March CS-1701F Reactive Ion Etcher

Standard Operating Procedure
Faculty Supervisor: Prof. Robert White, Mechanical Engineering (x72210)
Safety Office: Peter Nowak x73246 (Just dial this directly on any campus phone.)
(617)627-3246 (From off-campus or from a cell phone)
Tufts Emergency Medical Services are at x66911.

Revised: January 6, 2016

Note: This CS-1701F was modified by March Plasma to include a turbopump for lower pressure operation. Standard CS-1701F units without a turbopump will operate at higher pressures than indicated in this document.

Warnings:
The tool uses high power and low vacuum during deposition. Do not attempt to open the chamber until the etch cycle is complete.

The gases used in the tool, SF_6, CF_4 and O_2, are not toxic. O_2 is the most dangerous of the three because it can cause fire. Some of the *byproducts* of the etch process may be toxic (depending on what materials are being etched). Therefore, it is important that the tool pumps the chamber down below 80 mT before venting to atmosphere.

Required Checkout:
You must be formally tested by the faculty supervisor or lab manager before you may use this tool unsupervised. When you are first learning procedures, work with experienced lab users (students, post docs, faculty or staff) to become familiar with the tool before requesting a formal checkout procedure.

1.0 Material Requirements:

1.1 Equipment: substrate, wafer tweezers
1.2 Personal Protective Equipment: nitrile gloves, safety glasses
1.3 Chemicals: none
1.4 Gases: Oxygen, Nitrogen, Sulfurhexaflouride (SF_6), Tetrafluoromathane (CF_4, Freon 14)

2.0 Procedure:

2.1 Turn on the tool:

2.1.1 Turn on the RIE by pressing the large red "Power" button located on the front panel. Check to make sure that all front panel displays and switches light up.

2.1.2 Turn on the chiller located on the floor to the right of the tool. Set the chiller temperature to 20 C (to change the chiller setpoint, hold down the square black button and turn the knob).

2.1.3 Turn on the RF Power Generator using the toggle switch on the back side of the RF Generator.

2.1.4 Turn on the mechanical vacuum pump by flipping the toggle switch located under the chrome panel on the top of the pump.

2.1.5 Turn on the turbomechanical pump controller using the toggle switch located on the back.

2.1.6 Open all four gas cylinders. Make sure the outlet pressures of the regulators are as follows:

Oxygen: 15 psi ± 5 psi
Nitrogen: 60 psi ± 5 psi
SF_6: 15 psi ± 5 psi
CF_4: 15 psi ± 5 psi

2.2 Load the substrate:

2.2.1 After ensuring that the chamber pressure is at atmosphere, lift the camber lid using the chamber lid handle. Once in the open position the lid will settle into slots which keeps it open.

2.2.2 Clean any particles from the chamber surfaces and seals using IPA and a fab wipe. Blow the surfaces clean using clean dry air.

2.2.3 Place substrate on the center of the etching platen with wafer tweezers.

2.2.3.1 During pumpdown, air currents in the chamber can move the wafer. It is advisable to use 3 glass microscope slides positioned 120 degrees apart pushed up against the outer edges of the wafer to hold it in place. Put one slide at the back of the chamber (far from you) and one slide 120 degrees up on either side, so there is no slide at the front of the chamber (near the viewport… it appears that during pumpdown the slug of air from the viewport sometimes flips the slide onto the wafer it is directly in front of the viewport).

2.2.4 Make sure both chamber seals are free of particles. This will ensure a proper chamber seal and low base pressure.

2.2.5 *Lift the lid* out of the slots by raising chamber lid handle approximately 0.5". (You *must lift it up* before closing it!!) Lower the lid into the closed position. Take care not to the drop the lid on your fingers! Make sure it seats well and is centered.

2.3 Program etch recipe: Create and save a recipe or sequence that can be run automatically

2.3.1 Toggle the "program" button to select the desired Program #.

2.3.2 Program the gas settings:

2.3.2.1 Toggle the gas "SET/READ" button for the "R DISP" menu group to SET position (LED illuminated)

2.3.2.2 Toggle the "R DISP" button to each of the gas 1, gas 2, and gas 3 channels in turn.

2.3.2.3 Adjust the gas mass flow set point for each gas using the :INCR/DECR" button.

2.3.2.4 Toggle the gas "SET/READ" button for the "R DISP" menu group to READ position (LED illuminated). You can now monitor the current mass flow controller settings for each gas.

