



# IIT Bombay Nanofabrication Facility

## Tool Name: Inductively Coupled Plasma- Chemical Vapor Deposition CVD (ICPCVD)

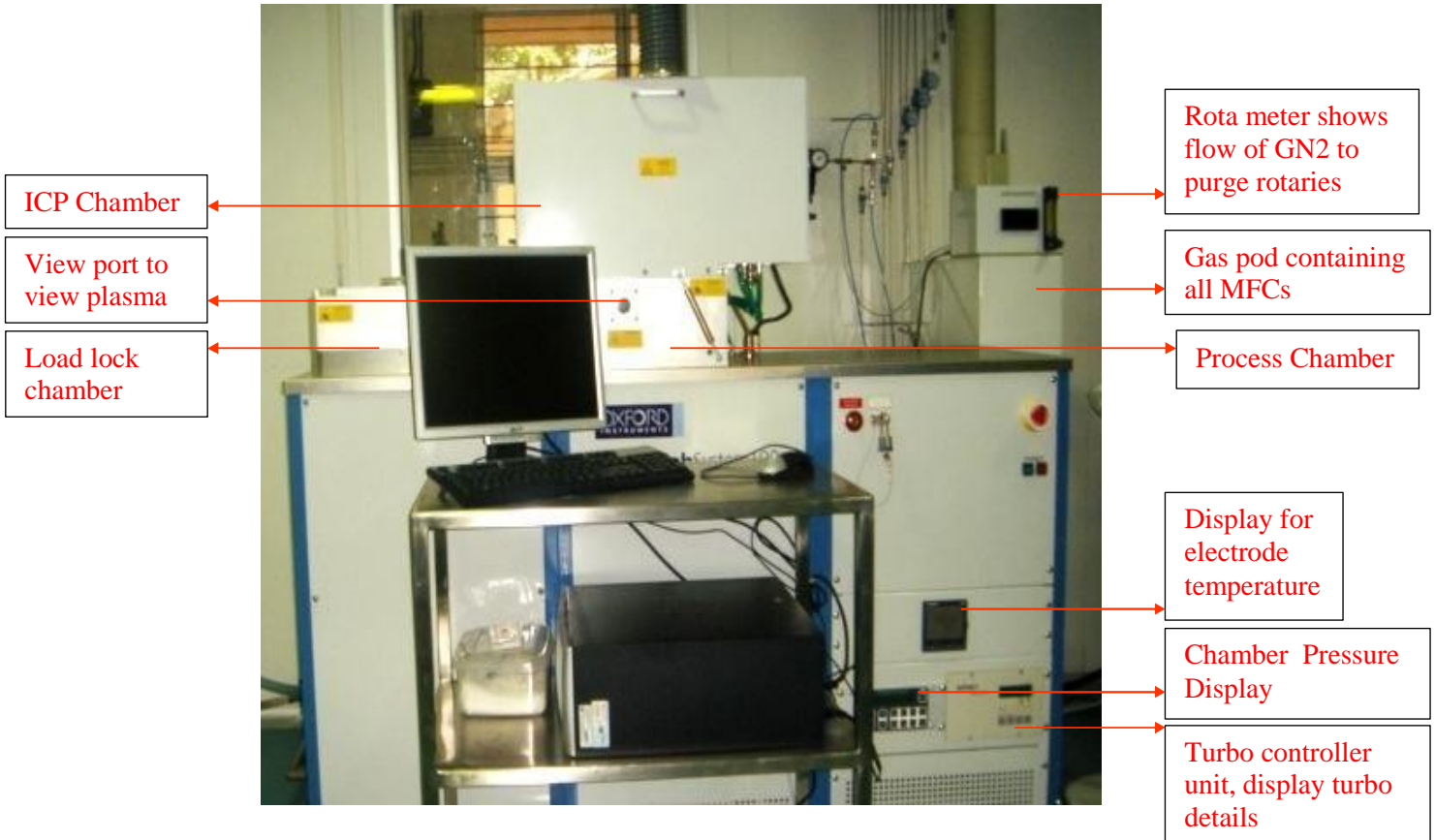
### Standard Operating System (SOP)

