

Basic ICP Operating Procedures

INTRODUCTION:

The ICP is an inductively coupled plasma etching system, which can be used to etch a variety of materials. It is currently equipped with boron trichloride (BCl_3), chlorine (Cl_2), argon (Ar) and hydrogen (H_2).

The samples sit on a helium-cooled holder and the system is purged with nitrogen. While these gases are plumbed into the system, they cannot be used as process gases.

SAFETY:

This system has a variety of safety interlocks to keep users as safe as possible. Do not attempt to defeat or override these interlocks without permission. If the system gives error messages, contact Beth to resolve the situation. If the system is alarming, you should silence the alarm, make note of the "Info", "Warning" and "Alarm" lines on the monitor. Call Beth and inform her of the problem and the reading on each of the lines. The ICP cannot be used until the problem causing the alarm has been resolved.

System safety is also assured by the use of a password system for ICP access. Only users that have been trained and issued a password are authorized to use the system. Users are not allowed to give out their password to others.

The ICP will not be run unattended. Running the system unattended will result in immediate loss of user privileges. You must remain in the ICP bay while the system is being used. Running the system while being anywhere else in the cleanroom is considered running the system unattended.

There are many reasons for someone's access code to be removed from the computer. These include, but are not limited to: allowing the ICP to run unattended, running toxic gases in the ICP outside of normal working hours without permission of the cleanroom manager and Beth, giving out your user ID to someone else, not logging out of the computer, not following proper operating procedures, unsafe operation of the ICP (such as ending purging steps or pump down steps, not informing Beth that there is a problem with the ICP or that it needs cleaning.

Unauthorized users or users who do not follow these procedures will face the following consequences before being allowed to use the ICP again. Improper actions causing injury to you or others or damage to the ICP or other cleanroom equipment will move the severity of the offense up at least one category. There will be no exceptions!

- A first violation of ICP procedures will result in the user being barred from the cleanroom for at least 1 week. At the end of one week, the user must ask the cleanroom manager to allow them back into the cleanroom and ask Beth to allow use of the ICP again. For a period of one month, the user will only be allowed to use the ICP during normal working hours (M-F 8am-5pm).
- A second violation of ICP procedures will result in the user being barred from the cleanroom for at least 1 month. At the end of 1 month, the user must submit a written request to the cleanroom manager to be allowed back in the cleanroom and must go through ICP training again. For a period of one month after undergoing retraining, the user will only be allowed to use the ICP during normal working hours (M-F 8am-5pm).
- A third violation will result in the user being barred from the cleanroom for at least 6 months. At the end of this time, the user's professor must request that the user be re-admitted to the cleanroom. The user will be required to undergo retraining for the cleanroom and the ICP. For a period of one month after being re-admitted to the cleanroom and being retrained in ICP operation, the user will only be allowed to use the ICP during normal working hours (M-F 8am-5pm).
- A fourth offense will result in permanent denial of cleanroom access.

TRAINING

All authorized users are required to undergo training on the ICP before being issued a password and allowed to operate the ICP. Since CHTM is a research facility, operating procedures and training requirements may change from time to time. All authorized users will be notified of changes in operating procedures. If training requirements change, all users will be notified and will be required to complete the new training requirements before using the ICP again. Notification of changes will be via e-mail and will be posted on the white board in the gowning area of the cleanroom.

Training is required to assure that everyone uses the ICP in a safe and proper manner. Unsafe or improper operation of the equipment affects all cleanroom users even if they do not realize or believe it does. Because all users must be trained, unsafe or improper equipment operation in the clean room will not be allowed.

To become an authorized user you must accomplish several tasks.

- You must read and understand this document.
- You will need to arrange for hands-on training with an authorized user in your group. If there is no authorized user in your group, you may contact another authorized user for hands on training. During your training period, you are not allowed to use the ICP without an authorized user with you at all times.
- After you feel comfortable operating the ICP you must demonstrate your ability to operate the equipment for Beth.
- After demonstrating your competence with the equipment, you will be sent to Beth where you will go through a brief question and answer session. This

question and answer session will cover not only this document but general cleanroom practice as well.

