. XG [Pa] indicator near right side of Main screen (should be near ~1E0 Pa)

4) Check the user
   a. From the Main screen, Press SET at top-left corner to enter the Mode screen

5) Under Login Status, (top-left of mode screen) ensure “User Name” is set to USER. If not, notify MNFL staff
Vent loadlock (LLC)

1) Select the LLC Vent Process Step
   a. Go to Mode Screen
   b. Ensure only the LLC vent ‘Auto Sequence’ step is selected
      i. Under “Auto Sequence” on the left side of the screen, touch the ‘Auto Sequence’ steps to select/deselect.
      ii. Select LLC vent before deselecting the others
   c. Go to Main Screen

2) Run Selected Auto Sequence Steps
   a. Press and hold RUN for 3 seconds to start the process.
      i. System will beep once when process starts
      ii. You should see the “XG [Pa]” (circled, blue) indicator increase to ~1E3, then quickly decrease again, a few times. This will be followed by an increase to 1E5, atmosphere.

NOTE: if system fails to vent and gives an error in the MsgBox, you likely forgot to log in via Mendix. See Appendix E to resolve issue

Sample Loading: *MOUNTING STEPS are discussed during staff training*

1) Find a 100mm carrier wafer, if using piece-parts
   a. For predictability in processing, uncoated 100mm Si wafers are typically used
   b. If performing a through-wafer etch on a piece-part, a photoresist-coated Si wafer, or ALD Al2O3-coated Si wafer, should be used instead

   *NOTE: The carrier must be electrically conductive to be electrostatically clamped to the chuck.*

2) Clean (isopropanol/N₂) exposed areas of the front/back of the carrier wafer to remove residue
   a. Use the N2 gun located across from the tool

   *NOTE: Particulates compromise the seal between the carrier and the He-backside-cooled chuck.*

   NOTE: if using full wafers coated with photoresist, you must perform an edge-bead removal procedure to eliminate thick resist from the edges and backside of the wafer. These will char onto the cover ring or the ESC, causing the next user to be unable to use the tool

3) Secure the sample to the carrier
   Details covered in staff training
4) **Prepare your workspace for loading**
   a. Open hasp for cover ring
   b. Ready your wafer for placement
   c. Ready your tweezers (if necessary)

![Figure 8. Cover ring carrier. Open hasp in the center, carefully](image)

5) **Open the load lock chamber door**
   a. Press the two Open buttons on the panel just below the load lock (once at atmosphere); these have a spring-loaded plastic lid that you must flip up

![Figure 9. Buttons located on front of tool. Press both at once.](image)

6) **Don second pair of gloves**
   a. Immediately before touching items which are going into the chamber

![Figure 10. Wafer centered, in correct orientation, on robot arm](image)

7) **Place the carrier on the robot arm.**
   a. Make sure it is properly centered, with the flat facing you

![Cross-section of cover ring: Lip-side up. Will feel like “texture-side down”](image)

8) **Place a cover ring (ceramic or quartz) on the carrier, center it**
   a. Carefully pick it up, blow off with N2, and verify correct orientation
      a. place with flat facing you

   NOTE: Cover ring protects an exposed region of the chuck in the process chamber, and keeps CFx polymer from building up in helium ports. **Do not run an etch process without it**

![Figure 11. Correct orientation of cover ring. Upper lip will cover edge of wafer.](image)

9) **Close the load lock door**
   a. Check door o-ring and its mating surface for particles/obstructions
   b. Press both buttons simultaneously and hold

![Figure 14. Cover ring centered, in correct orientation, on robot arm](image)
Recipe Editing and Sample Etching

Users do not have permission to modify recipes, and may only change the “loop count” of the main etch (i.e. the etch depth) in standard recipes.

Superusers: If recipe changes are required, notify the MNFL staff. Poor planning can damage the tool. e.g. long runs using SF6 without some O2 can damage the turbopump.

- NOTE: never turn off the electrostatic chuck or He backside cooling components of the recipes, unless directed otherwise.

