

## OXFORD DEEP REACTIVE ION ETCHING



The Oxford Deep Reactive Ion Etching system is used for highly anisotropic etch processes, creating deep penetration, steep-sided holes and trenches in wafers/substrates with high aspect ratios. The main process used on the NCF system is the Bosch etching process, although other process can be programmed. The Bosch process can fabricate 90° walls, but often the walls are slightly tapered, e.g. 88° ("reentrant") or 92° ("retrograde").

The Bosch process alternates repeatedly between two modes to achieve nearly vertical structures.

1. A standard isotropic plasma etch is applied. The plasma contains some ions, which attack the wafer from a nearly vertical direction. Sulfur hexafluoride ( $SF_6$ ) is often used for silicon.

- Deposition of a chemically inert passivation layer that condenses on the sidewalls, and protects them from lateral etching. A metal or photoresist mask can be used to protect areas of the wafer not meant for etching. Octafluorocyclobutane ( $C_4F_8$ ) is often used for passivation.

## System of Procedures

Outside the cleanroom,

- Before going into the cleanroom, turn on the NESLAB HX300 chiller in the hallway. Place the system tag on the chiller.



- Open the Nitrogen tank in the hallway and place the Oxford DRIE tag on it.

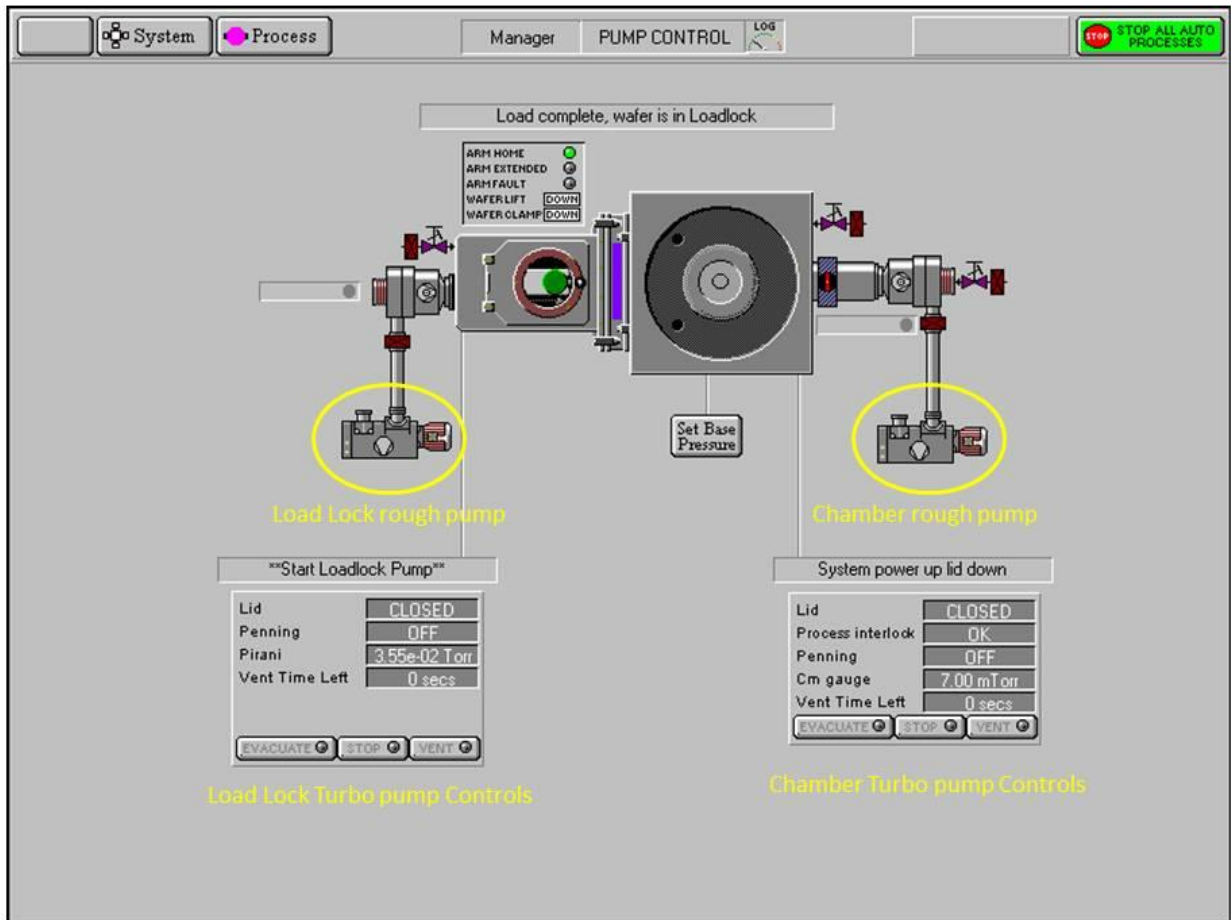


- Look through the window to make sure the yellow chiller amber light on the wall inside the cleanroom is on. The light should be on if the HX300 is running.

