Chapter 7.33

Centura Metal Etch Chamber C

(centura-met) (586)

1.0 Equipment Purpose

1.1 The Centura MET is a DPS (Decoupled Plasma Source) etch chamber typically used for etching aluminum film, as well as other films that get deposited prior to depositing aluminum (promote adhesion or act as diffusion barrier) or after the aluminum has been deposited for ant-reflecting coating, examples of which are Ti, TiN, TiW.

1.2 The Centura platform is a fully automated, multi-wafer capacity, multi-chamber system. The system consists of a mainframe assembly (load locks, transfer chamber, process chambers) and an associated set of remote support equipment (RF power supplies, vacuum pumps, heat exchangers, computers). All wafer handling and processing takes place in the mainframe assembly. Operator interface takes place at the Centura computer terminal located at the front of the system.

1.3 The Centura MET chamber is configured for the processing of 6-inch (150 mm) silicon substrates. The plasma is inductively coupled at an RF of 13.56 MHz via a matching unit and coil assembly. Directional energy control is provided by biasing of the cathode with a separate power supply and independent impedance matching. A DTCU, or Dome Temperature Control Unit, heats the dome of the chamber thus helping to keep particle contamination at a minimum. Cooling of the cathode and DTCU is provided by a DI (de-ionized) water chiller. Helium gas is used for aiding backside cooling of the substrate.

2.0 Material Controls & Compatibility

2.1 Centura-met offers chlorine-based etch of common semiconductor industry electrical metals. All metals listed below are allowed, any others require staff approval.

2.1.1 Allowed Materials for etch:

2.1.1.1 Aluminum
2.1.1.2 Tungsten
2.1.1.3 Titanium
2.1.1.4 Titanium Nitride

2.1.2 Allowed Materials for Mask

2.1.2.1 Photoresist
2.1.2.2 SiO2
2.1.2.3 Si3N4

2.1.3 Allowed Substrates

2.1.3.1 Silicon

2.2 Temperature controls:
2.2.1 Centura-met cathode temperature is locked at 45 C. This gives good process control. Further increases will cause leaks in the water system and damage the tool.

3.0 Applicable Documents
3.1 DPS Metal Etch Centura Chamber Manual (Applied Materials® document)
3.2 Centura Mainframe (Applied Materials® document)
3.3 Material Safety Data Sheets for the following gases: Cl2, BCl3, O2, SF6, Ar, He, and N2 (copy in Microlab lobby).

4.0 Definitions & Process Terminology
4.1 AR: Aspect Ratio (the height to width ratio of a feature)
4.2 Ch A: Chamber A; designation of DPS DT silicon etch process chamber
4.3 Ch B: Chamber B; designation of MxP oxide etch process chamber
4.4 Ch C: Chamber C; designation of DPS MET Al etch process chamber
4.5 Ch D: Chamber D; designation of post Al etch passivation/resist STRIP process chamber
4.6 Ch E: Chamber E; designation of the COOL process chamber
4.7 Ch F: Chamber F; designation of flat finder or orienter chamber
4.8 CRT: Cathode Ray Tube
4.9 DPS: Decoupled Plasma Source
4.10 DPS DT: Deep Trench etch chamber. Note: DPS DT has a separate operations manual, and a separate qualification is required to use this chamber.
4.11 DRIE: Deep Reactive Ion Etch
4.12 DTCU: Dome Temperature Control Unit
4.13 ESC: Electrostatic Chuck
4.14 LLA: Loadlock A
4.15 LLB: Loadlock B
4.16 MFC Mass Flow Controller
4.17 MxP: Oxide etch chamber. Note: MxP has a separate operations manual, and a separate qualification is required to use this chamber.
4.18 RF: Radio Frequency
4.19 SOI: Silicon On Insulator
4.20 TGV: Throttled Gate Valve
4.21 TMGM: Time Multiplexed Gas Modulation
5.0 **Safety**

5.1 The Centura DPS MET chamber uses reactive gases that require careful handling. These gases are toxic, poisonous, flammable, or caustic. The system also uses high voltage electrical power, radio frequency (RF) energy, microwave energy, and magnetic fields.

5.2 **RF Power**

5.2.1 This system, like many other dry etching systems, uses high-power radio-frequency (RF) energy to generate plasma. Avoid touching or otherwise disturbing RF cables at all times. UV Radiation - Ultraviolet light is generated in the etch chamber during normal operation. View port allows the plasma and wafer to be observed. An ultraviolet shield provides eye protection. The view port is recessed to allow endpoint detection.

