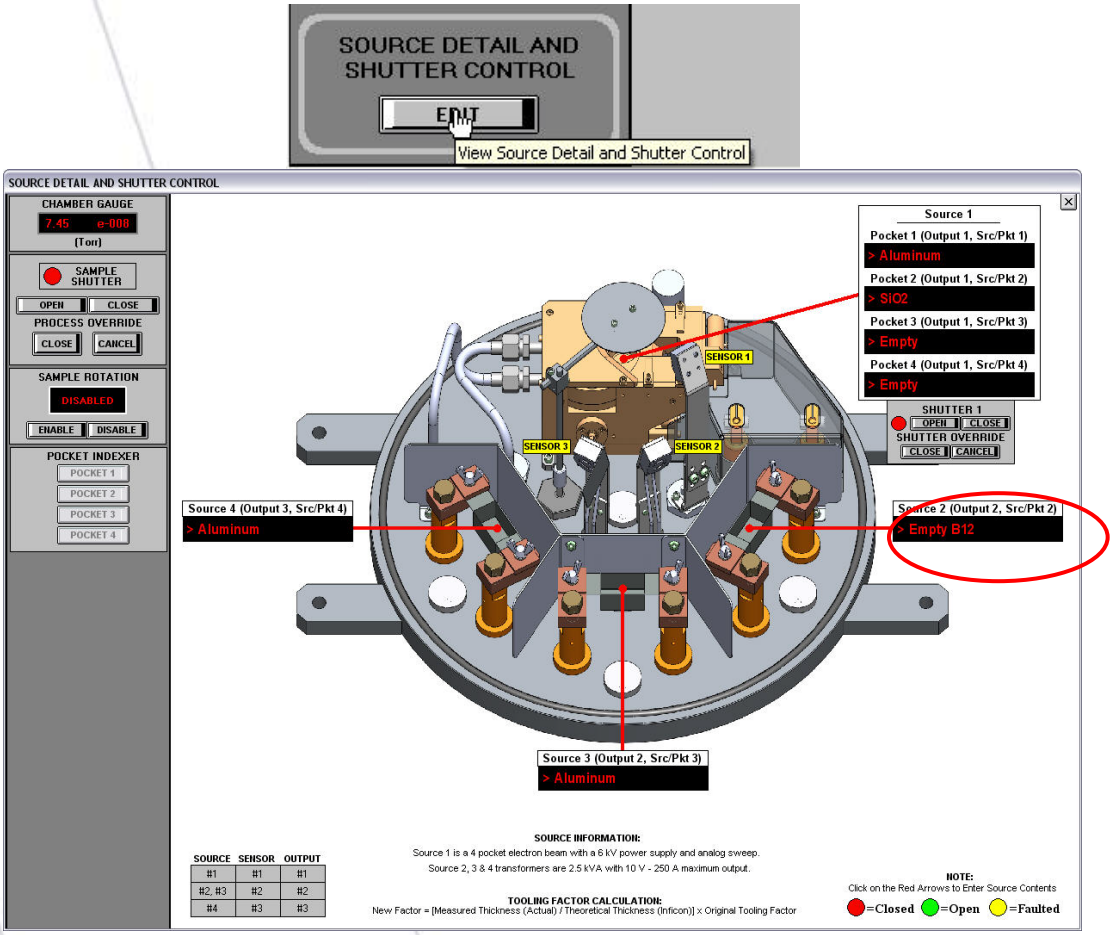
CHAPTER 5: Deposition Tutorial (Åmod configuration used for demonstration)

This section is designed as a tutorial for new users to follow as an example of how to set up and run a new material with the Inficon deposition software. It includes screen captures of an example of a single layer deposition of aluminum. The section is laid out and worded similar to verbal instructions given when new users are taught how to operate a system during an installation. Many helpful tips are included. Our systems are typically provided with generic processes and films created in the Inficon software. Users can copy and rename these to make the process of setting up a deposition easier. The Inficon software is provided with a detailed manual. A copy of this manual can be found in the system components section of our PDF manual if further information or detail is required. Note that the example is from one of our Åmod systems, however almost all of the information is applicable to an EvoVac system as well.

