University of Minnesota Nano Center

PECVD - Standard Operating Procedure

Badger Name:	K3 PECVD Plasmatherm	**Revision Number:**	3
Model:	Plasmatherm 790	**Revisionist:**	Wanjohi Kimani
Location:	Bay 3 Keller Hall	**Date:**	April 17, 2020

Table of contents

University of Minnesota Nano Center

PECVD - Standard Operating Procedure

1. Scope

1.1. This document provides detailed instructions on how to properly operate the PECVD deposition system.

2. Tool description

2.1. The Plasmatherm PECVD is used to deposit thin films (Silicon Nitride, Silicon Dioxide, or Amorphous Silicon) from a gas state to a solid state on a substrate. The chemical reaction takes place after an RF plasma is created between the top electrode and the heated platen. An embedded resistance heater with a range of 80-340 ºC heats the platen. This system has processes setup for the deposition of Silicon Nitride, Silicon Dioxide and Amorphous Silicon. The system processes are in located in folder **c:\sysmon.** Program naming convention is the following, SIN340.prc is Silicon Nitride at 340 ºC, SiO2340 is Silicon dioxide at 340 ºC, and ASi340 is Amorphous Silicon at 340 ºC.

3. Safety

3.1. The safety item beyond the normal electrical hazards to watch out for are the platen temperature can reach 340 ºC. The process gases that are available in this system are N_2, 0_2, CF_4, N_2O, 2%SiH_4/He, NH_3, and He. In case of an emergency press the RED EMO button and contact am MNC person about any problems.

4. Restrictions

4.1. Must be a qualified customer on the Badger and PECVD system.

4.2. No Amorphous Silicon (ASi) deposition from **Tuesday 12:00pm - Thursday 12:00pm**

4.3. FYI. If you deposit SiO_2, SIN, or ASi on any substrates in the PECVD system, those substrates **may not** go back into any thermal oxide tubes. They can however be used in

the RTA. Please use the RTA in Bay 1 to densify the PECVD deposited film or contact a MNC staff person for additional options.

5. Required facilities

5.1. The system needs electrical power, gases, cooling water

6. Definitions

6.1. Process = A program that controls the sequence of events.

6.2. Platen = The main base plate that the wafers or substrates are placed on

6.3. Lid = the top bell jar cover of the system that opens up.

7. Setup

7.1. To hold your substrate in the center of the platen use1" x 3" glass slides. Due to the placement of the pumping port, your substrates will tend to move to the back-right area of the platen.

7.2. It is a good idea to place a piece of bare silicon in with your process so that you can measure the thickness of your deposited film and refractive index of your deposited film.

8. Operating procedures

8.1 Enable the PECVD

8.1.1 To enable the PECVD in Badger, first highlight the PECVD by going to K3 > PECVD, then under Equipment Actions select Enable. The green light should now be lit.

