

## GENERAL PROCESS AND OPERATION SPECIFICATION

### Oxford Instruments Plasmalab 80Plus PECVD Deposition Tool

#### I. SCOPE

- a. The purpose of this document is to describe requirements and basic operating instructions for the Oxford Instruments Plasmalab 80Plus PECVD. The PECVD tool is intended for plasma-enhanced physical vapor deposition of silicon oxide, silicon nitride, silicon oxynitride films, and amorphous silicon over various substrates.

#### II. SAFETY

- a. Be sure that you are trained and signed off to use this equipment.
- b. Be sure to keep all doors and protective shields in place before operating this equipment.
- c. Use care when operating around high voltage, RF energy, or high temperatures.
- d. High-pressure gas cylinders for this tool are stored in ventilated gas cabinets located in the 7H1 service corridor. Be sure to ask a staff member for assistance to change out any gases.
- e. A recipe can be aborted at any time by selecting STOP ALL PROCESSES, located in the top right corner of the software display.
- f. When the chamber is open, do not touch the inside of the chamber or the gas showerhead.
- g. Beware of residual process gases when opening the chamber. Gases such as  $\text{NH}_3$ ,  $\text{SiH}_4$ , and  $\text{CF}_4$  are very toxic. Do not skip the final pump step in deposition or clean recipes.
- h. Use caution when loading/unloading samples. The chamber table is usually very hot, so avoid directly touching it or any sample that is being removed.
- i. If you are unsure about any procedure or indication while operating this equipment be sure to contact a staff member or trainer for assistance.

#### III. APPLICABLE DOCUMENTS, MATERIALS AND REQUIREMENTS

- a. For more information on the tool and its processes, AggieFab staff can provide the equipment manual upon request.
- b. This tool is intended for a relatively wide range of substrate and target materials.
- c. This tool is configured to run with the following gases for normal processing:  $\text{N}_2$ ,  $\text{N}_2\text{O}$ ,  $\text{NH}_3$ , 5%  $\text{SiH}_4/\text{He}$ . Also,  $\text{O}_2$  and  $\text{CF}_4$  are available only for running in “Clean” mode. Clean mode is not available to regular users and can only be run with manager access.
  - i. If the tool is still in clean mode when you sign in, ask a staff to change it back to “Manual”.
- d. Gases are stored in the service corridor but are available under software recipe control.
- e. This tool uses a mechanical pump (Leybold-Heraeus D90AC) with an Alcatel Blower RSV 600 to maintain adequate working pressures with relatively high gas flow rates. Ask a staff member for assistance to turn these pumps on or off as needed.

#### IV. OPERATION

- a. Log in and open the process chamber:
  - i. Log in by clicking the login status box on the top of the screen. (Fig. 1)
    1. This login menu can also be accessed by clicking “System” then “Password”

## 2. Login is case sensitive

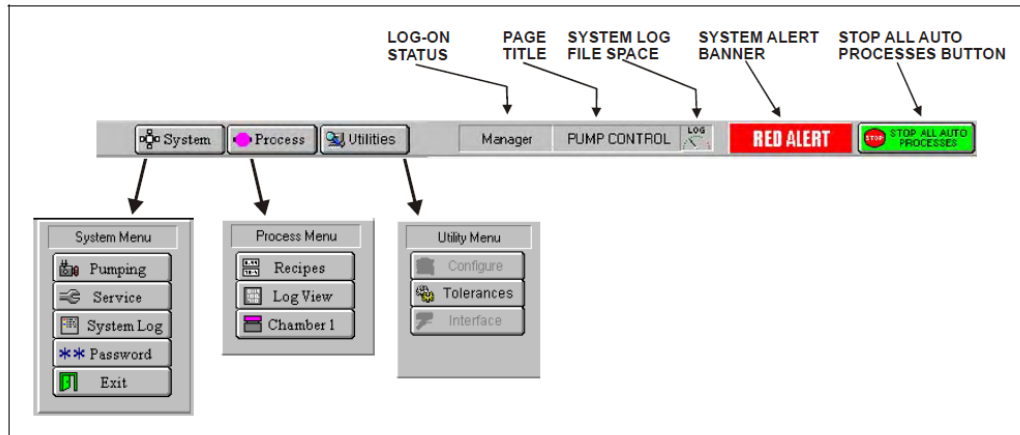


Figure 1: Top toolbar

- ii. Open the pumping menu by clicking “System” then “Pumping” (Fig. 1)
- iii. Press “STOP” at the bottom of the process chamber status panel. (Fig. 2)

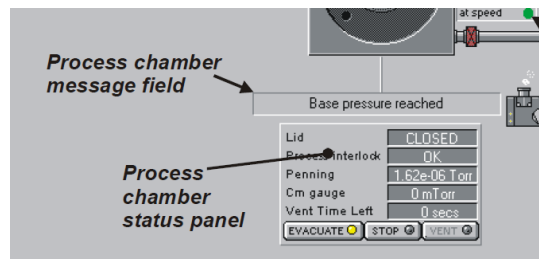


Fig 2: Pump control page

- iv. Press “VENT” and wait until it says, “Venting Finished” in the process chamber message field. (Fig. 2)
- v. Open the process chamber. (Fig. 3)
  1. Flip the switch on the front of the machine to “Chamber Up”, then press and hold the two blue “Hoist” buttons until the chamber is completely raised.



Fig 3: Opening/Closing the process chamber

- b. Ready sample and close the process chamber:
- (Rev A) Operation Spec Oxford PECVD Plasmalab 80Plus)

- i. Place sample on the holder plate (Fig. 4)
  1. Kapton tape is not allowed inside the chamber.
  2. Do not touch the holder plate, it may be very hot! (like 350 °C/660 °F hot!)
  3. Hold your hand below your sample as you move it to prevent dropping it into the chamber. Dropped samples are very difficult to remove and they will likely be damaged afterward.
  4. Center your sample on the substrate table so that it gets the best uniformity.

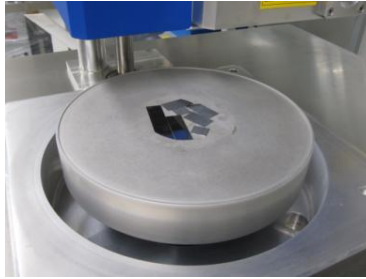


Figure 4: Substrate table and properly centered substrates

- ii. Close the chamber. (Fig. 3)
  1. Flip the switch on the front of the machine to “Chamber Down”, then press and hold the blue “Hoist” buttons until the chamber is completely raised.
  2. Make sure your hands don’t get pinched by the closing chamber
- iii. Ensure that the “SOFT PUMP” is 30 seconds. (located to the left of the process chamber status panel, Fig. 2)
  1. This is easier on the pump and keeps small samples from moving.
- iv. In the “Pumping” page, click “STOP” then “EVACUATE”. (Fig. 2)
- v. When prompted enter a wafer name, then click “OK”.
  1. **ALWAYS ENTER A WAFER NAME!** No-name wafers cause software errors.
  2. Don’t start a wafer name with a number or a special character.
- vi. Wait until the display says, “Base pressure reached” (Fig. 2)
- c. Load and run a recipe:
  - i. Select “PROCESS” in the top left of the screen. (Fig. 1)
  - ii. Select “Recipes”. (Fig. 1)
  - iii. Select “Load”
  - iv. Select “YES” to overwrite the current recipe. This does NOT delete or save over the recipe it loads a new one.
  - v. Select desired recipe from the menu list and click “OK”
    1. If only clean recipes are visible, then the tool is still in “Clean” mode. Contact staff to return it to “Manual” mode.
  - vi. Edit recipe as needed by clicking on a recipe step.
    1. See the appendices for information on AggieFab made recipes.
  - vii. When the recipe is ready click “RUN”.
    1. Do not save the recipe when prompted to unless it’s your recipe.

- viii. Running the recipe:
  - 1. While the recipe is running, fill out the logbook. This is the best time to do it since all the values you need are right in front of you.
  - 2. The system will begin the recipe when all parameters are within tolerance. The software will switch to the process control screen (titled “Chamber 1” under “Process”) to show recipe progress and current values.
  - 3. When the recipe is complete, a yellow alert will appear saying “Process Complete”. Click “Continue”

- d. Remove sample, and ready the tool for the next user:
  - i. Go to the pump control page by selecting “System” then “Pumping” (Fig. 1)
  - ii. Press “STOP” then “VENT” and wait until it says, “Venting Finished”. (Fig. 2)
  - iii. Open the chamber: (Fig. 3)
    - 1. Flip the switch on the front of the machine to “Chamber Up”, then press and hold the blue “Hoist” buttons until the chamber is completely raised.
  - iv. Remove sample and set it on aluminum foil to cool down.
    - 1. Please use caution since your sample is likely to be very hot.
    - 2. Hold your hand below your sample as you move it to prevent dropping it into the chamber.
  - v. Close the chamber: (Fig. 3)
    - 1. Flip the switch on the front of the machine to “Chamber Down”, then press and hold the blue “Hoist” buttons until the chamber is completely closed.
    - 2. Make sure your hands don’t get pinched by the closing chamber
  - vi. Select “Stop” then “EVACUATE”, enter a wafer name, and select “OK”. (Fig. 2)
  - vii. Before logging out **MAKE SURE YOU FILL OUT THE LOGBOOK!**
  - viii. Log out by clicking the login status box on the top of the screen then click “Verify” (Fig. 1)

SIGNATURES AND REVISION HISTORY

- e. Author of this document: Larry Rehn and Cheng-Chung Chang
- f. Author Title or Role: Technical Manager/Student Lab User
- g. Date: 1/29/21
- h. Revision: A
- i. Revision notes: Re-wrote operation section for clarity, reformatted operation section to follow standard SOP template, added parameter information (Appendix A), added 5% silane recipes (Appendix B), archived old recipes into Appendix C

Approvals:

Technical Manager Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Revision History:

| Revision       | Author    | Date     |
|----------------|-----------|----------|
| Original Issue | L. Rehn   | 5/2/2014 |
| Rev A          | E. Colter | 1/29/21  |
| Rev B          |           |          |
| Rev C          |           |          |
|                |           |          |
|                |           |          |

## **Appendix A: Recipe Parameter Information:**

- Step time: How long that step should run for. Box 1 is hours, box 2 is minutes, box 3 is seconds.
  - Do not put anything larger than 60 in the minutes or seconds place, it will always autocorrect to 60.
- Ignore tolerance: Certain parameters have certain tolerances. For example, if the recipe's table temperature setpoint is 20 °C and the actual value is 30 °C, then it is out of tolerance. By checking this, the recipe will continue to run while tolerances are not satisfied.
- Auto Pressure Controller (APC): The APC controls the chamber pressure automatically based on the gas flow rates and pressure setpoint.
  - Chamber Pressure [mTorr]: Pressure in the process chamber. **DO NOT** exceed 1000mTorr.
  - Strike Pressure [mTorr]: Value at which the RF should turn on and strike the plasma. If a zero is entered, the feature is disabled, and the RF will turn on once the pressure has stabilized at the requested process pressure
  - DC Bias Minimum [V]: Enter a positive number for the minimum DC bias value expected once the plasma has struck. Enter zero if DC bias cannot be read because the substrate (and any wafer clamp) completely cover the electrode, or if the electrode has an insulating coating. A non-zero value is used by the software to detect if the plasma has been properly established. If a zero is entered, then the software assumes the plasma has struck once the RF reflected power goes low.
  - Ramp Rate [s]: Sets the rate at which the pressure is reduced from the strike value to the set point. The higher the number entered, the faster the transition to process conditions will be. Too high a value can cause the plasma to go out.
- RF Generator:
  - Forward Power [W]: Value of the RF power applied to the plasma.
    - **MAXIMUM = 200 W**
  - Larger RF power increases the deposition rate and anisotropy/directionality but decreases selectivity.
  - DC Bias [V] and Reflected Power [W] are functions of the forward power and other parameters. If DC Bias is larger than 500 V, an error will occur, and the tool will abort the process.
- ICP (Inductively Coupled Plasma):
  - Forward Power [W]: Value of ICP power applied to the plasma.
    - **MAXIMUM = 2000 W**
  - Larger ICP power results in a denser (more ions) plasma. This increases the etch rate and selectivity but decreases anisotropy/directionality.
- Process Gases [SCCM]: Flow rates of the gases. Larger gas flow rates increase the deposition rate.
  - **MAXIMUM = 100 SCCM**
- Hold (seen next to the list of recipe steps): When hold is on, the plasma is continuous between steps. If NOT selected, the plasma will turn off between steps while the APC stabilizes.

