University of Minnesota, MN Nano Center
Standard Operating Procedure

Equipment Name:	HDPCVD	**Revision Number:**	5
Badger Name:	HDPCVD	**Revisionist:**	L. von Dissen
Model:	Advanced Vacuum "Apex SLR ICP"	**Date:**	3/20/2020
Location:	PAN, Bay 3		

1 Description

The Apex SLR ICP is a high density plasma enhanced chemical vapor deposition system with an inductively coupled plasma configuration.

2 Safety

a. Be careful when lowering the load-lock chamber lid or when pumping down the load-lock, so you don't get your fingers pinched.

3 Required Facilities

a. Electrical: 208 VAC (120 VAC for G200 Hydrogen Generator)
b. Compressed dry air
c. Process Gas Cylinders: Ar, B2H6, CH4, He, O2, PH3, SF6, SiH4
d. Process Gas Generator: H2
e. Process Gas (House): N2
f. Toxic/Combustible Gas Monitoring (for B2H6, CH4, H2, PH3, and SiH4)
g. House Exhaust (burnbox, pump, gas box, and gas cabinets)
h. House Process Chilled Water (RF components, pumps, heater/chiller, chamber)
i. Dedicated Water Heater/Chiller (wafer chuck)

4 Operating Instructions

a. Enable the HDPCVD in Badger.

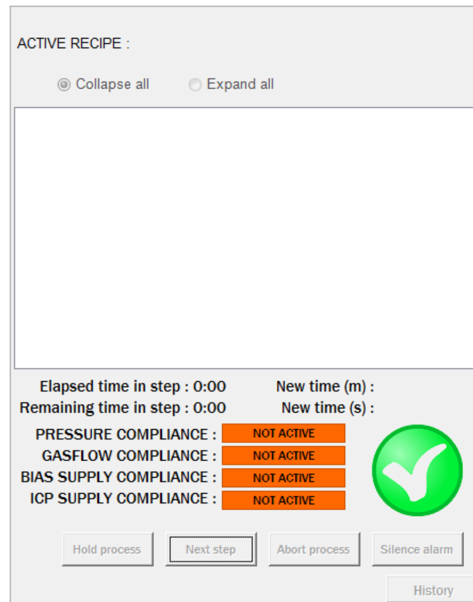
b. In the lower left quadrant of the computer screen, you should see a set of buttons which includes the **"Login"** button (as shown below). Click on it.

Start batch	Run (last)	System tasks
Edit process	Unload	Login
Process log	Manual process	Logout

Click here to login

c. A window will pop up prompting you to enter the appropriate user name and password. The user name is **"operator"** (no quotes) and the password is **"operator"** (no quotes). Press the **Enter** key to finish logging in to the system.

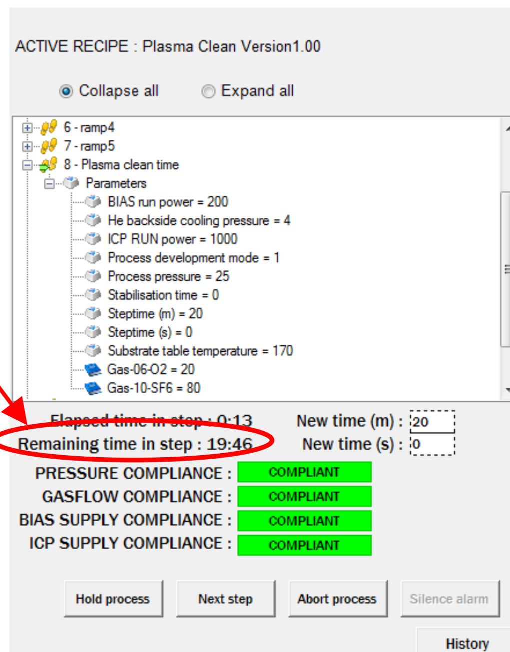
d. Check to see if there is a **"Plasma Clean"** process running from the previous user. The simplest way to do this is to look in the right region of the software screen to see if there are any active process recipes running. If there are no recipes running, it should look like the following:



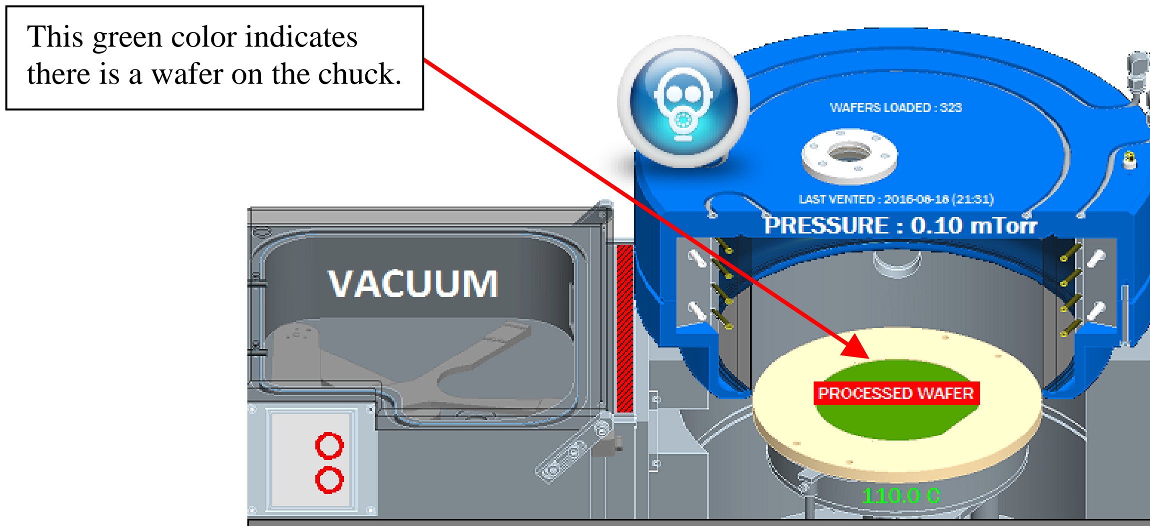
e. On the other hand, if there is an active **"Plasma Clean"** recipe running in this window, you can check to see how much time is remaining on the recipe. If it's going to be more than a minute or so, feel free to disable the HDPCVD in Badger while you are waiting for the clean recipe to finish running. The window should look like the following:

Check to see how much time is needed before the current step is finished.