NOTE: The gas flow setpoint reads in percentage of maximum flow (0-100). To compute the actual flow rate in sccm, use the following formulae:

Gas 1 (SF_6): Flow rate in sccm = (setpoint/100) x 50 sccm x 0.27
Gas 2 (CF_4): Flow rate in sccm = (setpoint/100) x 250 sccm x 0.41
Gas 3 (O_2): Flow rate in sccm = (setpoint/100) x 100 sccm x 1

2.3.3 Program remaining process settings:

2.3.3.1 Toggle the "SET/READ" button for the "L DISP" program group to set position (LED illuminated)

2.3.3.2 Toggle the "L DISP" button to set each of the proper process parameters in sequence.

2.3.3.3 Adjust the selected parameters setpoint using the "INCR/DECR" buttons

2.3.3.4 Here is some useful information about these parameters

PRESS: Enables Independent Pressure Control. Set to zero to disable. Units are mT. If you want a high pressure etch (>200 mT) this may be useful, but most of the time it will be set to 0 and the pressure will be controlled by the gas flow rate.

POWER: Process power in Watts. (max 600)

ENDPT: UV based endpoint detection feature. Refer to manual before using. Set to 100 to disable.

TIME: Process time in seconds. ***Do not run etches longer than 10 minutes = 600 seconds, because the tool will become too hot.***

TEMP: Our tool is not equipped with this feature. Platen temperature is controlled by the chiller.

BP/RP: Base pressure in mT. Set to 80 at highest, 30 at least. The tool will pump down to this pressure before running the etch and before venting.

2.3.4 Select the next program step, if any, you wish to program using the "PROGRAM" button.

2.3.5 **When you are finished programming your recipe, advance to the next program # slot and set it's time to 0.** Otherwise, the programs will be executed in sequence!!!! Note that this may be a useful feature if you are trying to do a Time Multiplexed etch. (for advanced users only)

2.3.6 Toggle the "SET/READ" button to read (LED extinguished.) This stores the parameters in the process controller memory. You may now monitor the current value of any of the process parameters on the "L DISP" menu by cycling through them.

2.4 Execute the recipe:

2.4.1 Make sure the tool is in Auto Mode. If the "Man Op" LED is OFF it is in Auto mode. If the "Man Op" LED is on, then turn off "Man OP" (The LED should extinguish)

2.4.2 Toggle the "PROGRAM" button to the program number for your program (see programming in section 2.3 above).

2.4.3 Push "START".

2.4.3.1 The tool will now go through an automatic sequence of pumping down below the base pressure, then turning on the gas flow, waiting for pressure to stabilize, and turning on the RF power.

2.4.3.2 When RF power turns on, check that you have a stable, uniform plasma in the chamber. If the plasma does not stabilize within 10 seconds, push "STOP" to end the sequence.

2.4.3.3 If everything looks good, the etch will proceed for the programmed length of time.

2.4.4 When the recipe is complete, the tool will automatically pump out the etch products and then bleed back to atmosphere.

2.4.5 Once the bleed step is complete, open the chamber and remove your sample.

2.4.6 Push "STOP".

2.5 Ashing of Photoresist: After exposure to plasma, some photoresists become hardened and require an oxygen clean prior to resist stripping. This is a lower intensity plasma used to remove hardened resist at the surface.

2.5.1 Low power O_2 clean recipe: Power: 200 watts, Oxygen flowrate (gas 3): 100%, All other gas flowrates 0%, Base pressure 80 mT, Time 30 seconds.

2.5.2 Wet strip remaining photoresist: Remove remaining resist with acetone, IPA and remover 1165 if necessary

2.6 Chamber Clean

2.6.1 After you are finished processing, you are required to run a high power oxygen clean on the empty chamber:

2.6.2 High power O_2 clean recipe: Power: 300 watts Oxygen flowrate (gas 3) 100%, All other gas flowrates 0%, Base pressure 80 mT, Time: 300 seconds.

2.7 Shutdown:

2.7.1 WAIT FOR TURBOPUMP TO REACH A SPEED OF LESS THAN 10,000 RPM BEFORE PROCEEDING WITH SHUTDOWN. (Turbopump speed can be seen on the front panel of the turbopump controller)

2.7.2 **Turn off all gas bottles**

2.7.3 Turn off power to the tool, the RF power supply and the turbo controller.

2.7.4 Turn off the mechanical vacuum pump.

2.7.5 Turn off the chiller.

2.7.6 **Check to make sure all four gas bottles are off**

3.0 Emergency Shutdown:

3.1 *Processes can be interrupted by toggling the "STOP" button*. This should turn off the RF power and pump the tool down.

3.2 *If for some reason "STOP" is not working and something very bad is happening, pushing the large red power button will turn off all power to the tool*. If you push this button to shut of power to the tool and there are etch gases in the chamber, immediately evacuate the lab. Although SF_6 and CF_4 are not themselves dangerous, it is possible that etch products (results of reactions in the chamber) could be hazardous, and if you shut of power the tool will not pump the chamber out.

If at any time you feel a situation is dangerous, do not hesitate to call the safety office (x73246, Peter Nowak) the faculty supervisor/lab manager (x72210, Robert White), or Tufts Emergency Services (Police/Fire/Ambulance at x66911).

Report all accidents (injuries, major spills, fires) to the safety office at x73246 (Peter Nowak) and Prof. White at x72210. For emergencies, call Tufts Emergency Services at x66911.