1) Edit loop count of desired recipe
   a. Select the recipe: Press SET (touchscreen)→ Edit (top-left of touchscreen), Recipe (touchscreen), change recipe # by using jog wheel, lock in selection by pressing Set (physical button)
   b. Change Loop count: Press step number of interest
   c. Press “loop count” parameter box
   d. Use jog dial & set button to change value

2) Check recipe parameters at each step (recipes 1-4 shown at right)
NOTE: changing the loop count for “Group B” means that “all steps included in Group B will be run x times, in a loop”

***NOTE: for the standard recipes supplied with the tool (e.g. 20um Trench), “Group A” is a descum step. Check through every step in the process before changing loop counts, to be sure of which sequence you wish to modify

Figure 15. Recipe Edit screen with relevant regions highlighted. If using standard recipes (2&3), make sure you don’t change the loop count of Group A! Group A is typically a resist descum step.

20u Pill (recipe 1)
ESC: 500V, 2000Pa
Step 1 (descum): 140/10 O2/SF6, 1500/300W, 100%, 15s
Step2: 100*/100/5 SF6/C4F8/O2, 600/10W, 100%, 2s
Step3: 100/5 SF6/O2, 600/40W, 100%, 2s
Step4: 100/100*/5 SF6/C4F8/O2, 600/10W, 100%, 1s

20u Tren (recipe 2)
ESC: 500V, 2000Pa
Step 1 (descum): 140/10 O2/SF6, 1500/300W, 100%, 3s
Step2: 100*/100/5 SF6/C4F8/O2, 1000/10W, 100%, 2s
Step3: 100/5 SF6/O2, 600/50W, 100%, 2s
Step4: 100/100*/5 SF6/C4F8/O2, 600/10W, 100%, 1s

200u Tren (recipe 3)
ESC: 600V, 2000Pa
Step 1 (Descum): 140/10 O2/SF6, 1500/300W, 100%, 3s
Step2: 100*/300/10 SF6/C4F8/O2, 2000/10W, 100%, 2s
Step3: 100/10 SF6/O2, 500/120W, 100%, 2s
Step4: 400/10 SF6/O2, 2000/10W, 100%, 4s
Step5: 400/300*/10 SF6/C4F8/O2, 2000/10W, 100%, 1s

450nm SE (recipe 4)
ESC: 750V, 2000Pa
Step 1 (descum): 140/10 O2/SF6, 1500/300W, 100%, 4s
Step2: 30*/50/2.0/30.00(?) SF6/C4F8/O2/SF6, 100/50W, 100%, 1s
Step3: 30/50*/2.0/30.00(?) SF6/C4F8/O2/SF6, 100/50W, 100%, 1s

*=GVV (bypass valve) enabled for this gas during this step

NOTE: descum step has been shown to remove ~800nm AZ4330 per minute
3) Select ‘Auto Sequence’ steps (Fig. 5)  
   a. Press Mode (touchscreen)  
   b. Select each ‘Auto Sequence’ function  
   c. LLC pumpdown, load sample, run etch, unload sample, LLC vent  

4) Select recipe  
   a. Press ‘recipe’  
   b. Use jog dial & set button to change value  

5) Run recipe  
   a. Press “Main” (touchscreen),  
   b. Verify that the correct recipe is loaded (circled)  
   c. Press and hold “Run” (2-3 seconds)  

6) Watch Helium backside cooling status, wait until plasma ignites  
   a. Verify that wafer passes the HBC leak check.  
   b. Ensure that DG2 (top value, circled) reaches the setpoint (middle value, circled), and that VPos (lower value, circled) equilibrates between 40-45%.  
   c. NOTE: If it doesn’t, you likely have contaminants on the back side of your wafer or the cover ring. If VPos >65% the process will abort, and your sample will unload. If VPos >45%, a minor leak may be present. Metrology is a MUST, in this case  
   d. Once the process steps begin running, look in the side viewport on the chamber, make sure plasma has struck (blue/purple light in viewport)  

7) Check operator screen to find logbook values:  
   a. He VPos (%)  
   b. DG1 (Pa)  
   c. CGV (%) (if non-Bosch) and TMP (RPM) (if Bosch)  

