SPTS Si DRIE standard operating procedure

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DRIE, SPTS DRIE SOP, Deep Reactive Ion Etch, Si Deep Etching
Standard Operating Procedure (SOP)

SPTS DRIE

(DE-03)

In case of fire or injury please call 911 (511 from Penn phones)

If there is an error on the system/tool please report it on IRIS, the staff will take care of it

Please DO NOT run diagnosis without a staff member’s approval

General safety tips and common mistakes

1) If the system is not running, make sure you are logged into the tool on IRIS.
2) You MUST use cleaning wafer for conditioning and cleaning the chamber
3) Endure there is no more than 3 minutes of break between runs (conditioning, etch, cleaning), otherwise the main chamber cools down below acceptable operating temperature!
4) Backside of your wafer MUST be clean of any kind of resist or adhesive
5) Tool runs ONLY with 4” substrates. If your sample is smaller than a 4” wafer, you MUST use crystal bond to mount your sample to a 4” carrier wafer. Consult the staff before using crystalbond on your sample
6) If you have multiple wafers to run, you MUST run the chamber clean process after EACH wafer
7) DO NOT log out of the tool before the clean process is finished!
SPTS Deep Reactive Ion Etcher (DRIE)

- Primary tool owner: Sam Azadi.
  For questions regarding process development and characterization of etch rates contact Sam Azadi at: azadi@seas.upenn.edu
  Problems with the tool MUST be reported on IRIS. Do not contact primary tool owner with tool issues directly.

**Tool Policies:**

1. Not cleaning the backside of your wafer is considered tool misuse.
2. Not running the conditioning/cleaning recipe is considered tool misuse
SPTS Rapier is an anisotropic dry etch tool. The tool uses Bosch Process to etch silicon with high selectivity and nearly vertical sidewalls. Bosch process consists of two steps: 1) Deposition of a passivation layer, using $\text{C}_4\text{F}_8$ gas. This passivation layer is a polymer that protects the sidewalls from being etched. 2) A nearly vertical plasma etch step using $\text{SF}_6$. A bias is applied in the chamber that forces the ions to attack the surface vertically and etch through the passivation layer at the bottom of the trench, exposing the silicon underneath. That Si is then etched within the same step. The passivation layer is also deposited inside the chamber and the etch results in a layer of deposited polymer inside the chamber walls which makes it critical to run a cleaning recipe at the end of each etch run.

Shorter cycle times result in smoother sidewalls while longer cycle times achieve higher etch rate. The tool in QNF is connected to Ar, $\text{O}_2$, $\text{N}_2$, $\text{C}_4\text{F}_8$, and $\text{SF}_6$ gases.

A list of characterized processes and etch rates can be found here.

Tool video trainings can be found in the links below:

1. Introduction and wafer cleaning
2. Operating the tool
Full procedure:

- Log into the tool via IRIS

- If you need to log into the tool on the tool, click on the “Key” icon. And use “PENN_OPERATOR” as username and password both.

1. Inspect the conditioning wafer
   1.1. Click on the icon on the upper right corner of the screen.
   1.2. The following screen will appear
   1.3. Click on the “Transport” button on the upper left side of the screen. The LPX Station Control popup window will appear.
1.4. Click “**Vent**” on the LPX Station Control popup window. Click “**OK**”.

Once the loadlock finishes venting, the transport status reads atmospheric pressure and the color turns blue. At this point, you may proceed to the next step.

1.5. Open the loadlock and inspect the cleaning wafer. If the wafer feels too thin (~200 μm and less – or thinner than half of the thickness of a 525 μm wafer) change it with a wafer from the wafer box next to the tool, labeled as “DRIE cleaning wafers” and through the thin wafer into the sharp container.
Attention! Make sure the major flat of the wafer is aligned with the markers of the arm.

1.6. Pump the loadlock by clicking on “Transport”, then “Pump”. Click “OK”
2. Run chamber conditioning
   2.1. If the “sequencer” panel on the bottom left corner shows an icon, click on it. If this icon is deactivated, proceed to step 2.3

2.2. Click “Yes” on the following dialog box.

2.3. Click on the icon on the “sequencer” panel.
     A list of sequences appears.

2.4. Depending on your etch recipe select either “Prelot-Smooth” or “Prelot-Deep”.

Attention! The Prelot recipes must be ran before you run your etch recipe.
   - Failing to do so is considered tool misuse
Attention! You MUST run your etch recipe no more than 3 minutes after the Prelot recipe is finished. Failing to do so is considered tool misuse.

Attention! If it took you longer than 3 minutes between the end of conditioning and having your recipe started, you must run the conditioning again.

2.5. Click the button on the “Sequencer” panel.

2.6. The system will ask you if you are sure to run the recipe, click “Yes”. Give the wafer a number in the lot and click “Start”. The system will run the Prelot recipe and will bring the wafer back to the loadlock. Once that’s done, the tool will vent the loadlock.