8.2 Login to the system

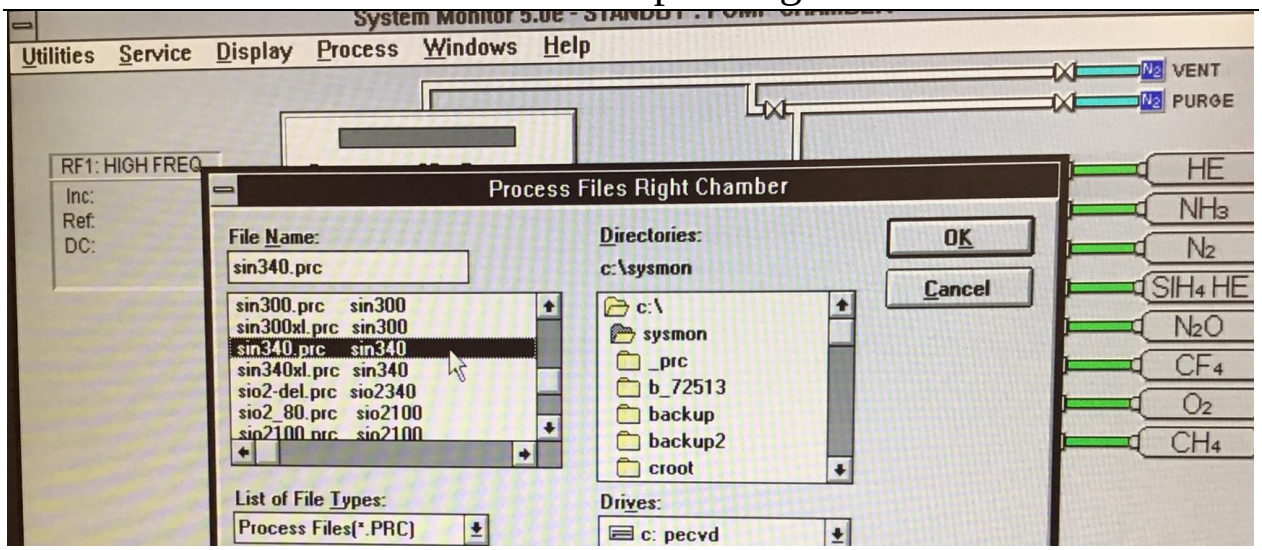
8.2.1 The Operator Login window should now be in the middle of the screen. In the **Operator** box enter **MLRE** and press TAB. In the Password box enter **1234** and then click **OK** box. The operator name and password are in uppercase letters. The system monitor window should now be on the screen. The system monitor gives you the status of the system parameters. (The top left trackball mouse button and the roller ball are used in operation of the PECVD system).

8.3 Load a Process.

8.3.1 Using the pull-down menus at the top of the system monitor screen **Select PROCESS>LOAD.** Also, fill out the logbook on the table.

University of Minnesota Nano Center

PECVD - Standard Operating Procedure



8.3.2 The list of process files right chamber window will appear. Check to see that the directory or folder should be **c:\sysmon.** If not, change folder to c:\sysmon. Then, highlight the process you would like to run by clicking on the name with the left-hand mouse button (sin250, sin340, sio2250, sio2340, etc.).

8.3.3 The process you selected should now appear in the **File Name** box. Click **OK** in the upper right-hand comer of the window. Your process should now be loaded. Check the process box for your process.

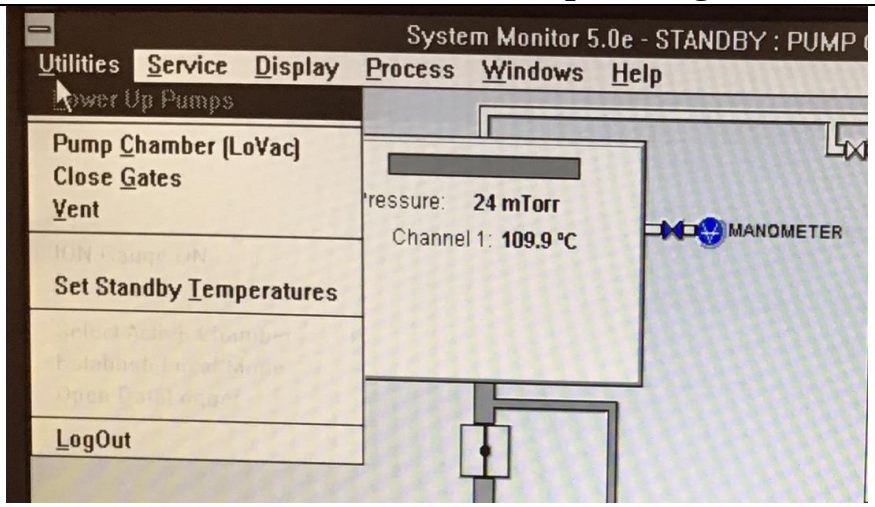
8.4 Type of films

8.4.1 The Nitride film is the cleanest film, then oxide film, while the amorphous films are the dirtiest films. So, the PECVD system should be cleaned when changing from an oxide deposition to a nitride and from amorphous silicon to any of the other two films

8.4.2 If the last process used was an amorphous silicon process, the system a clean process should be ran before depositing nitride or oxide. See section 9 on cleaning the system.

