

1.0 SPUTTER II - AJA ORION SPUTTER SYSTEM

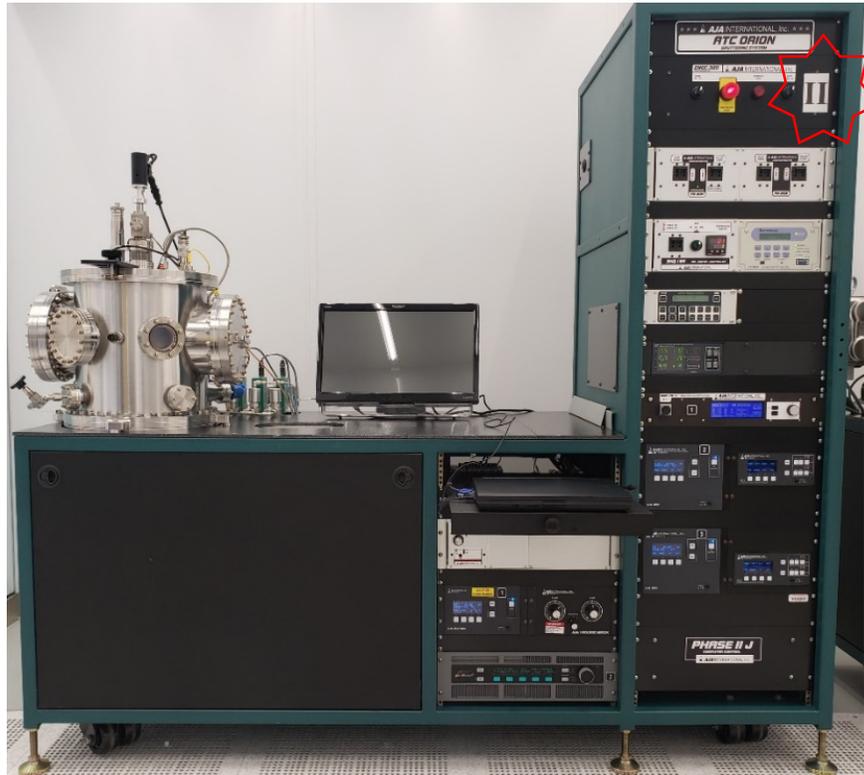


Figure 1: Sputter II - AJA Orion Sputter System

1.1 Introduction

AJA Orion Sputter System deposits metal as well as dielectric films over a substrate up to 6" in diameter. It is fitted with two 3" diameter sputter guns; one that is powered by RF, and one by pulsed-DC, and can be used for single or multi-layer deposition. The system additionally has two 2" diameter sputter guns, one that is powered by RF and one that is powered by DC, and can also be used for single or multi-layer deposition. The computer control provides for recipe generation and process data storage. Substrate heating, rotation, and RF biasing is available. Users need to provide targets that are not available.

Only trained and approved (qualified) users may use this tool. Users are not allowed to change targets. Only high-purity, low vapor pressure targets may be used.

1.2. Features and Specifications:

- a) Substrate targets pre-loaded by NUFAB staff for seep, simplicity and maximizing up-time
- b) Designed to accommodate wafers up to 6" in diameter
- c) Two RF, one DC and one pulsed-DC power source
- d) Two 3" diameter sputter guns and two 2" diameter guns
- e) Sputter up configuration
- f) Substrate heating to 800° C
- g) Substrate rotation
- h) Substrate biasing for cleaning and during deposition
- i) Base vacuum 5×10^{-8} Torr or better
- j) Uniformity $\pm 2.5\%$ for 6" wafer

1.3 Safety

- a) RF, DC and pulse power sources are present. Do not open any panels or defeat interlocks.
- b) There are two interlocks: (1) In case of water failure, the tool shuts down, (2) the power sources don't turn on if the chamber is near atmospheric pressure.
- c) If substrate heater is being used, there is burn hazard. Do not touch the hot surfaces.
- d) Pay attention to safety symbols on the equipment.
- e) Sputter guns and the viewport shutter have strong magnets that can adversely affect pace makers.
- f) Press EMO button if there is an immediate danger to personnel or the equipment. Inform the staff.

