Operations Manual for the Unaxis Deep Silicon Etcher-DSE II

Tool Description:

The DRIE system is a Unaxis Shuttleline series system with a sample loadlock. The system has an Inductively Coupled Plasma (ICP) coil and a capacitively coupled substrate RF supply to independently control plasma density and ion energy in the system. This system is dedicated to deep etching in silicon for MEMS structures. The Bosch process is used for obtaining the deep, vertical, high aspect ratio structures. This process cycles between a polymer deposition cycle using C_4F_8 gas and no substrate bias, and an etching cycle using a SF_6 / Ar mixture with substrate bias. The system is fully computer controlled in all aspects of the pumping cycles and process control, and can be programmed by the user. The fixturing is configured for 3" and 4" diameter Si wafers and uses a clamp ring to hold the sample on the RF chuck.

The materials allowed in the system are limited to Silicon, SiO_2, Si_3N_4, SiO_XN_Y, and polymer films such as photoresist, PMMA, and polyimide. Other materials can be placed in the chamber, such as metal layers on the surface, only if they will remain completely protected from the plasma by an allowed material during the entire etch. Some alternate stop-etch materials may be allowed upon discussion with Nanofab Manager.

Helium back-side cooling is used to keep the sample cool during the etch step. This is very important as the polymer passivation layer is chemically etched away by the fluorine gas at elevated temperatures, resulting in loss of profile control. Pieces of wafers or other small samples can be mounted onto 3" or 4" silicon wafers using thin, uniform, bubble-free hard baked photoresist. The etch rate is dependant on the open area of silicon (macro-loading effect) with large open area samples etching slower than small open area samples. Features with a high aspect ratio will also etch slower than more open areas. This is known as RIE lag or the micro-loading effect.

Detailed Specifications:

- 2500 W ICP coil power at 2 MHz and 300 W substrate bias at 13.56MHz plasma generators.
- C_4F_8, SF_6, O_2, Ar, N_2 gases available
- Helium back-side cooling.
- Windows-based computer control of process and wafer handling.
- Allowed materials: Silicon, SiO_2, Si_3N_4, SiO_XN_Y, and polymer films such as photoresist, PMMA, and polyimide. Other etch-stop materials on request.
- Realized etch rates (including passivation steps) of > 3um/min. Using the standard Unaxis recipes. A nominal etch rate of 2 um/min is achieved. Etch rate dependent on conditions and open area.

Safety Precautions:

- Use care when handling the wafer shuttle and ceramic holder, they are fragile and expensive. Handle with clean gloves only!
- The shuttle can be **"HOT".** Remove with care.
- Do not force open the load lock, when in vacuum.
- Use gloves or tweezers when loading and unloading samples and wafer shuttles.

Starting the System

Perform the following steps to start the SHUTTLELINE Control (SLC) system:

1. **Switch on the Cluster Tool Controller (CTC) computer and press enter once the login window comes up.**
    a. This is the small desktop PC on the table, to the right of the tool.
2. **Verify that all other support components for the control system are running.**
3. **Initialize the embedded computer (PMC) by pressing the Reset button.**
4. **Log on the SHUTTLELINE software. See next section.**

Logging on the System

1. **Click on the yellow-edged [Login here] in the Current User window in the control panel.**
    a. The <<Log in/out>> window appears.
2. **Enter the user name in the <<User Name>> field.**
    a. The user name is <<2222>>.
    b. The pull-down menu can also be used to select the available user names. Select by clicking in the list.
3. **Enter the password in the <<Password>> field.**
    a. The password is <<2222>>.
4. **Confirm password entry by clicking the [OK] button or by pressing the ENTER key.**

Substrate Loading

Process as follows to load a substrate into the system:

1. **Make sure the load lock is isolated from the from the reactor chamber.**
    a. Refer to the <<Vacuum>> screen section of the Maintain menu if necessary.
2. **Vent the lock.**
    a. Refer to the <<Vacuum>> screen of the Maintain menu for the venting the lock procedure.
3. **Place a substrate in the shuttle arm.**
4. **Pump the lock.**
    a. Refer to the <<Vacuum>> screen

Software Preparations

This section describes the set up needed for getting the SLC software ready for process operations. It is important to address all of the following prior to activating a process from the software.

Control System

1. **Make sure the SLC application is running.**
    a. Refer to the start up section in this manual if necessary.
2. **Make sure an Operator is properly logged into the system.**
3. **Make sure there are no active alarms on the system. Address as needed.**

Process Recipes

1. **Make sure any needed recipes are created and saved on the system. This can be verified in the <<Run>> screen of the Jobs menu.**
    a. If not, refer to the <<Recipe Editor>> screen in the Editors menu for creating and saving process recipe if necessary.
2. **Verify that the recipe being used has the correct parameter settings for the process.**

System Chambers

1. **Verify that the software recognizes a loaded substrate on the shuttle arm. Also, verify that the software recognizes the reactor chamber as being empty.**
    a. Refer to the <<Material ID>> fields in the Overview screen to confirm this.
2. **Make sure that the system pumps are working and the system is capable of being pumped down.**

Running a Process on the SHUTTLELINE

Verify the following before running a process on the SHUTTLELINE system.

- The system and all support components are powered.
- The SLC software is currently running.
- Required process recipes are created and saved on the system.
- Substrate is loaded into the lock. Reactor chamber is empty.
- System is cleared of active alarms.

NOTE: If any of the conditions above are not met, refer to the previous sections to ready the SHUTTLELINE for processing.