- When all the steps are completed, you will be allowed to sign the authorized user list. At that point, you are considered an authorized user of the ICP.
- If you do not complete all steps in the training process, you are not considered an authorized user and are not allowed to use the equipment without supervision.

OPERATION:

Boldface Type indicates a pull-down menu. *Italics* indicate an option in a pull-down menu. Underline indicates yet another level of the pull-down menu.

Idle Mode:

1. System is turned on.
2. System is in “Stand-by” mode.
3. No alarms are active in system.
4. Chamber is being pumped with turbo pump.
5. Ion gauge is on.
6. Sample is not loaded in loadlock or main chamber.

ICP Operation:

1. Prepare sample with appropriate mask.
 - a. If you are unsure of what masking material you should be using, contact Beth for assistance in choosing an appropriate mask.
2. Alphastep the mask thickness to record in the logbook.
3. Sign up for ICP time.
 - a. The ICP will not be available some Monday mornings in order to allow Beth to run calibration processes.
 - b. The ICP is cleaned after every 50 runs. Your time may be rescheduled in order for the system to be cleaned. If your time is rescheduled you will be notified.
 - i. Cleaning of the ICP takes only a short time, but it must be baked out overnight after cleaning. It then takes most of a day to cool down to the point where the ICP can be used again.
 - ii. The ICP can be used shortly after the bake-out cycle, but it is not recommended as process parameters could vary wildly from what is expected.
4. Verify that there are no notices posted on the system.
 - a. Notices will be posted if the system is acting unusual or there are special procedures that need to be followed.
 - b. If there are notices telling you not to use specific gases or not to use the system and you do anyway, your user ID will be removed from the computer and you will need to follow the procedures listed earlier in order to use the system again.
 - c. Check the logbook to verify that the ICP is not in need of a cleaning process.

- i. There are log sheets indicating that it is time to clean the ICP. You must not continue without permission from Beth.
5. Check to see that there is sufficient gas for your process.
 - a. Do not touch the gas cabinets unless authorized by the cleanroom manager.
 - b. If there is not sufficient gas, contact Beth or the cleanroom manager.
 - c. Do not use the system until the appropriate gas cylinders have been changed.
6. Check the oil level in all vacuum pumps.
 - a. The oil levels in the blower pump and the large mechanical pump always appear to be a little low. This is normal.
 - b. If the oil is low, contact Beth, the cleanroom manager or the shop staff.
 - c. Do not run the system until the oil level has been brought to normal.
7. Verify that all facilities (nitrogen, chilled water, electricity, etc.) required are available.
 - a. Looking at the lower right corner of the monitor easily does this. There are several green rectangles.
 - i. As long as these are green, the facilities are available.
 - ii. If one of them is yellow, the system cannot be used until the situation is rectified.
 - b. If there are warning or alarm messages on the system, it typically indicates that the required facilities are not available.
8. Log on to ICP computer.
 - a. Select **Utilities**→*Logon* to logon to the system. Do not use anyone else's password and do not allow anyone to use your password.
9. Open batch editor window to load process.
 - a. Select **Process**→*Batch* to bring up batch editor window.
 - b. Select to **File**→*Load* to load the desired batch process. Confirm that it has been loaded by checking the status box in lower right corner of screen.
 - c. Close the editor window by selecting **File**→*Close*.
10. Check chamber pressure with ion gauge. Record pressure on log sheet as base pressure.
11. Turn off the ion gauge.
 - a. Select **Utilities**→*Ion Gauge OFF* to turn off ion gauge. The system will let you do only a few things with the ion gauge on.
12. Vent the loadlock to load sample.
 - a. The system will not allow the loadlock to be vented without turning off the ion gauge first.
 - b. Select **Utilities**→*Loadlock*→V*ent* to vent the loadlock. When the loadlock is vented, remove the sample platen.
 - i. It takes approximately 3 minutes for the loadlock to vent.
 - ii. Since several sample platens are available, you can mount your sample on a platen while venting the loadlock to save time.
 - c. Clean the sample platen with isopropanol and a Tex-wipe.
 - i. Do not touch the platen with your bare hands.

