

Standard Operating Procedure: Sputter

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Hardware Description and Principle of Operation

AJA International Orion 8 RF Sputter

The AJA Sputter System is a load-locked sputtering system capable of depositing metal and dielectric films over a substrate up to 6 inches in diameter. It is equipped with seven high vacuum magnetron sputtering sources that are powered by two RF generators (300 W) and three DC generators (750 W) for single or multi-layer deposition or co-sputtering. Computer control provides recipe generation and process data storage. The max substrate is 4" with rotation (0-40 RPM), radiant heating to 850°C, and RF/DC biasing with 100 W RF generator for substrate pre-cleaning. Process gases are also available for reactive sputter deposition.

Material Requirements

Equipment: substrate and tweezers

Personal Protective Equipment: nitrile gloves

Procedure

Estimated Time: 30 minutes for loading/unloading sample + strike/ramp/deposition time

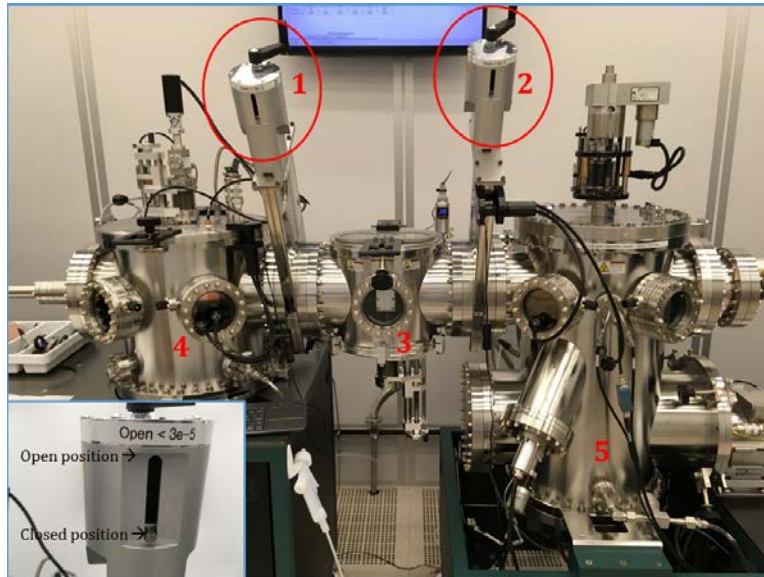
Check Targets

1. Check the instrument to confirm that the target material(s) that you wish to deposit are loaded into the sputter tool. The materials installed in the tool are listed on the Google sheet and on the tool computer control. If there is a discrepancy between the Google sheet and the software, notify staff.
2. If you are planning to deposit a material or stack of materials that you have not deposited before, you may want to check the list of processes that are saved on the tool. If there is not already a process for a material that you want to deposit, you will need to create one and consult with staff to determine the process parameters.

Load Sample

1. Before venting the load lock, make sure that the gate valves connecting the load lock to the sputter chamber [1] and the EBE chamber [2] are completely closed.

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2. Check the pressure in the sputter chamber.
3. Make sure that the hatch clamp on the load lock is disengaged.
4. Begin venting the load lock by turning off the power to the load lock vacuum pumps. This is done by flipping the corresponding switch [1] on the console to the left of the sputter chamber from the on position (up) to the off position (down).



5. After turning off the pumps, wait for a few minutes for the pressure in the load lock to increase to about ambient pressure ($\sim 7.5E+02$ Torr).
6. Open the hatch and remove the aluminum rack from within the load lock. Set it on a couple of clean fab wipes on the metal tabletop to the left of the sputter main chamber.
7. If it will only take you a minute or two to fix your samples to the stage, then you may leave the load lock vented during this time. In that case, close the hatch loosely after removing

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the rack to keep the load lock free of dust. Do not try to make a seal and do not engage the clamp.