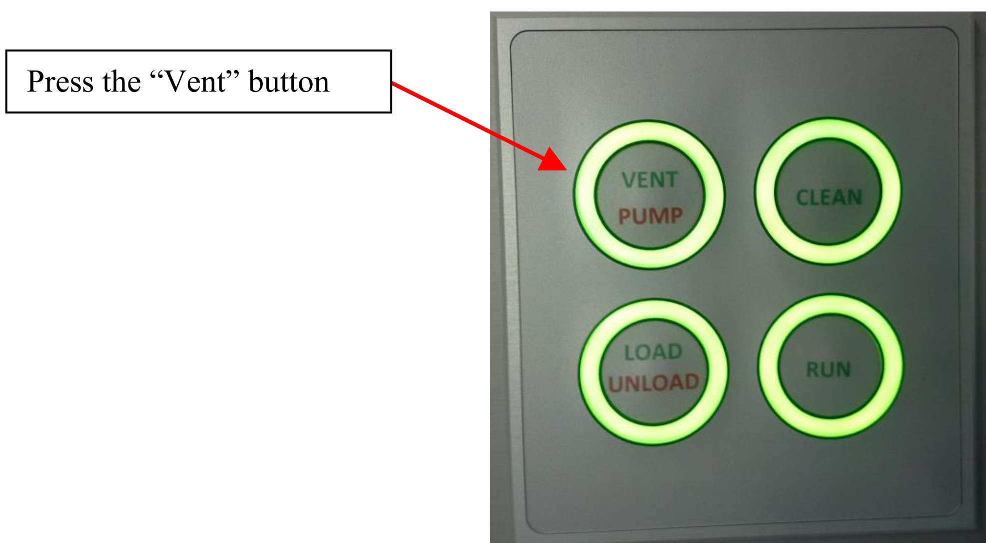
The current step is always in an expanded view where you can see all the parameters within it.



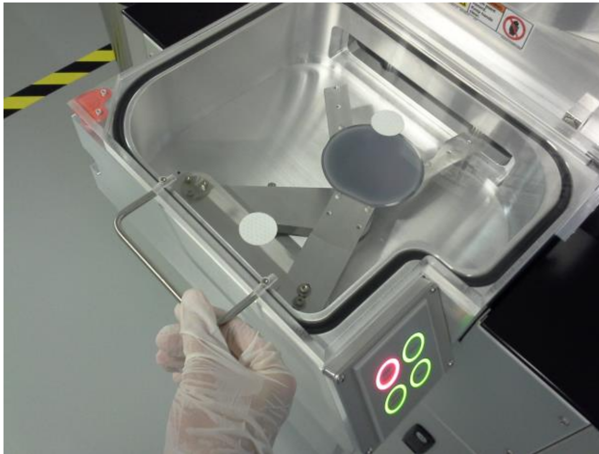
f. The chamber should be seasoned with the recipe you plan to use for at least 10 minutes prior to loading your own wafer and running your final process. In order to season the chamber, there needs to be a dummy wafer loaded into the system. There should already be a dummy wafer loaded in the system. You can verify this by looking at the chamber diagram and seeing if there is a "green wafer" on the chuck. It will look like the following:

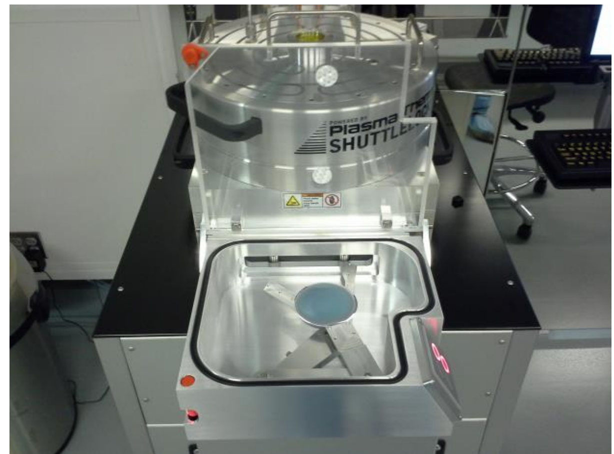


g. If there is a dummy wafer loaded in the chamber already, then you can proceed to step **"L"**. If there is NO dummy wafer loaded in the chamber yet (and if there is NO dummy wafer in the load-lock chamber), then you will need to vent the load-lock chamber and load a dummy wafer onto the robot arm. To do this, locate the **"Vent"** button on the load-lock control panel. If the button is surrounded by a green-colored light (as shown below), that means that the "Vent" option is available and so you can press the **"Vent"** button to vent the load-lock chamber.



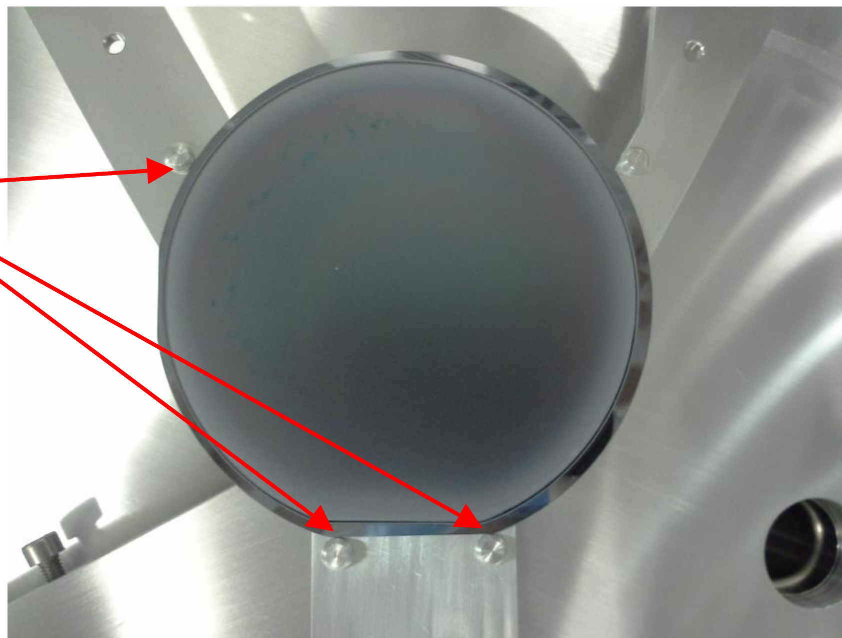
h. This venting happens relatively quickly, so after about 10 seconds, check to see if you can lift the load-lock chamber lid. Once you can lift the lid, open it up all the way so the lid rests up against the side of the main chamber.