5.3 **Automatic Loadlock (LLA, LLB) – Pinch hazard**

5.3.1 Users must be aware of moving loadlock doors and components at all times. !!! Moving parts can crush or cut !!! Be aware that the cassette handler in the loadlock swings out and down automatically. Keep away from loadlock doors during automatic loading or unloading. Keep away chairs or other items that would potentially interfere with the loadlock doors or cassette handler at all times.

5.4 **Emergency Stop Button**

5.4.1 Red button located on front panel of tool. Pressing this button will cut power to the entire system. Use this button only if person or equipment is in harm’s way - e.g. earthquake, flood, or for any other dire circumstance.

6.0 **Process Data**

6.1 Quality Monitor is available on Mercury Web - Measure

7.0 **Available Processes, Gases, Process Notes**

7.1 Automatic Operation:

7.1.1 The equipment operation notes below detail manual mode operation only. Automatic operation of the centura platform requires systemwide operation training. This must be done by process staff and requires staff approval to run in this mode.

7.2 MET AL-ME: Standard Aluminum main etch.

7.2.1 The main etch process is also capable of etching a thin Ti film (~30 nm) under the Aluminum layer (typically 500-700nm).

7.3 MET AL-OE: Standard Aluminum over etch.

7.3.1 The over etch process is designed to etch other films under the Aluminum, e.g. TiN. The selectivity over oxide or photo resist is worse than the main etch process. Do not use this step if only etching Aluminum film is desired. See Table 1 for selectivity data.

7.3.2 The increased BCl3 is used for two purposes - to increase oxygen gettering and more aggressively attack photoresist for re-deposition on sidewalls. The extra re-deposited photoresist helps maintain sidewall angle and prevent undercut of more chemically etched metal films.

7.4 MET AL-STD: Standard Aluminum main etch + over etch.
7.4.1 Lab member should not change the standard recipes. Contact staff with requests for new, permanent recipes specialized for your application. Ideas for new recipes and suggested improvements to current recipes are encouraged.

<table>
<thead>
<tr>
<th>Etch Step</th>
<th>MET AL-ME</th>
<th>MET AL-OE</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Power (W)</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Bias Power (W)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Pressure (mTorr)</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>BCl3 sccm</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>Cl2 sccm</td>
<td>90</td>
<td>45</td>
</tr>
<tr>
<td>Typical Etch Rate</td>
<td>6000 A/min</td>
<td>3100 A/min</td>
</tr>
<tr>
<td>Typical Selectivity</td>
<td>8:1</td>
<td>4:1</td>
</tr>
<tr>
<td>Photo Resist</td>
<td>2:1</td>
<td>1:1</td>
</tr>
</tbody>
</table>

Table 1 - MET Chamber Available Standard Process Parameters

<table>
<thead>
<tr>
<th>Process gas</th>
<th>Max. MFC flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cl2</td>
<td>200 sccm</td>
</tr>
<tr>
<td>Ar</td>
<td>200 sccm</td>
</tr>
<tr>
<td>N2</td>
<td>50 sccm</td>
</tr>
<tr>
<td>BCl3</td>
<td>100 sccm</td>
</tr>
<tr>
<td>O2</td>
<td>200 sccm</td>
</tr>
<tr>
<td>SF6</td>
<td>200 sccm</td>
</tr>
</tbody>
</table>

Table 2 – MET Chamber Available Process Gases
8.0 **Equipment Operation**

8.1 Logging into the System

8.1.1 Enable the MET chamber on Mercury (equipment name is: centura-met).

8.1.2 The CRT monitor at the front of the system will turn ON.

8.1.3 Use the light pen to select the Enter User Name: field. An alphanumeric keypad will pop up. Enter **USER** using the light pen and select ENTER.

8.1.4 Use the light pen to select the Enter Password: field. Enter **NANO** using the light pen and again select ENTER.

8.1.5 Use the light pen to select the Processing field. A Log In Complete message will appear on the screen.

8.2 Viewing a Recipe

8.2.1 To view a recipe’s parameters, use the light pen to select the Program header, followed by the Process Programs option.

8.2.2 Use the light pen to select the arrow keys at the bottom left hand corner of the screen to scroll up or down the recipe list.

8.2.3 Once the desired recipe has been located in the list, select it with the light pen.

8.2.4 Select the More Step Info field to view the RF and other parameters.

8.2.5 Selecting the Header/Exchange field will display all of the auxiliary information of the recipe.

8.2.5.1 This includes Helium backside wafer cooling pressure, ESC de-chuck voltage, and other specific items. **Do not change these items without staff approval.**

8.2.5.2 Select the Edit Steps field to return to the process recipe screen.

8.3 Loading a wafer in Manual Mode

8.3.1 Use the light pen to select Wafer again, followed by selecting Load/Unload A. The LLA field should read …Venting… It generally takes 3-5 minutes to vent the loadlock.