- a. If it will take you longer than five minutes or so to fix your samples to the stage, you should remove the rack from the load lock, then remove the sputter sample stage from the rack, and then return the rack to the load lock, close the hatch, engage the clamp, and turn on the vacuum pump so that the load lock will evacuate while you fix your samples to the stage. By keeping the rack and the load lock under vacuum for this time, it will be easier to evacuate later. Then, when you have secured all of your samples to the stage, vent the load lock again, load the plate onto the rack, close and seal the hatch, and evacuate the load lock.
8. The sputter sample stage will be on the highest two rungs on the rack. Remove it from the rack, invert it so the sample side (the “concave” side, or the side that has a ridge around the edge with the heads of screws showing) is facing up, and place it on another couple of clean fab wipes.
9. Attach your samples to it using Kapton (polyimide) tape or a proper clamp. Make sure that your samples are securely fastened to the stage so that they will not fall off when the stage is inverted.
10. Then invert the stage so the samples are facing downwards and place the stage on the second highest rung of the aluminum rack. Try to make sure that the stage is centered on the rack with one of the trenches on the sample holder lying perpendicular to the rack.
11. Open the hatch on the load lock, and place the rack with the sample stage onto the pedestal such that the two bolts protruding from the pedestal align with the holes on the bottom of the rack. When sealed correctly, the rack will be stable and will not wobble or rotate.
12. Close the hatch, engage the clamp, and observe a small pressure increase indicating that the hatch is sealed.
13. Turn the load lock vacuum pump back on to begin evacuating the load lock.
14. After turning the pumps back on, wait for the load lock pressure to decrease below $5.0\text{E}+02$ Torr, at which time you may disengage the clamp. The load lock will then continue to evacuate.
15. It may take several minutes before the load lock achieves a pressure of less than $3.0\text{E}-05$ Torr, when you may transfer your sample from the load lock to the sputter main chamber.

Sample Stage Transfer

1. Using the crank on top of the main chamber next to the propeller shaft, raise the substrate holder height to allow enough clearance for insertion of the transfer arm.
2. After ensuring that the pressure in the load lock is sufficiently low ($< 3\text{E}-05$ Torr), you may open the gate valve between the load lock and the sputter main chamber.
3. Using the magnetic sleeve, carefully move the transfer arm from the position all the way at the left to the “Entering Load Lock” demarcation line. It will glide smoothly. If you feel any resistance, stop and look through the windows to figure out what is stopping the arm.

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4. The arm should be entering the gate valve. Look through the gate valve window to adjust the rack height so that the arm will move below the sample stage.
5. After ensuring that the arm will not hit the aluminum rack or sample stages, ease the arm fully into the load lock so that the “palm” is right under the sample stage to be loaded into the chamber.
6. Using the crank underneath the load lock, lower the rack until the sample stage is resting on the palm of the transfer arm, with each side of the plate touching the middle ledge of the transfer arm palm.
 - a. If the stage is tilted or is not seated correctly on the palm, then you should lift the stage by cranking the rack up. Then you may need to adjust the position of the transfer arm by wedging a folded fab wipe between the sleeve and metal collar to the left of the sleeve. Then lower the rack and stage to the black line again. Repeat as needed so that the sample plate is resting level on the palm of the transfer arm.
7. Retract the transfer arm into the sputter main chamber, stopping when the magnetic sleeve is just to the left of the “Chamber Center” demarcation line. This line indicates that the palm of the transfer arm is in position for loading the sample stage onto the sample holder.
8. Visually confirm that the sample stage and transfer arm are completely within the sputter main chamber and out of the way of the gate valve.
9. Close the gate valve.
10. Lower the propeller blades into the recess on top of the substrate holder. Lower the blades until a slight bend in the transfer arm is detected.
11. Manually rotate the propeller blades 30° clockwise to engage the sample holder mount.
12. Lift the substrate holder from the transfer arm so that the transfer arm has enough room to be retracted.
13. Move the transfer arm all the way to the left so that it is out of the main chamber.
14. Lower the substrate holder to the desired process distance.

Recipe Creation

1. Create a recipe by clicking on the **Create Layer** button on the top right of the Main Menu. A process consists of one or more layers. It is generally quicker to open an existing layer by clicking on **OPEN** and modifying its entries.
 - a. For dielectric targets, a plasma strike layer is needed before the deposition layer. It strikes the plasma at a higher pressure (30 mT) than the deposition layer lowers it to the deposition pressure and opens the shutter.
 - b. If multiple layers need to be deposited, they can be added to the process.

