Chapter 7.6

Matrix-Etch Silicon Oxide/Nitride Etcher

(Matrix-Etch - 584)

1.0 Title
Matrix-Etch Silicon Oxide/Nitride Etcher

2.0 Purpose
Matrix-Etch Silicon Oxide/Nitride etcher, refurbished by Allwin21 Corporation, is a general purpose etcher for one micron and above feature size etch processes. The system, controlled by AW-303 software, is fully automated machine. The graphic user interface on this tool is relatively simple and easy to use. This software utilizes a touchscreen input to perform all operation controls and recipe editing. The system is currently set up for 6” and 4” substrates (wafers), however smaller samples can also be etched by putting the sample on the rough backside of a 6” or 4” wafer. Kapton tape is allowed in this tool and can be used to mount small samples on a carrier wafer. Matrix_etch is equipped with end point detection system, and nitride and oxide etch recipes are currently available on this tool. Figure 11.1 shows the physical layout of the system.

3.0 Scope
This document covers the operation procedures, recipe editing, and some trouble shooting solutions.

4.0 Applicable Documents
4.2 Online manual (by clicking the On Line Help and Manual button on the front page of the GUI).

5.0 Definitions & Process Terminology
5.1 Plasma Etcher: An etcher uses RF plasma to generate radical species that etches exposed material on the substrate. The substrate seat on the chuck that is grounded and the RF coil locate on the top of the chamber.
5.2 Etch Rate (ER): The thickness of the film etched away, per unit time and usually in Å/minute.
5.3 Isotropic/Anisotropic Etch: An etch process that has the same ER in all directions is isotropic. An etch process that etches in the direction perpendicular to the substrate surface is anisotropic. A plasma etcher, e.g. Matrix_etch usually etches more anisotropically.
5.4 Etch Anisotropy: The degree of anisotropy is defined by 1 – (lateral etch rate/vertical etch rate). A value of zero means isotropic etching and one is perfect anisotropic.
5.5 Etch Non-Uniformity: A measure of the etch uniformity. Microlab process monitoring sites defines as (max ER – min ER)/ (average ER), usually in %.
5.6 Etch Selectivity: The ratio of etch rates between the etched thin film (top layer) and the underlying substrate, if/when etched with the same recipe.

6.0 Safety
Follow the general safety guidelines in the lab as well as the specific safety rules, as per follows:
6.1 **RF Power Hazard:** Matrix_etch uses high power RF power generators. Never touch a RF power cord when the RF power is on. Do not look at the plasma for a long period of time.

6.2 **Chemical Hazard:** All process gases used by Matrix-Etch are confined in the gas delivery system and the vacuum chambers. However, if you smell bleach or other un-usual odor, stop the etch process and evacuate the area. Inform NanoLab staff immediately. There may be a leak in the system, or problem in the ventilation.

6.3 **Pinch Hazard:** The wafer cassette elevators may pinch your fingers. Load/unload wafer cassette with caution, keep hands away from the robot arms.

6.4 **Rule Applied to New Recipe or Modifying Existing Recipe:** It is required that you consult the process staff before creating a new recipe or modifying old ones. A recipe defined outside the machine specification may damage the tool and/or create potential hazardous situation.

**7.0 Statistical/Process Data**

The following data are from the system start-up check. They should be used as reference only.

7.1 Etch data using SF$_6$ + O$_2$ chemistry

<table>
<thead>
<tr>
<th></th>
<th>Etch Rate (Å/min)</th>
<th>Uniformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitride</td>
<td>576</td>
<td>5.34%</td>
</tr>
<tr>
<td>Oxide</td>
<td>279</td>
<td>1.43%</td>
</tr>
<tr>
<td>Photo Resist</td>
<td>111</td>
<td>1.80%</td>
</tr>
<tr>
<td>Mo</td>
<td>1130</td>
<td></td>
</tr>
</tbody>
</table>