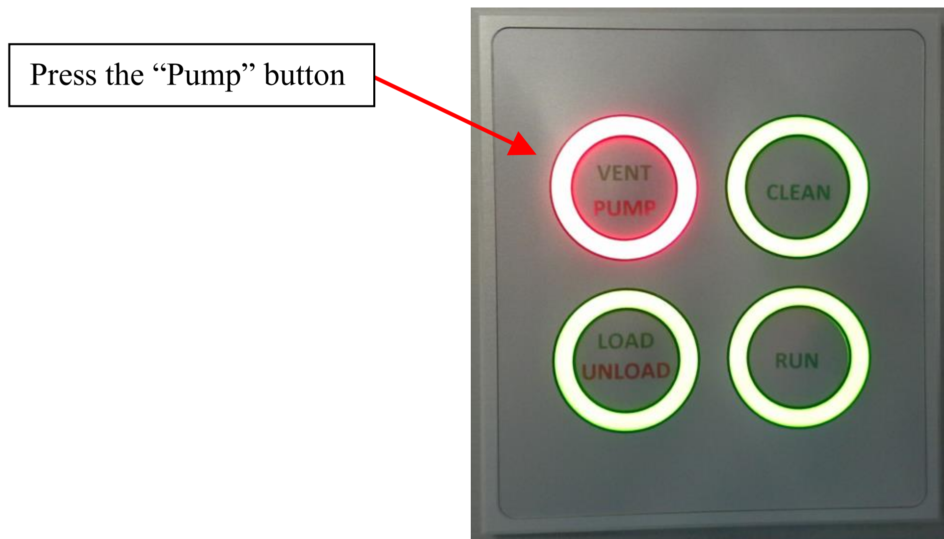


i. Load the dummy wafer onto the robot arm, taking extra care to gently align the wafer's major flat up against the two pins that are farthest from the chamber. Then gently align the left side of the wafer up against the left-most pin. When loaded properly, the dummy wafer should be oriented like the image below:

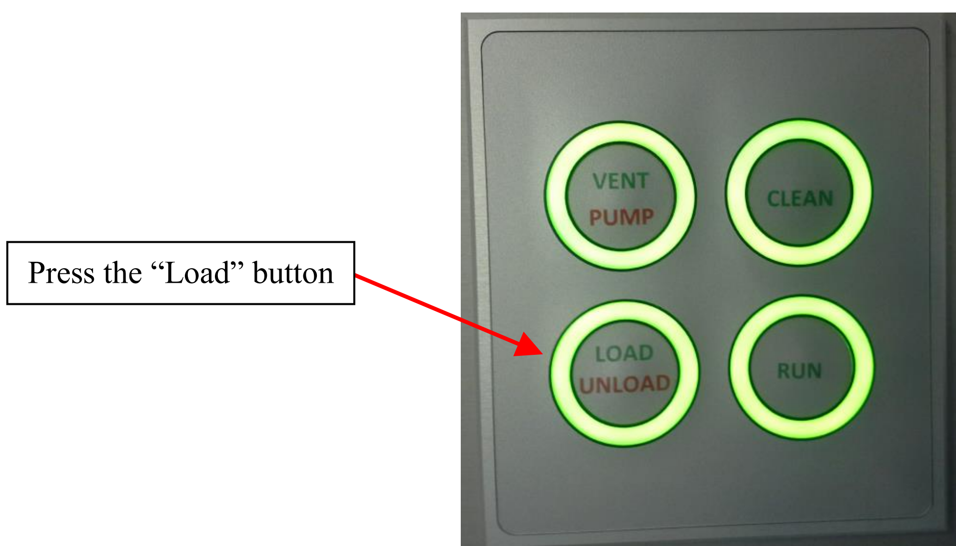
Notice how the wafer is resting up against these three pins. **This is very important!!!** If this is not done properly, **the wafer may be shattered** when the clamp comes down on the wafer after loading!!!



j. After the dummy wafer is loaded onto the robot arm properly, close the load-lock chamber lid. On the load-lock control panel, locate the **"Pump"** button. If the button is surrounded by a red-colored light (as shown below), that means that the "Pump" option is available and so you can press the **"Pump"** button to pump down the load-lock chamber.

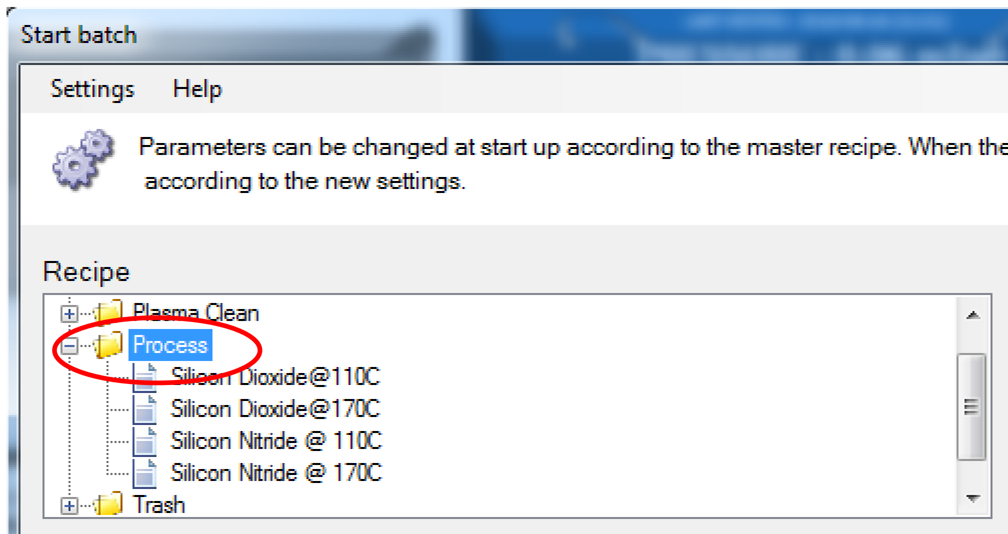


k. Once the Vent/Pump button turns green, that means that the load-lock is now pumped down which means you can load your wafer into the chamber. To do this, locate the **"Load"** button on the load-lock control panel. If the button is surrounded by a green-colored light (as shown below), that means that the "Load" option is available and so you can press the **"Load"** button to load the wafer.