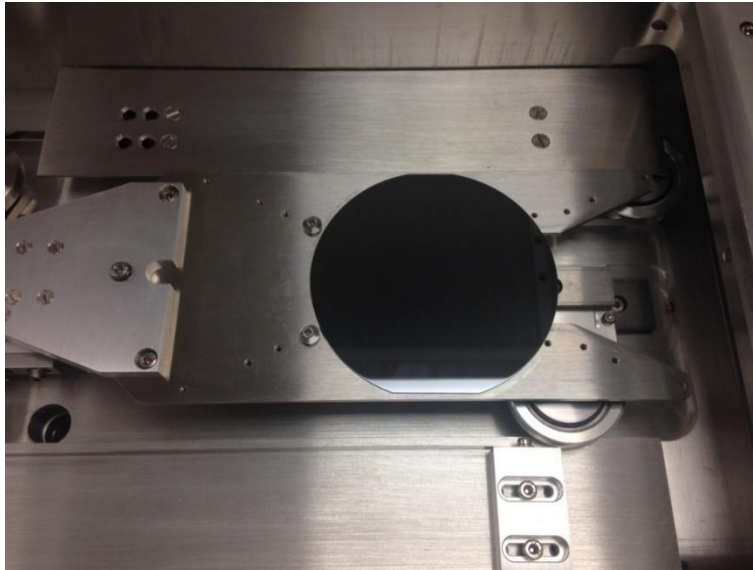
Once inside the cleanroom,



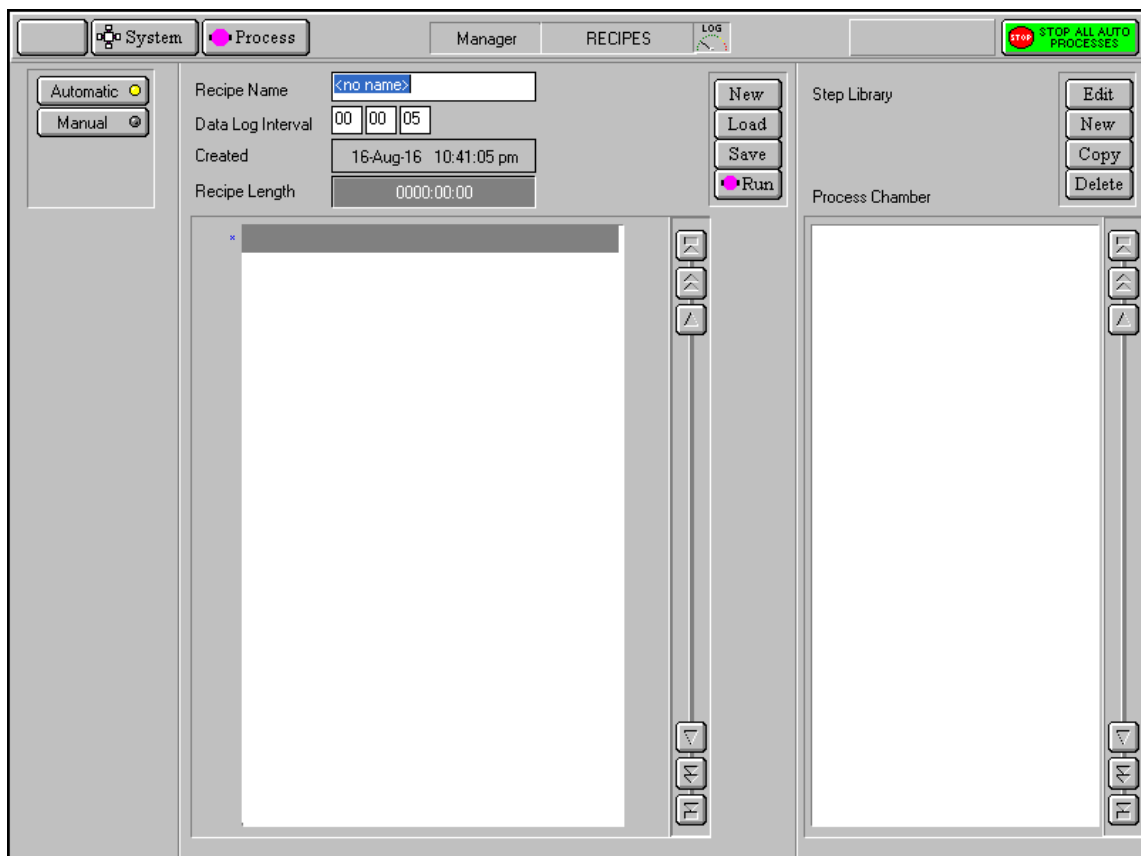
- Check the water level of the cleanroom chiller and add DI water if needed. Turn on the cleanroom chiller using the power button on the back. It displays a temperature lower than 20°C. Check the water level in the chiller.
- Turn on system power (Green button). It takes about 15 minutes after start-up for the chamber to warm up. **It's a good idea to run a chamber clean during this window in case the last user didn't clean it after running their process.**
- Start the computer and Oxford DRIE software and login. Personal login credentials are created after completing the training and checkout.



