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1 INTRODUCTION

1.1 Scope
These procedures apply to the NORDSON MARCH PX-1000 Plasma Asher system. All maintenance should follow the procedures set forth in the manufacturer's maintenance and operations manuals. This document is for reference only. Personnel should be trained by authorized staff before operating this equipment.

1.2 Description
The NORDSON MARCH PX-1000 Plasma Asher system is a large capacity batch system ideal for resist stripping, etching, surface adhesion/activation and cleaning applications. The PX-1000 produces a high energy uniform Oxygen Plasma or an Oxygen/Argon plasma to chemically remove thick layers of photoresist, to remove organic compounds and contaminants from the surface of substrate, to enhance surface wettability, descum photolithographic patterns, to improve surface adhesion and to perform surface activation treatments while leaving the bulk material unchanged. The MARCH PX-1000 delivers a high energy uniform plasma with unmatched reliability, safety and ease of operation. The PX-1000 system is completely self-contained, requiring minimal space. The PX-1000 plasma system consist of three modules: a Reaction Chamber with removable shelves to reconfigure the chamber interior for various plasma modes, a Process Controller to monitor and regulate the variable parameters of the plasma process (Base Pressure, RF power level, process duration, and gas flow) in either Automatic or Manual modes and the solid state RF Power Generator that operates as a separate unit which is controlled by the Process Controller's microprocessor.

1.3 Safety
1.3.1 This machine uses Oxygen (O2) and Argon which both are compressed gasses at high pressures and can in high concentrations can be simple asphyxiated. Oxygen (O2) can cause or intensify fire and is an oxidizer. The Oxygen (O2) gas in under high pressure and may explode if heated. Close both gas valves after each use and when empty. The process gases are normally pumped out of system; if the process pressure is not being maintained or system cannot reach base pressure notify Nanofab staff immediately.
1.3.2 This machine uses RF frequency power. DO NOT operate this machine with any RF component enclosures or tool side and back panels open.

1.3.3 This system is equipped with a large RED, clearly marked front panel mounted EMO (Emergency Off) switch/button, mounted on the left side panel. When activated the main power to the system is disconnected through main power relay. The EMO switch should be pressed only in an emergency. An emergency would be fire, smoke, electrocution hazards, and an injury to anyone using this particular piece of equipment. If the EMO is pressed notify Nanofab staff immediately.

1.3.4 This tool is equipped with a RF power safety interlock if the chamber pressure is out of specified range (above 2000 mTorr) will prevent the RF from being turned on. Also the system side panels are interlocked to main power.

1.3.5 This tool has a potential hazard from Radio Frequency exposure. Do to run the tool with the back panel open. This system runs at an RF frequency of 13.56 MHz and up to 600 Watts.

1.3.6 The plasma chamber and shelves can become quite hot during some processes. Use caution to prevent burns.

1.3.7 The reaction chamber is accessed through a two part door equipped with a large viewing window. The plasma environment is rich in UV light in the region of the electromagnetic spectrum just beyond the visible light. Do not run the tool with the stainless steel door open. During a process keep this door closed to prevent any UV exposure to yourself and other users.
2.0 HARDWARE

2.0 The PX-1000 microprocessor automated control with manual override.

2.1 Two Porter Mass Flow Controllers: O₂ MFC size is 1000 SCCM, Ar MFC size is 200 SCCM.

2.2 RFX-600 Watt 13.56MHz radio frequency power generator with automatic impedance matching network.

2.3 The PX-1000 system can be quickly switched from one process mode to another, including Direct, Downstream, and Reactive Ion Plasma.

2.4 The PX-1000 adjustable work shelves for different electrode spacing and plasma mode configurations for maximum process flexibility. Currently only RIE and a grounded shelf are available.

2.4 The Vacuum system is Alcatel 2063CP mechanical pump @ 50 CFM.

2.5 The tool measure pressures with MKS Baratron (capacitance manometer). Pressure range 1mt to 2000mt.

2.6 Front loading reaction chamber. Chamber interior dimensions 18” Wide x 18” High x 24” Deep. Chamber material is stainless steel.

2.7 The reaction chamber is accessed through a two part door equipped with large viewing window for limited observation of the plasma.