Single layer deposition process configuration

First consult the Source Detail and Shutter Control page in the Angstrom Control Software. Typically this page is opened with a button in the lower left hand side of the main screen of the control software. The page provides information that will be used in the configuring of the deposition process to ensure the correct output, source and pocket are utilized.



In this example an aluminum deposition will be performed from source location 2 using a B12A wire filament source from R.D. Mathis. First mount your substrates to the substrate holder and transfer in or load the substrate holder and any mask holder to be utilized onto the substrate stage. If adjustable, set the substrate height with the z-stage on top of the chamber to your desired height. Choosing and setting an appropriate source to substrate distance with the z-stage and using this height consistently is important for maintaining proper thickness after a tooling factor has been calculated. Once a tooling factor has been derived for a specific height the user will need to attempt to maintain this height each time they deposit, or the actual deposited film thickness will be incorrect.

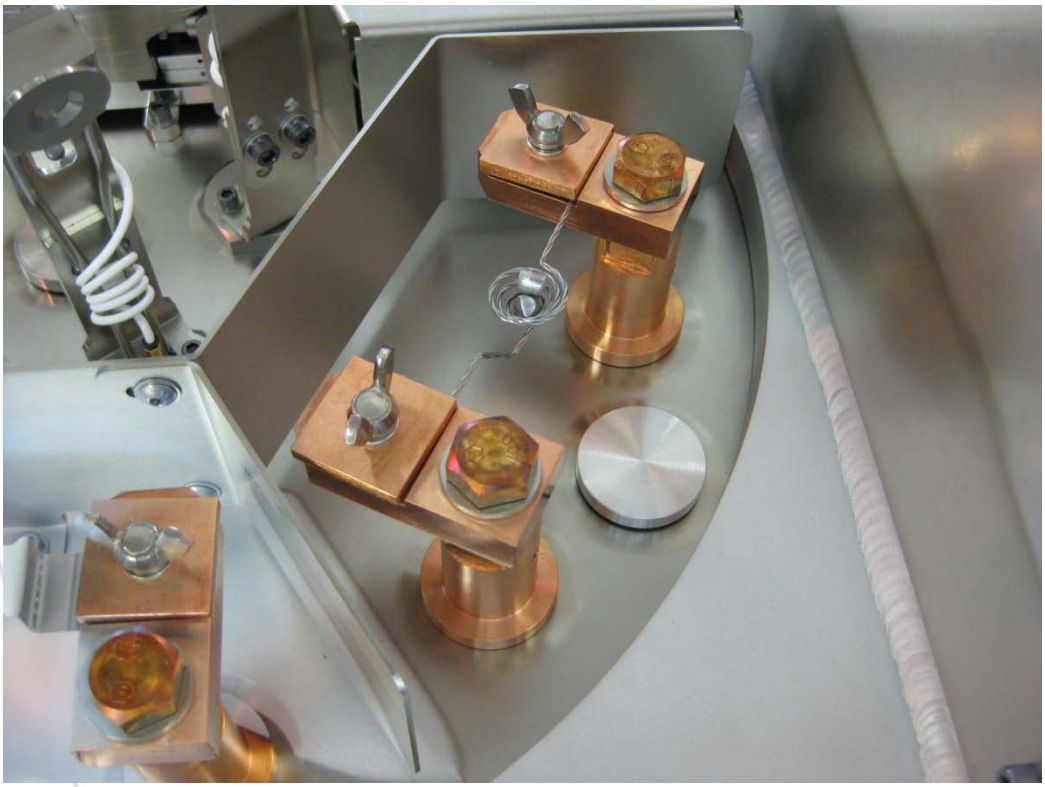
A Note on Tooling Factors

The new tooling factor calculation is shown on the Source Detail and Shutter Control page in the control software. The tooling factor represents in percent the amount of material deposited on the substrate in comparison to what is deposited on the sensor used to formulate thickness and rate. A sensor mounted at the substrate height would have a tooling factor of 100%. A sensor mounted closer to the source, which is our typical geometry, will have a lower tooling factor as it sees more material than the substrate. Typically we start with a guess based on the relative distances between the source and the sensor compared to the source to the substrate. Good starting values for our Åmod, EvoVac and NexDep systems are usually around 10-15%. Values around 48% are closer for a CoVap system. If the substrate height is increased the tooling factor decreases as less material reaches the substrate.