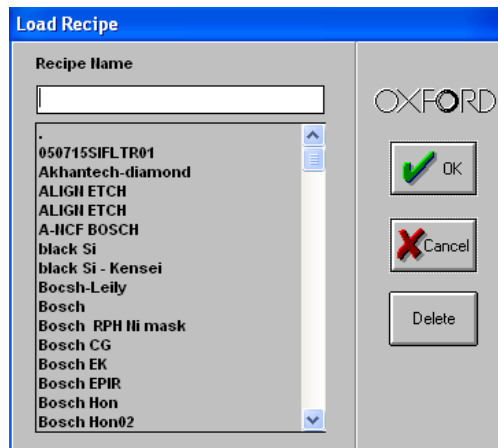
7. Using the mouse, click on the load-lock and chamber rough pumps to turn them on. The pump graphics will begin to show a smoke simulation, indicating the pumps are on.
8. Click the **STOP** buttons on the load-lock and chamber turbo pump controls. This step closes the valve between the mechanical pumps and turbo pumps, and stops the turbo pumps for the load-lock and the chamber.
9. Click the **VENT** button for the load-lock and click the **EVACUATE** button for the chamber. For the chamber, an indicator will show that the pump is accelerating and will become solid green when the turbo pump is at full speed (~27krpm).
10. On the load-lock control, when Pirani gauge gets to  $7.5 \times 10^{-2}$  Torr and **Vent Time Left** is below 60 seconds, you can open the load-lock.
11. Load wafer. The major flat of the wafer should be parallel to the bottom edge of the loading arm. The left side of the wafer should be a few millimeters away from the two metal pins. [It's a good idea to load a dummy wafer to run the Chamber clean process to allow the system to warm up.](#)



12. Click the **STOP** button on the load-lock controls, then click the **EVACUATE** button. An indicator will show that the pump is accelerating and will become solid green when the turbo pump is at full speed (~27krpm).
13. Click on Process >> Recipes. The recipe window will appear.