- ii. If the anodization has been completely removed from the platen, use a new one and give the old one to Beth for re-anodization. More platens are available from Beth if needed.
- d. Place sample on platen using Mung II.
 - i. Make sure the sample is flat on the platen or you will be etching your sample at an angle.
 - ii. Remove excess Mung II with the soft tip of the cleanroom swabs.
 - iii. Blow off the platen with nitrogen to remove any particles on the platen.
 - iv. All samples must be held down to the platen with Mung II. Not only will the samples move around during transfer, but also the sample temperature will not remain constant.
- e. Place platen on transfer arm to the left and back and close lid.
- f. Wipe off the o-ring and sealing surface with isopropanol and a tex-wipe.
 - i. Acetone will dissolve o-rings so don't use it.
 - ii. The proper order for wiping down the lid and o-ring is: wipe down the lid from back to front, and then wipe down the o-ring from back to front.
 - iii. If you notice that there are particles embedded in the o-ring or that it is cracked, notify Beth immediately. Do not use the system.
- 13. Place system in "Ready" mode by pressing "Ready" button.
- 14. Press "Run" to run the loaded batch process.
 - a. The system will automatically move the sample from the loadlock to the etch chamber, run the process, move the sample back into the loadlock and vent the loadlock.
 - b. Occasionally, the helium cooling pressure will fluctuate to the point that the ICP will alarm. If this happens reset the alarm and allow the process to restart. This is the only instance where you are allowed to reset the alarm.
- 15. Record data in the logbook after etch process has been running for approximately 1 minute.
 - a. Short etch times will require rapid recording of data. Be prepared.
- 16. If the process needs to be stopped for any reason, the following steps may be used:
 - a. Press "End Step" to end the current step if needed. This will need to be done for ending the etching process step.
 - b. Press "Abort" if something appears wrong with the process.
 - c. Press red emergency off button if something is really wrong.
- 17. When the process is complete, the machine will alarm to let you know that the system has vented. Unload the sample, clean the platen with isopropanol and load another sample if needed.
 - a. While doing this, you can turn on the ion gauge to get the base pressure for the next run.
 - b. The Mung II should be removed from the back of your sample with isopropanol and a swab. Avoid getting Mung on the top of your sample. It is very difficult to remove once it is on the front of a sample.
- 18. If no other samples need to be etched, pump down the loadlock.

- a. Select **Utilities**→*Loadlock*→*Pump*.
19. When you are finished etching, there are several steps to follow.
 - a. Place the system in standby mode by pressing the “Standby” button.
 - b. If the system temperature was changed, return it to 25°C.
 - i. Select **Utilities**→*Set Standby Temperatures*
 - ii. Enter 25.
 - c. Turn on the ion gauge.
 - i. Select **Utilities**→*Ion gauge on*.
20. Log off the computer.
 - a. Select **Utilities**→*Logout*.
21. Inform Beth if the logbook indicates that the ICP needs to be cleaned.
 - a. Users not informing Beth that the ICP needs to be cleaned will be denied use of the ICP for a period of 1 week for a first offense.
22. Alphastep the depth before the mask is removed and after the mask has been removed. Record these numbers in the logbook. Add copies of SEM photos to the logbook too. The more data we are able to obtain about a process, the more likely we are to notice that a process is not working right.

Chamber Process Structure

Users are not allowed to create processes, but these instructions are included so you will know what parameters are needed for constructing a process. If you need to construct a process, contact Beth and she will give you a process construction sheet that you will fill out. Beth will create the process and let you know when it is available. If you are doing process development, Beth will create 3 processes for you while you are developing the process.

A chamber process must have at least 2 steps, an initial step and an end step. When a process is created, those 2 steps are automatically included. The rest of the steps must be manually added. This section will discuss the requirements for constructing a chamber process.

