

Operations Manual for the 790 Unaxis PECVD System

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Introduction

A PECVD (Plasma Enhanced Chemical Vapor Deposition) system reacts gases in a RF- (Radio Frequency) - induced plasma to deposit materials such as SiO₂ and Si_XN_Y. This PECVD system operates at 13.56MHz and has one chamber that is used for all depositions. The bottom electrode where the samples are placed is called the platen, and the upper electrode where the gases enter the chamber is called the showerhead.

The Unaxis PECVD can process a wide range of sample sizes. The number of samples depends on the size of the samples. A typical run can process anywhere from one to four 4" wafers, and deposition will be uniform regardless of any through-wafer or through-sample holes. Typical deposition rates range from 80Å/min to 400Å/min, depending mainly on power and temperature.

Machine Specifications

This system is used primarily for depositing low-stress silicon nitride films, silicon dioxide, and Polysilicon layers. It can be used for depositing silicon oxynitride and *thin* layers of amorphous silicon.

This system has the following gases available for processing:

- SiH₄ (5% in He)
- N₂O
- NH₃
- N₂
- O₂

This system uses the following gases for cleaning:

- SF₆
- N₂O

Safety Precautions:

1. **The wafer platen is very HOT!- DO NOT TOUCH**
2. **This system uses toxic gases, do not skip purge steps.**
3. **The lid is heavy and can injure fingers, use care when closing.**

DO's and DON'Ts

DO NOT

- attempt to open the chamber while a process is running.
- use the ABORT button; DO use the END STEP button.
- touch the showerhead or chamber walls at all.

- touch the platen with anything besides uncoated metal tweezers - your tweezers / samples / body parts could be melted and/or burned.
- proceed with processing in the face of an unknown error. Contact the trainer and/or Nanofab staff first.
- use the machine if another user has placed a 'machine down' sign on it; ask the technical staff to verify that it is working.
- skip the purge step at the end of your recipe under any circumstance

DO

- ask the trainer, Nanofab staff, and other users questions about anything that is not clear or that you do not understand.
- make sure that your recipe has the 5 minute purge step immediately before the end

Deposited Materials and Precursor Gases

1. SiO₂ - SiH₄, N₂O
2. Si_XN_Y - SiH₄, NH₃
3. SiO_XN_Y - SiH₄, NH₃, N₂O
4. a-Si - SiH₄

Operating Instructions

1. Loading a sample

1. Login to the access controller box
2. If the system asks for a logon, user name is '2222', no password, or password is '2222'
3. Press the ON button in the bottom left of the screen.
4. Press the STANDBY button located in the same location.
5. Select the **Utilities** Menu and select **VENT**
6. Once the chamber on the screen turns blue and displays atmosphere; open the chamber.
 - The system should stop venting once the chamber is opened all the way. If it does not, select the **Utilities** Menu and click the **CLOSE GATES** option.
 - **CAUTION:** If the chamber is not opened within about 20 seconds of showing that it is vented on the screen, it will begin to pump down again and the vent process must be repeated; open the chamber *quickly* after the system is at atmosphere to avoid this.
 - **HINT:** If you try to vent the system and the display does not show the chamber as vented after 40 seconds, try **gently** pulling on the lid to see if it can be raised; if raised, see step 5(a).
7. Take a dry TexWipe and wipe the outer edge of the chamber, taking care **not to touch the platen** - just the metal areas outside the O-ring on the bottom.

- If the chamber appears dirty, **RUN A CLEAN PROCESS.**
 - **DO NOT** touch the showerhead or the walls of the reaction chamber, with anything, as it will contaminate them and prevent proper gas flow.
8. Load sample(s) into the **center of the chamber.**
- **DO NOT** use plastic tweezers or Teflon-coated tweezers to load or unload your wafers. They will melt when they come in contact with the platen, contaminating it and the sample(s). Use only uncoated stainless steel tweezers to touch the platen, nothing else.
 - **Note:** If the sample(s) are to be processed at a temperature different than the current chamber temperature, you may put them into the system, **but** if you need the system to cool down to a lower temperature, you **must not** put your samples in the chamber until it cools down to the desired temperature. You will need to load the recipe and give the system time to adjust to the desired temperature.
 - **If your sample contaminates the chamber, e.g. polymer that decomposes and clogs the showerhead, etc., YOU WILL LOSE ACCESS TO THE SYSTEM.** Think very carefully before putting anything (e.g. polymers, photoresist, etc.) that could melt or char into the chamber!
9. Close the chamber lid completely.

2. Operating

1. Record the normal operating parameters of your recipe in your notebook. Once a process is loaded, **open it to check that the parameters match those that you have written down in your notebook. If recipe information is not recorded, the staff will not provide any assistance in dealing with process-related issues. Make sure the purge step has been added to your recipe.**
2. If the recipe needs to be modified, choose the **EDIT** option from the **Process** menu. Open the recipe in question, make required changes, and save it (see section “Creating Recipes” for details).
 - **DO NOT** overwrite standard processes, e.g. if you choose a recipe that is not yours, **DO NOT** save it under that filename. Save it under a filename that will allow others to determine what it is, in the same directory you found it. Use only 8-character (e.g. DOS compatible) filenames. If only deposition time needs to be changed, that will be taken care of when the process is run. Try to share processes with other members of your group to avoid excessive numbers of personalized recipes on the system.
 - **Make sure** that your recipe has the required 5 minute purge step at 100mTorr before the vent (last) step.

3. Select the **Process** menu and **LOAD** your recipe Note: System must be in **STANDBY** or **READY** mode to load a recipe.
4. Press the **READY** button
5. Make sure the chamber lid is closed completely, as the system **will not** run a process if the lid is open.
6. Press the **RUN** button

Select the **Process** menu and **LOAD** your recipe. Note: System must be in **STANDBY** or **READY** mode to load a recipe.

7. If the selected process has the **variable (var)-time** option enabled for the RF/process step, enter the desired run time if not the default one; press Enter or select OK.
8. Watch the process until it has been depositing for one minute. Most errors, if any, with processes occur during either the gas stabilization phase or during the first minute of the process depositing. (See the troubleshooting section for more details on what errors can occur and how to resolve them). **Record any unusual readings or results.**

3. Unloading a Sample

1. Select the **STANDBY** button.
2. If the system does not auto-vent, select the **Utilities** menu; click on the **Vent** option.
3. Once the chamber is vented, lift the chamber lid and unload samples. The chamber will continue to vent for 180 seconds after it reaches atmosphere. You will not be able to pump the system or start a process until that has completed itself. You **MUST** wait 180 seconds, the system will be done venting and will announce that.
4. Unload sample(s) from chamber.

***Hint:** Let the sample(s) cool before placing them in a container. Otherwise, they **will** melt the plastic of your holder or box, contaminating the sample(s) and making it very difficult to remove them from the container. (The only exception is if the sample holder(s) are fairly thick Teflon, and even then this is **NOT** recommended.)*

5. If more samples are to be processed, repeat.
6. Close the chamber lid completely.
7. Start a clean process running.
 - 30 - 45 minutes should be adequate for film thickness of less than one micron. If thicker, increase the clean time accordingly.
8. Log out of the access controller box.

Creating a Recipe

Overview

In general, a recipe should have four steps: an initial step, two process steps, and an end step. The initial step evacuates the chamber, removing the air inside, and brings the chamber to the process temperature. The first process step is a gas purge step, and it also sets the process pressure. It allows the chamber pressure and gas flows time to stabilize. Because the RF power is off, no processing will actually take place during this step. The second process step performs the process. **Always record the parameters of the recipe and its name in your notebook.**

Instructions

From the **Process** menu choose **Build** to create a new recipe or **Edit** to edit an existing one. A list of the recipe steps will be displayed on the right side of the screen. To edit a step, double click on it. To create a new step, select the step that will go after the new step and click the appropriate button for the type of step you want at the bottom of the screen.

Initial Step

All recipes start with an initial step. This step will evacuate the chamber and bring the chamber to the desired operating temperature. Set the pressure to 30mTorr and set the time to 30 seconds. This will cause the system to evacuate as much air from the chamber as possible before starting the process. Do not attempt to use pressure set points below 30mTorr. The chamber will be evacuated as much as possible regardless of the set point. Set the temperature to the desired process temperature. Note that the temperature is measured in degree Centigrade. The user should describe the recipe in the Description box. The first few words will be displayed by the file name when the recipe is loaded.

Process Steps

Most processes usually have two process steps. They should be identical with a few exceptions. The process step dialog box has five major areas: time, temperature, pressure, gas flow, and power.

Time

The first process step's "Terminate by" time should be set to "Fixed Time" This step will be used to stabilize the chamber conditions. The time for this step is not critical, but 30 seconds is good. The second step will actually perform the deposition. If the process' "Terminate by" time is set to "Variable Time," upon running the recipe the user will be prompted for the process time before each time the recipe is run. This is usually more convenient than editing the recipe each time. However, the process time can be selected as "Fixed Time" and set manually in the recipe.

Temperature

Set the temperature to the desired process temperature for both process steps. This is done in the initial step.

Pressure

Set the pressure to the desired process pressure for both process steps. The process pressure is measured in mTorr.

Gas Flow

Set the flow rate for each gas here. The flow rates are given in sccm (standard cm³/min). The maximum flow rates are shown on the gas bottles displayed on the screen as well as the same line as the gas flow. The flow rates should be the same for both process steps; **DO NOT** exceed 90% of the rated maximum MFC flow rate.

Power

Leave the power set to zero in the first step. Set it to the desired process for the second process step. **DO NOT** exceed 400W.

Purge

All recipes have purge step immediately before the end. Set the time for the purge step to be 5 minutes and the pressure to be 100mTorr.

End Step

All recipes have an end step that evacuates the chamber. Set the pressure to 30mTorr and set the time to 60 seconds. Make sure that the auto-vent setting is set to YES so that the chamber will vent when done if this is desired.

Note: when a process is modified, only the copy on the disk is changed. If the process is already loaded, it will need to be reloaded for the changes to be reflected.

Troubleshooting Q&A

Q: The system is alarming. How do I silence the alarm?

A: Select the **SILENCE** button in the lower right corner of the screen.

Q: How do I stop a process that has a problem?

A: Use the **END STEP** button on the bottom to skip the other step(s) and end the process. Do not use the **ABORT** button.

Q: The process went into HOLD during the gas stabilization phase and began alarming. What do I do?

A: The process pressure may not have been in compliance. If this caused the error, press the **HOLD** button in the middle of the bottom of the screen and let the gases back to the desired pressure. Sometimes the system does not increase gas flow fast enough and can cause this error. The process should continue without problems. If this happens more than twice, **cease processing and go find the Nanofab staff and/or the trainer.**

Q: The system's reflected power is more than 1W but it is not alarming. What do I do?

A: This indicates the chamber is still dirty. The run can proceed, but the quality of the deposited film will not be as good as normal. It is recommended to run a clean process.

Q: The system is stuck in a mode - e.g. when the process is complete, it will not switch from READY to STANDBY. No process is running, and at least 30 seconds have elapsed. What do I do?

A: This is the **ONLY** case where pressing the **ABORT** button is acceptable. If pressing this button only once does not solve the problem, **go find the maintenance staff.**

Q: The chamber appears visibly dirty (e.g. non-metallic, non-grey color(s)). What do I do?

A: Run a clean process. Always remember to check the schedule and see what material the user before you was depositing. Allot time to run a clean process. If the previous user was depositing silicon carbide, **at least one hour** will be necessary for cleaning.

Recommended Training Check-off requirements

To be checked off, you must be able to do, to demonstrate, and to know the following items if asked:

- Locate the relevant components of the system (heat exchanger, etc.)
- Know the materials that can be deposited and know what each gas is used for (e.g. clean, precursors for what materials, etc.)
- Know the specific materials and processes **you** will be using the system for
- Be able to explain why there is a purge step required at the end of each process, what gas it uses, what pressure it runs at, and for how long.
- Be familiar with the other materials that can be deposited in the system.
- Vent the chamber - know how to do it manually
- Load a sample
- Load a process
- Edit a process and save it as yours.
- Run a sample
- Unload a sample
- Run a clean process
- Demonstrate how to handle the following errors:
 - Pressure will not go into equilibrium during the gas stabilization phase of a process
 - Levels of reflected RF power exceeding 1W
 - Levels of reflected RF power exceeding 5W
 - Process that has a general error and must be terminated