1.4 Precautions

- a) Do not scratch or put any metallic objects on the surfaces where vacuum seals are.
- b) Before venting the chamber, ensure that substrate heater is off and substrate temperature is below 70° C. Ensure substrate holder is not too hot before touching it.
- c) If the turbo pump does not accelerate to 100% rotation (as displayed on the turbo pump controller) after starting, turn the pump off to avoid damaging it. Inform the staff.
- d) Do not expose the turbo running at 100% rotation to the atmospheric pressure to avoid damaging it.
- e) Do not sputter or turn sputter guns on without substrate holder plate in place or the heater quartz window will get coated and will require an expensive replacement.
- f) The 6" substrate holder is made of aluminum and can only be used with substrate heating up to 400° C. The 4" substrate holder is made of inconel and can be heated up to 850° C.
- g) Press EMO button if there is an immediate danger to personnel or the equipment. Inform the staff.

1.5 Operating Procedure

Activate the equipment in NUCore before you start. Deactivate it when finished.

Figure 2: Glass slides mounted on the substrate holder



1.5.1 Mounting the Substrate

- a) Ensure your gloves are clean.
- b) Select 4" or 6" substrate holder keeping in mind that 4" holder can be heated up to 850° C while 6" holder can be heated only up to 400° C.
- c) Mount the substrates using screws and clips as shown in Figure 2. To avoid contamination, do not touch the substrates with hands, handle with tweezers.

1.5.2 Venting the Chamber

All gases and plasma must be off before attempting to vent the chamber as displayed on laptop screen (Figure 8). Follow the procedure below that applies.

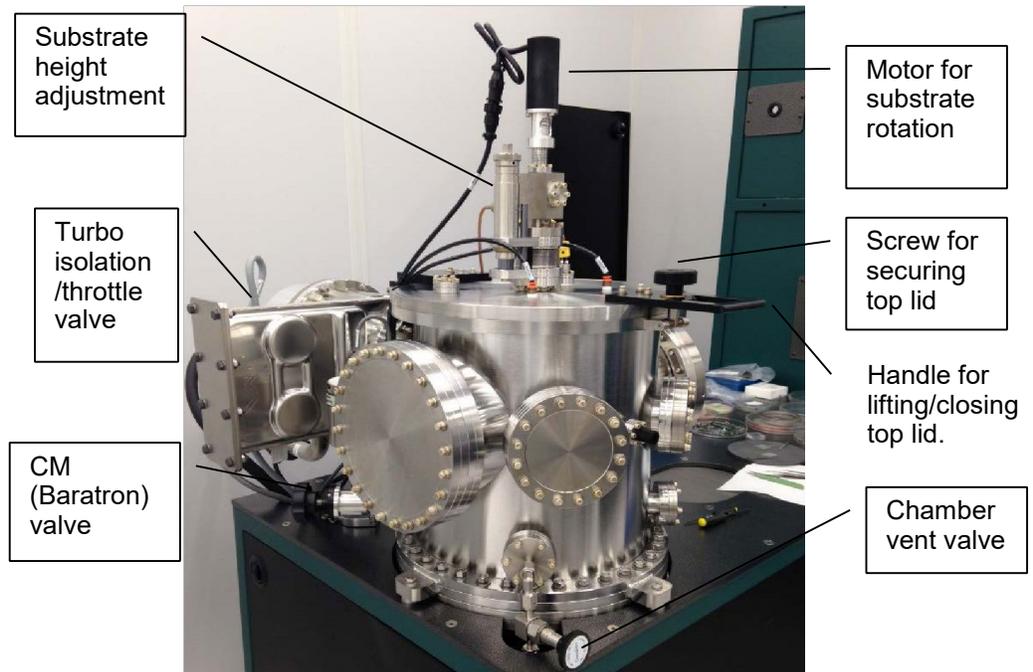


Figure 3: Sputter chamber view from left.