For consistent film thickness from run to run:

- The substrate needs to be at the same height or distance from the source.
- The same source or style of source must be used.
- The source must be mounted in the same location in the clamps or not removed for loading material.
- The same source location and sensor must be used.
- A consistent amount of material must be in the source.
- To a lesser degree the chamber should be at the same pressure and the rate should be consistent to what was used for a tooling factor calculation.

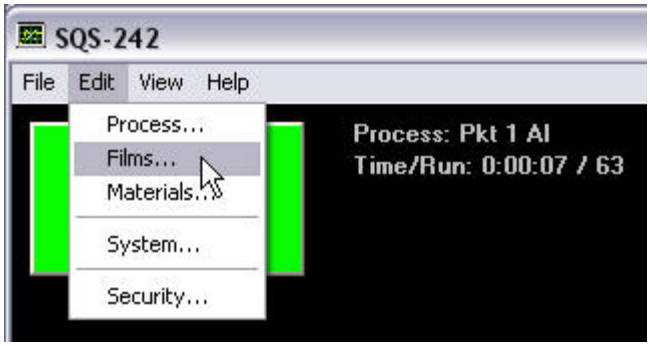
Wipe the source with alcohol and mount the source carefully between the source clamps. Center the source length wise and bias the source to the outside of the clamps for consistency when replacing. Be careful not to over tighten the wing screws and try not to impart any torque or twist in the filament, as this may cause the source to break prematurely. Add 2-3 pellets ¼” in size of material.

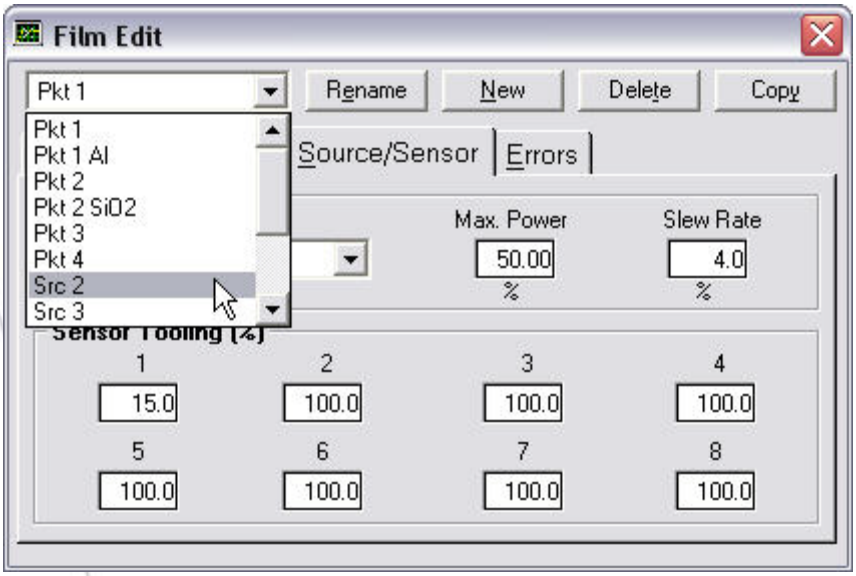


Wipe the door seal and seal face with a clean room cloth to remove any particulate. Close the door carefully and select and start a full pump down in the control software. While waiting for base pressure the user can start configuring the process in the Inficon software. Before closing the Source Detail page click on the red arrow in the black box for the source location you are going to use and change the description to match the material and the source chosen. For this example B12 – 2 Al would be a good description.