2.8 The PX-1000 has Vacuum - RF Interlock Protection.

2.8 The PX-1000 is equipped with front panel EMO button/switch circuit.
3.0 REQUIREMENTS

3.1 Training
You must be a qualified user on MARCH PX-1000 Plasma Asher system. The Asher is for cleaning 1” to 6” diameter resist or polyimide coated and patterned Silicon, SOI, Thermal Oxide, Sputter and PECVD Oxide, Nitride wafers, Glass slides and Metal coated wafers and samples. Pieces (Si, SOI, SiO2, Si3N4, Glass slides and Metal) can be cleaned by using appropriate size quartz boat or placing the smaller samples directly on the RF self. The tool can also be used to remove organic compounds and contaminants from the surface of substrate, descum photolithographic patterns, to enhance surface wettability, to improve surface adhesion and to perform surface activation treatments of approved materials.

3.2 System Restrictions

3.2.1 All wafers must not have any edge chips, nicks, or cracks. The backside must be clean and flat (no warps, dimples, defects).

3.2.2 Metal coated wafers and metal hard mask are allowed to be cleaned.

3.2.3 Polyimide cleaning and PTFE activation allowed. All other materials need staff approval.

3.2.4 A wafer needs to be loaded for all runs. OK to use appropriate size clean quartz boats in the Asher. If cleaning or activating small pieces ok to place them on a shelf.

3.2.5 User are NOT Allowed to adjust O2 or Ar gas bottle regulators.

3.2.6 The PX-1000 Asher can ONLY be run in Automatic Mode, the RF power can only be ran in Automatic Mode. The only time Manual mode is allowed is when setting up gas flow rates to determine the partial pressure of the gasses.

3.2.7 Users are NOT allowed to change electrode/shelf plasma configurations. If you have any questions about shelf re-configuration, please contact staff to perform the task.
3.2.8 **The Maximum RF power is 525 Watts**

3.2.9 **The Maximum RF ON TIME is 2 hours**
(then idle 30 minutes between longer than 2 hour runs)

3.2.10 Do not run the plasma with the stainless steel door open. During a process keep this door closed to prevent any UV exposure to yourself and other users.

3.2.11 **The March Asher PX-1000 is available 7 days a week / 24 hours a day.**

3.2.12 Read any posted *Nanofab Engineering Change Notices (ECN)* for any hardware, process or safety changes before running the tool.

3.2.13 You must reserve the tool on the Nanofab Reservation System to run this tool.
4.0 OPERATING PROCEDURES

4.1. *System Pre-Checks*

4.1.1. Check to see if March Asher is not being used by someone else.

4.1.2. Turn ON the Main Power Switch at the back of the Process Controller. The switch should be in the UP position.

4.1.3. Check to ensure the RFX-600 RF generator Main power switch at the back of the generator is ON, it should be in the UP position.

4.1.4. Check to ensure the stainless steel door is closed and latched, the Chamber should be under vacuum.
4.1.5. Go to Chase 3 to open gas bottles, check House N₂, Alcatel pump oil level and the pump exhaust.

4.1.6. In Chase 3, Open the O₂ and Ar (if using Ar) gas bottle valves by rotating the gas bottle valves CCW full turn. The Open the gas line final valve CCW a full turn. **DO NOT ADJUST the gas regulators valves.** Check to ensure the gas delivery pressure is 10 to 20 psi for both gasses.

4.1.7. Check to ensure the House N₂ is 40-50 psi.

4.1.8. Check to ensure the Alcatel 2063CP pump oil (Fomblin) level ¾ up the site glass.
4.1.9. Check to ensure Alcatel 2063CP pump exhaust is connected to house exhaust.

4.1.10. OK to turn Alcatel pump power **ON**.

4.1.11. Holding the breaker/switch and move the switch to the **UP** position. The pump should start up.

4.1.12. Go back to clean room.
4.2. Operating the March PX-1000 Asher in Manual and Automatic Modes

4.2.1. If you have not completed the System Pre-Checks in steps 4.1.1 – 4.1.11 then you must complete those before proceeding.

4.2.2. Turn on the Main Power to the Process Controller by pressing the green button.

4.2.2. Check to ensure the RFX-600 front panel Remote Control and Remote Signal LEDs are illuminated. If they both are not ON, call staff to enable the functions.