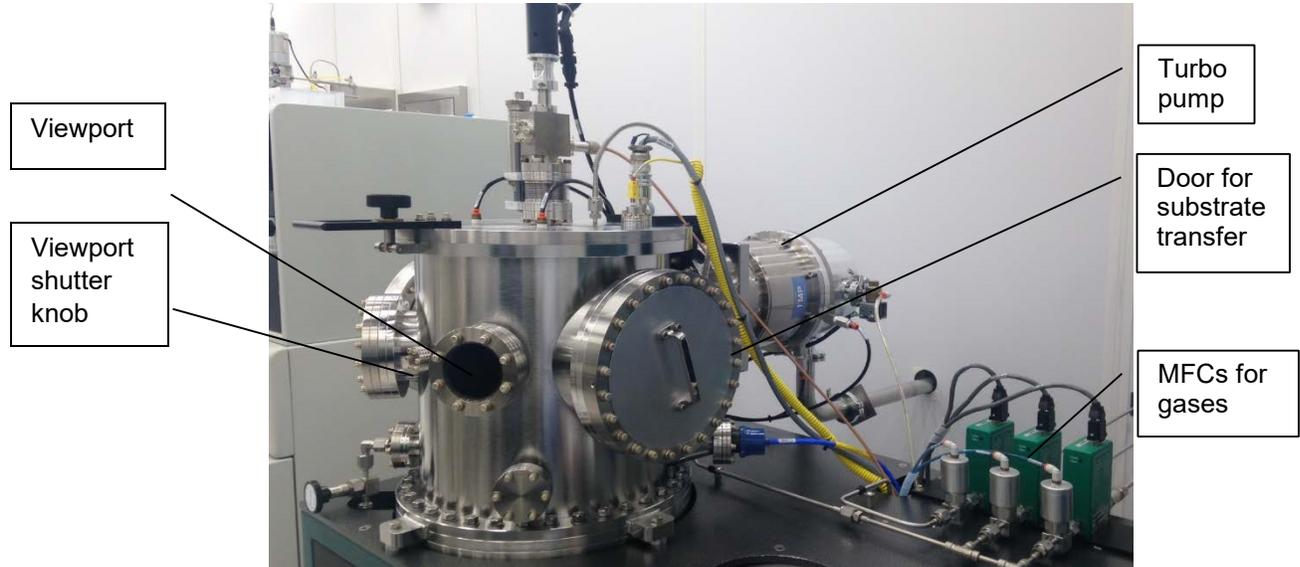


Figure 4: Sputter chamber view from right

- a) If turbo pump is running: (i) ensure turbo-isolation valve is closed (see PRESSURE CONTROL on laptop), (ii) ensure Baratron valve is closed (manually turn it clockwise (Figure 3)), (iii) the ion gauge is off (Press the IG1 button (Figure 6)), (iv) turn the pump switch off (Figure 5) to turn off the turbo and backing pump. When the turbo stops spinning (rotation 0% on its controller in Figure 5), the manual chamber vent valve (Figure 3) can be slowly opened to speed up venting.

- b) If the turbo pump is off: (i) ensure turbo isolation valve is closed (on laptop), (ii) ensure Baratron valve is closed (if not, manually turn it clockwise (Figure 3)), (iii) the ion gauge is off (if not, press the IG1 button (Figure 6)), (iv) the manual chamber vent valve (Figure 3) can now be slowly opened for venting.
- c) When the Convectron reads about 760 Torr (atmosphere), the substrate transfer door (Figure 4) can be opened and the manual vent valve should be closed.

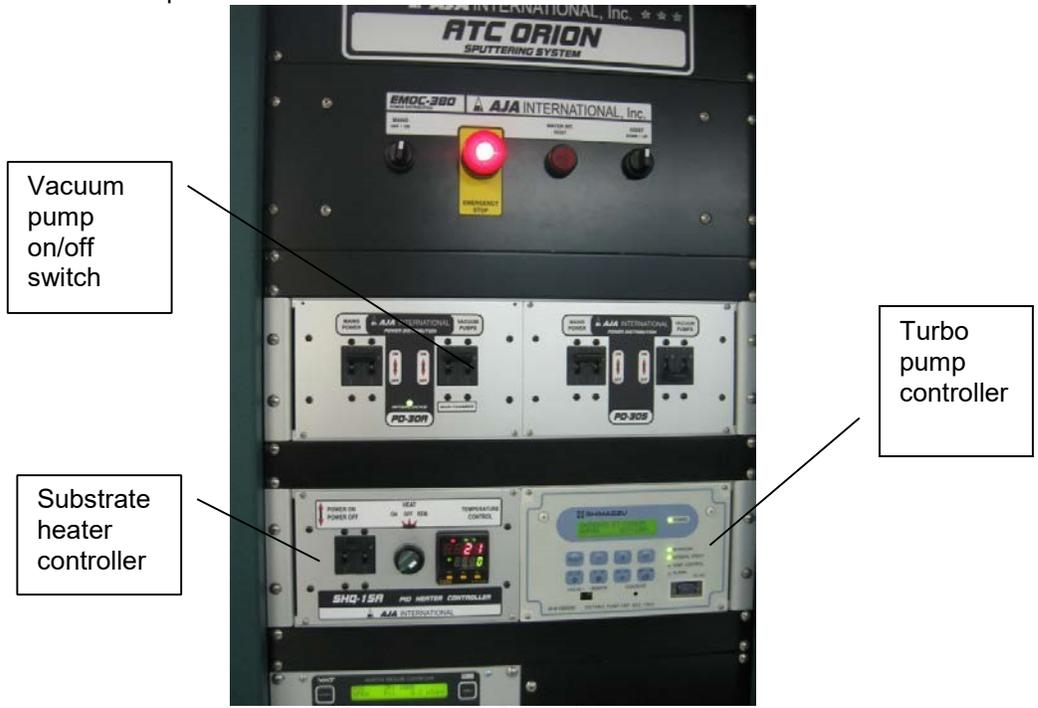


Figure 5: Control Rack (upper).

