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PECVD - Standard Operating Procedure

Badger Name:	K3 PECVD Plasmatherm	Revision Number:	5
Model:	Plasmatherm 790	Revisionist:	Wanjohi Kimani
Location:	Bay 3 Keller Hall	Date:	October 27, 2022

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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. A blend of these films is also possible. 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 °C heats the platen. This system has processes setup for the deposition of Silicon Nitride, Silicon Dioxide and Amorphous Silicon. The system processes are located in folder **c:\sysmon**. Program naming convention is the following, SIN340.prc is Silicon Nitride at 340 °C, SiO2340 is Silicon dioxide at 340 °C, and ASi340 is Amorphous Silicon at 340 °C.



3. Safety

3.1. The safety item beyond the normal electrical hazards to watch out for are that the platen temperature can reach 340 °C. The process gases that are available in this system are N₂, O₂, CF₄, N₂O, 2%SiH₄/He, NH₃, and He. In case of an emergency press the RED EMO button and contact an 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

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- 4.3. FYI. If you deposit SiO₂, 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 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 use 1" 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 wafers so that you can measure the thickness and refractive index of your deposited film.

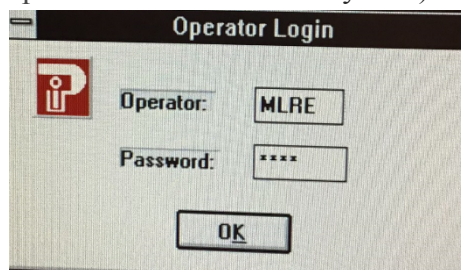
8. Operating procedures

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 is 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).

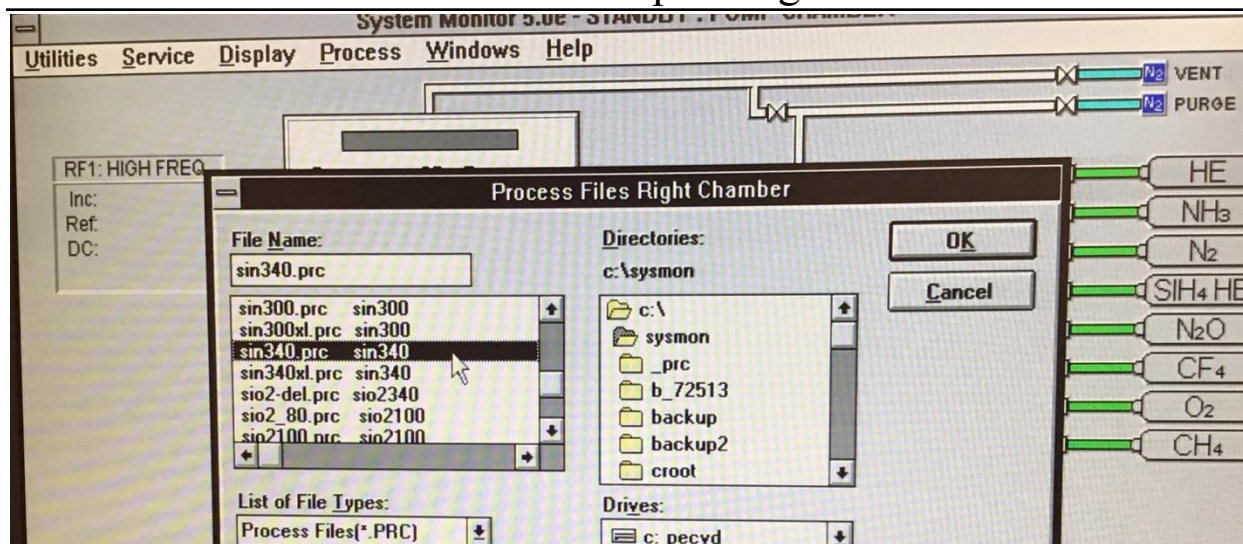


8.3 Load a Process.

- 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.

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- 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 corner of the window. Your process should now be loaded. Check the process box for your process.

8.4 Type of films

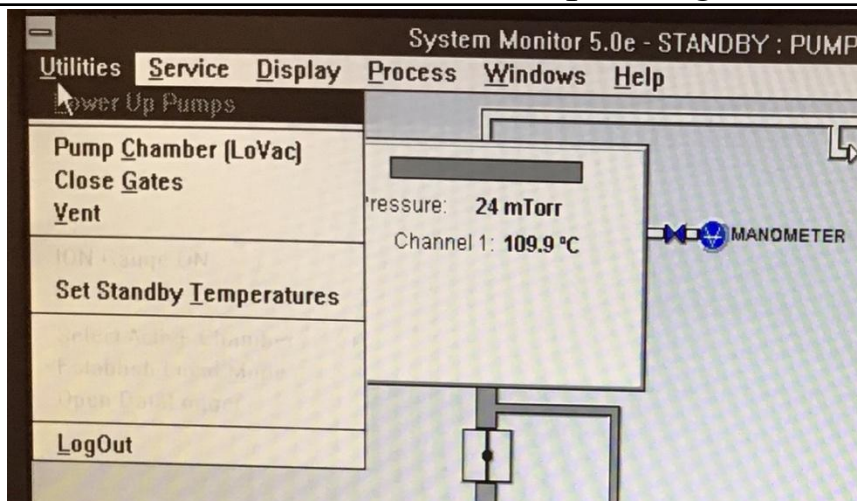
- 8.4.1 The Nitride film is the cleanest film, then oxide film, while the amorphous films is the dirtiest film. So, the PECVD system should be cleaned when changing from an oxide deposition to a nitride and from amorphous silicon to any of the other two films
- 8.4.2 If the last process used was an amorphous 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).

