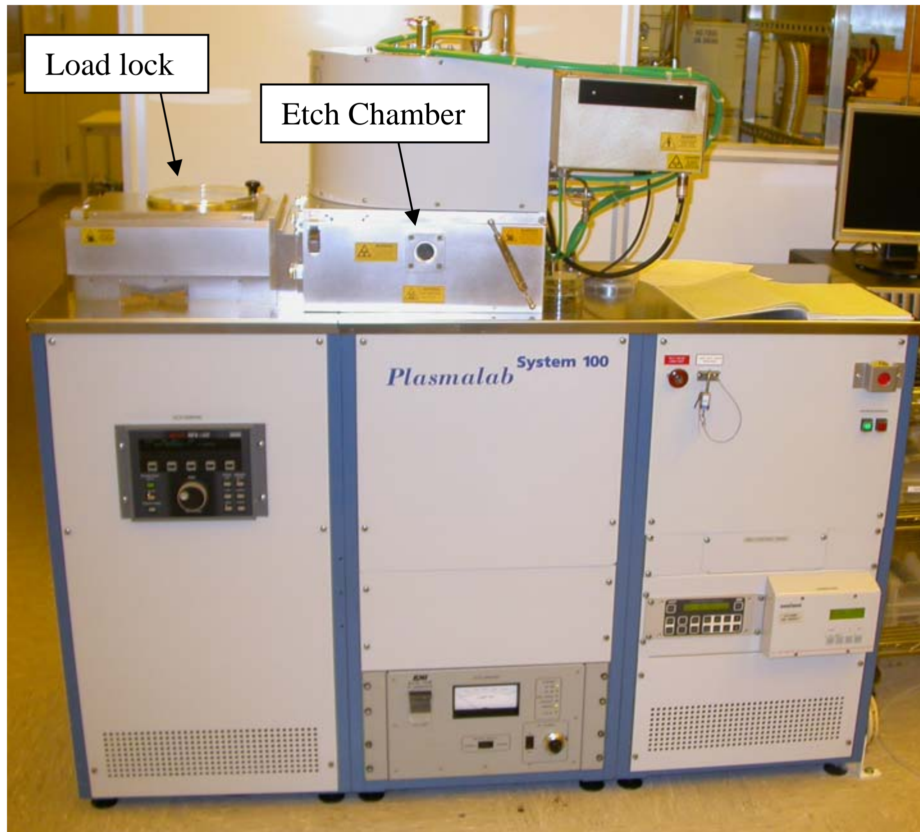
Oxford Deep RIE SOP



Purpose:

The Oxford PlasmaLab System 100 is used to etch deep anisotropic trenches in silicon substrates using the patented Bosch process. An inductively coupled plasma (ICP) generates a very dense plasma near the top of the electrode. A 2nd RIE generator which is capacitively coupled to the wafer chuck is used to independently bias the substrate. In this way, high selectivities and high etch rates can be obtained. The Bosch process uses alternating depositions and etches to maintain very low undercut and nearly vertical sidewalls. However a slight rippling of the sidewalls results from this sequence (individual ripples are called "scallops") and also results in the deposition of a Telfon-like fluorocarbon polymer which must be removed subsequent to the etch. The standard Bosch process chemistry can only etch silicon (or polysilicon/amorphous silicon). The system is by default set up for processing 4 inch wafers.

IMPORTANT Guidelines:

- ONLY SILICON etching is permitted. Etching of other materials can compromise the internal lining of the chamber leading to irreversible contamination and degradation of etching efficiency. On a similar note, there is a single standard recipe for etching silicon that all users will use. In the event that you would like to create a new recipe, please consult the cleanroom manager or superuser and obtain approval **before** your run. You need to justify the purpose of the recipe.
    - **Available recipes:**
        - Bosch-Condition: conditioning recipe (5 min)

- Bosch-120: calibrated Bosch etch process 120 loops or less
- Bosch-480: calibrated Bosch etch process 480 loops
- Clean: O_2 plasma chamber cleaning recipe