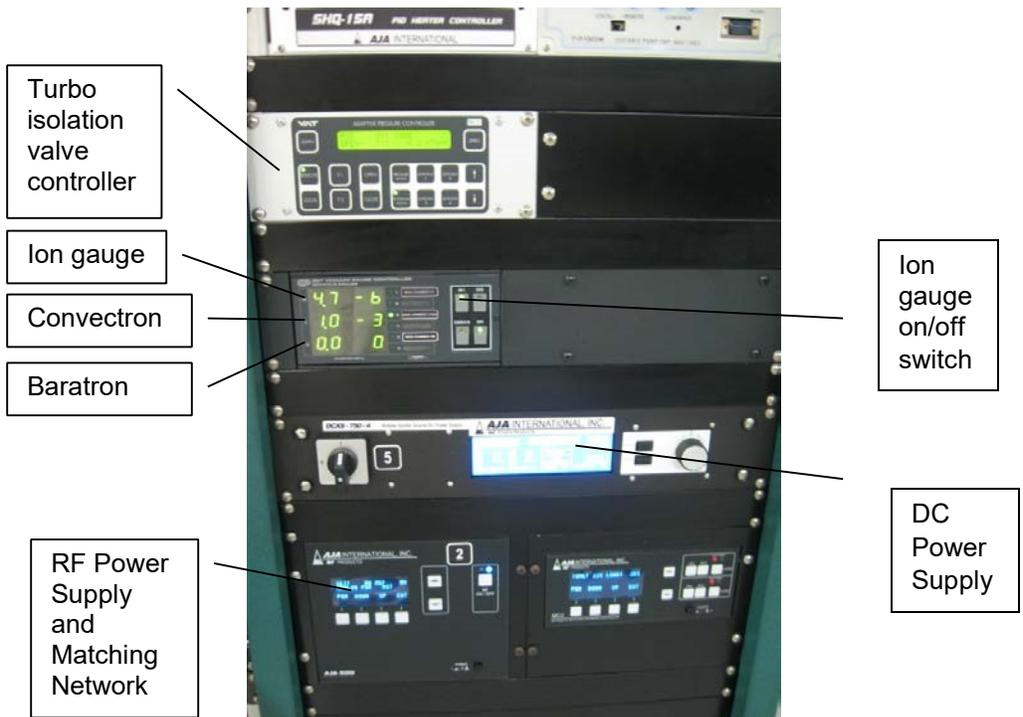


Figure 6: Control Rack (lower).



Figure 7: Control Rack (center).

1.5.3 Transferring the Substrate to Chamber

This procedure is best learned by practice with a staff member.

- a) Ensure the substrate transfer door is open. Always place the door with O-ring facing up to avoid damaging it.
- b) Hold the substrate holder plate from the edges with your right hand. The substrate should be facing your palm but not touching.
- c) Turn the plate over with substrate facing down now and transfer through the door under the quartz mounting plate.
- d) Raise it against the propeller in the center of the quartz plate (Figure) and turn the propeller clockwise with your left hand by turning the motor shaft on the top lid (Figure 3). This will engage the propeller in the grooves on the back of the substrate plate.
- e) Ensure the substrate plate is held securely before removing your hand.

1.5.4 Pump Down

- a) Close the top lid gently using the handle (do not drop it!) and tighten the screw (Figure 3). b) Close the side door (Figure 4).
- c) Ensure the vent is off (manual screw valve that closes clockwise, Figure 3).
- d) Ensure the turbo isolation valve is fully open (check on laptop and its controller, Figure 6).
- e) Turn the pump on/off switch to ON (Figure 5).
- f) If you hear hissing sound from the side door, press on it to stop the leak.
- g) Watch the turbo speed going up on its controller (Figure 5). It should reach 100%. If it does not, turn the pump switch off and let the staff know.
- h) Open the Baratron valve CCW (Figure 3).
- i) The chamber will pump down to 10^{-7} Torr range in 15 minutes. You will need to wait longer for higher vacuum.

1.5.5 Deposition

Deposition can be done in a manual mode or by running a recipe. All this is done through the software on the laptop. The main software screen is shown in Figure 8. The explanation of the screen starting from its top left is given below:

- a) Rotation: Clicking on OFF button will turn the substrate rotation on and clicking again will turn it off. Rotation should always be used when thickness uniformity is needed.