8.5 Vent the system

8.5.1 Using the pull-down menus at the top of the system monitor screen **Select Utilities>Vent.** The chamber will vent will take 1-2 minutes. The chamber lid will pop open when the chamber has vented and the pressure screen turns from vacuum (red/white) to atmosphere (blue).



8.6 Load your substrates

8.6.1 You can now lift chamber lid up by hand and load your samples or substrates. There is a chain available to hold the chamber lid open while you load your substrates. **CAUTION: THE PLATEN IS VERY HOT - AVOID CONTACT.** Use l"x3" glass slides to hold your substrates in the center of the platen. It is possible to load four - 4" wafers, one - 6" wafer, or one 8"wafer.

8.6.2 To get the best uniformity on your substrates, load them in the center of the platen, using a couple 1"x3" glass slides to hold them in the center of the platen. Remember a 1"x3" glass slides are 1 mm thick and most substrates are thinner than 1mm, so it is best if you hold your substrate in the center of the platen with the corner of the glass slide. This loading technique will allow the gas to flow over the glass slide more uniformly, thus getting a uniform deposition on your substrate.

8.6.3 The way to determine the deposited film thickness and refractive index is to load a piece of bare silicon along with your substrates and measure this piece of silicon on an ellipsometer in bay one when your run is complete.

8.7 Pumping the system down

8.7.1 Using the pull-down menus at the top of the system monitor screen **Select Utilities>Pump Chamber (LoVac),** while pressing the chamber lid down with a little pressure. Hold down the chamber lid until the pressure screen turns from atmosphere (blue) to vacuum (red/white). You will notice that the gap from the top lid will get smaller as the chamber pumps down

8.8 To run your Process

8.8.1 Click on **READY** in the **System Status** cluster at the bottom of the screen

8.8.2 **Wait until the process temperature has been reached.** (Note: This could take up to 45minutes for the higher temperatures.) When the system has met all initial parameter requirements the entire **READY** button will

tum yellow and the status bar will give the following message **"Ready Mode Temperature Compliance Achieved"**.

8.8.3 Once the system is in the **READY** mode, click on **RUN**

8.8.4 The system moves automatically through steps 1-6. At step 4 you will need to stop your deposition at the correct time and advance the program to the next step by hitting the **end step button**. See below.

Step 1: Initial Pump down (1 minute)
Step 2: Pre-purge- Important: removes water vapor from the chamber. (3minutes)
Step 3: Gas stabilization (2 minutes)
Step 4: Process - This is the actual deposition step. (Deposition time)
Step 5: Post-purge – Important: removes hazards gases from the chamber. (2minutes)
Step 6: End and vent (3 minutes)

8.8.5 Since most processes in c:process are written with a standard 120 minute actual deposition time (Step 4 Process) you will need to time your deposition using the clock visible in the lower right side of the screen. When the time in the **Elapse** box has reached the deposition time, click on the **END STEP** button **once only** in the **System Status** cluster at the bottom of the screen. This will end your deposition and advance the process to the step 5.

8.8.6 If you make a mistake and click the END STEP button more than once, wait until the system has pumped the chamber for ~ 30seconds, then click the ABORT button in the **System Status** cluster; then click - Yes to abort. Select one of the following processes (Purge150, Purge250, or Purge300). Select the process that is closest to your process temperature; run this process. These processes will purge the chamber of all gases and vent the system. Please see the appendix for process summary sheets that include deposition rates, stress, refractive index, etc.

8.9 Remove your samples

8.9.1 After the process is completed, the chamber will vent, and the lid will open. Remove your substrates and place them on the glass plate on top of stainless-steel top of the system until they cool. Cool your substrates slowly to minimize thermal shock. **CAUTION: THE PLATEN AND THE SAMPLES BEING REMOVED ARE VERY HOT - USE CAUTION WHEN HANDLING.** The process complete window appears stating that the process is done and the automatic process was completed. Click **OK.** If you would like to deposit on more samples go to step 8.6. If not, continue to next step.

8.10 Pump the system down

8.10.1 Using the pull-down menus at the top of the system monitor screen. **Select Utilities>Pump Chamber (LoVac),** while holding the chamber lid closed. Hold down the chamber lid until the pressure screen turns from atmosphere (blue) to vacuum (red/white). You will notice that the gap from the top lid will get smaller as it pumps down.