4.2.3. Check the Chamber idle vacuum pressure by pressing LDISP button and scroll through the panel options until the PRESS indicator is illuminated. This will display the Chamber pressure.
4.2.4. Press the MAN OP button to enable the vent button for venting the chamber to atmospheric pressure, load samples, enable pump down button to pump chamber to base pressure at set gas flow-process pressure parameters. The MAN OP led will be illuminated.

4.2.5. Vent the process chamber by pressing the BLEED button, the BLEED led will illuminate and the chamber will vent to atmospheric pressure in 2-3 minutes.

4.2.6. Pull the chamber door latch handle out and rotate the handle CCW ½ turn to open the door.

4.2.7. OK to use Isopropanol Alcohol and wipe to clean the chamber shelves and walls.
4.2.8. Check the condition of the square o-ring door seal, if damages or loose call staff.

![Image of o-ring door seal](image1)

4.2.9. Place your wafers in a quartz boat and place on an desired self, if you have small pieces place them face-up directly on the shelf as shown.

![Image of wafer placement](image2)

4.2.10. Please note the powered and grounded shelves electrode-plasma mode configuration below. Use grounded shelf for indirect plasma mode Use powered shelves for RIE/ directional plasma mode.

![Image of shelves configuration](image3)
4.2.11. Gently close chamber door and lock the door by latching the interlocking metal hooks and rotating the door handle CW \( \frac{1}{2} \) then pushing the handle to the down position flat against the side of the chamber panel as shown.

4.2.12. **Note:** To determine chamber base pressure set point and gas flow-chamber partial pressure parameters we need to pump chamber down in **Manual mode** and flow gas in **Manual mode** before running your wafers in **Automatic Mode**.

4.2.13. **Operating the March PX-1000 Asher in Manual Mode to set Base Pressure set point (starting point) and gas flow set points to achieve gas partial pressures and plasma pressure**

4.2.14. Press **PROGRAM** button until you see the program you wish to set, displayed as a number between **1 and 9**.

4.2.15. Press the **MAN OP** button to enter the manual mode. This LED should now be illuminated and we should be able to sequence through the process event buttons located to the right of the **MAN OP** button.
NORDSON MARCH PX-1000 PLASMA ASHER SOP

Version: 1.0

4.2.16. Depress the **VAC ON** button. This will open the valve between the chamber and the vacuum pump and evacuation of the chamber will begin. The **VAC ON** LED will be illuminated.

4.2.17. After **30 seconds** depress the button labeled **PRESS**. This opens a valve in the system and exposes the capacitance manometer pressure gauge to the chamber. The pressure reading on the **LEFT DISPLAY** should now begin to drop. (L DISP must be toggled to **PRESS** in order for the display to show pressure).

**NOTE:** **IF the “PRESS” button has not been depressed, the pressure reading is not accurate since the gauge is not exposed to the chamber.**

4.2.18. Allow the Chamber to pump down to ultimate base pressure. This should take 20 minutes to remove any residual moisture from the chamber. After 20 minutes of pumping, the Chamber base pressure should be less than 50 mtorr.

4.2.19. Now we set the base pressure for future AUTOMATIC runs. Toggle the **LDISP** button until **BP/RP** (Base Pressure/Reflected Power) is illuminated. Press the **SET** button for the left display and note that the **SET LED** is lit. Now increase or decrease the left display value until it is equal to your Base Pressure set point (50mtorr to 100mtorr is sufficient) using the **INCR** and **DECR** buttons below the display. Press the **SET** button again, this time extinguishing.
the set LED. The base pressure for subsequent Automatic recipes are now set.

4.2.20. Now we set the O\textsubscript{2} and Ar gas flows to a proper setting to achieve a specific process pressure.

4.2.21. Toggle the left display to the PRESS position to view the Chamber pressure.

4.2.22. Toggle the R DISP button to observe the gas settings for the various gas channels. All the gas channels should initially be set to zero. Only GAS1 and GAS2 channels are used, so toggle R DISP until GAS1(O\textsubscript{2}) or GAS2 (Ar) is illuminated.

GAS1  O\textsubscript{2}  MFC size 1000 SCCM

GAS2  Ar  MFC size 200 SCCM

4.2.23. Depress the SET button on the right display to enter the set mode (LED lit) and toggle the R DISP button to the desired gas channel for O\textsubscript{2} or Ar. Press INCR and DECR buttons below the R DISP and SET displays to set an gas flow based on % of the MFC open.