- b) Heat: Substrate heating should be used with extreme care. Ensure that your substrate holder and substrate can handle the temperature that you intend to use. Heating results in outgassing of the chamber and will bring the pressure up. Hence pump down times will be much longer. Follow these guidelines; (i) Do not heat above 400 °C if 6" substrate holder is installed or it will melt, (ii) Only heat up to the temperature that your substrate can handle, (iii) Do not heat if there are polymers on the substrate like resists, etc. (iv) Increase the temperature slowly (no faster than 50° every 5 minutes), (v) consult the staff if you need to use the temperature over 600°C, (vi) after deposition, turn the heater off and wait until temperature comes down to 70°C or below before venting the chamber.
- c) Gas 1, 2, 3: There are three gases as listed, Ar, N₂, and O₂. Argon is needed for sputtering and is fed into Gun1 but will work for other guns too. N₂ and O₂ are for reactive sputtering only and hence are fed close to the substrate. Ensure pressure control valve (same as turbo isolation valve) is fully open as indicated after the gases on the screen, and the ion gauge (Figure 6) is off (or press IG1 to turn it off) before setting the gas flows and opening gases. 20 sccm flow is generally used for Ar with this system.
- d) Pressure Control: It is same as turbo isolation valve. After opening the gases, change this to pressure mode and enter the sputter pressure desired (generally between 1- 5 mT). This controls the pressure using the Baratron reading, ensure its manual valve is open (Figure 3).
- e) RF1: It is RF biasing for the substrate and is used for two purposes, (i) It can be used to clean the substrate surface before deposition, and (ii) it can also be used during deposition to modulate the properties of the films. **It can only be used at 50W or less** with no ramping at 1-5 mT pressure for 2 -3 minutes. If there is no plasma, increase the pressure up to 30 mT (enter in pressure control on laptop) to strike the plasma, and then lower it to the desired value. Any RF power supply should not be left on for longer than 6 sec if there is no plasma. This RF supply has a manual matching (Figure 7). Use the Load and Tune knobs in sequence if the reflected power on the power supply display is larger than 3 W. It can be used in conjunction with heating and rotation.
- f) RF2: It is an RF power supply that is connected to sputter gun 2 that has Ti target installed. The maximum power is 600W for this supply **but using higher than 200 W will damage the targets and the gun**. The ramp rate of 2 W/sec should be used (i.e., 50 sec for 100 W). It can be turned on by clicking on red OFF button after entering the power and ramp values. If the plasma does not turn on (plasma button does not turn purple) increase the chamber pressure to 30 mT to strike the plasma and then bring it down to the sputter pressure. This supply has auto matching, so no manual matching is needed. It is advisable to pre-sputter with gun shutter closed for 2-3 minutes to clean the target surface before opening the shutter by clicking on the big green button. It can be used in conjunction with substrate rotation, biasing, and heating if desired.
- g) DC1: DC1 is 5000W pulse supply. It is connected to Gun 3. However, **maximum power of 200 W should be used to avoid damage to targets**. Follow the procedure described for RF2 for using these supplies also.
- h) DC5A and DC5B: DC5A and DC5B guns share a 750W DC supply. DC5A uses 3" targets and DC5B accommodates 2" target. **Maximum powers for DC5A and DC5B are 200 W and 75 W, respectively**. To switch between DC5A and DC5B, click on the 'SW' button shown in Figure 8. Green means enabled.
- i) Venting, substrate removal, and pump down: Follow procedure in section 1.6.2 for venting the chamber. Reverse the procedure described in 1.6.3 for removing the substrate and use procedure described in 1.6.5 for pump down before leaving the tool. The chamber should always be left in pump down mode after finishing your process.