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AJA INTERNATIONAL PHASE II J COMPUTER CONTROL

SYSTEM CONFIGURATION

OPERATOR

 CONFIG SAVE/CLOSE
 CANCEL PRINT SCREEN

MAX TEMP
 HEATER 850 °C
 200 mTorr
 CM HEAD SIZE

GAS 1
 2.78 FACTOR
 20 MFC
 GAS INFO: Ar G1
 VALVE POSITION: 6

GAS 2
 2 FACTOR
 20 MFC
 GAS INFO: N2 SUB
 VALVE POSITION: 7

GAS 3
 1.98 FACTOR
 20 MFC
 GAS INFO: O2 SUB
 VALVE POSITION: 8

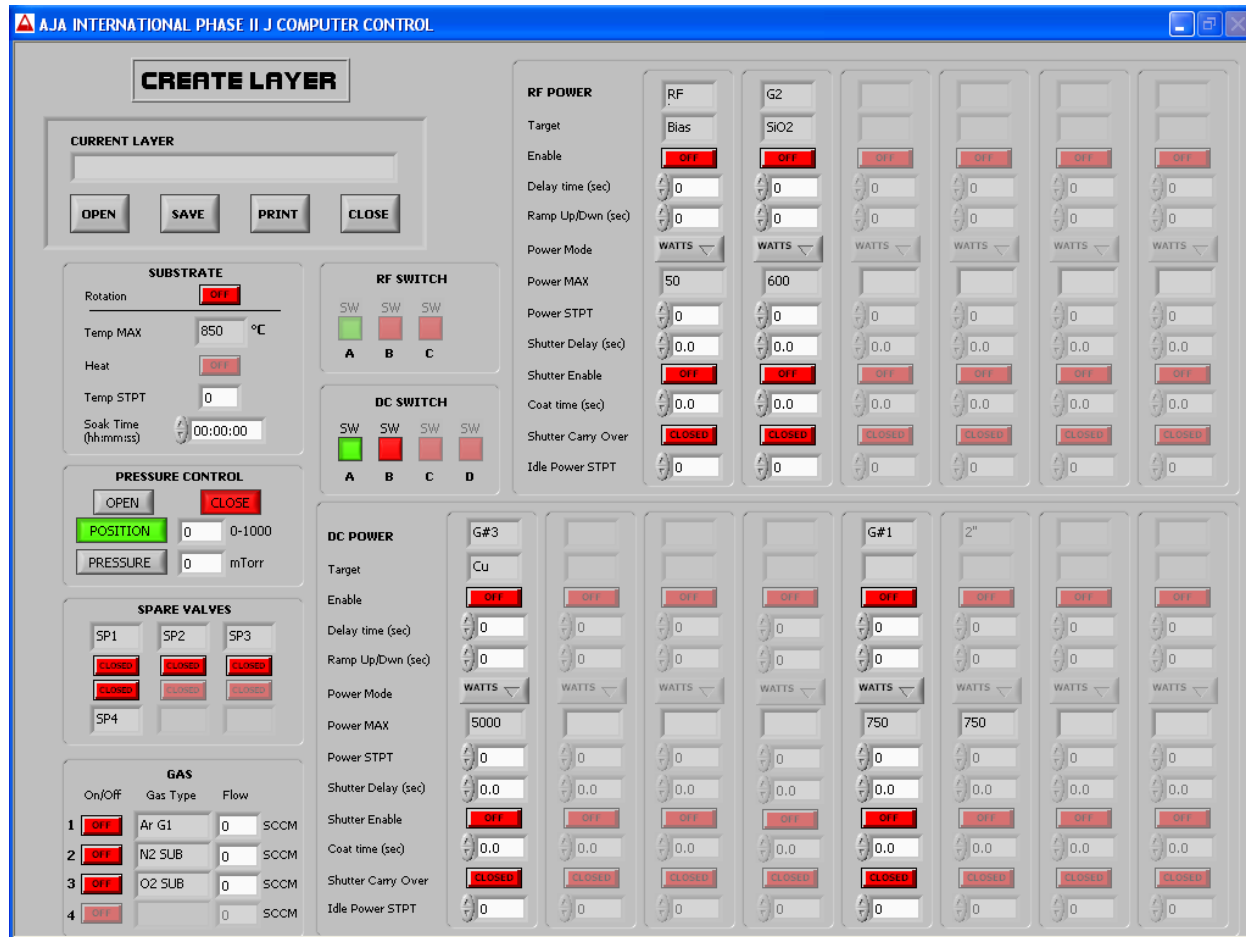
GAS 4
 0 FACTOR
 0 MFC
 GAS INFO:
 VALVE POSITION: 0