Note: The Process Controller’s right display indicates the percentage % of the MFC’s orifice that is open for gases to pass through it.
(i.e. 80 entered in the display would be MFC is open 80%)

After you have entered a % value press the SET button again, this will turn OFF SET led.

4.2.24. To convert percentage displayed on Microprocessor to the actual gas flow in SCCM or if the desired gas flow (SCCM) is already known, converting known gas flow in SCCM to % displayed on Process controller use the following formulas:

Converting Percentage Displayed on Microprocessor to Actual Gas Flow:

GAS FLOW IN SCCM (standard cubic centimeters) = (Displayed Gas Percentage on Process Controller / 100%) x (MFC Size in SCCM)x (Gas Conversion Factor).

i.e. for O2 set at 80%, MFC size is 1000sccm, G.C.F is 0.994,

\[ O_2 \text{ gas flow in SCCM} = \left( \frac{80\%}{100\%} \right) \times 1000 \text{ SCCM} \times 0.994 = 795.2 \text{ SCCM} \]

Converting Gas Flow to Percentage Displayed on Microprocessor:

PERCENTAGE SETTING ON PROCESS CONTROLLER =

(Desired Gas Flow in SCCM / MFC Size) (100%) / (Gas Conversion Factor)

i.e. for Ar the desired flow is 200 SCCM, MFC size is 200 SCCM, G.C.F is 1.44

Therefore, the required percentage on the Process Controller to achieve Ar flow of 160 SCCM is:

\[ \left( \frac{160 \text{ SCCM}}{200 \text{ SCCM}} \right) \times (100\%) / (1.44) = 55 \text{ percent} \]

Below is gas conversion factors table for reference.
4.2.25. After you have set the % value for the O$_2$ and/or Ar gas channel, press GAS ON button to flow gas into the Chamber. The Chamber pressure will rise and stabilize at a certain pressure. If the pressure is higher or lower than the desired process pressure then you have to increase or decrease the appropriate gas channel accordingly per section 4.2.22 to 4.2.24.

4.2.26. Once you have verified and tested % of gas channel flow on the display to Chamber pressure press GAS ON button to stop the flow gas into the Chamber. The GAS ON led will turn OFF.
4.2.27. **Programming Recipes in the March PX-1000 Asher to run in Automatic Mode**

**Note:**

*Programming a process in the auto mode is accomplished the same way as in the manual mode. However processing in the Automatic Mod parameters cannot be changed during a process. Also the Process Controller will automatically shut down the RF power and gas flow at the end of the process and bleed the chamber back to atmospheric pressure. Once the chamber has been brought back to atmosphere an alarm sounds to let you know the process has been completed.*

4.2.28. Toggle **PROGRAM** button to select the program step in which you wish to enter your desired process parameters use program 1 (do not use program 0). There are 9 program channels available.

4.2.29. Press the **MAN OP** button select **Automatic mode** of operation. (MAN OP led will turn OFF).

4.2.30. Start with programming the % gas flow settings by using the **R DISP** button per section 4.2.22 to 4.2.24

a) Toggle the **R DISP** switch to read the desired gas channel #1 (O2) or channel #2 (Ar)

b) Toggle the gas **SET/READ** switch to the **SET** position (LED illuminated).

c) Adjust the gas set point by using the **INCR/DECR** buttons.

d) Toggle the gas **SET/READ** switch to the **READ** position (LED extinguished).
4.2.31. To program all other process parameters of RF power, Base Pressure, Process Ash time, Pressure (independent pressure control not available) and Endpoint Detection (not available) use the L DISP switch.

4.2.32. Starting with pressure parameter press the L DISP button to toggle the display to PRESS, the below table are the programming button steps to create a recipe for automatic operation. The SET button led will be illuminated when a parameter value is being changed, after the parameter values are changed the SET button need to be pressed again to save the value in the recipe.