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## Tool's Overview



*Fig. Inductively Coupled Plasma Enhanced Chemical Vapor Deposition Tool*

### Checklist (Before starting the tool)

1. After checking if the following conditions are satisfied only, one should enter the lab to start the system:
  - The 3 water lines – Turbo: 11pm, RF Generator: 81pm, ICP/ AMU: 21pm are fine
  - The 2 exhausts are switched ON- Leak exhaust and Turbo exhaust
  - High purity Nitrogen (PN2) cylinder is at 4bar
  - GN2, Commercial Nitrogen Plant is working and giving a minimum pressure of 6bar
  - The AHU in the lab is working
  - There is no condensation of water along water lines going into the system.
2. Please don't open the process chamber under any circumstances without consulting the system owner.
3. The authorized users are allowed to carry out only the 'Automatic Process Run' on their own, processes at >200C needs to be done in the presence of SO's or by SO's. Tool must be operated manually beyond 200C by experienced user only.
4. Whenever the transmission disc or wafer clamp needs to be changed, please consult the system owner.
5. Make sure that the processes you want to run are contamination protocol compliant. person(s).
6. Refer to the **people list** in case of any doubt or emergency and consult the relevant

## Introduction

**Plasma Enhanced Chemical Vapor Deposition (PECVD)** is a process to deposit thin films from a vapor phase to a solid state on a substrate. There are chemical reactions involved in the process which occur after creation of plasma of the reacting gases or vapors.

### Plasma

- Ionized gas
- High free electron content
- Unique state of matter

## Inductively Coupled Plasma (ICP)

Plasma can be generated by two ways: DC discharge and RF discharge. DC discharge is not useful in depositing insulated materials because plasma created gets extinguished as soon as a layer of insulator is deposited. Plasma driven from AC signal can solve this problem.

When a time varying electric current is passed through a coil, it creates time varying magnetic field around it, which in turn induces azimuthal currents in the rarified gas leading to break down and formation of plasma. Thus plasma is generated by electromagnetic induction. The RF coil around the ICP chamber is operated at 13.56MHz and with a maximum power of 1KW.

## Advantages of ICPCVD over Conventional PECVD

1. High density plasma (higher than capacitively coupled systems)
2. Low deposition pressures
3. Low operation temperatures
4. Lower chances of cracking deposited layers
5. Good dielectric properties of deposited layers
6. Good step coverage (by deposition + etch process)

## Disadvantages of ICPCVD

1. Toxic byproducts
2. High cost of equipment

## Applications of thin films deposited of ICPCVD

- Passivation layer for packing of devices
- Solar cells, optical fibers – Amorphous silicon and anti-reflective coating
- Antireflection and ant scratch layers in optics
- Interlayer dielectric