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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 1"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 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

- 8.1.1 Click on **READY** in the **System Status** cluster at the bottom of the screen
- 8.1.1 **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 turn yellow

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and the status bar will give the following message **“Ready Mode Temperature Compliance Achieved”**.

- 8.1.2 Once the system is in the **READY** mode, click on **RUN**
- 8.1.1 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** (If the recipe deposition step is on “Fixed Time”). If the recipe deposition step is on “Var Time”, then you will be able to enter the exact time in minutes and seconds that you want the deposition to run. 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. (2 minutes)

Step 6: End and vent (not all recipes will vent) (3 minutes)

- 8.1.2 For processes with a fixed 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.

- 8.1.3 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 (Purge 100, 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.

8.2 Remove your samples

- 8.2.1 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.

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8.3 Pump the system down

- 8.3.1 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.
- 8.3.2 To measure the film thickness and refractive index of your samples use the ellipsometer or Filmetrics in Bay 1 Keller. Please record this information in the logbook on the table below the monitor.

8.4 Return the system to standby (If temperature is between 100°C – 110°C). If not see below (8.11.2)

- 8.4.1 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.
- 8.4.2 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)

8.5 Logout

- 8.5.1 Click on the **Utilities>Log 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 N₂ 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 SiO₂ 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

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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 N₂ 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 (Purge 100, 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.

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- 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 Ctrl-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.

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Summary Sheet - Silicon Nitride (SiN)			
Parameters			
	Gases	2% SiH ₄ /He	140 sccm
		N ₂	520 sccm
		NH ₃	2.5 sccm
	Time (If fixed)		120 minutes
	Pressure		900mtorr
	Power		20W
	Uniformity		± 3% across 4" wafer
Process			
SiN100.prc			
	Temperature		100°C
	Deposition rate		130 Å/min
	Refractive index		1.85
	Stress		137 Mpa (tensile)
SiN150.prc			
	Temperature		150°C
	Deposition rate		115 Å/min
	Refractive index		1.90
	Stress		130 Mpa (tensile)
SiN200.prc			
	Temperature		200°C
	Deposition rate		102 Å/min
	Refractive index		1.92
	Stress		1317 Mpa (tensile)
SiN250.prc			
	Temperature		250°C
	Deposition rate		96 Å/min
	Refractive index		1.95
	Stress		? Mpa
SiN300.prc			
	Temperature		300°C
	Deposition rate		83 Å/min
	Refractive index		1.99
	Stress		1515 Mpa (tensile)
SiN340.prc			
	Temperature		340°C
	Deposition rate		78 Å/min
	Refractive index		2.01
	Stress		480 Mpa

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Summary Sheet - Silicon Dioxide (SiO ₂)			
Parameters			
	Gases	2% SiH ₄ /He	200 sccm
		N ₂ O	450 sccm
	Time (If fixed)		60 minutes
	Pressure		900mtorr
	Power		20W
	Uniformity		± 3% across 4" wafer
Process			
SiO₂100.prc			
	Temperature		100°C
	Deposition rate		343 Å/min
	Refractive index		1.42
	Stress		134 Mpa (compressive)
SiO₂150.prc			
	Temperature		150°C
	Deposition rate		370 Å/min
	Refractive index		1.45
	Stress		250 Mpa (compressive)
SiO₂200.prc			
	Temperature		200°C
	Deposition rate		372 Å/min
	Refractive index		1.44
	Stress		321 Mpa (compressive)
SiO₂250.prc			
	Temperature		250°C
	Deposition rate		370Å/min
	Refractive index		1.45
	Stress		250 Mpa (compressive)
SiO₂300.prc			
	Temperature		300°C
	Deposition rate		369 Å/min
	Refractive index		1.45
	Stress		247 Mpa (compressive)
SiO₂340.prc			
	Temperature		340°C
	Deposition rate		378 Å/min
	Refractive index		1.44
	Stress		251 Mpa (compressive)

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Summary Sheet - Amorphous Silicon			
Parameters			
	Gases	2% SiH ₄ /He	600 sccm
		He	100 sccm
	Time (If fixed)		60 minutes
	Pressure		900mtorr
	Power		20W
	Uniformity		± 4% across 4" wafer
Process			
ASi100.prc			
	Temperature		100°C
	Deposition rate		53 Å/min
	Refractive index		3.30
	Stress		385 Mpa (compressive)
ASi150.prc			
	Temperature		150°C
	Deposition rate		50 Å/min
	Refractive index		3.50
	Stress		? Mpa (compressive)
ASi200.prc			
	Temperature		200°C
	Deposition rate		49 Å/min
	Refractive index		3.50
	Stress		890 Mpa (compressive)
ASi250.prc			
	Temperature		250°C
	Deposition rate		50 Å/min
	Refractive index		3.50
	Stress		? Mpa (compressive)
ASi300.prc			
	Temperature		300°C
	Deposition rate		50 Å/min
	Refractive index		4.00
	Stress		1028 Mpa (compressive)
ASi340.prc			
	Temperature		340°C
	Deposition rate		50 Å/min
	Refractive index		4.00
	Stress		? Mpa (compressive)

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Summary Sheet - Clean Recipes			
Parameters			
	Gases	CF4	80 sccm
		O2	8 sccm
	Temperature		100°C
	Pressure		250, 500, 900mtorr
	Power		350W
Process			
CLEAN1.prc			
	Time		45 minutes
CLEAN2.prc			
	Time		90 minutes
CLEAN3.prc			
	Time		180 minutes
Summary Sheet - Purge Recipes			
Parameters			
	Gases	N2	200 sccm
	Pressure		730 mtorr
	Time		7 minutes
	Power		0W
Process			
Purge150.prc			
	Temperature		150°C
Purge250.prc			
	Temperature		250°C
Purge300			
	Temperature		300°C