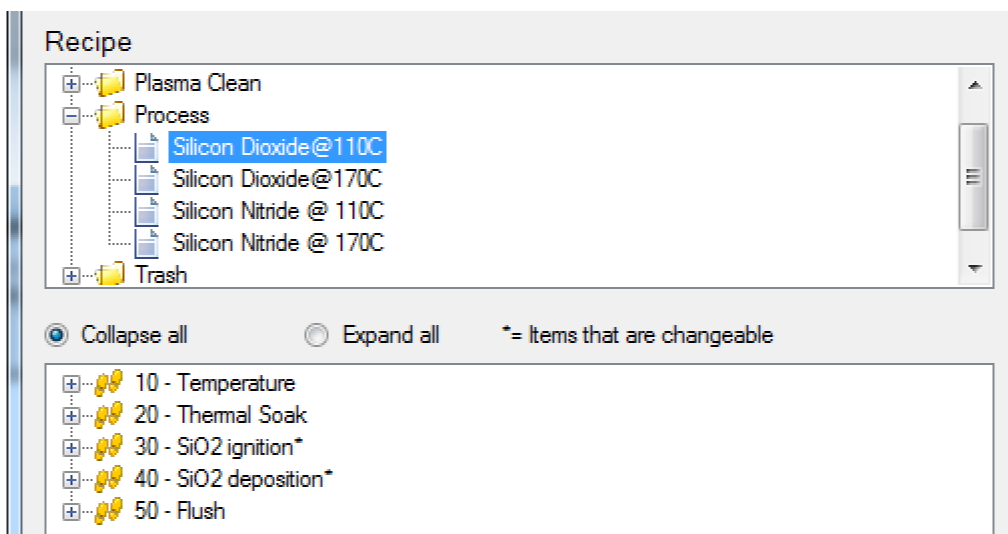


l. In the lower left quadrant of the computer screen (to the far left of the "Login" button), click on the **"Start Batch"** button.

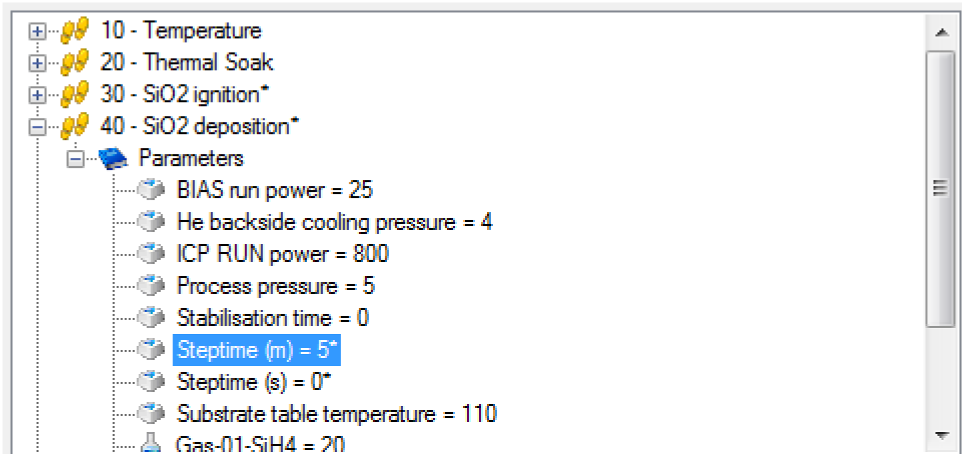
m. A "Start Batch" window will pop up with a list of folders containing various process recipes. In the upper left region of that window, you can access the process recipes by double-clicking on the "Process" folder as shown below.



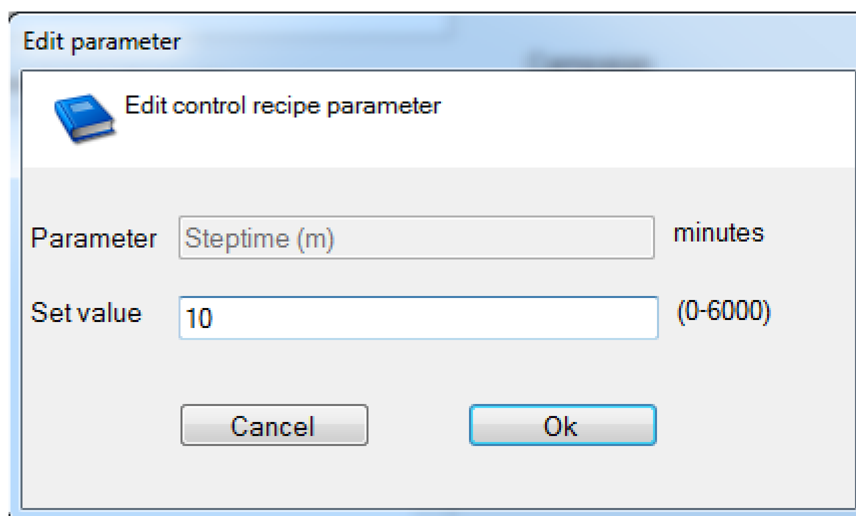
n. Select the recipe you want to season the chamber with. For example, if you want to run a Silicon Dioxide recipe at 110C, then you can select it by clicking on **"Silicon Dioxide@110C".** When you click on it, a set of recipe parameter steps will appear in the lower window as shown in the image below.



o. Double-click on the deposition step (in this recipe it is called "SiO2 deposition"). This will expand your view of that step so you can see the "Parameters" set that is contained within it. Double-click on the "Parameters" set and this will expand your view in order to see all the parameters in that step (as shown below). Notice that in this image, the **"Steptime (m)"** parameter has been highlighted.