7.2 Etch data using CF$_4$ + O$_2$ chemistry

<table>
<thead>
<tr>
<th></th>
<th>Etch Rate (Å/min)</th>
<th>Uniformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitride</td>
<td>780</td>
<td>7.36%</td>
</tr>
<tr>
<td>Oxide</td>
<td>534</td>
<td>1.48%</td>
</tr>
<tr>
<td>Photo Resist</td>
<td>35</td>
<td>2.18%</td>
</tr>
</tbody>
</table>

**8.0 Available Processes, Gases, Process Notes**

8.1 Available Processes:

8.1.1 **SF6_O2:** Etch recipe using SF$_6$ and O$_2$ chemistry. The etch profile is mainly isotropic.

8.1.2 **CF4_O2:** Etch recipe using CF$_4$ and O$_2$ chemistry. The etch profile is more anisotropic compared to the SF6_O2 recipe. CHF$_3$ can be added for more sidewall protection.

8.1.3 **SF6_O2_E:** Etch recipe using SF$_6$ and O$_2$ chemistry includes end point step.

8.1.4 **Purge:** This recipe is used when switching process gases that share the same MFC.

See Section 12.0 for the details of the above recipes.

8.2 Available Gases:

8.2.1 **CF$_4$:** Main etch gas.

8.2.2 **SF$_6$:** Another etch gas. It shares the same MFC 1 for CHF$_3$ (see Figure - 11.2).

8.2.3 **CHF$_3$:** Secondary etch gas. It also provides some etch sidewall protection.

8.2.4 **O$_2$:** Used during etch to remove etch byproducts.

8.2.5 **He:** Used as diluent. It share the same MFC 3 for O$_2$. (See Figure - 11.2).

8.3 **Process Notes:**
8.3.1 Do not try to use Matrix-Etch for photo-resist ashing, even though it looks the same as the Matrix asher. The chamber designs are completely different.

8.3.2 The etch selectivity over photo-resist is 10-20. However, photo-resist should be properly hard baked to prevent burning because the chuck temperature is set at 80°C.

8.3.3 The etch rate of silicon/poly-silicon is over 5000 Å/min. The center etches much faster than the edge (Bull’s eye effect).

8.3.4 The etch sidewall profile of the Fluorine chemistry is usually isotropic. Adding of CHF₃ can increase the polymer formation. But it is very difficult to obtain a real vertical sidewall.

8.3.5 Generally, increase RF power will increase etch rate. **The maximum allowed RF power for the system is 350W for all recipes.** See Section 12.5 for the effects of other process parameters.

8.3.6 The Matrix Etch may be used as a backup for PTherm. The same material restrictions for PTherm also apply to the Matrix Etch.

9.0 **Equipment Operation**

9.1 Creating/Editing Recipe

9.1.1 On the Main Menu page, click **Process for Production** button. Then, click **RECIPE EDIT**. The Recipe Edit Selection screen will show up. Select the recipe you plan to edit. To create a new recipe, select a similar saved recipe as a template to work on.

9.1.2 **RECIPE HEADER** - The top part of the Recipe Editor page. In the **RECIPE NAME** field, enter the new recipe name (eight characters maximum) if you are creating a new one. Do not change any other fields because they are calibrated by the equipment engineer for optimal operation.

9.1.3 **RECIPE BODY** – The table on the center region of the Recipe Editor page. All the fields are explained below:

**Step No.** The recipe step number, not editable.

**Step Temp Func** It can be Delay or Finish. Finish ends the recipe (The step is not executed). A process step uses Delay.

**Time (sec)** The time duration of the step. The maximum input is 32000 seconds.

**Temp (°C)** This is the target temperature for the step. Note: the software does not check whether the temperature is reached or not.

**Pin Up/Down** The position of the pins that support the wafer. The pins should be in down position for most of the recipe step. They come up, to cool the wafer, at the last step of the recipe before the wafer unload.