RECOMMENDED RECIPES:

Anisotropic Silicon Etch

Can use SPR, AZ or 1800 series resists as an etch mask.

SF_6 (gas 1) flowrate: 100% (13.5 sccm)	Power: 150 W
CF_4 (gas 2) flowrate: 0%	Base pressure: 40 mT
O_2 (gas 3) flowrate: 0%	Pressure setpoint: 0

Actual pressure during etch: 65 mT
<100> silicon etch rate: 240 nm/min
SPR220 resist etch rate: 120 nm/min
Silicon lateral etch rate (undercut):25 nm/min

Silicon Dioxide Etch

Can use SPR, AZ or 1800 series resists as an etch mask.

SF_6 (gas 1) flowrate: 0%	Power: 300 W
CF_4 (gas 2) flowrate: 20% (20.5 sccm)	Base pressure: 40 mT
O_2 (gas 3) flowrate: 0%	Pressure setpoint: 0

Actual pressure during etch: 140 mT
Silicon dioxide etch rate: 100 nm/min (Pyrex glass)

Silicon Nitride Etch

Can use SPR, AZ or 1800 series resists as an etch mask.

SF_6 (gas 1) flowrate: 0%	Power: 200 W
CF_4 (gas 2) flowrate: 100% (100 sccm)	Base pressure: 60 mT
O_2 (gas 3) flowrate: 1% (1 sccm)	Pressure setpoint: 0

Actual pressure during etch: 370-400 mT
PECVD Si_3N_4 etch rate: ≈180 nm/min
<100> silicon etch rate: ≈ 60 nm /min
SPR photoresist: ≈ 90 nm/min

O2 Plasma Clean / Organic Etch

SF_6 (gas 1) flowrate: 0%	Power: 200 W
CF_4 (gas 2) flowrate: 0%	Base pressure: 60 mT
O_2 (gas 3) flowrate: 100% (100 sccm)	Pressure setpoint: 0

Actual pressure during etch: 300 mT
SPR220 resist etch rate: 0.5 – 1 um/min
AZ9260 etch rate: 0.3-0.4 um/min

Organic Polymer Fast Isotropic Etch

SF_6 (gas 1) flowrate: 0%	Power: 300 W
CF_4 (gas 2) flowrate: 0%	Base pressure: 40 mT
O_2 (gas 3) flowrate: 100% (100 sccm)	Pressure setpoint: 0

Actual pressure during etch: 300 mT
SPR220 resist etch rate: 1-1.5 micron/min
Parylene C etch rate: 0.5-2 micron/min (variable)
Silk Fibroin thin film : > 1micron/min

Polyimide Etch

SF_6 (gas 1) flowrate: 0%	Power: 300 W
CF_4 (gas 2) flowrate: 12% (12.3 sccm)	Base pressure: 40 mT
O_2 (gas 3) flowrate: 50% (50 sccm)	Pressure setpoint: 0

Actual pressure during etch: 200 mT
PI-2610 polyimide etch rate: 0.7-1.2 micron/min
Use metal hardmask (aluminum or chromium thin film)

Fast Silicon Etch

Recommend Nickel or SU8 as an etch mask. Do not try using AZ9260 as an etch mask – it does not survive!

SF_6 (gas 1) flowrate: 100% (13.5 sccm)	Power: 400 W
CF_4 (gas 2) flowrate: 0%	Base pressure: 60 mT
O_2 (gas 3) flowrate: 2% (2 sccm)	Pressure setpoint: 0

Actual pressure during etch: 65-100 mT
<100> silicon etch rate:1.5-3 um/min
SU8 resist etch rate: 1-2 um/min

SU8 Etch

Recommend Nickel as an etch mask.

SF_6 (gas 1) flowrate: 15% (2 sccm)	Power: 400 W
CF_4 (gas 2) flowrate: 0%	Base pressure: 60 mT
O_2 (gas 3) flowrate: 50% (50 sccm)	Pressure setpoint: 0

Actual pressure during etch: 170 - 200 mT
SU8 resist etch rate: ≈3 um/min
<100> silicon etch rate:< 100 nm/min

PDMS/Glass Bonding

Note: consider using the ETP corona discharge wand for treating PDMS for PDMS/glass bonding – it is easier and more effective. See the separate SOP on that process.

SF_6 (gas 1) flowrate: 0%	Power: 40 W
CF_4 (gas 2) flowrate: 0%	Base pressure: 60 mT
O_2 (gas 3) flowrate: 100% (100 sccm)	Pressure setpoint: 0

Time: 10 seconds
Actual pressure during etch: 300 mT

Place surfaces to be bonded face up during plasma treatment.
After plasma treatment, place glass and PDMS surface into contact. Press together gently and try to avoid surface bubbles. Cure on hotplate at 80 ^{o}C for 10 mins to 12 hours. (No systematic study has been conducted of the effect of the cure time… different users have different protocols)