SP1 INFO: SP1 9
 SP2 INFO: SP2 10
 SP3 INFO: SP3 11
 VALVE POSITION: 0
 SP4 INFO: SP4 0
 SP5 INFO: SP5
 SP6 INFO: SP6

NOTES

RF1 RF bias TGT: Bias w: 50 v: 300 VALVE POSITION: 0 ACTIVE/INACTIVE: ACTIVE	RF2 G2 200WMx TGT: SiO2 w: 600 v: 1000 VALVE POSITION: 2 ACTIVE/INACTIVE: ACTIVE	RF3 TGT: w: v: VALVE POSITION: 0 ACTIVE/INACTIVE: INACTIVE	RF4A TGT: w: v: VALVE POSITION: 0 ACTIVE/INACTIVE: INACTIVE	RF4B TGT: w: v: VALVE POSITION: 0 ACTIVE/INACTIVE: INACTIVE	RF4C TGT: w: v: VALVE POSITION: 0 ACTIVE/INACTIVE: INACTIVE		
DC1 G#3 TGT: Cu w: 5000 v: 1500 mA: 20000 VALVE POSITION: 3 ACTIVE/INACTIVE: ACTIVE	DC2 TGT: w: v: mA: VALVE POSITION: 0 ACTIVE/INACTIVE: INACTIVE	DC3 TGT: w: v: mA: VALVE POSITION: 0 ACTIVE/INACTIVE: INACTIVE	DC4 TGT: w: v: mA: VALVE POSITION: 0 ACTIVE/INACTIVE: INACTIVE	DC5A G#1 200W TGT: w: 750 v: 1000 mA: 1000 VALVE POSITION: 1 ACTIVE/INACTIVE: ACTIVE	DC5B 2" 75W max TGT: w: 750 v: 1000 mA: 1000 VALVE POSITION: 4 ACTIVE/INACTIVE: ACTIVE	DC5C TGT: w: v: mA: VALVE POSITION: 0 ACTIVE/INACTIVE: INACTIVE	DC5D TGT: w: v: mA: VALVE POSITION: 0 ACTIVE/INACTIVE: INACTIVE