8.10.2 To measure the film thickness and refractive index of your samples use the ellipsometer in Bay 1. Please record this information in the logbook on the table below the monitor.

8.11 Return the system to standby

8.11.1 After the system has pumped down, (the pressure box has turned white), click on the **STANDBY** button box in the **System Status** cluster at the bottom of the page. This should put the system in the **STANDBY** mode.

8.11.2 If you had run a process at a temperature higher than 110, please select a low temperature recipe like SIN100, load it and leave the system in READY (rather than STANDBY mode as outlined above)

8.12 Logout

8.12.1 Click on the **Utilities>Log Out.** The system should now be in the **STANDBY** mode and logged out.

9 Cleaning the system

9.1 To clean the system, choose one of the following processes

9.1.1 **Clean1.prc – 45 minutes**

9.1.2 **Clean2.prc – 90 minutes**

9.1.3 **Clean3.prc – 180 minutes**

9.2 After the clean is complete, wipe out the system with kim wipes and then use the N_2 gun to blow out the chamber from the top to bottom. Then, run your planned process for 5 to 10 min to coat the chamber with SIN or $Si0_2$ this will help coat and seal any particles that might be left over from the cleaning process

9.2.1 Note: MNC will clean the system every Tuesday morning, so the system will be ready by 12:00pm for nitride and oxide depositions. If you have any questions, please contact MNC staff.

10 Tips/Techniques

10.1 Deposition Rate.

10.1.1 The deposition rates are on the Process Summary Sheets in the appendix of this SOP. If you need your deposition to be better than X +/- 10%. It is a good idea to do a dummy run (5-10 minutes) before the actual deposition, to get a more accurate deposition rate for your run. Please put your deposition rate in the logbook.

10.2 Check Platen temperature.

10.2.1 Check the system to see what the platen temperature is; open the front panel door below the chamber, and the top temperature displayed should be what is in the process. See below for an example. In the photo, the system is at 112 degrees and a 110-degree process has been selected.

10.3 To reduce-pin holes in Films

10.3.1 Depositing in more than one deposition for the total thickness, helps reduce the problems of film voids or pinholes. For example, a 750 Å film thickness could be split into three layers of 250 Å each. This technique of depositing three layers has helped customers solve their film quality problems. To take advantage of this technique, just split your total thickness into three parts. Another technique customer have used is to blow off their wafers or substrates with N_2 between deposition steps.

11 Problems/Troubleshooting

11.1 END STEP Problem

11.1.1 If you make a mistake and click the END STEP button more than once, wait until the system has pumped the chamber for ~ 30seconds, then click the ABORT button in the System Status cluster, then click **Yes** to abort. Select one of the following processes (Purge150, Purge250, or Purge300) select the process that is closest to your process temperature, run this process. These processes will purge the chamber of all gases and vent the system.

11.2 Software issues and rebooting system.

11.2.1 Sometimes the system will not accept passwords, or just operate in a strange fashion; this is a clue that the software has stopped working correctly. Rebooting the system by pressing the Crtl-Alt-Del keys will reboot the system. Once the software is running, login, pump the chamber down and continue with selecting a recipe and running a process.

11.3 Building Fire Alarm

11.3.1 Note the elapse time on the clock. Hit the Abort button in the system status cluster. Exit the lab through the closest door.

11.3.2 To restart the system after a fire alarm, contact an MNC staff member.

11.3.3 If you have any questions, contact an MNC staff member.

University of Minnesota Nano Center

PECVD - Standard Operating Procedure

Summary Sheet Silicon Nitride

Parameter

Gases……..2%SiH4/He……...200sccm
N2……740sccm
NH3……2.0sccm
Time…….....120 minutes
Pressure…….900mtorr
Power……...20W
Uniformity……<+/-3.0% Across a 4" wafer
Process

SiN100.prc

Temperature……..100 C
Deposition Rate……130 A/min
Refractive Index……1.85
Stress……..137 MPa (tensile)

SiN150.prc

Temperature……150 C
Deposition Rate…….~115 A/min
Refractive Index……..1.90
Stress……...130 MPa(tensile)