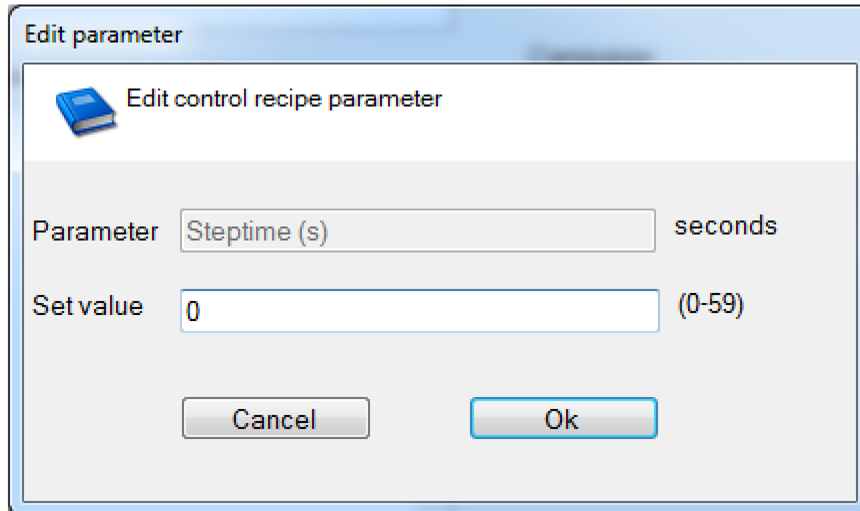


p. Double-click on the **"Steptime (m)"** parameter and this will cause a window to pop up where you can enter the number of **minutes** you'd like to run your deposition recipe for (as shown below).



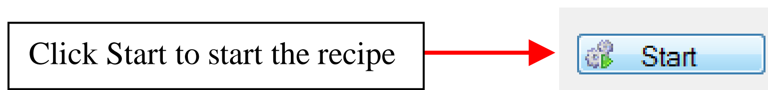
q. In the example above, you can see that 10 minutes was entered. This is the recommended number of minutes for seasoning the chamber with your desired process recipe. If you've already seasoned the chamber and would now like to enter the actual deposition "minutes", then enter the number of minutes you'd like to deposit for. Once the desired time is entered, click **Ok** to save that value.

r. Double-click on the **"Steptime (s)"** parameter and this will cause a window to pop up where you can enter the number of **seconds** you'd like to run your deposition recipe for (as shown below).



s. In the example above, you can see that 0 seconds was entered (because a total time of 10 minutes and **0 seconds** was desired for chamber seasoning). If you've already seasoned the chamber and would now like to enter the actual deposition "seconds", then you can do so now. Once the desired time is entered, click **Ok** to save that value.

t. When you are finished programming the seasoning time, then you can click on the **Start** button on the lower right portion of the "Start Batch" window as shown below.



u. When the recipe starts, you may see a yellow-colored “Stabilizing” timer pop up over the chamber diagram. You can keep track of what step is currently running by looking at the window on the right side of the software screen (as shown below).

Green arrow indicates the active step that is running.

You can see how much time is needed for the current step to be completed by looking here.

ACTIVE RECIPE : Silicon Dioxide@110C Version1.02

Collapse all   Expand all

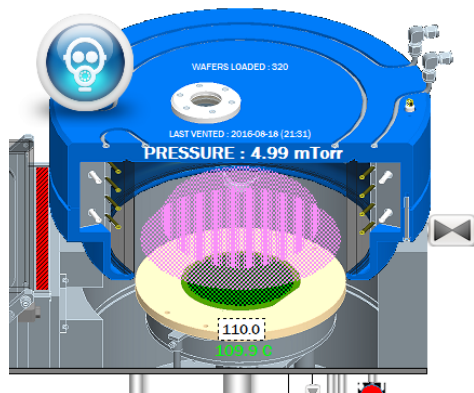
- 10 - Temperature
- 20 - Thermal Soak
  - Parameters
    - He backside cooling pressure = 4
    - Process pressure = 10
    - Stabilisation time = 15
    - Steptime (m) = 4
    - Steptime (s) = 0
    - Substrate table temperature = 110
    - Gas-09-Ar = 50
- 30 - SiO2 ignition
- 40 - SiO2 deposition
- 50 - Flush

Elapsed time in step : 0:23   New time (m) : 4
Remaining time in step : 3:36   New time (s) : 0
PRESSURE COMPLIANCE : COMPLIANT
GASFLOW COMPLIANCE : COMPLIANT
BIAS SUPPLY COMPLIANCE :
ICP SUPPLY COMPLIANCE :

Hold process | Next step | Abort process | Silence alarm

History

v. When the “ignition” or “deposition” steps are running, you’ll notice that the light tower (previously having a green light lit) now has a blue light on as well which indicates that a plasma is running (as shown below in the left image). You’ll also notice a plasma indicator in the software, by a purple/pink graphic located in the chamber diagram (as shown below in the right image).



w. If everything is operating normally, you'll also notice that all of the "Compliance" indicators are green as shown below.

All four of these should be green if everything is running normally. If one or more of them are NOT green for more than a few seconds, it will likely end up alarming and aborting the process recipe.

Report any problems of this sort in Badger if you experience any process aborting due to a non-compliance error.

ACTIVE RECIPE : Silicon Dioxide@110C Version1.02

Collapse all
Expand all

20 - Thermal Soak
30 - SiO2 ignition
40 - SiO2 deposition
Parameters
BIAS run power = 25
He backside cooling pressure = 4
ICP RUN power = 800
Process pressure = 5
Stabilisation time = 0
Steptime (m) = 12
Steptime (s) = 0
Substrate table temperature = 110
Gas-01-SiH4 = 20
Gas-06-O2 = 50
Gas-09-Ar = 30

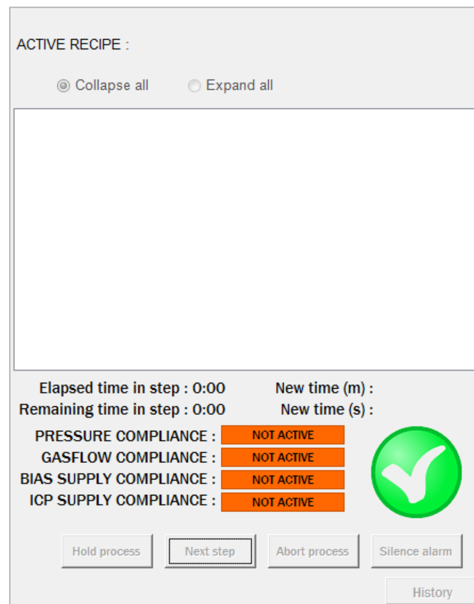
Elapsed time in step : 0:08
New time (m) : 12
Remaining time in step : 11:51
New time (s) : 0