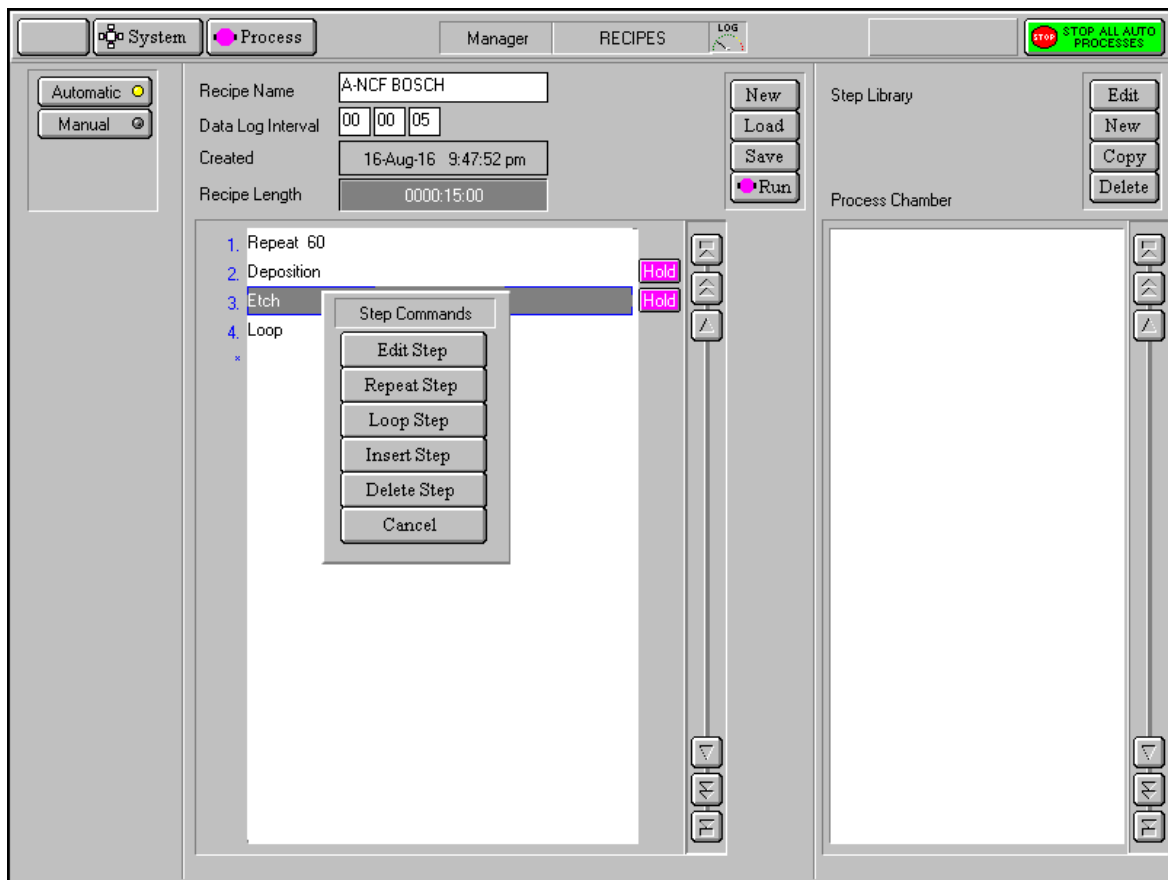


14. Click on **Load** to open up a saved recipe. To create a new recipe, skip to the section on recipe creation.

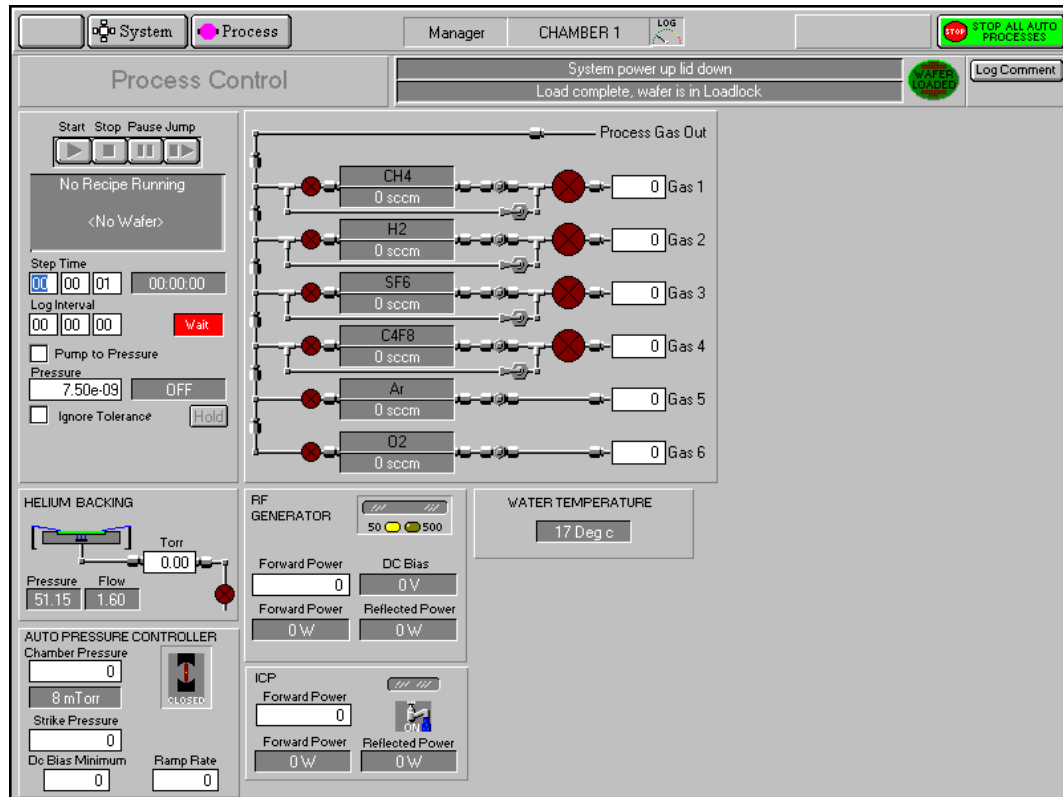


15. Click on the desired recipe and click **OK**.

16. To check the parameters of the recipe, click on a step and then click on **Edit Step**. The system will automatically switch to the recipe's parameters. Edit the necessary parameters and click **Ok**.