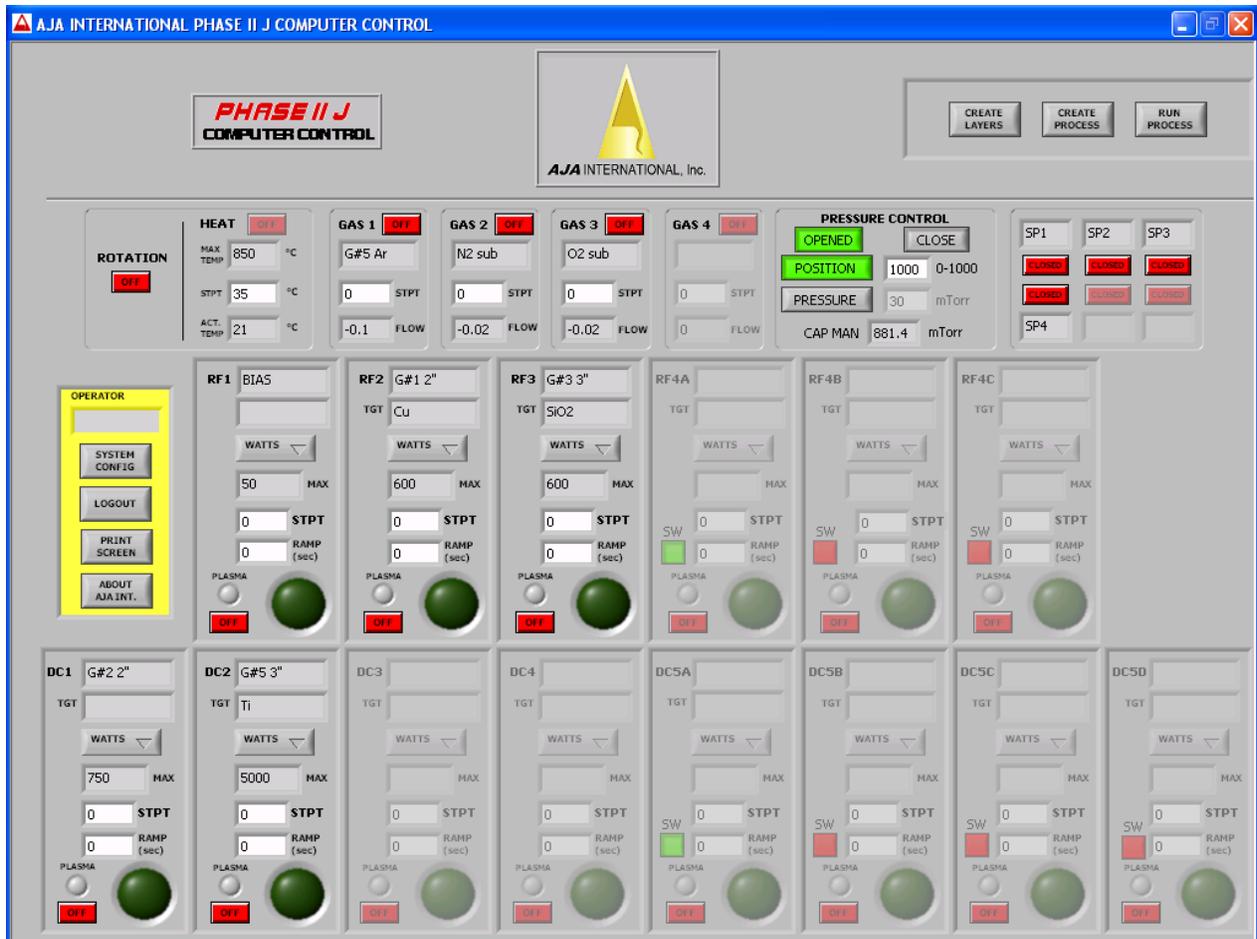


Figure 8: Main Screen.

1.5.6 Recipe Creation

Recipes are created by clicking on the Create Layer button on the top right of main screen (Figure 8). A process consists of one or more layers. For dielectric targets, a plasma strike layer is needed before the deposition layer. It strikes the plasma at a higher pressure (30 mT) then the deposition layer lowers it to the deposition pressure and opens the shutter. If multiple layers need to be deposited, they can be added to the process.

The create layer screen is shown in Figure 9. It is generally quicker to open an existing layer by clicking on OPEN and modifying its entries.

- Substrate: If substrate rotation is selected to be ON, substrates will start rotating when this layer is run. If the heat is selected to be ON and set point is entered, the heater will turn on. Note that the set point cannot be lower than 21 °C, the room temperature. Soak Time is the time after the heater reaches the set point and any further step on the layer. Since pressure in the chamber rises with heat, soak time can be used to pumps time to bring it down before opening gases and starting plasma.
- Pressure Control: Generally PRESSURE mode is selected and the deposition pressure (1-5 mT) entered. But if it is a plasma strike layer, enter 30 mT.
- Gas: Select gases desired and flow rates (maximum is 20 sccm). Argon is essential for sputtering and is generally used at 20 sccm.