- **Approximate etch rate for Bosch Process**
  - **120 Loops (0.3 μm/loop, 40 μm etch depth)**
- **Approximate etch mask selectivity**
  - **Photoresist – 50:1**
  - **Silicon dioxide – 100:1**

- Masking materials are limited to standard photoresists and SiO_2. Absolutely no metals are permitted in the system as they can sputter and redeposit elsewhere. The usage of metals a major cause of contamination in DRIE systems!
- In the event that you would like to etch a different material or try an alternative masking material, please consult the cleanroom manager or superuser and obtain approval **before** your run. You are responsible for justifying the new materials and proving that the reacted by products are volatile.
- All samples must be mounted to a 4 inch wafer. If you would like to perform a through-wafer etch on a 4 inch wafer, you are required to mount a 4 inch carrier wafer since backside He cooling is used throughout etching. Users are responsible for supplying their own 4 inch wafers.
- To mount a wafer, it is recommended that 4 small drops of photoresist are applied to in a North, South, East, West arrangement between your substrate and the 4 inch carrier. This will reduce the dissolution time of the photoresist compared to the case where resist is spin coated across the entire carrier wafer surface. In either case, bake the photoresist adhesive well to remove the solvent and prevent your samples from bubbling up during the etch process. It is also possible to substitute the photoresist with Fomblin oil. In all cases, use a minimal amount for mounting your sample. There is He gas cooling applied to the backside of the 4 inch wafer and applying a thick adhesive layer reduces the heat transfer and thus cooling of your sample. This may result in degradation of etch performance.
- If you are using a 4 inch wafer, remove the photoresist edge bead such that no photoresist comes into contact with the wafer clamp. Photoresist can transfer onto the clamp resulting in breakage of your wafer during handling by the robotic arm. Transfer results due to heating and reflow of the resist during extended etching processes. If photoresist is accidentally transferred to the clamp, please let the cleanroom manager or superuser know immediately so that it can be cleaned off.
- If you have metal anywhere on your sample, make sure the metal is not directly exposed in the plasma at any time during the etch process.
- After long runs or many short runs, the chamber may get dirty as evidenced by a poor base pressure ($>5.0\times10^{-6}$ T). Do not proceed if the base pressure is too high or the leak rate is too high (>.3 mT in 1 minute). Additionally a clean

process can be performed (recipe O_2 clean for 15 minutes) for every 8 hours of etch.

- You are responsible for proper preparation of your samples prior to etching. This means that you must descum in oxygen plasma and do an HF dip prior to etching or you will run the risk of a failed etch and creating "micrograss."
- If any problems occur, please let the cleanroom manager or superuser know immediately.

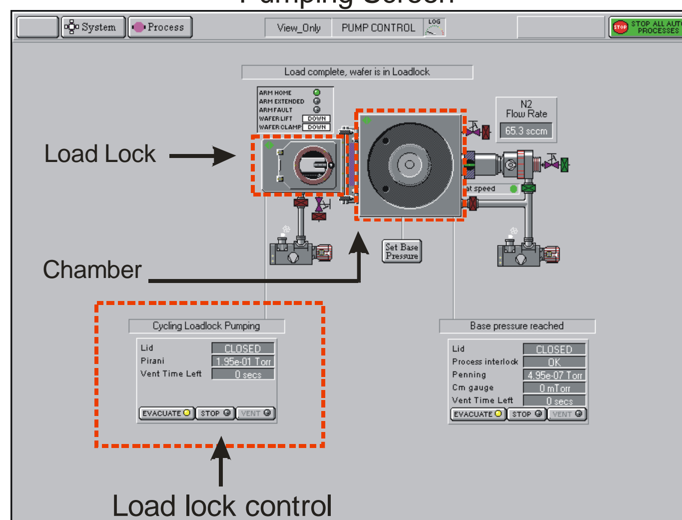
I. Preparation:

1. Login and check status of machine from last user. (Please remember to write down you login time)
2. Make sure sample is mounted on 4"wafer
3. If you are the first user of the day, a conditioning run is recommended.
4. Conditioning: Run the Bosch conditioning recipe.