8.3.2 Allow the wafer cassette handler will automatically lower and swing out towards the User. Do not touch any of the moving components until this procedure is complete.

8.3.3 When the green field on the loadlock screen reads: Can remove cass, carefully pick up the blue wafer cassette using both hands and place it on top of tech- wipe on the table opposite the Centura mainframe.

8.3.4 Load wafers carefully using 6-inch wafer vacuum wand or tweezers.

8.3.4.1 When loading wafers into the cassette, ensure that the wafers are correctly placed, and not cross-loaded (e.g. half of wafer in slot 4, half in slot 5).

8.3.4.2 Ensure that the wafer flat is facing up, and that the bottom of the substrate is facing the H-bar portion of the cassette.

8.3.4.3 The top of the substrate, or the side to be processed, should be facing away from the H-bar.
8.3.5 Always double-check the backside of each wafer using the green light available to the right of the tool and clean as necessary. Make sure to remove any contamination to protect the surface of the chuck.

8.3.6 Gently place the wafer cassette back into the loadlock handler.

8.3.6.1 The H-bar of the wafer cassette should point towards the Centura mainframe, opposite the User.

8.3.7 Verify that the loadlock field on the screen reads: Ready For Load, and that there are no wafers shown in the wafer cassette field on the monitor screen.

8.3.8 Check that the System header field is white. This verifies that the system is in manual operating mode.

8.3.9 Use the light pen to select Wafer and Monitor Wafers to obtain the Monitor Wafer Screen.

8.3.10 Use the light pen to select Wafer and Load/Unload A.

8.3.11 Verify that the quantity and position of the wafer(s) is accurate after mapping.

8.3.11.1 The color of the virtual wafer(s) should appear white, which indicates that the wafer has not yet been processed.

8.3.12 Use the light pen to select the desired wafer to be processed; then select Source for move.

8.3.13 Use the light pen to select the virtual Ch F position on the monitor, and the Destination for move option.

8.3.13.1 Note: All wafers must first be directed to Ch F. It is critical that the flat finder chamber find the flat of the wafer before it can be loaded into a process chamber.

8.3.13.2 Once the flat has been found, the virtual wafer should turn purple in color. It is good practice to physically view the wafer inside the flat finder chamber to ensure that it is indeed the correct wafer to be processed.

8.3.14 Using the light pen select the wafer in Ch F and Source for move.

8.3.15 Select the Ch C position using the light pen and select Destination for move.

8.4 Running a recipe

8.4.1 Select System and Control System using the light pen.

8.4.2 The Control System Screen will depict which recipe has been selected for each chamber under the column Wafer Process.

8.4.3 Select the recipe name under the column Wafer Process associated with Ch C. A pull down menu of all available recipes will be displayed.

8.4.4 Select the desired recipe from the pull down menu, and then confirm it by selecting the dark blue recipe loaded into the Wafer Process column.

8.4.5 Select Run and Run Process on Wafer in chamber using the light pen. The Ch C header will turn green, and the process will commence.

8.4.6 Select the Ch C header and the Monitor Process option.
8.4.6.1 All of the recipe process parameters are displayed in real time. To view other hardware parameters, again select the Ch C header, followed this time by the Monitor Chamber option.

8.4.7 To manually end a process, select Ch C, followed by Command.

8.4.7.1 You can stop the current recipe step and continue on the next step by selecting End Current Step.

8.4.7.2 Before moving the processed wafer back to load lock cassette, you may choose move it to Ch F, the flat finder chamber. Through the large chamber window port, you can check whether the film in the open area is cleared.

8.4.8 After the process is completed and the wafer is ready to be retrieved from the system, select Wafer and Monitor Wafers.

8.4.9 Select the wafer and Source for move.

8.4.10 Select the proper corresponding slot name in LLA and Destination for move.

8.4.11 Select the Wafer header and Load/Unload A field. The LLA field on the Monitor Wafer Screen should turn green and read: …Venting…

8.4.12 When the green field on the loadlock screen reads: Can remove cass. Carefully pick up the blue wafer cassette using both hands and place it on top of a tech wipe on the table opposite the Centura mainframe.

8.4.13 Wafers can now carefully be removed from the cassette using 6-inch wafer vacuum wand or tweezers.

8.4.14 Gently place the wafer cassette back into the loadlock handler.

8.4.14.1 The H-bar of the wafer cassette should point towards the Centura mainframe, opposite the User. The LLA field on the screen for should now read Ready For Load.

8.4.15 Select Wafer and Load/Unload A.

8.4.16 When the loadlock has reached the pump down stage, the loadlock field will read: Unload/Run. This is the proper state to leave the system in when finished processing: no wafers in the cassette, no wafers in either of the process chambers, no wafers in the flat finder or buffer chamber.