1. The 1st step defines initial parameters that the system must attain before doing anything else.
 - a. Set the pressure lower than 5×10^{-6} torr. Lower pressures will increase pump-down times, but will assure a cleaner etch process.
 - b. The pressure hold time should be at least 2 minutes.
 - c. The temperature should be set to the temperature you want to run the etch process at. The temperature range is 10°C to 80°C.
 - d. Make sure that the process is named and that a description is given. The chamber process name and batch process name must be the same.
2. The 2nd step should be a process step that will define gas flows.
 - a. Select fixed time for the process end.
 - b. Select the gases and flow rates desired.
 - c. Set the pressure at 20 mtorr.
 - d. Turn on helium cooling by checking the box.
 - e. Do not turn on any RF power.

- f. Set the time for 60 seconds.
 - i. You do not need a longer time for this step because the system will not begin timing the step until all the process gases have stabilized.
3. The 3rd step should be plasma ignition step. This step is necessary if you are running a process at less than 10mtorr.
 - a. The program should copy all the parameters from the previous step, but if it doesn't, put the appropriate parameters where they should be. If you are modifying an existing program, you will have to change the parameters manually.
 - b. Make sure the helium cooling is turned on.
 - c. Set RF powers to desired values.
 - d. This step should be 3 seconds.
4. The 4th step should be your etch step.
 - a. The program should copy all the parameters from the third step. Refer to 3a above.
 - b. Set the pressure to the desired etch pressure. It takes less than 10 seconds to stabilize a pressure going from the ignite step to the etch step.
 - c. Verify that the helium cooling is still turned on.
 - d. Etch time is set for 90 minutes. The user is required to end the step at the appropriate time. If a longer time is desired, inform Beth and a longer etch time will be inserted in the program. If you know that you will be using the same time and will never need to change it, Beth will put that time in the process.
5. The 5th step should be a pump step.
 - a. Pump process gases out of the chamber. Set the pressure lower than 5×10^{-5} torr.
 - b. Set the time for at least 2 minutes.
6. The 6th step should be a purge step.
 - a. Set the pressure to be 25 mtorr.
 - b. Set the time to at least 2 minutes.
 - c. Do not turn on RF power.
7. The 7th step should be a loop step to perform a pump/purge cycle.
 - a. Position the loop so the 5th and 6th steps are repeated.
 - b. Repeat the pump and purge process at least 5 times.
8. The 8th step will be the end step.
 - a. Set the pressure lower than 5×10^{-6} torr.
 - b. Set the time for at least 2 minutes.

Other steps may be added as needed. Consult Beth for additional information. If we notice odors coming from the machine when venting, or when cleaning the main chamber, the pump and purge times and pressure will be modified.

Batch Process Program Structure

A batch process is created to move the samples from the loadlock to the etch chamber, etch the samples, move the samples back to the loadlock and finally vent the chamber. This will describe the structure of a batch process.

Beth also creates batch processes. If you need a batch process created, Beth will create the appropriate one for you.

1. A batch process will have at least 2 steps. The 1st step is a pump loadlock step. You do not need to add this step as it is automatically entered for you.
2. Next, you need to move the sample from the loadlock to the process chamber. Press the button that moves the sample-holder to the right chamber.
3. After pressing the button to move the sample-holder to the right chamber, the machine assumes that you will be running a process. The process menu comes up, allowing you to select the process to run.
4. After selecting the first process, if there is another process that needs to be run, select the recipe card button for the right chamber. This will bring up the process menu list again, allowing you to select another process. Repeat this step until all the processes you wish to run have been included.
5. Once all processes have been selected, you must move the sample back into the loadlock. Press the button that shows the sample-holder moving to a lock.
6. The final step needs to be either a vent step or an end step. The vent step will vent the loadlock. The end step will stop the batch process but not vent the system. This is useful if you do not want the sample to be exposed to atmosphere immediately after etching.
7. There are several buttons that are "grayed out". These options are not available for use at this time. The vent button looks like it is "grayed out", but it isn't.