PRESSURE COMPLIANCE : COMPLIANT
GASFLOW COMPLIANCE : COMPLIANT
BIAS SUPPLY COMPLIANCE : COMPLIANT
ICP SUPPLY COMPLIANCE : COMPLIANT

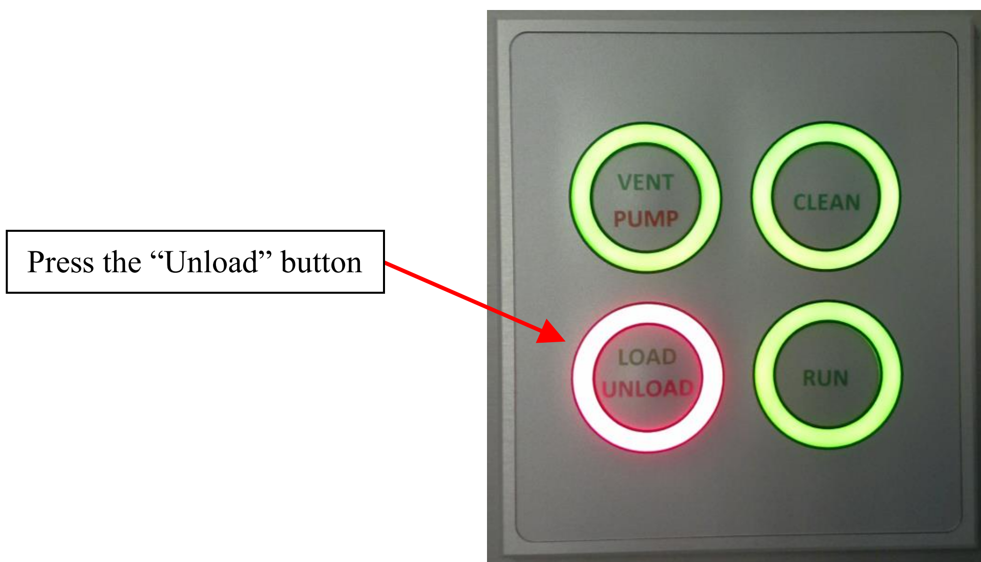
Hold process
Next step
Abort process
Silence alarm
History

x. <u>If you need to abort your run for any reason</u>, press the "Next step" button located at the bottom of the "Active recipe window". This will advance the process to the next step in the recipe. If you are running the deposition step, it will STOP depositing and advance the process to the chamber flush/purge step.

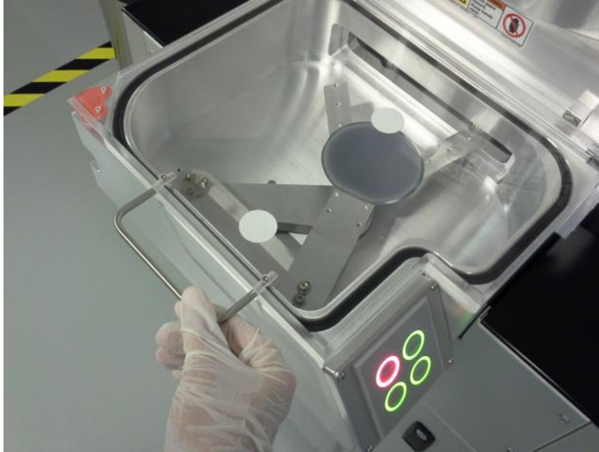
y. After the run has completed and the system has returned to standby, you will no longer see any active process in the window located on the right portion of the software screen. So it will likely look like this:

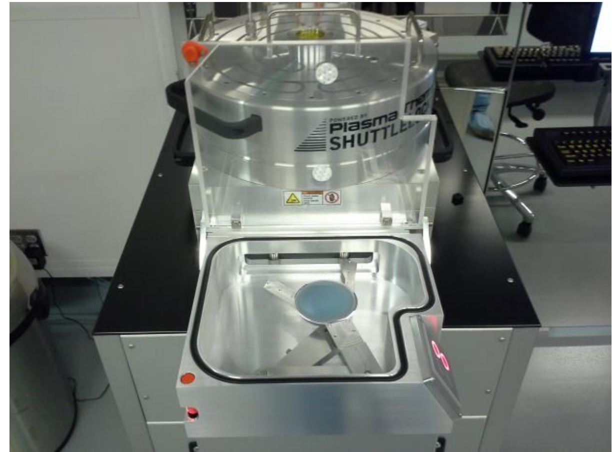


z. You will also notice that when the system is ready, you will have the “Unload” option available on the load-lock control panel (as shown below). Press the **“Unload”** button to unload your wafer into the load-lock chamber.



aa. Once the robot arm transfers the dummy wafer from the main chamber to the load-lock chamber, then the load-lock chamber will begin to vent automatically. This happens relatively quickly, so after about 10 seconds, check to see if you can lift the load-lock chamber lid. Once you can lift the lid, open it up all the way so the lid rests up against the side of the main chamber.

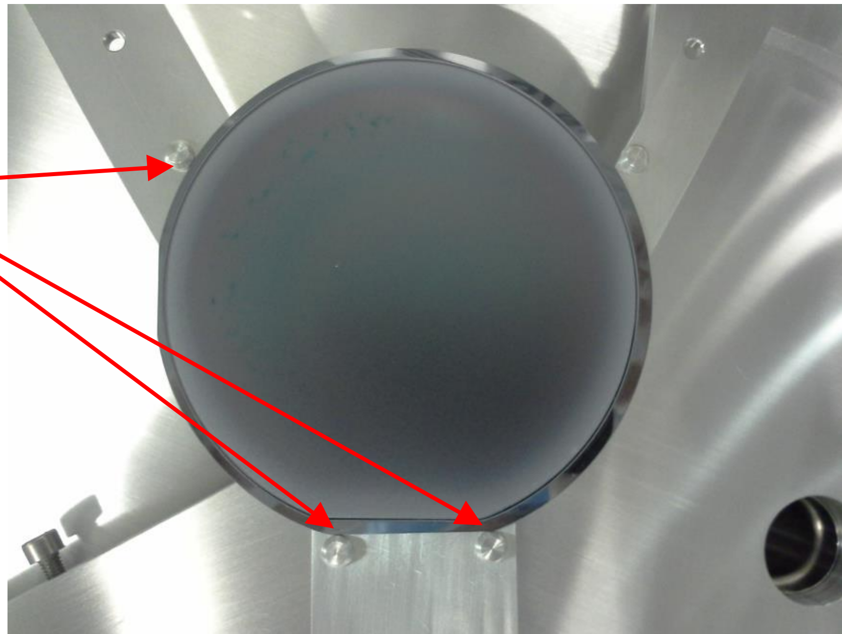




bb. Remove the dummy wafer from the robot arm (using a wafer tweezers) and place it in the dummy wafer cassette / box located next to the chamber.