II. Operation

1. On pumping screen– Press STOP on the load lock control

Pumping Screen

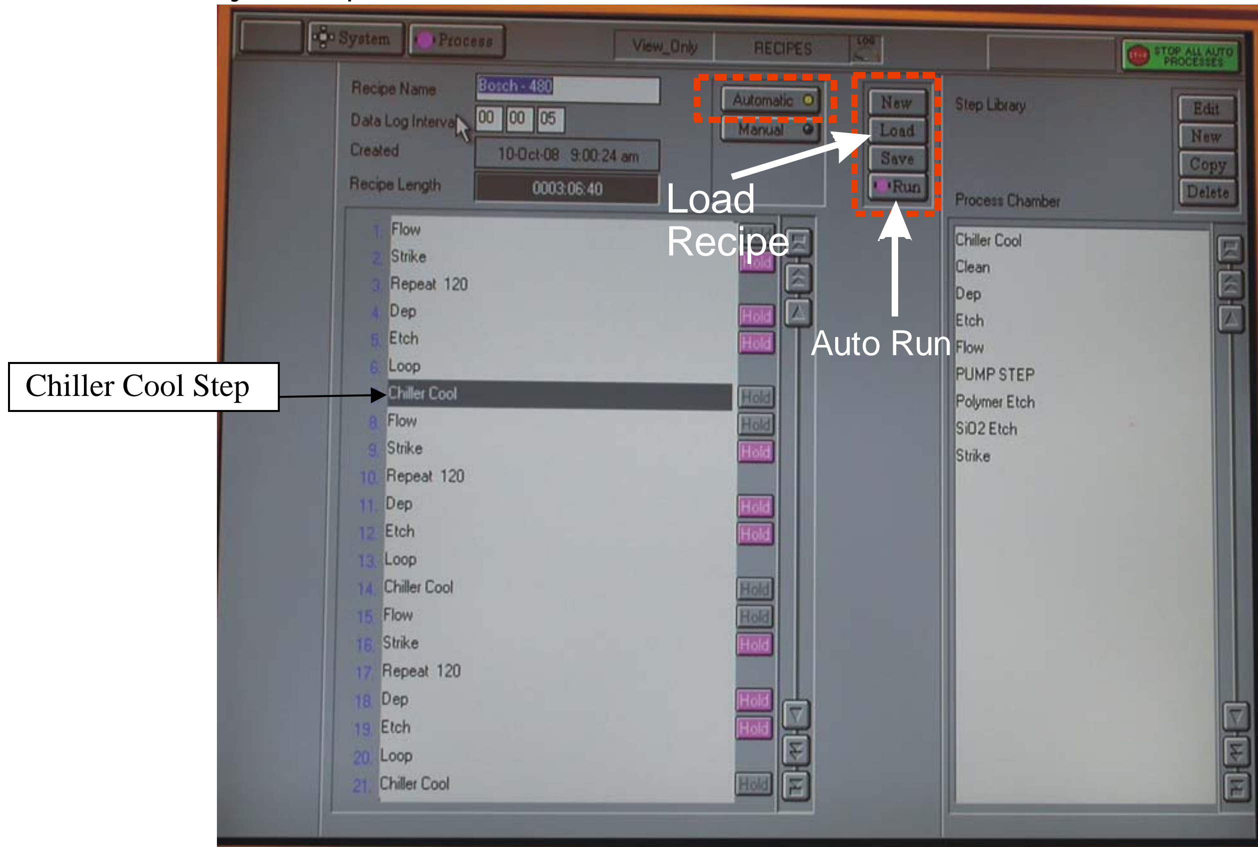


2. Press VENT – load lock will enter the venting cycle ~2 minutes
3. Open load lock and mount sample with flat of wafer flush again the guide pins
4. Close load lock – Press STOP, Press EVACUATE
5. Dialog box will ask for wafer name. Enter a name for the wafer and press OK. A wafer icon will appear in the load lock. This is only way to tell the software that a wafer is in the loadlock. If there is no wafer. Press CANCEL. This tells the software there is no wafer in the loadlock.
6. Wait for pumping screen to say "load lock cycling"
7. Switch to recipe screen by clicking on Process → Recipes.
8. Select LOAD and load appropriate recipe. Left click each step of the recipe, you can edit the step.

(i) Left click on the repeat step and type in the number of loops to control the etch depth for your process.

(ii) No more than 120 loops before a 30 min chiller cooling step is required.

9. Adjust recipe if needed



10. Select RUN - This will automatically load the wafer and start running the recipe. Once recipe is complete, the system will automatically unload wafer back to the load lock.

11. Keep on eye on the chiller for the ICP generator. The temperature interlock will trip at 40°C and the circuit breaker will need to be reset. ICP power of <1000W should minimize heat overloading.

Chiller and the temperature monitor

12. VENT load lock (steps 1-2) and unload sample
13. EVACUATE load lock (steps 4-5). When prompted for wafer ID, press cancel to indicate there is no wafer loaded. Remove your wafer.
14. Log off software
15. Log off in log book (Please remember to write down the log off time and total usage time)

III. Measuring Samples

1. Shallow etches <60 microns can be measure on with the Dektak. Deeper etches can be measured with the digital depth gauge (next to the furnace).

IV. Cold Start

1. Make sure mains power is back on
2. Go into the chase and make sure the chillers are turned on.
3. Turn on the PLC power by pressing the green button on the front of the machine
4. Go to the pumping screen and check status of chamber. Most likely it will need to be pumped down.
5. If the pumps are not on (no smoke coming out of pump icon) then they need to be turned on by clicking on the pump icons for both the load lock and the chamber. The light beside the turbo pump icon will blink yellow when the turbo is accelerating and will be a solid green when pump is at full speed. Press stop and evacuate to initiate the pump down once pumps are fully turned on.
6. Do not manually open or close the valves that connect to the chamber. Pump down should occur automatically. Manual valve operation requires contacting the Oxford rep.
7. It takes about 15 minutes for the chamber to warm up after power-ON

NOTE : Chamber roughing is to about 90 mTorr

Bosch process conditions and their effect on the etch parameters.

Process	Deposition Process					Etch Process				
Increasing Parameter	C_4F_8 flow	Pressure	ICP	DC bias	Step time	SF_6 flow	Pressure	ICP	DC bias	Step time
Silicon etchrate	–	optimum pressure depends on ICP power	↑↑	↑↓	↓	↑	Pressure depends on ICP power	↑↑	↑	↑
PR etchrate	–		↑↑	↑↓	↓	–	↓↓	↑↑	↑	↑
Oxide etchrate	–		↑↑	↑↓	↓	–	↓↓	↑↑	↑	↑
Profile	↑ (more +ve)	↑ (more +ve)	↓↓ (more -ve)	↑ (more +ve)	↑ (more +ve)	↓ (more -ve)		↓↓ (more -ve)	↑ (more +ve)	↑ (more +ve)
Sidewall roughness	↓	↓	↑	↑↓	↑(increased 'rippling')	↑	↑	↑	↑	↑(increased 'rippling')
Surface roughness	needs correct dep/etch time ratio & sufficient ion density/energy				↑	– could be related to ceramic ICP tube surface quality				↓
Etchrate uniformity	↑↓	↑↓	↑	↑	↑↓	↑↓	↑	↑	↑	↑↓
Profile uniformity	↑↓	↑↓	↑	↑	↑↓	↑↓	↑↓	↑	↑	↑↓
"Bottling"	↓	No effect	↑	↓	↓	↑	No effect	↑	↓	↑
"Foot"	more polymer dep creates 'trenching' to counteract 'footing'			↑	↑	↓	↓	↓	↓	↓

Note: ↑ Etchrate & Profile uniformity – uniformity getting worse