- d) RF Power: RF bias can be turned on if needed. Delay time is relative to the other power sources. For example, if you want to clean the substrate first, you can leave delay time zero for the substrate bias but enter Coat time of, say 120 sec. Now enter delay time larger than 120 sec for the sputter gun that you want to use to ensure that deposition starts after cleaning bias shuts down. There is no shutter for the substrate bias. The recommended power ramp for gun supplies is 2W/sec, so calculate the time accordingly. No ramp is needed for bias. The shutter delays for gun supplies are used to allow for pre-sputtering for cleaning target surfaces (2-3 minutes). Shutters can be left open by selecting Shutter Carry Over for the next layer (generally not used). Idle power is used if you do not want to shut down the power supplies before the next layer executes, for example in strike plasma layers. Also, if you are depositing multiple layers, it is recommended that all guns that are needed should be turned on together in the first software layer and then their powers lowered to the idle power (minimum power that sustains plasma reliably). Then, open the shutters in following layers of those sources that needs to be deposited.
- e) DC Power: These supplies are used similarly as described above for RF power. To switch between DC5A and DC5B, click the 'SW' button in DC switch section.
- f) Save the layer by clicking on SAVE (top left) and giving it a name.
- g) When finished with creating layers, clicking close will take you to main screen (Figure 8).
- h) Click on Create Process (top right on main screen). The window shown in Figure 10 will open.
- i) Select and add the layers in sequence they need to be executed. Give a name and save the process.
- j) Click RUN PROCESS on the main screen (Figure 8). The window shown in Figure 11 will appear. Click DATALOG to activate it. Enter the time interval (5 sec generally). Now clicking Run will execute the process. Datalog files are stored under the password folder (generally password1) in Phase II folder.

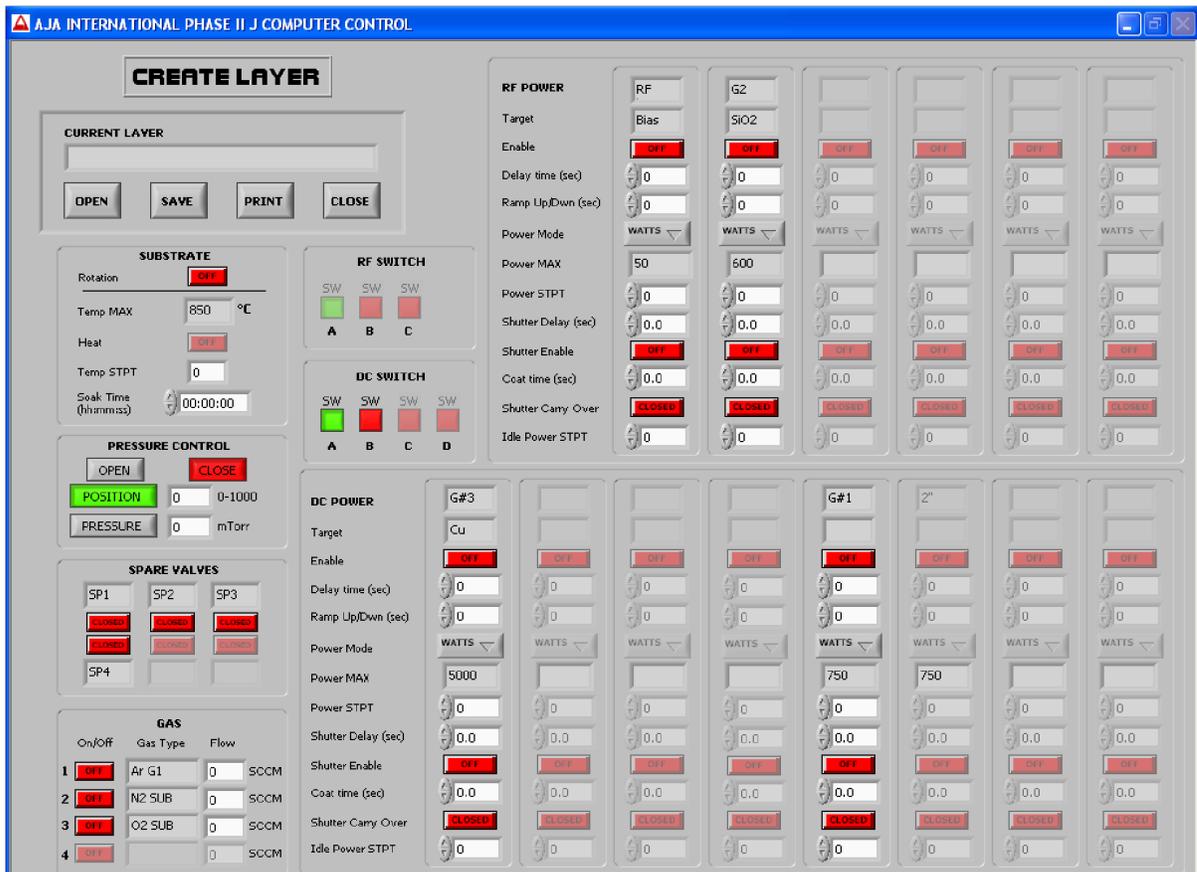


Figure 9: Create Layer screen.