cc. Load your **<u>process wafer</u>** onto the robot arm, taking extra care to gently align the wafer's major flat up against the two pins that are farthest from the chamber. Then gently align the left side of the wafer up against the left-most pin. When loaded properly, your wafer should look like the following:

Notice how the wafer is resting up against these three pins. **This is very important!!!** If this is not done properly, **the wafer may be shattered** when the clamp comes down on the wafer after loading!!!



dd. After your **process wafer** is loaded onto the robot arm properly, close the load-lock chamber lid. On the load-lock control panel, locate the **"Pump"** button. If the button is surrounded by a red-colored light (as shown below), that means that the "Pump" option is available and so you can press the **"Pump"** button to pump down the load-lock chamber.

Press the "Pump" button

ee. Once the Vent/Pump button turns green, that means that the load-lock is now pumped down which means you can load your wafer into the chamber. To do this, locate the **"Load"** button on the load-lock control panel. If the button is surrounded by a green-colored light (as shown below), that means that the "Load" option is available and so you can press the **"Load"** button to load the wafer.

Press the "Load" button

ff. Repeat steps **"L"** through **"bb"** (pages 6 through 12) to start a batch recipe and program the appropriate time needed for your actual deposition (using the same recipe that you just seasoned the chamber with). After removing your process wafer from the load-lock chamber**,** you will have to load a dummy wafer into the system and then run a **"Plasma Clean"** recipe. However, prior to loading the dummy wafer, **please weigh it** using the scale located on the work table to the right of the HDPCVD system. Then use the **reference guide** posted on the wall (to the right of the computer monitor) to verify how long of a clean can be run safely on that particular dummy wafer. You will want to run a clean for **twice as long** as your total deposition time (including any seasoning time).

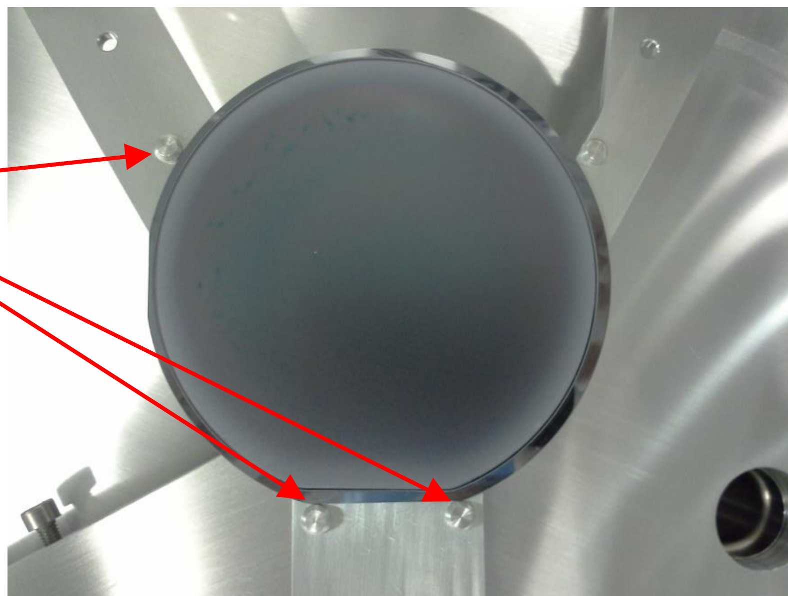
For example, if you ran a **10-minute** chamber seasoning (pre-dep) on a dummy wafer followed by **20 minutes** of deposition on your process wafer, then you would want to run a clean for (10 + 20)*2 = 60 minutes. This would mean that you would need a dummy wafer that weighs a little more than 4 grams (a copy of the dummy wafer reference guide can also be found on page 18).

If you can't find a dummy wafer meeting this minimal weight requirement, please run the clean for the maximum time allowed using the heaviest dummy wafer available. Please report this as a problem in Badger ("dummy wafer is too thin") and record the clean time you ended up using in the log book, as usual.

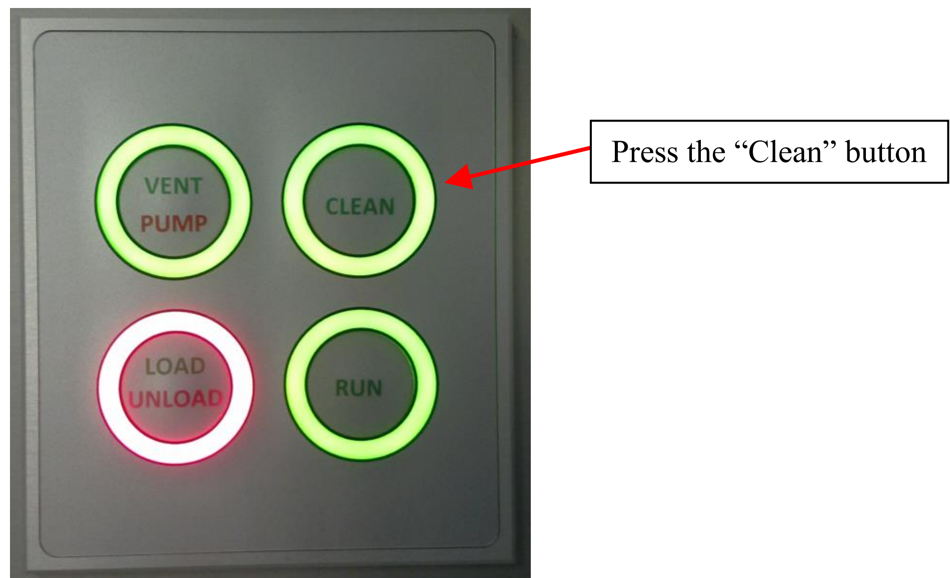
Note: if you are using the **"DLC Clean"** recipe (after running a **"DLC"** process), you **do not** need to worry about the weight of the dummy wafer, as the silicon wafer etches extremely slowly when using this special type of cleaning recipe.