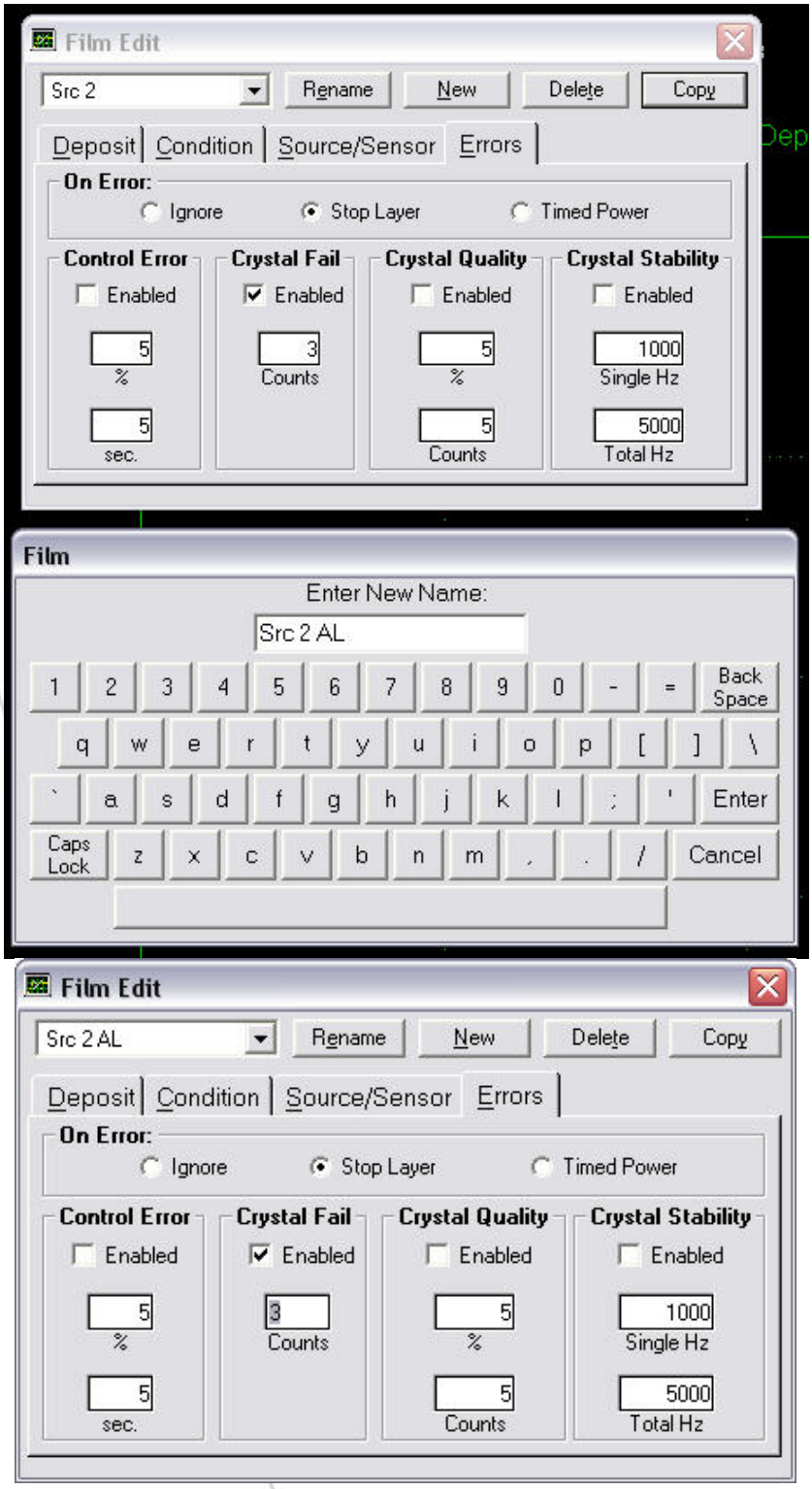
If the Inficon deposition software is not open double click on the green SQS-242 icon on the desktop to open the software. The software will go through a number of diagnostics before presenting a login window. The software default for User Name is Super and there is no password required. Click on the OK button or hit enter to clear the login. If the security login has been changed use the User Name and Password provided.

Click Edit/Films to open the Film Edit window. Choose the generic film for the source location you have chosen. In this example we are going to start with Src 2, as this is the generic film associated with Source 2.





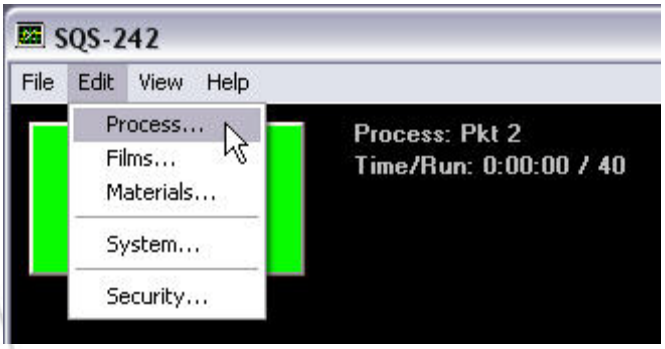
After choosing Src 2 from the Film Edit, click the Copy button and create a new film. Enter a new name for the film including in the name the material intended to be deposit at this location.