Note: While running the Prelot recipe is the best time to clean the backside of your wafer(s) and have them ready.

REMINDER: here is a video to show you how to clean the backside of your wafer

2.7. Once the chamber conditioning process is done, the loadlock vents and you can take the conditioning wafer out and load your wafer
3. **Load wafer – Back side must be cleaned.**

   **Attention! Not cleaning the backside of your wafer is considered tool misuse!**

   3.1. Load your wafer with major flat aligned with the markers on the loading arm.

   Note: The tool ONLY runs 4” wafers. If you have a smaller sample, you must bond it to a 4” carrier wafer using crystalbond.

   - Consult the staff before using crystalbond.

   3.2. Close the loadlock lid.

4. **Edit recipe and run etch**

   4.1. Click on the icon on the right side of the screen. The “Recipe Editor” dialogbox appears.
4.2. Click on “**Module**” and then “**RAP**”.
- You will see the name of all the etch modules and their “class” in the box on the right.

4.3. Choose the desired module from the list

4.4. Click “Reclassify” and choose “Development”. Click “Ok”.

4.5. Double-click on your module and the following window with all the details of the module will appear.
4.6. Change the number of loops.

*Attention!* The number of loops is the *ONLY* thing you are allowed to change.

4.7. Change the class of the module back to production by clicking on “Reclassify” and choosing “Production”. Click “Ok”.

4.8. Click the icon on the sequencer panel on the bottom left side on the screen. And click “Yes” on the pop-up window.
4.9. Select the icon and choose your recipe from the “Select Sequence” menu. Click “OK” followed by clicking on . Click “OK” and “Strat” to start your recipe.

**Attention!** DO NOT leave the tool while it is running. You must monitor your recipe’s progress.

Note: there are two values to keep track of:

a) Helium backflow into the main chamber, and

b) Loop counter, that tells you where in the process you are.

You can track these from the process chamber window:

i) Click on the main chamber view icon on the top right on the screen. This might be blue or green color. or . The main chamber screen will appear

ii) Monitor He back flow and the loop counter, highlighted in the following pictures.
Attention! If the He back flow is larger than 10 sccm, please report the value as a “Problem Report” on IRIS. This will allow the staff to plan a cleaning step.

- We also recommend that you monitor the chiller temperature as well. In the ideal working conditions it should be ~ -5 to -4 °C

Once the process is complete, the tool brings the wafer out and vents the loadlock.
<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.</td>
<td><strong>Unload wafer and load cleaning wafer</strong>&lt;br&gt;5.1. Click on the icon from the top right corner of the screen.</td>
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<td></td>
<td>5.2. Once the loadlock vent is complete, the transfer window on the top left corner of the main screen turns blue, reads “Idle” and shows pressure values ~ 830 Torr</td>
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<tr>
<td></td>
<td>5.3. Open the loadlock, retrieve your wafer and place the cleaning wafer back on the loading arm.</td>
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<td></td>
<td><strong>Caution!</strong> Make sure the backside of the cleaning wafer is clean, and the wafer does not feel too thin</td>
</tr>
<tr>
<td>6.</td>
<td><strong>Run cleaning recipe:</strong>&lt;br&gt;<strong>Attention!</strong> If you are running multiple etch runs, you must run the clean recipe after each etch. If you have multiple etch runs, the clean recipe you choose vents the loadlock at the end so you can load your next process wafer.</td>
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<tr>
<td></td>
<td>6.1. Click the icon on the sequencer panel on the bottom left side of the screen. And click “Yes” on the pop-up window.</td>
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<tr>
<td></td>
<td>6.2. Select the icon and choose the appropriate cleaning recipe:&lt;br&gt;<strong>These recipes take ~ 8-9 minutes to finish</strong>&lt;br&gt;- For single run of the deep etch: <strong>IPC Deep - NO VENT</strong></td>
</tr>
</tbody>
</table>
- For multiple runs of the deep etch: 
  **IPC Deep - VENT**

- For single run of the smooth etch: 
  **IPC Smooth – NO VENT**

- For multiple runs of the smooth etch: 
  **IPC Smooth - VENT**

**Attention!** If you let more than 3 minutes between cleaning and next etch, you must rerun the Prelot recipe.

6.3. Click “OK” followed by clicking on 
  Click “OK” and “Strat” to start your recipe.

**Attention!** DO NOT leave the tool while it is running. You must monitor cleaning recipe’s progress and report if the He back flow is larger than 10 sccm.

- If you have multiple wafers to run, move to step 3.
- If you have only one wafer, you may proceed the next step

**Before you log out of the tool on IRIS, make sure the clean recipe is finished, the wafer is in the loadlock, and the loadlock is pumped down.**

Log out of the tool via IRIS once the pumping is done

Feel free to contact the staff members with any questions about your process and the tool.