USC UNIVERSITY OF SOUTHERN CALIFORNIA

STANDARD OPERATING PROCEDURE FOR DRIE

USC University of Southern California

DPS emergency number 213-740-4321

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OVERVIEW

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 selectivity 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 Teflon-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” wafers.

APPROVED MATERIALS

This tool is predominantly for use with etching Si. Other previously approved materials include Parylene, polyimide, and SiO_2. Request approval from staff for other materials before etching.

RECIPES

Available standard 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 No He: O2 plasma chamber cleaning recipe with no He cooling

- **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**

(*Above data is from 2008)

New recipes may be developed if required. Contact staff for more details.

ADDITIONAL NOTES

• Masking materials are limited to standard photoresists and dielectrics. Absolutely no metals are permitted in the system as they can sputter and redeposit elsewhere. The usage of metals is a major cause of contamination in DRIE systems!

• If you would like to etch a different material or try an alternative masking material, please consult staff to obtain approval before your run. You are responsible for justifying the new materials and proving that the reacted by products are volatile.

• Small samples must be mounted to a 4” wafer. If you would like to perform a through-wafer etch on a 4” wafer, you are required to mount a 4” carrier wafer since backside He cooling is used throughout etching. Users are responsible for supplying their own 4” wafers.

• To mount a wafer, it is recommended that 4 small drops of fomblin oil applied in a North, South, East, West arrangement between your substrate and the 4” carrier. Use a minimal amount for mounting your sample. There is He gas cooling applied to the backside of the 4” wafer and applying a thick layer reduces the heat transfer and thus cooling of your sample. This may result in degradation of etch performance.

• If your sample is a 4” wafer with spin coated photoresist, 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 staff 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.

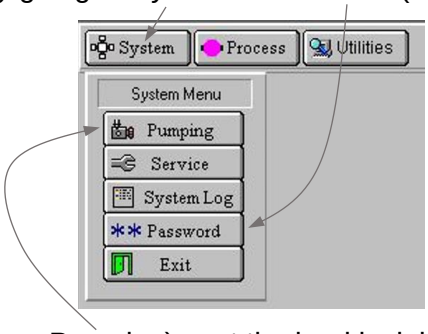
• After long runs or many short runs, the chamber may get dirty as evidenced by a poor base pressure (>5.0×10-6 T). Do not proceed if the base pressure is too high or the leak rate is too high (>.3 mT in 1 minute).

• 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.”

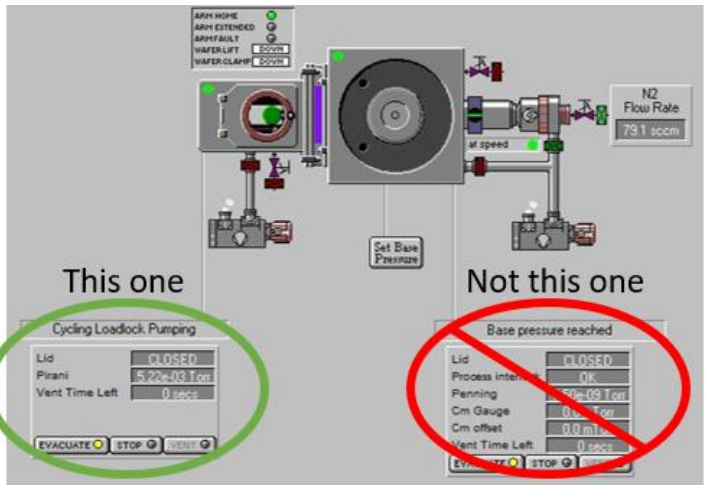
• If any problems occur, please let the cleanroom manager or superuser know immediately.