8) Record at the end of the long SF6 step of the Bosch process (step 3 for r2, step 4 for r3)  
   a. This can be tricky, watch the screen until the end of the step  

9) Check the datalogger program on the logbook PC to find the log # (4 digits, e.g. 4954)  
   a. Program should be running! Press the touchpad to wake up the monitor
## B) Run Chamber Clean process

<table>
<thead>
<tr>
<th>1) Wait until Process is finished</th>
<th>a. System will beep loudly two times and read “Auto Sequence Done”</th>
</tr>
</thead>
<tbody>
<tr>
<td>2) Unload sample</td>
<td>b. Open loadlock door (press both buttons simultaneously)</td>
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<tr>
<td></td>
<td>c. Remove cover ring</td>
</tr>
<tr>
<td></td>
<td>d. Gently place cover ring in wafer carrier. <strong>Ensure it is seated uniformly inside carrier before closing top.</strong></td>
</tr>
<tr>
<td></td>
<td>e. Remove wafer</td>
</tr>
<tr>
<td></td>
<td>f. Close loadlock door (both buttons)</td>
</tr>
<tr>
<td>3) Run chamber clean recipe (varies depending on the depth of your previous etch)</td>
<td>a. Press Set (touchscreen), then Edit</td>
</tr>
<tr>
<td></td>
<td>b. Find the recipe that corresponds to your etched depth:</td>
</tr>
<tr>
<td></td>
<td>a. recipe 98 (SClean) if &lt;20um were etched, recipe 94 (SLClean) for 20-100um etches, or LClean for &gt;100um</td>
</tr>
<tr>
<td></td>
<td>c. Change that recipe’s “step 2” time to be ~2/3 of your overall etch+condition time</td>
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<tr>
<td></td>
<td>d. Double-check that recipe’s “step 2” parameters:</td>
</tr>
<tr>
<td></td>
<td>a. <strong>Recipe 94: 300/30 sccm O2/SF6, 2 Pa, 1500W ICP, 0W Bias</strong></td>
</tr>
<tr>
<td></td>
<td>b. <strong>Recipe 98: 300/30 sccm O2/SF6, 2 Pa, 1500W ICP, 0W Bias</strong></td>
</tr>
<tr>
<td></td>
<td>c. <strong>Recipe 99: 300/30sccm O2/SF6, 3 Pa, 1500W ICP, 0W Bias</strong></td>
</tr>
<tr>
<td></td>
<td>e. Only select “LLC pumpdown”, and “Process”</td>
</tr>
<tr>
<td></td>
<td>f. Select appropriate Cleaning recipe</td>
</tr>
<tr>
<td></td>
<td>g. Press Main (touchscreen), then Run (press &amp; hold)</td>
</tr>
<tr>
<td>4) Wait until plasma ignites</td>
<td>a. Plasma should be blue/purple.</td>
</tr>
<tr>
<td></td>
<td>b. Once it ignites, you can leave the tool</td>
</tr>
<tr>
<td>5) Remove samples from your carrier wafer</td>
<td>c. See <strong>Appendix D</strong> for information on removing vacuum grease from your carrier wafer and sample</td>
</tr>
</tbody>
</table>

### Logbook and Logout

<table>
<thead>
<tr>
<th>1) Fill in logbook</th>
<th>End time, recipe #, data log file number (if you checked the laptop), and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2) Log out in Mendix</td>
<td><strong>Remember to log out in Mendix!!!</strong> Make note of any issues you had with the tool in the comments section</td>
</tr>
</tbody>
</table>
APPENDIX A: SYSTEM STARTUP

1) Press the green Main On switch on the front of the unit.
2) Once the computer boots up, login, press SET, then Mode
3) Select System Startup in the auto sequence box
4) Select Main, then and press and hold Run. The system will automatically turn on each of the pumps.
   o If an error occurs, press and hold Run again to continue the process.
5) Wait for system vacuum, signaled by a pair of beeps
6) Turn on and set the circulator temperature (???).
7) Wait 30 minutes for the chamber heaters to reach temperature.