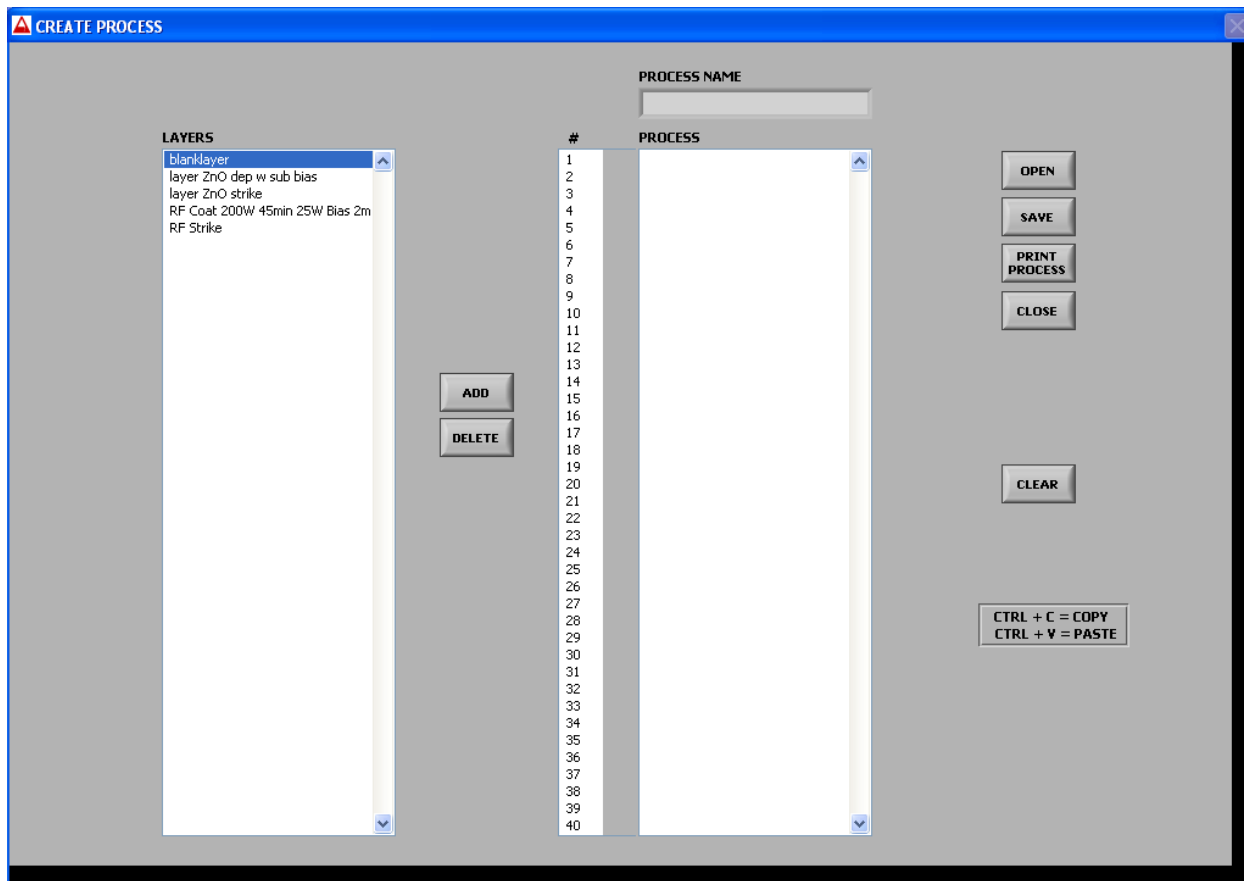
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2. Substrate
 - a. Substrate Rotation: when on, substrates will start rotating when this layer is run.
 - b. Heat: heater will warm to the set point temperature entered.
3. Pressure Control
 - a. **PRESSURE** mode is selected and the deposition pressure (1-5 mT) is entered.
 - i. Plasma strike layer: 30 mT.
4. Gas
 - a. Desired gases and their flow rates (maximum 20 sccm) can be selected.
 - b. Argon is essential for sputtering and is generally used at 20 sccm.
5. RF Power
 - a. RF bias can be turned on if needed. Delay time is relative to the other power sources.
6. DC Power
 - a. Click **SW** in DC switch section to switch between DC5A and DC5B.
7. Save the layer by clicking **SAVE** and giving it a name. When finished creating layers, clicking **CLOSE** will take you to the Main Menu.

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- Click on **Create Process**. Select and add the layers in sequence they need to be executed. Give a name and save the process.



Deposition – Running a Recipe

- Close the shutters of the main chamber.
- Click **RUN PROCESS**.
- Selected desired process to run and click **OPEN**.
- Click **OK**.
- Wait for plasma to strike and shutter to open before leaving the tool. If the plasma doesn't strike or the shutter doesn't open, **ABORT** the process and alert staff.
- When the deposition is done, press **OK**.
 - Note: If heater was used during processing, wait for the substrate to cool down to room temperature.

Deposition – Manual (One Target Deposition)

- Turn on the **ROTATION** and adjust the rotation speed.