## **Appendix B:**

### **(NEW) Recipe Details & Characterization (5% Silane/He)**

5% SiH<sub>4</sub>/He Characterizations:

| Recipe Name                                  | Pressure<br>[Torr] | 5%<br>Silane/He<br>[sscm] | Other<br>Gas<br>[sscm] | Temp<br>[°C] | Dep Rate<br>[nm/min] | Refract<br>Index* |
|--|--------------------|---------------------------|------------------------|--------------|----------------------|-------------------|
|  |                    |                           |                        |              |                      | Ocean<br>Optics   |
| <b>5% Sil SiO<sub>2</sub> Dep Fast Rate</b>  |                    |                           |                        |              | 60                   | 1.4348            |
| <b>5% Sil SiO<sub>2</sub> Dep High RI</b>    |                    |                           |                        |              | 45                   | 1.4524            |
| <b>5% Sil SiN w/ NH<sub>3</sub> Low Flow</b> |                    |                           |                        |              | 5.3                  | 1.915             |
| <b>5% Sil SiN w/ NH<sub>3</sub> Med Flow</b> |                    |                           |                        |              | 9.3                  | 1.9516            |
| <b>5% Sil SiN w/ N<sub>2</sub></b>           |                    |                           |                        |              | 11                   | 2.0174            |
| <b>5% Amorphous Silicon</b>                  |                    |                           |                        |              |                      | 4+                |

## **Appendix C:**

### **(OLD) Recipe Details & Characterization (1% Silane/N2)**

1% SiH<sub>4</sub>/N<sub>2</sub> Characterizations:

|                             |                             |   |
|-----------------------------|-----------------------------|---|
| <b>Deposited Film/Layer</b> | <b>Recipe Name:</b>         | Gases: SiH <sub>4</sub> /N <sub>2</sub> (1%) = 425 sccm |
| <b>SiO<sub>2</sub></b>      | SiO <sub>2</sub> Deposition | N <sub>2</sub> O = 710 sccm                             |
|                             |                             | T = 350°C, p = 1000 mTorr                               |
|                             |                             | RF power = 20W  |
| <b>time (min)</b>           | <b>thickness (nm)</b>       | <b>Refractive Index</b>                                 |
| 1                           | 42.4                        | 1.4   |
| 2                           | 94.14                       | 1.47  |
| 5                           | 223.1                       | 1.58  |
| 10                          | 478.7                       | 1.5   |

|                             |                               |  |
|-----------------------------|-------------------------------|--|
| <b>Deposited Film/Layer</b> | <b>Recipe Name:</b>           | Gases: SiH <sub>4</sub> /N <sub>2</sub> = 120 sccm |
| <b>SiN<sub>x</sub></b>      | SiN <sub>x</sub> dep 13nm/min | N <sub>2</sub> = 900 sccm                          |
|                             |                               | T = 350°C, p = 600 mTorr                           |
|                             |                               | RF power = 60W                                     |
| <b>time (min)</b>           | <b>thickness (nm)</b>         | <b>Refractive Index</b>                            |
| 2                           | 12.17                         | 2.06   |
| 5                           | 24.2                          | 2  |
| 10                          | 41.48                         | 2.05   |
| 20                          | 75.2                          | 2.15   |

|                                    |   |  |
|------------------------------------|---|--|
| <b>Deposited Film/Layer</b>        | <b>Recipe Name:</b>                             | Gases: SiH <sub>4</sub> /N <sub>2</sub> = 125 sccm |
| <b>Si<sub>3</sub>N<sub>4</sub></b> | Si <sub>3</sub> N <sub>4</sub> Growth 7.2nm/min | N <sub>2</sub> = 700 sccm                          |
|                                    |   | T = 350°C, p = 600 mTorr                           |
|                                    |   | RF power = 15W                                     |
| <b>time (min)</b>                  | <b>thickness (nm)</b>                           | <b>Refractive Index</b>                            |
| 7                                  | 50  | 1.98   |
| 14                                 | 100   | 1.98   |
| 42                                 | 310   | 1.98   |