APPENDIX B: SYSTEM SHUTDOWN

1) Log in to Mendix (and the tool)
2) Press SET then Mode
3) Press System Shutdown on the auto sequence box
4) Press Main, then press and hold Run.
5) System will automatically turn off all pumps and isolate the chambers.
6) Wait for system ready, signaled by a pair of beeps
7) Press red Main Off switch (front of tool)

APPENDIX C: HBC FAILURE

- If the helium backside pressure (V Pos > 65%) check fails during your process, the chamber will abort the process
  and leave your wafer in the chamber.
  o Wait for the abort procedure to finish (it will take a few minutes). Then run "Wafer unload" and "LL
    vent" to retrieve your wafer.
  o If there is no photoresist on the back of your wafer (again, there should never be photoresist or
    photoresist residue on the backside of your wafer), inspect your wafer for particulates and blow off any
    particulates with N2 or solvent clean your wafer.
  o If the helium backside pressure check continues to fail, alert a staff member.

APPENDIX D: REMOVING VACUUM GREASE FROM WAFERS

1. Toluene: fill a glass dish (diameter >1.25x that of your sample) with about ½” of toluene. Place your sample
   inside, grease-side up. Push it around with your tweezers to make sure the grease dissolves. Feel free to gently
   swirl the beaker. There is no time limit on this, toluene will not evaporate rapidly.
2. Place the acetone, methanol, and IPA bottles close by, have them ready to use in rapid succession.
3. Acetone: Pick up the sample with tweezers, and quickly spray both sides with acetone so that the liquid lands
   in your toluene dish. Keep spraying until you can no longer see the toluene mixing with the acetone on the sample
   surface. This may take a few seconds
4. Methanol: Quickly spray the sample with methanol, before the acetone is allowed to dry (acetone will leave
   residue if allowed to dry)
5. IPA: quickly spray the sample with IPA (less time-critical than acetone, but be quick enough to ensure the
   methanol doesn’t evaporate)
6. Blow-dry with N2: device-side first; quickly, to ensure you push the IPA off the sample, and that it doesn’t
   evaporate, leaving residue.
APPENDIX E: RECOVERING FROM FAILED VENT (LOGIN ISSUE)

- Attempting to vent the load lock chamber without logging in to Mendix causes the etcher to isolate the process chamber and throw an error
  1) Log in to Mendix (and the tool)
  2) Press "Buzz Off" (Main screen) to turn off the alarm.
  3) Follow the Startup instructions (from step 2) in Appendix A. Should take ~2 minutes to recover.

APPENDIX F: SYSTEM OVERVIEW

Hardware

(1) Computer Interface (Figs 2-4)

There are 3 screen displays that are regularly used:

- The **Main screen**, showing the status of the sub-systems (Fig. 3) at the bottom.
  - PS, FS1, FS2, FS3, and FS4 should be highlighted.
- The **Mode screen**, where the user logs in and sets up process runs (Fig. 4).
  - Operation Mode (lower right): tool should be in “Auto” mode, allowing ‘AUTO Sequence’ recipes (lower-left area) to be run
  - Login (upper-right): where users can select their profile and enter their password
- The **Edit Screen**, where the user edits recipes (Fig. 5). Normally, only the loop counts are modified.
Figure 4. The Set/Mode screen. There are 3 main sections, the login Menu, the Auto Sequence, and the Operation section. Normally, the operation mode should be “Auto”.

Figure 5. The Set/Edit screen. Users should only modify the “loop count” boxes in established recipes.

### Version history

<table>
<thead>
<tr>
<th>Draft</th>
<th>Date</th>
<th>Author</th>
<th>Notes on changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>v.0.1</td>
<td>November 15, 2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>v.0.2</td>
<td>November 22, 2016</td>
<td>Jin-Sung Kim</td>
<td>Filled in procedure overview, critical precautions and common mistakes, before you start, and tool condition for next user.</td>
</tr>
<tr>
<td>v.0.3</td>
<td>5/18/18</td>
<td>Eric Mills</td>
<td>Logbook, cleaning</td>
</tr>
<tr>
<td>v.0.4</td>
<td>7/17/18</td>
<td>Eric Mills</td>
<td>Recipe information</td>
</tr>
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