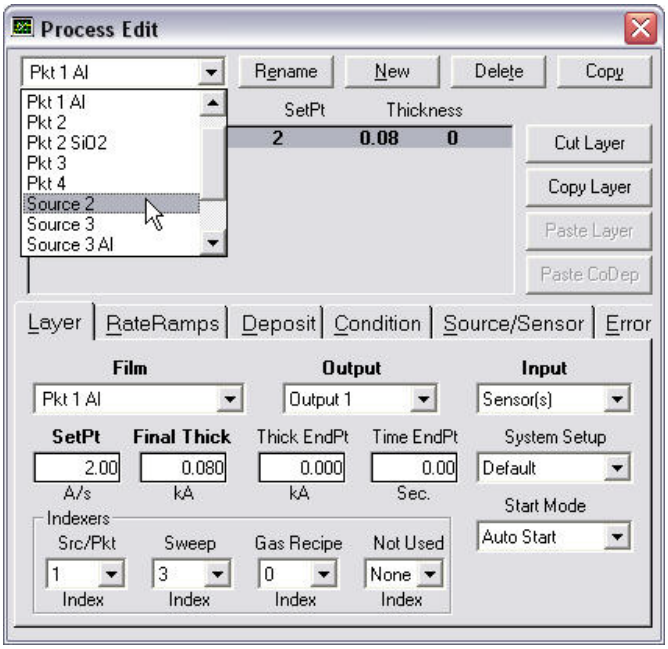
A Note on Films

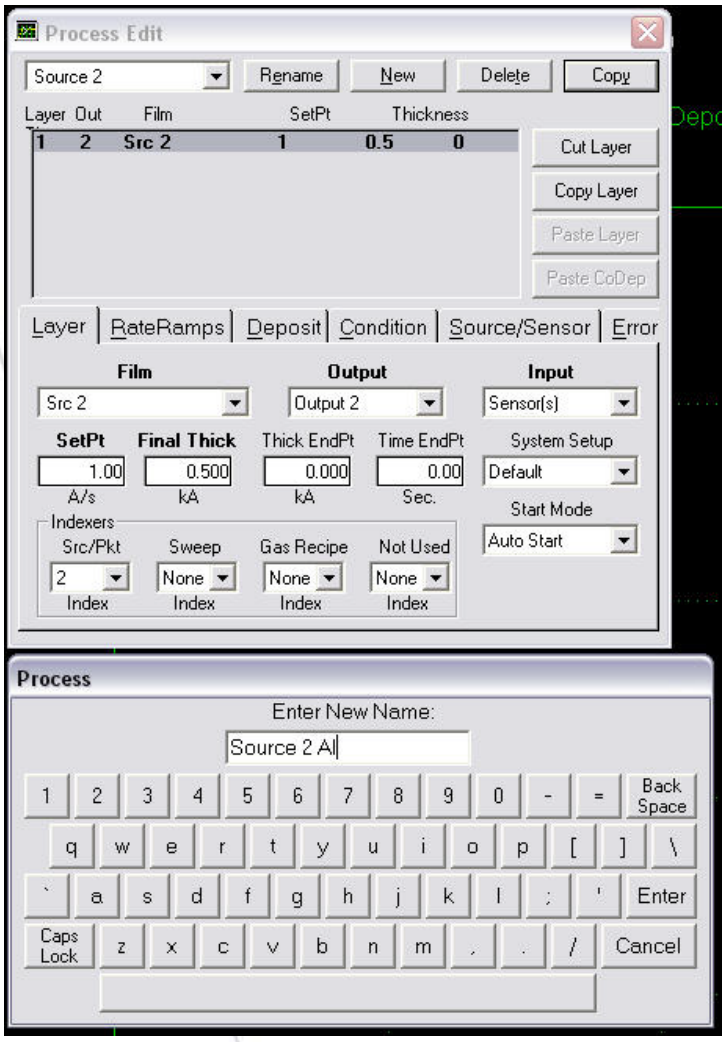
The choice of what film to start with is a bit arbitrary; however there are a number of reasons to choose a film that exists, and to create a film specific to the material and source location you are using. An existing film may have PID values and a tooling factor that is a good starting point, especially if it is for a similar material. Conditioning values may represent useful starting values as well.
A film will typically contain correct PID values, pre-condition values that match the initial rate you wish to achieve, and a tooling factor that is specific to the material, source type, and location you are specifying. You can use a film for more than one source location however it is not recommended based on slight differences in the tooling factor. If you change any parameters in a film they are retained regardless of what recipe uses the film. If changes are made to the initial rate the conditioning values will also likely need to change so that the ramp power brings the rate close to the desired initial rate as the deposition software enters the deposit phase of the process.