8.5 Logging Out and Leaving System in Default State

8.5.1 First ensure no other User is processing in the DPS or MxP chamber. If another User is running a process in the DPS or MxP chamber, be sure to notify that person that they will need to log in to the tool.

8.5.2 To log out of the system when finished processing, use the light pen to select System and Login\Logout.

8.5.3 Ensure that the load locks are pumped down with no wafers in the cassettes and that no processes are running (System in manual mode).

8.5.4 Disable the Centura MET chamber on Mercury.

8.5.5 The CRT monitor at the front of the system will turn OFF (as long as the DPS is not enabled at the same time).
9.0 Troubleshooting Guidelines

9.1 Problem: Process pressure can not stabilize time out.
   9.1.1 Cause: The throttle valve lost its position. This happens when the tool has been idle for long period of time.
   9.1.2 Solution: Use the Chamber Command to restart the recipe step.

9.2 Problem: Dome temperature over tolerance.
   9.2.1 Cause: Cooling water flow too low.
   9.2.2 Solution: Wait for the Dome temperature to drop. Or report on WAND.

9.3 Problem: Etch rate low or no etch at all
   9.3.1 Cause: Photo resist was under-developed or expired BARC.
   9.3.2 Solution: Descum photo resist or pre-etch BARC.

9.4 Problem: Process time out alarm when lowering the wafer to cool chuck.
   9.4.1 Cause: The system needs more time, especially for the 1st wafer after long idling period.
   9.4.2 Solution: Use the Chamber Command to restart the recipe step.
### System Status by Header Color

<table>
<thead>
<tr>
<th>Header</th>
<th>Color</th>
<th>Text</th>
<th>System Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSTEM</td>
<td>Blue</td>
<td></td>
<td>Automatic mode</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td></td>
<td>Manual mode</td>
</tr>
<tr>
<td></td>
<td>Red</td>
<td>White blinking</td>
<td>Fault</td>
</tr>
<tr>
<td></td>
<td>Red</td>
<td>White</td>
<td>Pause</td>
</tr>
<tr>
<td>CHAMBER</td>
<td>Blue</td>
<td></td>
<td>Online</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>Blue</td>
<td>Offline</td>
</tr>
<tr>
<td></td>
<td>Green</td>
<td></td>
<td>Running process/wafer transfer</td>
</tr>
<tr>
<td></td>
<td>Red</td>
<td></td>
<td>Fault</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>Green</td>
<td>Manual mode running service program</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>Red</td>
<td>Manual mode fault</td>
</tr>
<tr>
<td></td>
<td>Yellow</td>
<td>Black blinking</td>
<td>Operator needed/system hold</td>
</tr>
<tr>
<td></td>
<td>Yellow</td>
<td>Black</td>
<td>Warning</td>
</tr>
</tbody>
</table>

**Figure 1. System Status Color Codes**

### Wafer Status by Displayed Color

<table>
<thead>
<tr>
<th>Color</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>White dashed</td>
<td>Unprocessed wafer, not confirmed as existing.</td>
</tr>
<tr>
<td>White</td>
<td>Unprocessed wafer, confirmed as existing or created by an operator.</td>
</tr>
<tr>
<td>Light blue (cyan)</td>
<td>Wafer in chamber, processing (when auto sequencing).</td>
</tr>
<tr>
<td>Yellow</td>
<td>Process warning occurred on the wafer, at some step, or the wafer was created for calibrating wafer transfers.</td>
</tr>
<tr>
<td>White on red</td>
<td>Process fault occurred on the wafer, at some step (during auto sequencing).</td>
</tr>
<tr>
<td>Purple (magenta)</td>
<td>Inter-process; partly processed in multi-recipe sequence (when auto sequencing).</td>
</tr>
<tr>
<td>Green</td>
<td>Wafer processed successfully.</td>
</tr>
</tbody>
</table>

**Figure 2. Wafer Status Color Codes**
NanoLab Qualification Form

**Centura Metal Etch Chamber C**

*(centura-met) (586)*

Name ______________________ Office ______________________ Date _________________

Campus Phone ______________________ Home Phone ______________________

Login ___________________________ Trainer ___________________________

Qualification Test Passed (Signed by Front Desk) _____________________

Oral Qualification Checklist

- Materials allowed etching in the MET chamber.
- Colors and their meaning of header fields and virtual wafers under manual and automatic operation
- Complete operation of the MET chamber (operation steps from enabling to disabling).
- Safety issues regarding the User, process and the MET chamber.
- Grants and restrictions of standard users.
- Basic theory of etch process in the MET chamber.