Loading a Recipe

1. **Select a recipe from the recipe list and highlight the selected recipe.**
    a. Refer to the <<Run>> screen in the Jobs menu.
2. **Enter an ID for the substrate being processed in the <<Material ID>> field.**
3. **Click on the [Run] button to start the process recipe selected.**
    a. Once processing of the substrate begins, details of the process recipe can be viewed in the upper right corner of the main screen panel <<Run>>

Monitoring Systems Parameters

Once Processing begins, the user can view different aspects of the system. The following table lists where to monitor specific system activity.

SLC Monitoring Screens

Parameters	***Screen***	***Menu***
Process Data (State, Recipe, Step, etc.)	**Run**	**Jobs**
Process Data, Chamber Data, Material Status (Recipe info, pressure, temp, etc.)	**Overview**	**Systems**
Material Status	**Material Editor**	**Editors**
Vacuum System	**Vacuum**	**Maintain**
Process Gas Flow	**Gas**	**Maintain**
Digital and Analog Signals (Input & Output)	**I/O**	**Maintain**
Active Data logging	**View Data**	**Data Log**
Alarm Messages	**Alarm Field**	**(Control Panel)**
Alarm Response/Clear	**Alarms**	**Alarms**

Stopping a Process

Process recipes can be stopped in the <<Run>> screen of the Jobs menu.

1. **Click on the [Stop] button to cease the process currently being executed.**

Substrate Unloading

Process as follows to unload a substrate from the system:

5. **Make sure the load lock is isolated from the from the reactor chamber.**
    a. Refer to the <<Vacuum>> screen section of the Maintain menu if necessary.
6. **Vent the lock.**
    a. Refer to the <<Vacuum>> screen of the Maintain menu for the venting the lock procedure.
7. **Place a substrate in the shuttle arm.**
8. **Pump the lock.**
    a. Refer to the <<Vacuum>> screen

Logging off the System

1. **Click on the yellow-edged [Login here] in the Current User window in the control panel.**
    a. The login/out window appears.
2. **Click on the [Log out] button to log off the system.**

Creating a Recipe

Proceed as follows to create a process recipe in the <<Recipe Editor>> screen:

1. **Click on the [New] button and enter a name for the new recipe.**
    a. The SLC software will default this field to “untitled”.
2. **Create the recipe by inserting, copying, or deleting steps in the <<Recipe Steps>> list.**
    a. Process
    b. Transfer
    c. Evac
3. **Set up the parameters in the step panel for each step. Apply ramping, compliance, and endpoint detection parameters if necessary.**

Step Parameters

Step Type	Behavior/Function	Configurable Parameters
INIT	Begins the process recipe by preparing the chambers temperature, pressure, and material status.	• Material Handling • Pumping • Temperature
XFER	Calls for the system to transfer material in or out of the chamber.	None (Transfer Step Only)
EVAC	Programs the system to pump the chamber to a specified pressure.	• Pumping
PROC	This step type performs the actual reaction on the substrate based on the process parameters and duration of its parameters.	• Duration • Throttle Control • Backside Cooling • Gas • RF
END	Ends the process recipe by setting the chamber to a specified pressure and removing the material.	• Pumping • Material Handling

INIT Settings

Panel	Parameter	Settings
Material Handling	Transfer Material In	• Enabled • Disabled
Pumping	Base Pressure Hold Time (step time)	Setpoint (Torr) (hr, min, sec)
Temperature	Heat Exchanger	Setpoint (º C)

PROC Settings

Panel	Parameter	Settings
Duration	• Time -or- • Endpoint Detector	(hr, min, sec) (set in endpoint panel)
Throttle Control	• Pressure -or- • Position (Relative)	Setpoint (mTorr) Setpoint (%)
Gas	Channel Name	Setpoint (sccm)
Backside Cooling	He (flow)	Setpoint (sccm)
ICP RF	Power *	Setpoint (Watts)
Bias RF	Power AMN Mode Load* Tune*	Setpoint (Watts) (Auto, Man/Auto, or Manual) Setpoint (%) Setpoint (%)

XFER Settings

(None)

EVAC

Panel	Parameter	Settings
Pumping	Base Pressure Hold Time	Vacuum Setpoint (in Torr) (hours, minutes, seconds)

END Settings

Panel	Parameter	Settings
Pumping	Base Pressure Hold Time (step time)	Setpoint (Torr) (hours, minutes, seconds)
Material Handling	Transfer Material Out	• Enabled • Disabled
	Vent Lock	• Enabled • Disabled

Editing a Process Recipe

Proceed as follows to edit a process recipe in the <<Recipe Editor>> list.

1. **Select the recipe being edited from the <<Stored Recipes>> list.**
    a. The <<Step Name>> field should display the selected step's name.
    b. If the recipe is being saved as a new recipe, change the recipe name here.
2. **Edit the selected recipe by inserting, copying, or deleting steps in the <<Recipe Steps>> list.**
3. **Set up the parameters in the step panel for each step. Apply ramping, compliance, and endpoint detection parameters if necessary.**

Deleting a Process Recipe

Proceed as follows to delete a process recipe in the <<Recipe Editor>> screen:

1. **Select the recipe being deleted from the <<Stored Recipes>> list.**
2. **Click on the [Delete] button to remove the recipe from the system.**
3. **The system will ask for confirmation. Select [yes] to delete.**
    a. The recipe should now be removed from the <<Stored Recipes>> list.

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