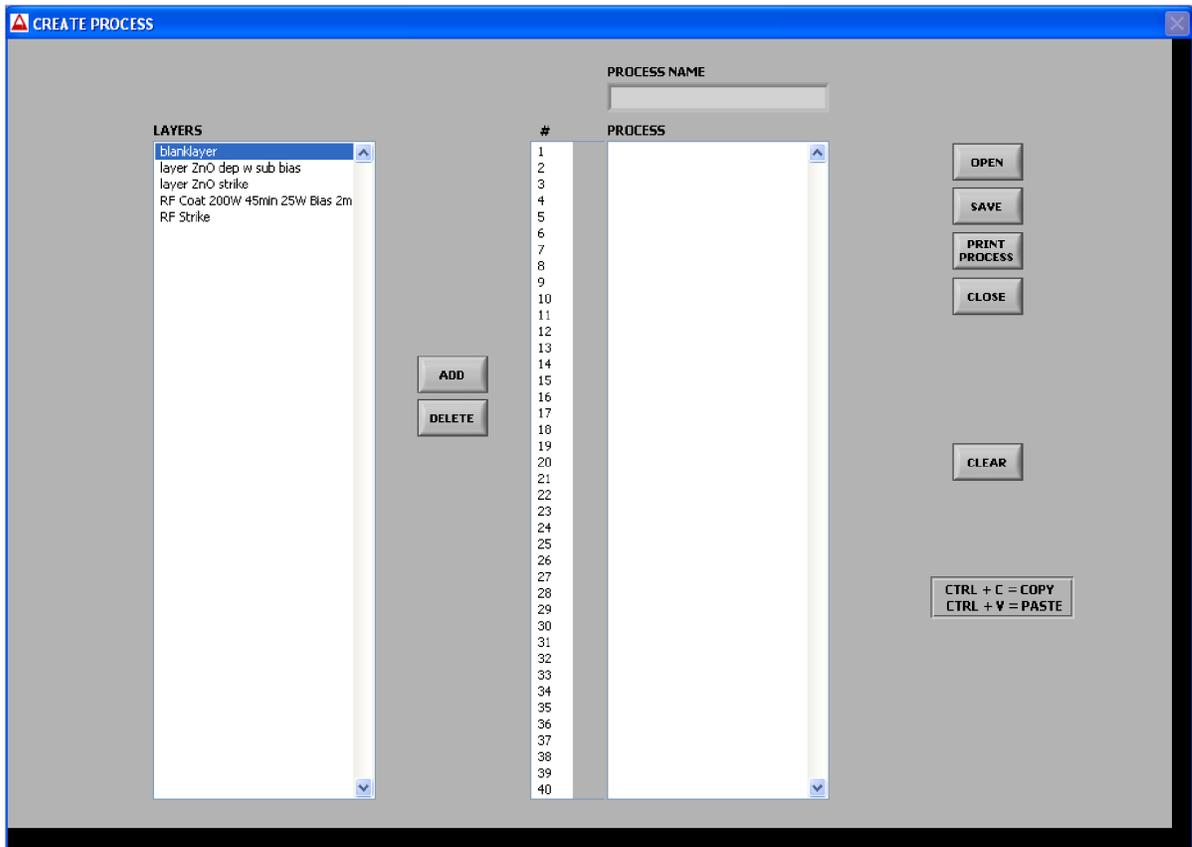


Figure 10: Create process window.

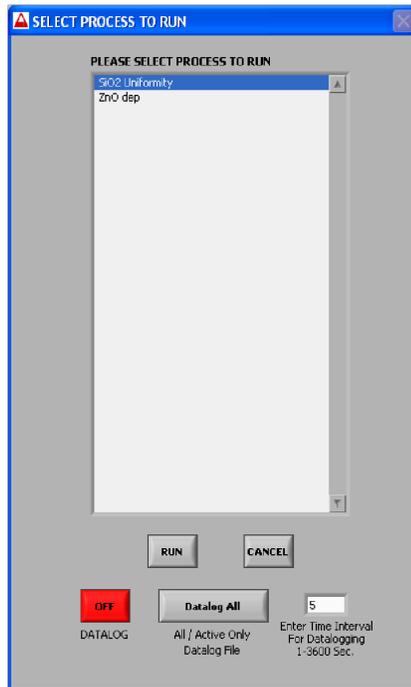


Figure 11: Run process window.

APPENDIX