<table>
<thead>
<tr>
<th>Pressure (mTorr)</th>
<th>Power (Watts)</th>
<th>Endpoint</th>
<th>Time (secs)</th>
<th>Temp</th>
<th>BP/RP (mTorr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L DISP</td>
<td>L DISP</td>
<td>L DISP</td>
<td>L DISP</td>
<td>L DISP</td>
<td>L DISP</td>
</tr>
<tr>
<td>SET</td>
<td>SET</td>
<td>SET</td>
<td>SET</td>
<td>Not Used</td>
<td>SET</td>
</tr>
<tr>
<td>INCR/DECR</td>
<td>INCR/DECR</td>
<td>INCR/DECR</td>
<td>INCR/DECR</td>
<td>Not Used</td>
<td>INCR/DECR</td>
</tr>
<tr>
<td>(Decrease to 0)</td>
<td>(25-525Watts)</td>
<td>Set to 100 (default value)</td>
<td>2 hours maximum</td>
<td>Not Used</td>
<td>50-150 mTorr</td>
</tr>
<tr>
<td>SET</td>
<td>SET</td>
<td>SET</td>
<td>SET</td>
<td>Not Used</td>
<td>SET</td>
</tr>
</tbody>
</table>
4.2.33. After Program 1 has been created, if you need to make subsequent steps for your process press the PROGRAM button to toggle to the next step (step 2) and repeat the recipe programming steps in section 4.2.32.

4.2.34. When your final recipe step has been created advance to the next program steps by pressing the PROGRAM button and toggle the L DISP to the Time parameter and adjust to zero using INCR/DECR button.

4.2.35. Press the SET/READ switch to READ (the led will turn OFF) to store the parameters in the Process Controller memory.

4.2.36. Press the PROGRAM button to toggle to the 1st program step (typically no. 1).

4.2.37. Press the START button to run the process in Automatic mode.

Note:
The system is now running the process in Automatic mode. The Process Controller
will vacuum down the reactor to the preset base pressure, turn on gas flow, turn on RF power, and process the sample until the programmed time has elapsed. The controller will then read the TIME setting in the next program number to evaluate whether to proceed with an additional program step. If a TIME value greater than zero is found, the Process Controller will load the next program's parameters and start that program; if not, the Process Controller will turn off the RF power and gas flow. The system will then pump down to the preset base pressure and vent to atmospheric pressure. When the chamber is at atmospheric pressure, the End of Process alarm will sound to indicate that machine is ready to be unloaded. The amount of time remaining and the actual conditions of power, pressure, reflected power, and gas flow in the chamber can be monitored at any time during the course of the process:

1. Toggle the SET/READ to READ position (LED extinguished).
2. Toggle the L DISP for PRESS, POWER, TIME and RP parameter readings.
3. Toggle the R DISP for GAS1-GAS6 percent flow readings.

4.2.38. During the run, the only button active is the STOP button to abort the process.

Note: Reasons to abort, base pressure too high, gas flows not being maintained, high reflected power, wrong recipe, wrong wafer.
The RF matching network should tune the plasma to minimum reflected power with 5 to 15 secs, reflected power should always be < 5% of the forward power setting.

4.2.39. At the end of the process the Chamber will automatically vent to atmospheric pressure. This will take 1 to 2 minutes to vent the Chamber.

4.2.40. To manually vent press MAN OP (led will illuminate), then press BLEED.
4.2.41. After the Chamber has vented remove your wafers from chamber by moving door handle out and rotate the handle CCW ½ turn to open the door as per section 4.2.6.

4.2.42. Gentle close chamber door and lock the door by latching the interlocking metal hooks and rotating the door handle CW ½ then pushing the handle to the down position flat against the side of the chamber panel as per section 4.2.11.

4.2.43. Pump down the Chamber to base pressure per section 4.2.15 to 4.2.18.

4.2.44. After Chamber is pump down to base pressure for idle mode, press the PRESS button (led will go OFF) then press the VAC ON button (led will go OFF) to close all solenoid valves.
4.2.45. Go to Chase 3 to turn close gas bottle valves and turn mechanical pump **OFF**.

4.2.46. In Chase 3 close the O2 and Ar (if using Ar) gas bottle valves by rotating the gas bottle valves CW full turn until it stops. Close the gas line final valve CW a full turn until it stops.

4.2.47. Turn **OFF Alcatel** mechanical pump by holding the breaker/switch lever and move the switch to the **DOWN** position as shown. The pump should turn OFF.

4.2.48. Go back to clean room and turn OFF the March PX-1000 asher power by pressing the large **RED** button on the front panel.

4.2.49. Enter the required information in the logbook