17. Click **RUN** to start the recipe. The system will switch to chamber view and start running the recipe.



18. *If the reflected power is high, you can try pausing the recipe using the **PAUSE** button in the chamber view. You can also try decreasing your process pressure.*
19. Once done, the system will automatically load the wafer back into the load-lock.
20. Click **Ok** on the prompt that appears saying the process was successful.
21. Click **STOP** on the load-lock controls and click **VENT**. When Pirani gauge gets to  $7.5 \times 10^{-2}$  Torr and **Vent Time Left** is below 60 seconds, you can open the load-lock.
22. To run another wafer, simply put it into the load-lock and repeat from step 11.
23. Once finished running your recipe, a chamber clean should be performed. Put in dummy wafer and run the **Chamber Clean** recipe.

## Turning Off the System

24. The chamber and load-lock should always be left under vacuum. Click **STOP** on the load-lock controls then click **EVACUATE** to leave it under vacuum.
25. When the load-lock pump is at speed  $\sim 27$  k rpm, click the **STOP** buttons on the load lock and chamber turbo pump controls.

26. Wait for the turbo pumps to get below ~3K rpm. Click on the load lock and chamber rough pumps to turn them off. The pump graphics will stop the smoke simulation, indicating the pumps are off.
27. Click on **System >> Exit**.
28. Turn off the PC and turn off the system (red button).
29. Turn off small cleanroom chiller.
30. Close the Nitrogen gas outside in the hallway and put the tag back in its place.
31. Wait 30 minutes before turning off the HX300 NESLAB chiller.

### Creating a Recipe

32. To run a recipe using the Bosch method, your recipe should have the following steps in the same order.
  - a. Repeat – this tells the system to repeat the process
  - b. Passivation – this the passivation step that deposits the polymer
  - c. Etch – this is the etching step
  - d. Loop – this loops the process

**Note: that the total etch time is the time programmed for the etching step only.**

33. Click on the blank space in the recipe window. A menu will pop up. Click on **Repeat**. The window below will pop up. Enter the number of cycles the Bosch process will run.
34. Click below the new recipe item. Click on **Insert Step**. A blank chamber view will open. Name the step Passivation. Enter values for the parameters in the table below. Click Ok when done.

Parameter	Meaning
Time	Actual time for etching or passivation
Log Interval	Time before etching, or passivation step begins; allows for stabilization of the reflected power.
Process Gas	Enter flow rate for the gas needed in the step
Forward Power	Power for the step
ICP Forward Power	ICP power for the step
Pressure	Chamber pressure for the step
Helium Backing	Enter flow rate for Helium backing of the sample



35. Click below the new recipe item. Click on **Insert Step**. A blank chamber view will open. Name the step Etch.

Enter values for the parameters in the table above. Click Ok when done.

**NOTE: You may insert a cooling step after the etching step in which the recipe lets the sample cool for a few seconds or minutes. This helps make sure that your photoresist doesn't heat up too much and become hardened, making it difficult to remove after etching. This is helpful especially when using thin photoresist as a mask.**

36. Click below the new recipe item. Click on **Loop**.

37. Enter a name for the recipe and click on **Save**.

### Recipe example

Repeat 60

Passivation

Etch

Loop

Cooling

Parameter	Passivation	Etch	Cooling
Time	5 seconds	10 seconds	1 minute
Log Interval	4 seconds	5 seconds	5 seconds
Process Gas	$C_4F_8 = 100 \text{ sccm}$	$SF_8 = 100 \text{ sccm}$	-
Forward Power	20 Watts	40 Watts	-
ICP Forward Power	1000 Watts	1500 Watts	-
Pressure	30 mTorr	30 mTorr	30 mTorr
Helium Backing	10 sccm	10 sccm	10 sccm

Note that a cycle means the Passivation + Etch step. So a 60 cycle recipe will run 120 steps. The total etch time will be

$$60 \text{ cycles} \times \frac{10 \text{ seconds}}{\text{cycle}} = 600 \text{ seconds} = 10 \text{ minutes}$$