Next close the Film Edit window and open the Process Edit window. Once a film is created all the film parameters can be edited in the edit/process window if this film is being used in the process.

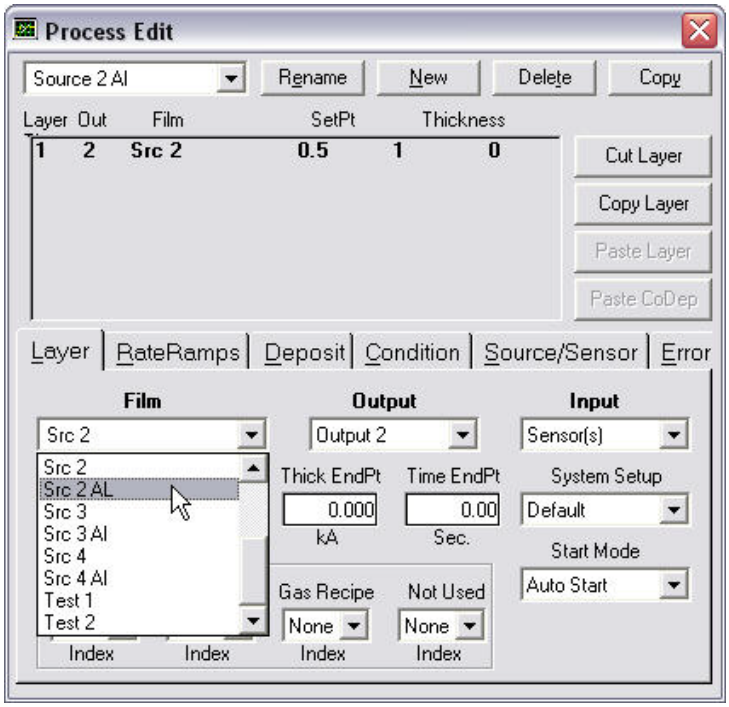


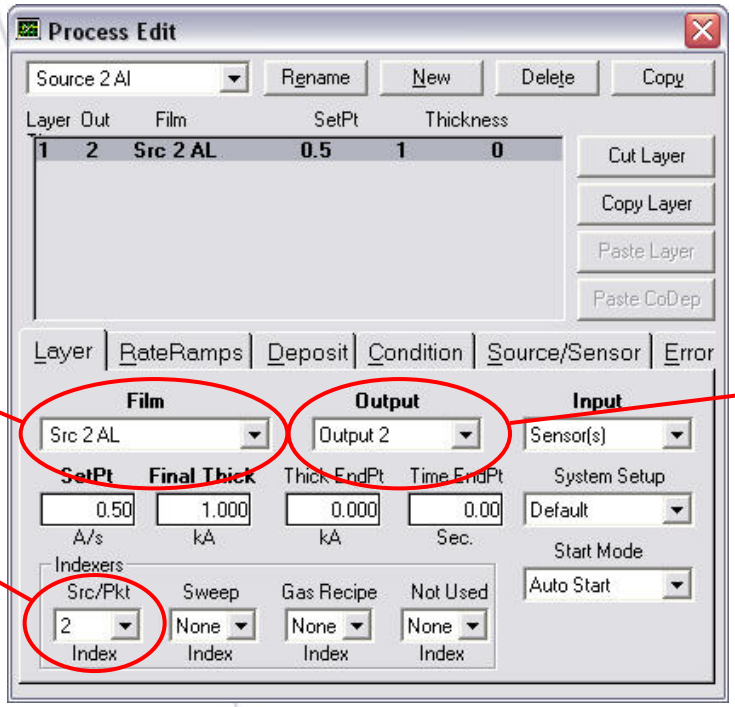
Open the generic process for the source location you are going to start with. In this example the Process is Source 2. Copy the process and then rename it including the material you intend to deposit at this location in the name. Ensure that the correct process is showing in the drop down box after renaming. The user may need to pick the newly renamed process in the dropdown box after closing and then re-opening the Edit/Process window.