**Gas 1, 2, 3** Process gas flow. MFC#1 is shared by He and O₂; MFC#2 is CF₄; MFC#3 is shared by CHF₃ and SF₆.

**RF Power** The RF power in (Watt) for etch step.

**Vacuum Press** Vacuum pressure of the recipe step (in Torr).

**Endpoint Det** When the etch material changes, the intensity of the 704 nm F atom plasma glow will change. The Endpoint detection captures this point using, \[ \text{max\_intensity} \times (100\% - \text{Endpt\_threshold}) \]. Start with an Endpt_threshold value of 40% and vary based on the
change in intensity at the end point. An SF6/O2 recipe has been developed for general use. However, this recipe may or may not work for your specific case.

**RF**
The status of the RF generator. It can be ON or OFF

9.1.4 **Recipe Validation** - Click **Recipe Validate** Button on the lower right corner of the Recipe Editor page. The software will check the recipe for any error. All errors need to be corrected before the recipe can be used.

9.1.5 **Recipe Save** – Click **Save** button to save the recipe. Recipe will be saved as using the name in the **Recipe Name** field on the top left on the screen. Click **Exit** button to access the Main Menu page.

9.2 **Operation**

9.2.1 Enable Matrix-Etch on Mercury.

9.2.2 Make sure correct gases are selected the process gas panel at the wall behind the tool.

9.2.3 On the Main Menu page, click **Process for Production** button. The Process for Production page shows up (This page is designed for production record keeping).

9.2.4 Touch **Auto Start** Button on the center right of the screen. The WTM Manual Operation page shows up, Figure 11.4.

9.2.5 Check the process gas set up. Make sure the 3-way valves, on the wall in the back of the tool, are set correctly. If not, run the PURGE recipe using a dummy (follow section 9.3.5 to 9.3.9 instructions)

9.2.6 Load wafers into the cassette with flat up. There is no flat finder on this tool.

9.2.7 Load the cassette onto the elevator. Make sure the cassette is secured with the H-bar firmly in the two holding rings.

9.2.8 Select the recipe you plan to run. Available recipes are listed at the right side of the screen.

9.2.9 On the top of the screen, enter the slot number of the first wafer in the cassette and total number of wafers to be processed. You can not skip slot numbers.

9.2.10 Click **Auto Run** button. The screen starts showing the wafer movement. When the wafer is loaded into the chamber, the Process Monitor page shows up Figure 11.5. All the process parameters are monitored. Note the Y axis is the percentage of the full value of all the parameters. Click **Abort** button to stop processing the wafer in the chamber.

9.2.11 When all the wafers are processed, the screen returns to the WTM Manual Operation page. It beeps to remind you to unload the cassette.

9.2.12 On the center of screen, a vertical wafer bar shows the status of the each wafer. Green color indicates the wafer has been processed successfully and red color indicates the process has been aborted. The number on the left side shows the etch time of each wafer.

9.3 **End Point detection**

9.3.1 Select recipe with end point set up to monitor your oxide or nitride etch end points.

9.3.2 Currently these recipes use gain of 4, and end point detect values of 6.9 for blanket oxide and nitride “SF6-O2-E” recipe.
9.3.3 Consult with process staff if you have patterned photoresist oxide or nitride wafers, which may require a different settings for an optimized process specific to your needs. **DO NOT ALTER STANDARD RECIPE ON THE TOOL.**

9.3.4 If you want to develop your own end point recipe, please copy a known working recipe to start with, and be very mindful of the limits of the tool. Start with understanding Section 9.1.3. Any questions – please just ask staff before (not after) you stress the tool.

10.0 **Trouble Shooting Guidelines**

10.1 Problem: Process gases or pressure does not stabilize.
   Solution: Increase the time delay in the stabilization step. Try again. If problem repeats, report fault on Mercury.