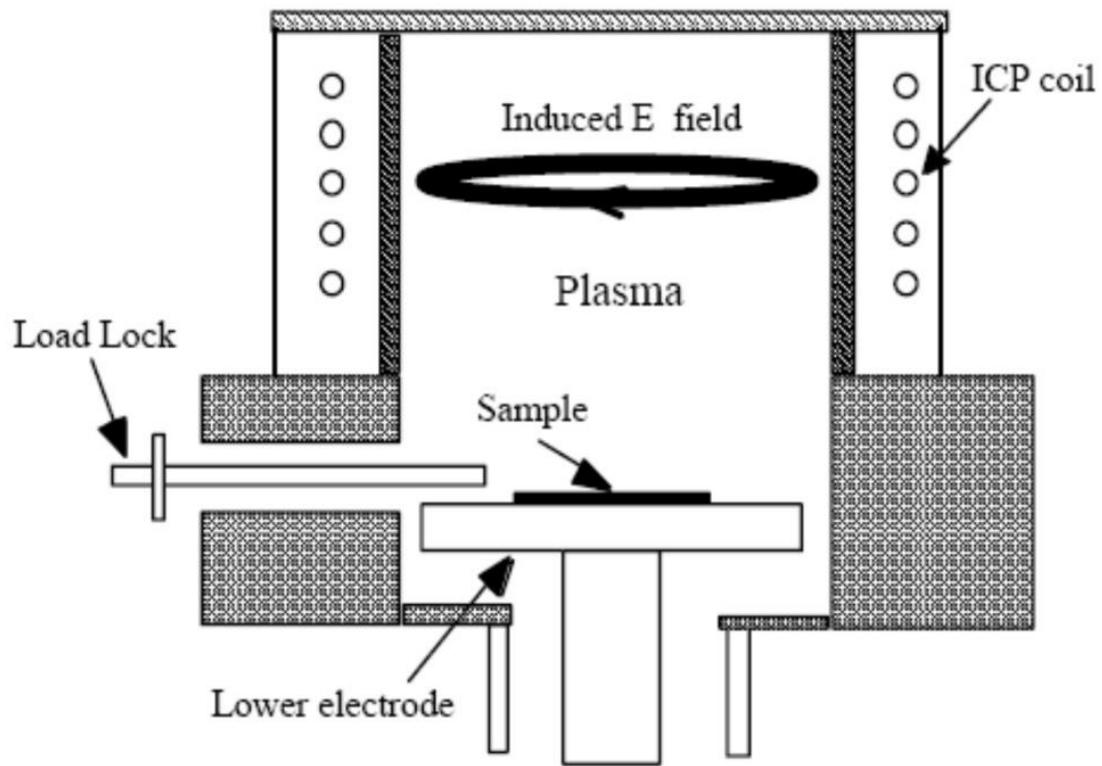
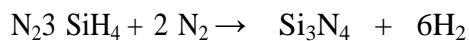
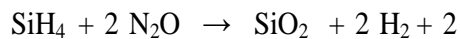
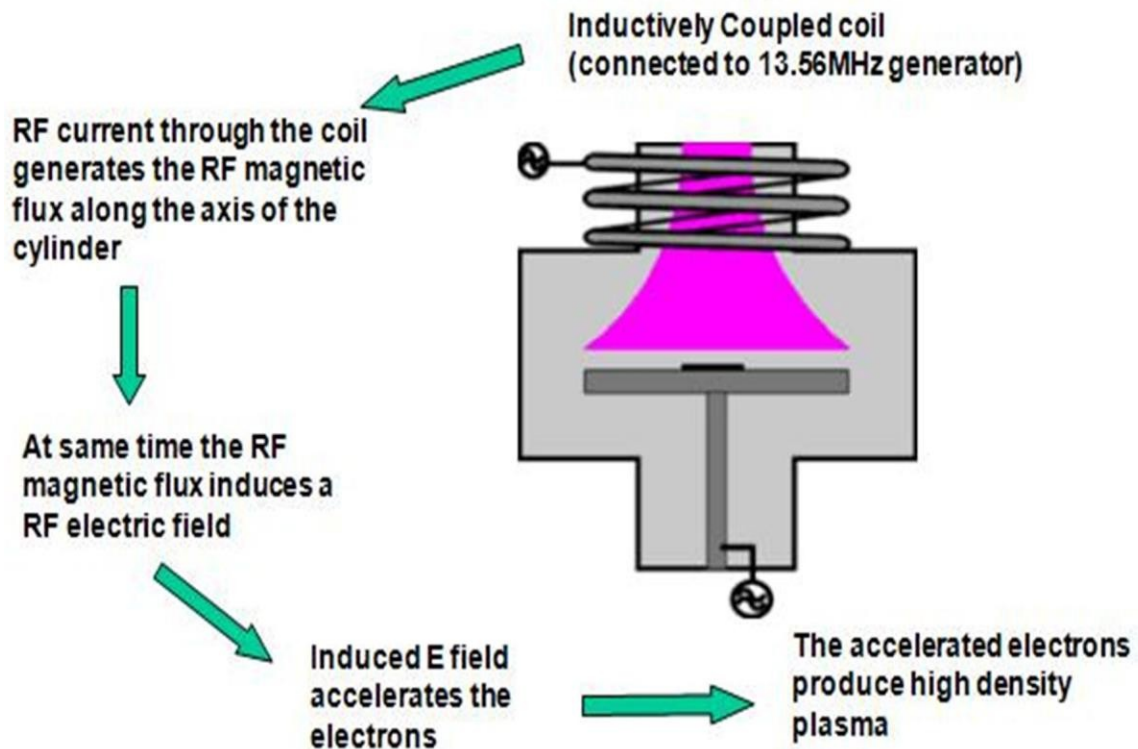


Fig. 1. Schematic diagram of the ICP CVD system.