OPERATION

1. Activate the tool on NEMO
2. Log into PC2000 software by going to System > Password (it is on the top-left of the screen)

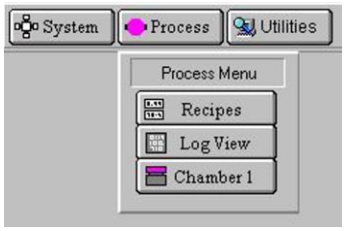


3. On the pumping page (System>Pumping) vent the load lock by clicking STOP and then VENT

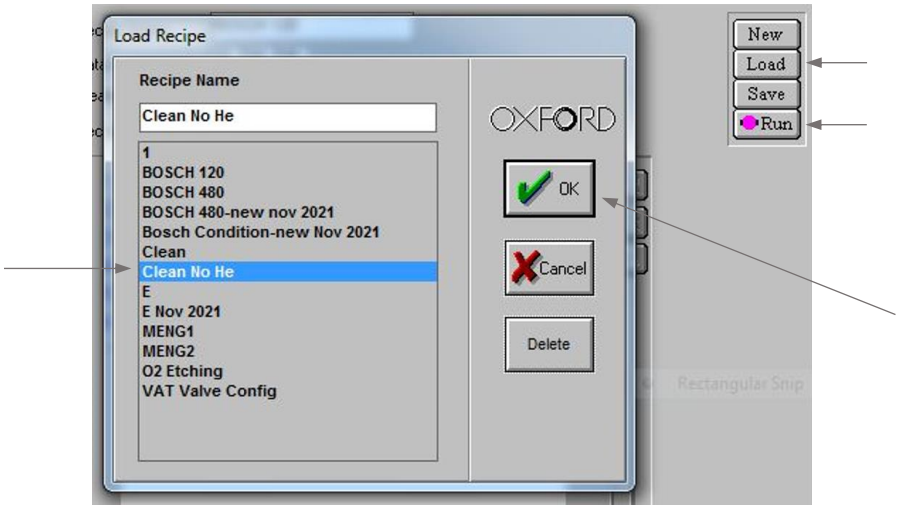


4. When venting is complete, load cleaning Si dummy wafer, with the flat facing away from pins

5. Evacuate load lock by clicking STOP, and then EVACUATE
6. The system will prompt you to give your wafer a name – name it as “CleaningWafer”
7. Click Process > Recipes (it is on the top-left of the screen)



8. Click Load > Clean No He > OK > Run



9. Watch the loading arm when it goes in/out of the chamber at the start and end of process
10. After the cleaning recipe is complete, log it. Make a note if there were any issues
11. Vent load lock (repeat step 3), remove cleaning Si dummy wafer, and load your sample wafer

STOP!

Does your sample wafer satisfy these conditions?

Is wafer edge clean?	Is wafer backside clean?	Will metal be exposed to plasma?
Wafers with a photoresist soft mask must have edge bead removal (EBR). 2 mm is OK, but 4 mm is recommended	Inspect backside by eye. If there are smudges, carefully wipe backside with a texwipe wetted with acetone. Then use another texwipe wetted with IPA.	If there is metal on your wafer, ensure that it is completely or almost completely covered by your masking material. Do not etch metal with this tool.
Why? If dirty, the edge can get stuck to the wafer clamp. Then, the wafer may get shattered during arm loading or unloading.	**Why?** If the backside is dirty, then the wafer might stick to the bottom of the process chamber. This may cause the wafer to get shattered during arm loading or unloading.	**Why?** Metal may get etched by the plasma and then redeposited onto other parts of the tool. This may cause unwanted tool contamination or short-circuiting.

12. Evacuate load lock, name your wafer, load desired recipe, and run it (similar to steps 5 – 8)
13. Log your run after process is complete. Make a note if there were any issues
14. Vent load lock (repeat step 3), remove your sample wafer
15. If you have multiple sample wafers, load the next wafer and repeat steps 12 – 14
16. When load lock is empty, evacuate load lock by clicking STOP, and then EVACUATE
17. The system will prompt you to name your wafer – just press CANCEL to pump down empty
18. Log out of PC2000 software and NEMO

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ETCH PARAMETER TABLE

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

Contributors	Revised Date
Eugene Yoon	08/11/2023
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