SIN200.prc

Temperature……200 C
Deposition Rate…….102 A/min
Refractive Index……1.92
Stress……...…1317 Mpa (tensile)

SIN250.prc

Temperature……250 C
Deposition Rate……~ 96 A/min
Refractive Index…….1.95
Stress……..? MPa(tensile)

SIN300.prc

Temperature……....300 C
Deposition Rate……..83 A/min
Refractive Index……...1.99
Stress……1515 MPa(tensile)

SIN340.prc

Temperature……..340 C
Deposition Rate……..78 A/min
Refractive Index……..2.01
Stress……480 MPa

University of Minnesota Nano Center

PECVD - Standard Operating Procedure

Summary Sheet Silicon Dioxide

Parameter

Gases……..2%SiH4/He……..…...200sccm
N2O……..…450sccm
Time……..120 minutes
Pressure……..900mtorr
Power……..20W
Uniformity……<+/-3.0% Across a 4" wafer

Process

SiO2100.prc

Temperature……100 C
Deposition Rate……343 A/min
Refractive Index……..……1.42
Stess……..134 MPa (compressive)

SiO2150.prc

Temperature……..150 C
Deposition Rate……..370 A/min
Refractive Index……..……...1.45
Stess……..250 MPa (compressive)

SiO2200.prc

Temperature……...200 C
Deposition Rate……..372 A/min
Refractive Index……..……..….1.44
Stess…….……..321 MPa (compressive)

SiO2250.prc

Temperature…….250 C
Deposition Rate……370 A/min
Refractive Index……..……1.45
Stess……250 MPa (compressive)

SiO2300.prc

Temperature…….300 C
Deposition Rate……369 A/min
Refractive Index……..……1.45
Stess……247 MPa (compressive)

SiO2340.prc

Temperature…….340 C
Deposition Rate……378 A/min
Refractive Index……..……...….1.44
Stess……...251 MPa (compressive)

University of Minnesota Nano Center

PECVD - Standard Operating Procedure

Summary Sheet Amorphous Silicon

Parameter

Gases……...2%SiH4/He 600sccm
He……...100sccm
Time .....…120 minutes
Pressure 900mtorr
Power……..20W
Uniformity……<+/-4.0% Across a 4" wafer

Process

ASi100.prc

Temperature……100 C
Deposition Rate……..53 A/min
Refractive Index……~3.30
Stress……385 MPa (compressive)

ASi150.prc

Temperature……..150 C
Deposition Rate……~50 A/min
Refractive Index……~3.50
Stress……?

ASi200.prc

Temperature……200 C
Deposition Rate……49 A/min
Refractive Index……~3.50
Stress……890 MPa (compressive)

ASi250.prc

Temperature……..250 C
Deposition Rate……..~50 A/min
Refractive Index……...~3.50
Stress……?

ASi300.prc

Temperature……..300 C
Deposition Rate……50 A/min
Refractive Index……~4.00
Stress……1028 MPa (compressive)

ASi340.prc

Temperature……..340 C
Deposition Rate……~50 A/min
Refractive Index……~4.0
Stress……?

University of Minnesota Nano Center

PECVD - Standard Operating Procedure

Summary sheet clean recipes

Clean1.prc

Parameter

Gases…… CH4 ..... 80 sccm

O2 ..... 8 sccm

Time ..... 45 minutes

Pressure 250, 500, 900mtorr

Power 350W

Temperature ..... 100 C

Clean2.prc

Parameter

Gases.....CH4……80 sccm

O2……8 sccm

Time……90 minutes

Pressure 250, 500, 900mtorr

Power 350W

Temperature ..... 100 C

Clean3.prc

Parameter

Gases……CH4..... 80 sccm

O2..... 8 sccm

Time ..... 180 minutes

Pressure 250, 500, 900mtorr

Power. 350W

Temperature ..... 100 C

Summary Sheet Purge Recipes

Parameter

Gases……N2……200sccm

Pressure……730mtorr

Time……7 minutes

Power……0W

Purge 150.prc

Parameter

Temperature……150 C

Purge 250.prc

Parameter

Temperature……250 C

Purge 300.prc

Parameter

Temperature……300 C