Helium gas –Some pressure is applied to the back of wafers to provide good thermal contact between chuck and wafer. All process gases pass through a transmission disc and Silane is introduced through a gas distribution ring before entering the Process Chamber. [1]

### Chemical Reactions for the Silicon Dioxide and Silicon Nitride Deposition





*Fig.2. Plasma Strike [2]*

## Specifications

- **Substrate:** Si, GaN, GaAs, quartz, glass, other wafers (subject to contamination clearance, presently given by Prof. Anil Kottantharayil).
- **Substrate size:** 2", 4", 8" wafers and small pieces.
- **Types of depositions:** Silicon nitride, Silicon dioxide, Silicon oxynitride, Amorphous Silicon.
- **Vacuum attained :** Load lock chamber  $\sim 10^{-3}$  Torr ;  
Process chamber  $\sim 10^{-7}$  to  $10^{-9}$  Torr.
- **Temperature of substrate:** Room temperature to 350degC.
- **ICP power :** 3KW (maximum)
- **Substrate bias power :** 300W (maximum)
- **Gases presently connected to system:** Silane, Nitrogen, Ammonia, Nitrous oxide, Argon, Helium, CF<sub>4</sub>/O<sub>2</sub> (clean gas).
- **Mass Flow Controller (MFC) Limit/Range:**  
Ar: 200sccm, SiH<sub>4</sub>:50sccm, N<sub>2</sub>O:50sccm, NH<sub>3</sub>:50sccm.



## Operation Procedure

### Precautions

1. The system can be operated by authorized users only. The names of the authorized users can be found in the *people list*.
2. All the gas cylinders must be open to 20~30psi, Helium gas to be open to 15psi, SiH<sub>4</sub> to be open to 12psi. **Gas cylinders to be operated only by lab staff trained in handling specialty gases. Please check the *people list* for the names.**
3. Rota meter reading should read between 4.5 and 7slpm: adjustment can be done only after the System starts some procedure or the other. It displays nitrogen flow for purging rotary pumps.
4. Silane gas is connected to Furnaces and ICP-CVD System with a T-connection in the gas cabinet located in the service corridor. Care must be taken while opening the cylinder, i.e. **the other line to Furnaces should be closed.**
5. **Coordination with RTP, ICPRIE users** is a must as all 3 systems share the same gas lines of Ar, N<sub>2</sub>. Also, RTP uses high power, hence deposition must not be made when RTP is ON, i.e., **system can be ON but the RF generators must not be ON.**

### SWITCH ON Procedure

1. Start the three water lines
  - Turbo: 1 lpm RF Generator: 8lpm ICP/ AMU: 2lpm
2. PN<sub>2</sub>: 4 bar, High purity nitrogen used as a precursor gas, and to purge turbo molecular pump, process chamber, load lock chamber. We have 2 MFCs for PN<sub>2</sub>. MFC rating for purging is 100sccm; MFC rating for process gas is 50 sccm.
3. GN<sub>2</sub>: 6 bar, Commercial grade nitrogen used for operating solenoid valves and purging rotary pumps.
4. Check if Process Chamber leak Exhaust and Turbo Exhaust are ON.
5. Switch ON the mains of the system. Turn the green button of the System ON.
6. Open valves for PN<sub>2</sub>, GN<sub>2</sub>, and Helium inside the lab.
7. Turn ON the PC.
8. Choose the software **PC2000**.
9. We get a display as: **Name            OPT Password   \*\*\*\*\***
10. Click **OK** ..... Is load lock empty **OK**.....Sure **OK**
11. Go to **System**.....**Service**.....
12. To activate both the Rotary pumps, click on the schematic for pumps. When a yellow lining appears around the pumps, we have control over them. The pumps will start working.
13. Go to **System**.....**Service**   **Exit Service**.....
14. We get a display: **Danger, Machine is about to reset, Stand clear....This means the machine will reset to home position....click on OK.**
15. We are in the **Pump Control** page now.
16. Wait for about 20min., for warming up of the pumps.

17. Click on  for both chambers.
18. We get a display....**Enter Wafer ID**...**Cancel** if there is no wafer/give ID otherwise, and then click on **OK**.
19. Wait for a few minutes, Turbo pump starts, initially... **accelerates**, after ~6minutes it shows... **At speed**. This means the Turbo is at its maximum speed of 34000rpm. And we need to wait for the Process Chamber to reach the required vacuum  $\sim 10^{-7}$  Torr, Load lock chamber at a vacuum  $10^{-3}$ Torr.
20. When both the chambers are ready, green arrows  appear on both the chamber.
21. Now the **system is ready** for all processes.