10.2 Problem: Photo-Resist burned after etch.
   Solution: Make sure the Photo-Resist has been properly hard baked.

10.3 Problem: Wafer did not come out after process.
   Solution: Stop processing. Report faults and wait for equipment engineer to check the system.

11.0 **Figures And Schematics**

Figure 11.1 Physical Layout Matrix-Etch Silicon Oxide/Nitride Etcher
Figure 11.2   Process Gas Switch Panel
Figure 11.3  Main Menu Page

Figure 11.4  Recipe Editor Page
Figure 11.5 WTM Manual Operation Page

Figure 11.6 Process Monitor Page
### 12.0 Appendices

#### 12.1 SF6\_O2 Recipe

<table>
<thead>
<tr>
<th>Step No</th>
<th>Step Time Func</th>
<th>Time (Sec)</th>
<th>Temp (°C)</th>
<th>Pin Up Down</th>
<th>Gas 1 O2 sccm</th>
<th>Gas 2 CF4 sccm</th>
<th>Gas 3 SF6 sccm</th>
<th>RF Power (W)</th>
<th>Vac Press (Torr)</th>
<th>End Point Detect</th>
<th>RF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Delay</td>
<td>10</td>
<td>80</td>
<td>Down</td>
<td>15</td>
<td>0</td>
<td>90</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>OFF</td>
</tr>
<tr>
<td>2</td>
<td>Delay</td>
<td>120</td>
<td>80</td>
<td>Down</td>
<td>15</td>
<td>0</td>
<td>90</td>
<td>300</td>
<td>0.5</td>
<td>0</td>
<td>ON</td>
</tr>
<tr>
<td>3</td>
<td>Delay</td>
<td>10</td>
<td>80</td>
<td>Up</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>OFF</td>
</tr>
<tr>
<td>4</td>
<td>Finish</td>
<td>0</td>
<td>80</td>
<td>Down</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
</tbody>
</table>

Note: Turn Gas3 three-way-valve to SF$_6$ and Gas1 to O$_2$.

#### 12.2 CF4\_O2 Recipe

<table>
<thead>
<tr>
<th>Step No</th>
<th>Step Time Func</th>
<th>Time (Sec)</th>
<th>Temp (°C)</th>
<th>Pin Up Down</th>
<th>Gas 1 O2 sccm</th>
<th>Gas 2 CF4 sccm</th>
<th>Gas 3 SF6 sccm</th>
<th>RF Power (W)</th>
<th>Vac Press (Torr)</th>
<th>End Point Detect</th>
<th>RF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Delay</td>
<td>10</td>
<td>80</td>
<td>Down</td>
<td>30</td>
<td>90</td>
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<td>0</td>
<td>0.5</td>
<td>0</td>
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<tr>
<td>2</td>
<td>Delay</td>
<td>120</td>
<td>80</td>
<td>Down</td>
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<td>90</td>
<td>0</td>
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<td>0.5</td>
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<td>ON</td>
</tr>
<tr>
<td>3</td>
<td>Delay</td>
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<td>4</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>OFF</td>
</tr>
</tbody>
</table>

Note: Turn Gas1 three-way-valve to O$_2$.

#### 12.3 Purge Recipe

<table>
<thead>
<tr>
<th>Step No</th>
<th>Step Time Func</th>
<th>Time (Sec)</th>
<th>Temp (°C)</th>
<th>Pin Up Down</th>
<th>Gas 1 O2 sccm</th>
<th>Gas 2 CF4 sccm</th>
<th>Gas 3 SF6 sccm</th>
<th>RF Power (W)</th>
<th>Vac Press (Torr)</th>
<th>End Point Detect</th>
<th>RF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Delay</td>
<td>300</td>
<td>80</td>
<td>Down</td>
<td>90</td>
<td>0</td>
<td>90</td>
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<td>1.3</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>OFF</td>
</tr>
</tbody>
</table>

Note: Turn Gas1 and Gas3 three-valves to gases planned to use.