Load the dummy wafer onto the robot arm, taking extra care to gently align the wafer's major flat up against the two pins that are farthest from the chamber. Then gently align the left side of the wafer up against the left-most pin. When loaded properly, your wafer should look like the following:

Notice how the wafer is resting up against these three pins. **This is very important!!!** If this is not done properly, **the wafer may be shattered** when the clamp comes down on the wafer after loading!!!

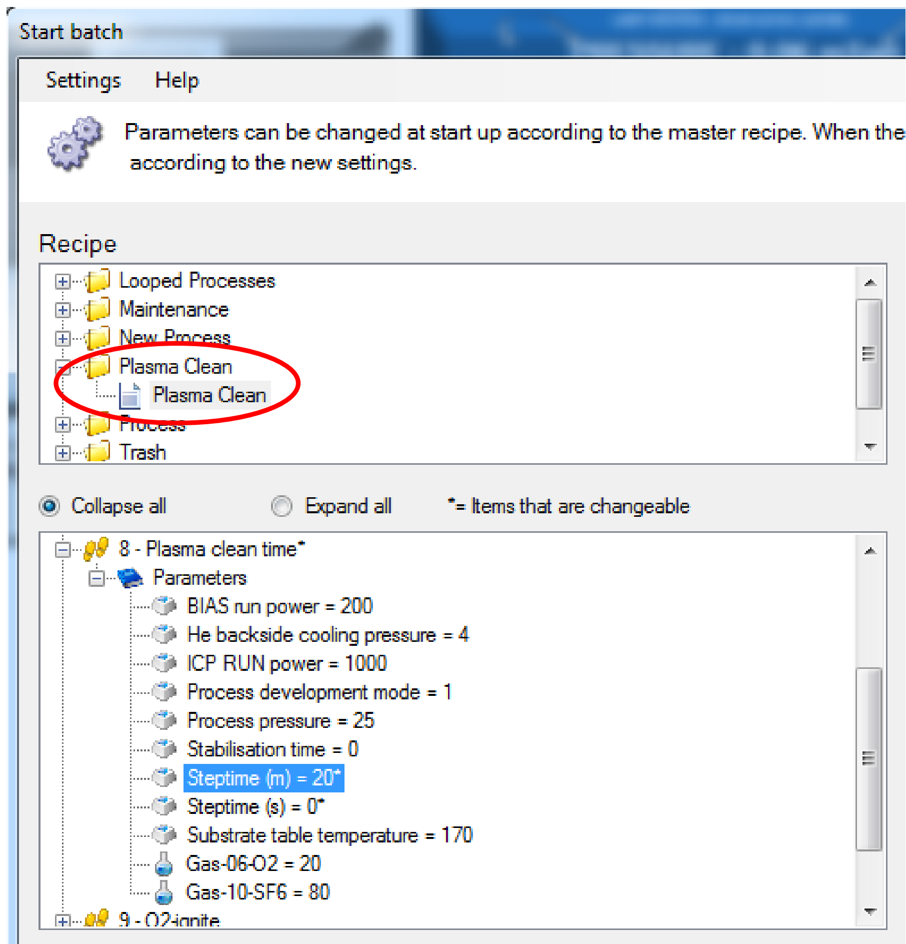


gg. If your total deposition time was **<u>less than 10 minutes</u>**, you can run a 20-minute long **"Plasma Clean"** by simply pressing the **"Clean"** button, which is located on the load-lock control panel (as shown below). This is programmed to run for exactly 20 minutes. Then you can skip ahead to step **"ii"**.

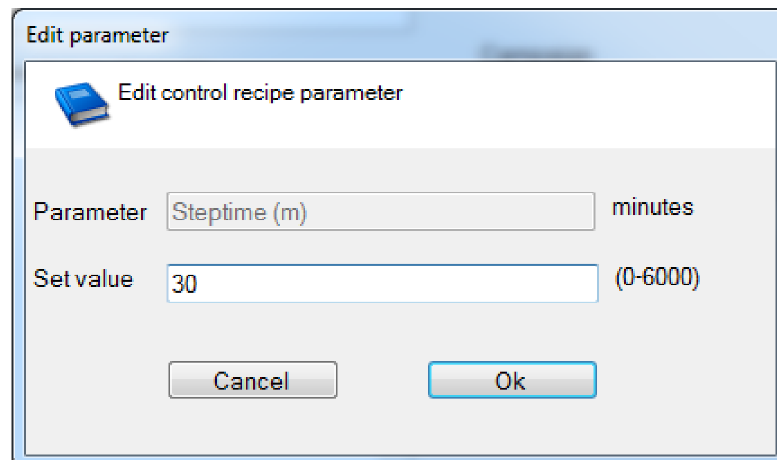


If your total deposition time was **<u>greater than 10 minutes</u>**, then you must manually start a clean recipe. Remember to program the clean time for **double your total deposition time (which should include any seasoning time)**, and then start the clean recipe.

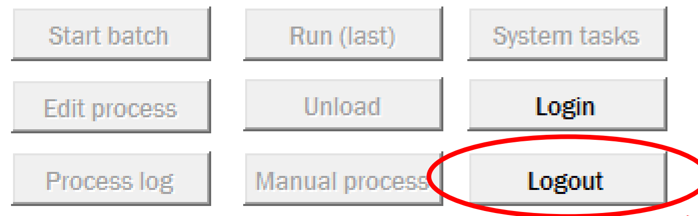
The clean recipe is located in the "Plasma Clean" folder (see image on next page).



hh. Double-click on the **"Steptime (m)"** parameter and this will cause a window to pop up where you can enter the number of **minutes** you'd like to run your **"Plasma Clean"** recipe for (as shown below). Once the desired time is entered, click **Ok** to save that value.



ii. Once the **"Plasma Clean"** recipe has started, you can click the **"Logout"** button in the lower left quadrant of the computer screen (as shown below).



Click here to logout

jj. Disable the HDPCVD in Badger.

"Plasma Clean" Time Allowed for Dummy Wafer

Wafer Mass (grams)	Remaining Thickness (microns)	Maximum Clean Time Allowed (minutes)
3.0	133	19
3.5	163	39
4.0	193	58
4.5	223	78
5.0	253	97
5.5	284	116
6.0	314	136
6.5	344	155
7.0	374	175
7.5	404	194
8.0	434	213
8.5	465	233
9.0	495	252
9.5	525	272