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2. If desired to use the heater for deposition, enter a HEAT set point value and turn HEAT on.
3. Enter GAS set point values and turn GAS(ES) on.
4. Click **PRESSURE** in the PRESSURE CONTROL section. Enter **30** mT as the set point and press **ENTER**.
5. Enter 20 W for the POWER set point value on the desired gun and turn on OUTPUT.
 - a. If plasma strikes, enter ramp time, desired power set point, and press **ENTER**.
 - b. If plasma does not strike, turn off the gun, click **OPENED** in the PRESSURE CONTROL section, turn off the gas(es), heater and rotation. Alert staff.
6. When the gun has completed ramping to the desired power, open the SHUTTER to start the deposition.
7. When you are done depositing, close the SHUTTER.
8. Enter the ramp down time, type **0** W for the POWER set point, and press **ENTER**.
9. If you used the heater for your deposition, turn off HEAT to start cooling the substrate.
10. When the ramp down time reaches 0, turn off the OUTPUT.
11. Click **OPEN** in the PRESSURE CONTROL section.
12. Turn off the GAS(ES).
13. Turn off the ROTATION.

Unload Sample

1. Raise the substrate holder height to allow enough clearance for insertion of the transfer arm.
2. Move transfer arm into position so that the palm of the transfer arm is underneath the sample stage.
3. Lower the sample holder so it comes to rest on the palm of the transfer arm. Make sure it is lined up properly so that the stage is resting on the two middle steps or ledges on the right and left sides of the palm of the transfer arm.
4. Lower the stage a few millimeters further and detach the sample stage from the holder by rotating the propeller blades counterclockwise.
5. Raise the substrate holder up so that it is out of the way of the transfer arm.
6. Check to make sure that the load lock is evacuated ($< 3.0E-05$ Torr).
7. Open the gate valve and gently move the transfer arm until it reaches the main chamber/load lock threshold.
8. Position the aluminum rack so that the sample stage can be unloaded onto one of the two highest rungs.
9. Move the transfer arm completely into the load lock.
10. Using the crank underneath the load lock, raise the rack until it lifts the stage off of the transfer arm, then continue to lift so the arm can be retracted from the load lock.
11. Carefully withdraw the transfer arm out of the load lock, through the main chamber, and all the way back to its left-most position.
12. Close the gate valve.

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13. Make sure both gate valves are closed.
14. Release the clamp on the load lock hatch (if it is not disengaged already) and turn off the power to the load lock vacuum pumps to vent the load lock.
15. Once the load lock has reached atmospheric pressure, open the hatch, remove the rack, and loosely close the hatch to prevent dust from entering the load lock, but DO NOT engage the clamp.
16. Unload the stage from the rack and remove your samples from the stage.
17. Replace the stage on the rack, return the rack to the load lock, close the hatch, engage and tighten the hatch clamp until a seal is formed, and turn on the vacuum pumps.
18. Watch the pressure gauge for the load lock for a minute to make sure that the load lock is indeed being evacuated. Wait for the pressure in the load lock to get below $4.0E+02$, then disengage the clamp and allow the load lock to continue to evacuate.
19. Always leave the sputter with the rack and all stages inside the load lock, and with the load lock under vacuum with the vacuum pumps on.

Cleanup and Waste Disposal

1. Dispose of tape used to hold samples onto the substrate holder with metal traces into the metal chemical waste bottle located under the PECVD computer.

Emergency Stop

Press **ABORT** in the computer software to shut down process.

Allowed Activities

- Configuration screen can be accessed from the main screen by clicking on **SYSTEM CONFIG** in the OPERATOR section of the main screen. It is important that nothing is changed on this screen other than the target name after replacing the target.
- Sputter chamber can be used for annealing samples. Max temperature is 850°C.

Disallowed Activities

- The gate valve cannot be opened to “speed up” pump down of load lock.

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What to watch out for during operation

- Wait for plasma to strike and shutter to open before leaving the tool.

Common Troubleshooting Tips

- If main chamber is not pumping down:
 - o Make sure **OPENED** is highlighted on the PRESSURE CONTROL section the Main Menu.
 - o Turn off the vacuum to the main chamber, wait for 30 seconds, and then turn back on the vacuum.

When to call staff?

- Plasma is not striking.
- Target needs to be changed.
- The chamber or loadlock is not pumping down.
- Discrepancy between the loaded targets listed on the tool and on the Google sheet.

Badger Criteria

Report Problem:

- Plasma is not striking for a specific gun.

Shutdown:

- The chamber is not pumping down.

Revision History: