

# **\*Reactive ion etch #1\* SOP**

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### **"Reactive ion Etch #1 (RIE-1)" Standard Operation Procedure**

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## **Overview**

### **The RIE-1 Etch System**

The RIE-1 is a Single Wafer Reactive Ion Etching (RIE) system. RIE1 is suited for etching of semi-conductor substrates like Silicon, Compound semiconductor wafers etc.

The system consists of

- a plasma reactor with vacuum load lock
- control rack with RF generator and computer with display
- mains supply rack
- backing pump for the reactor and dry pump for the load lock

The substrates will be loaded into the load lock manually. Inserting the wafer to the electrode and retracting it will be done automatically.



### Revision History

#	Revised by:	Date	Modification
1			
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# 1 Safety Considerations

## RIE1 and RIE2 Safety Considerations

### 1.1. Safety Considerations

The modern and user friendly program for the control of the plasma systems of RIE1 was developed with regard to the ease of use and control of the plasma system. Nevertheless, from safety considerations, it is indispensable for each user of the machine to acquaint himself with this **SOP**. The Staff who is in charge of this system must go through both the **Operating Manual** and the **Service Manual**.

It is the responsibility of the user to carefully read and strictly observe all safety precautions described in the operating instructions and manuals, for all components of RIE1.

It is especially important to **take into account the safety regulations (interlocks)** described within the service manual (**Appendix 2**).

Users with the access right to **edit** the system **configuration** have to observe the following:

***The configuration of the system (see software manual) is only intended for the setup when the system is safety or when additional parts are added. Incorrect use of the options can damage the system. It can lead to the destruction of the system or of the wafer inside of the system.***

User with the right to **bypass the interlocks** (safety locks) have to observe the following:

***Bypassing the safety locks can lead to serious damage to the system, personnel injury or death. These rights, therefore should be reserved for trained personnel only.***

When the **safety considerations are not observed, risks** can occur to :

- the health and the life of the operators
- the system and samples of the owner
- the intended use of the plasma system

**All persons who are in charge of the operation, service and maintainance** of the particular system **have to :**

- be qualified for their duties
- observe the know the contents of the relative manuals
- properly administrator user priviledges.

### 1.2. Mechanical hazards

Risk of injury!

Avoid exposing any part of the human body to the vacuum. Only open the load lock or the reactor when it is vented.



### 1.3. Electrical hazards

Risk of injury (electrical shock)!

Dangerous voltages are present at the mains connections. Before beginning with any maintenance or service work disconnect the machine from all power supplies

Voltages of up to 400V will be present in the mains supply rack, in the control rack and at the connection cables from the mains supply rack to the control rack

and to the rough pumps (process foreline pump, load lock pump) and to the machine (control rack, machine rack). Mains voltage will be present also at the fan of the turbomolecular pump and at the RF-Matchbox, which both are within the machine rack. Install the cables so as to protect them from damage.



### 1.4. Hazards caused by high/radio frequency (RF)

Alternating electromagnetic fields can have an unwanted, damaging effect on active and passive health aids (pacemakers, implants...). Persons with active and passive health aids must not be present in the area affected by the RIE1 system, which has a rf powered substrate electrode.



### 1.5. Hazards caused by materials and substances

The machine is not suited for operation in explosion hazard areas.

Do not use the machine with explosive gas mixtures.

Pumped process gas could be dangerous and toxic and could cause severe injuries or death.

Contaminated parts can be detrimental to health and environment.

Before beginning with any work, first check whether any parts are contaminated. Adhere to the relevant regulations and take the necessary precautions when handling contaminated parts.

If necessary, use gloves, a respirator and/or protective clothing and work under an exhaust hood.



### Software safety interlocks for RIE-1

- Valve VSK cannot open while valve VBSK is open.
- Valve VBSK cannot open while valve VSK is open.
- Foreline valve VVV cannot close while gas inlet valve VGQ0 is open.
- Gas inlet valve VGQ0 cannot open while the foreline valve VVV is closed.
- Main gas valve VGQ0 cannot close while gas valve VGQx is open.
- Gas valve VGQx cannot open while the main gas valve VGQ0 is closed.
- Gas inlet valve VGQ0 cannot open while the throttle DR is closed.
- Throttle DR cannot close while the gas inlet valve VGQ0 is open.
- Gas inlet valve VGQ0 cannot open while the gate valve TR isn't closed.
- Gate valve TR cannot open while the gas inlet valve VGQ0 is open.
- Foreline valve VVV cannot close while turbopump PTM is on.
- Venting valve VBR cannot open while the foreline valve VVV isn't closed.
- Foreline valve VVV cannot open while the venting valve VBR is open.
- Venting valve VBR cannot open while the turbomolecular pump PTM isn't switched off.
- Turbomolecular pump cannot be switched on while the venting valve VBR is open.
- Valve VVV cannot close while valve VSH is open.
- Valve VSH cannot open while valve VVV is closed.
- Spatula cannot drive into the reactor while there is a wafer in the reactor and the lift pins aren't in upper position.
- Lift pins cannot be moved while the spatula isn't in defined position.
- Gate valve TR cannot close while the spatula isn't in the load lock.
- Spatula cannot drive into the reactor while the gate valve TR isn't open.
- Spatula cannot drive into the reactor while there is a wafer on the spatula and the lift pins aren't in lower position.
- Valve VBSK cannot open while gate valve TR isn't closed.
- RF generator cannot be switched on while lower electrode isn't cooled.
- RF generator cannot be switched on while there is no wafer in the reactor.
- Electrode cooling cannot be switched off while the RF generator is on.
- Gate valve TR cannot open while pressure in load lock is above the threshold value (MSK).
- Gate TR cannot be opened while pressure in reactor is above threshold value.
- Penning cannot be switched on while pressure in reactor is above threshold value.
- Gas inlet VGQ0 cannot open while there is no vacuum in the reactor.
- Gas valve can't open because of an interlock to an other gas line.
- RF generator cannot be switched on while there is no vacuum in the chamber (MDR).

## 2. RIE-1 Standard Operation Procedure

2.1 Turn on Computer.

(1). Click the "SI591 Chlorine etching system" The LCD screen will show system statue and the reactor configuration.

(2). The statue will show " the PLC running"

(3). The reactor window shows the system diagram and all the parameters.

(4). Check both load luck and reactor mechanical pumps in operation condition. Both pumps (PS ans PW) must show green color on the screen.

(5). Open the valve between reactor mechanical pump and turbo pump WV. Turn on the turbo pump by click the PTM icon.

(6)., When the vacuum reading down to 50 mTorr on the parameter window, click MPE icon to turn on the high vacuum gauge. This will show the vacuum level inside the reactor chamber.

The screenshot displays the 'SI Plasma Systems Ver. 1.31' software interface. The main window is titled 'Reactor' and contains a schematic diagram of the system. The diagram includes a 'gas box' with six gas channels (1-6) controlled by VGE/B MFCs and VGQ valves. A 'load lock' is connected to the reactor chamber via a TR valve. The reactor chamber is equipped with a DR gauge and is connected to a mechanical pump (PW) and a turbo pump (PTM) via WV and VSH valves. A VBR valve is also present. The status bar at the bottom indicates 'Home positioning finished'.

On the right side of the interface, there is a 'Parameter' table and a 'Gas channels' table.

Parameter	nominal	actual	L
Baratron pr. (mTorr)	0.0	0.61	
Penning pr. (Torr)		8.15E-8	
RF power (W)	0.0	0.0	
RF bias(V)		0.0	
Proc. per. (h:mins)	00:00:00	00:00:00	


Gas channels	nominal	actual	status
1 Ar	0.0	-0.1	green
2 O2	0.0	-0.1	white
3 Cl2	0.0	0.0	yellow
4 BCl3	0.0	0.0	red
5 NN	0.0	0.0	green
6 NN	0.0	0.0	green

Legend:  
 ■ vacuum (green)  
 ■ compr. air (yellow)  
 ■ nitrogen (red)


## 2.2 Loading wafer

1. Close the load lock chamber vacuum valve by click VSK.
2. Click VBSK to vent the load luck chamber.
3. Open the load lock chamber top window and load your sample, then close the window.
4. Click VBSK to close the vent valve. Open the load lock chamber vacuum valve to pump the chamber down to less then 50mTorr. The load lock chamber pressure can be checked by move the mouse in red MKS indicator.
5. Click TR to open the gate valve between load lock and reactor.
6. Insert the sample into the reactor chamber by click the yellow →The loading arm will move to the reactor center.
7. Rising the wafer support pin by click the yellow ↑ arrow. Move out the loading arm by click the yellow ← arrow.
8. Lower the wafer support arm by ckick the yellow ↓arrow. This will put the wafer to the exact position.
9. Click the TR to close the gate valve.

## 2.3 Etching (setting flow rate, pressure and power)

1. From the gas channel section of the parameter window choose the gas you want to use.
2. Click the first column of this gas, its color changing from black to blue.
3. Use the key board input the flow rate (sccm) then press the enter key.
4. Set the pressure by click the Baratron pr. Left column. Input the pressure value (mTorr) then press enter.
5. Set the RF power by click RF Power first column and input the power value.
6. Open the main gas inlet valve by click the right VGQ. ( The color will change to green)
7. Open the specific gas inlet valve and deliver process gas into the reactor chamber.
8. Check the gas flow rate and chamber pressure from the second column to make sure it match the setting value.
9. Click Proc. Per (h:mm:s) first column to set the process time.
10. Click the  to turn on the wafer chuck cooling water.



11. Turn on RF power by click RF icon.
12. The plasma is "on"
13. When the process time reach the setting time, the RF power. turn off automatically.
14. Turn off the chuck cooling water by click  .
15. Click left VGQ to close the specific gas valve.
16. Click the main VGQ (right one) to turn off the gas inlet valve.
17. Reset gas flow, pressure and RF power to zero.

#### 2.4 Unload the sample

1. Check the load lock chamber pressure by move the mouse to MSK icon. Its valve must be lower then 50 mTorr.
2. Open the gate valve between reactor chamber and load lock chamber by click TR icon.
3. Click the yellow ↑ arrow to rise the sample.
4. Click the yellow → arrow to insert the loading arm into the reactor chamber.
5. Click the yellow ↓ arrow to lower the sample support pin.
6. Click the yellow ← arrow to move the sample to the load lock chamber.
7. Close the gate valve by click the TR icon.
8. Click VSK to close the vacuum valve.
9. Vent the load lock chamber by click the VBSK.
10. Open the load lock chamber top cover and take your sample out.
11. Close top cover, turn off the vent valve VBSK.
12. Click the VSK to open the vacuum valve to pump down the load lock chamber