Process Edit
Pkt 1 Al
Rename
New
Delete
Copy
Pkt 1 Al
Pkt 2
Pkt 2 SiO2
Pkt 3
Pkt 4
Source 2
Source 3
Source 3 Al
SetPt
Thickness
2 0.08 0
Cut Layer
Copy Layer
Paste Layer
Paste CoDep
Layer
RateRamps
Deposit
Condition
Source/Sensor
Error
Film
Output
Input
Pkt 1 Al
Output 1
Sensor(s)
SetPt
Final Thick
Thick EndPt
Time EndPt
System Setup
2.00
A/s
0.080
kA
0.000
kA
0.00
Sec.
Default
Start Mode
Auto Start
Indexers
Src/Pkt
Sweep
Gas Recipe
Not Used
1
3
0
None
Index


Process Edit
Source 2
Rename
New
Delete
Copy
Layer Out Film SetPt Thickness
1 2 Src 2 1 0.5 0
Cut Layer
Copy Layer
Paste Layer
Paste CoDep
Layer
RateRamps
Deposit
Condition
Source/Sensor
Error
Film
Output
Input
Src 2
Output 2
Sensor(s)
SetPt
Final Thick
Thick EndPt
Time EndPt
System Setup
1.00
A/s
0.500
kA
0.000
kA
0.00
Sec.
Default
Start Mode
Auto Start
Indexers
Src/Pkt
Sweep
Gas Recipe
Not Used
2
None
None
None
Index
Process
Enter New Name:
Source 2 Al
Back Space
Enter
Caps Lock
Cancel

Click on the Layer Tab and then click the dropdown for the film. Choose the film that you created previously, in this case Src 2 AL. Because we started with a generic film and a generic process many of the fields in the process will have values that we can use. Choose an appropriate initial rate and a final thickness. In our example we will deposit a film of aluminum at an initial rate of 0.5 Å/s. We have chosen 1000 Angstroms (1.000 kÅ) for the film final thickness.





Selected Film

Selected Output

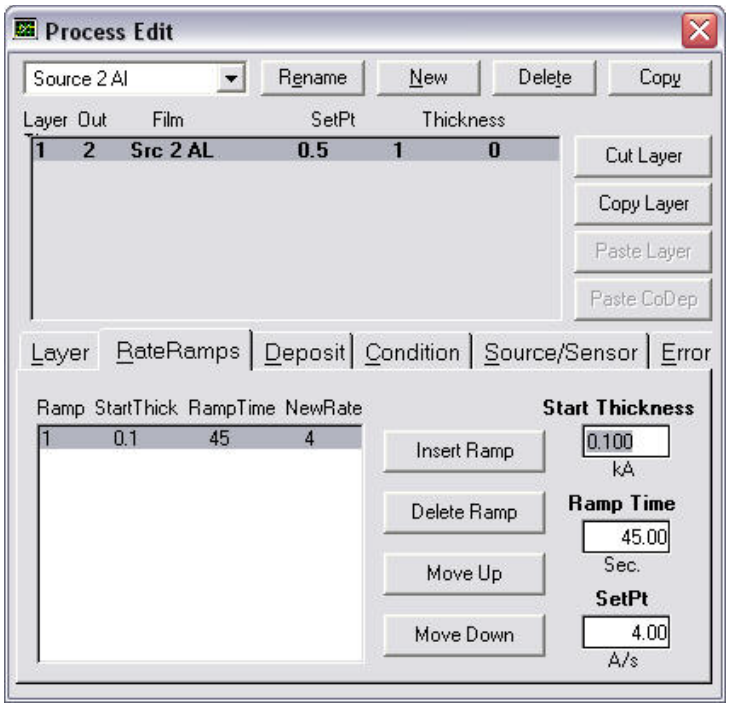
Selected Source

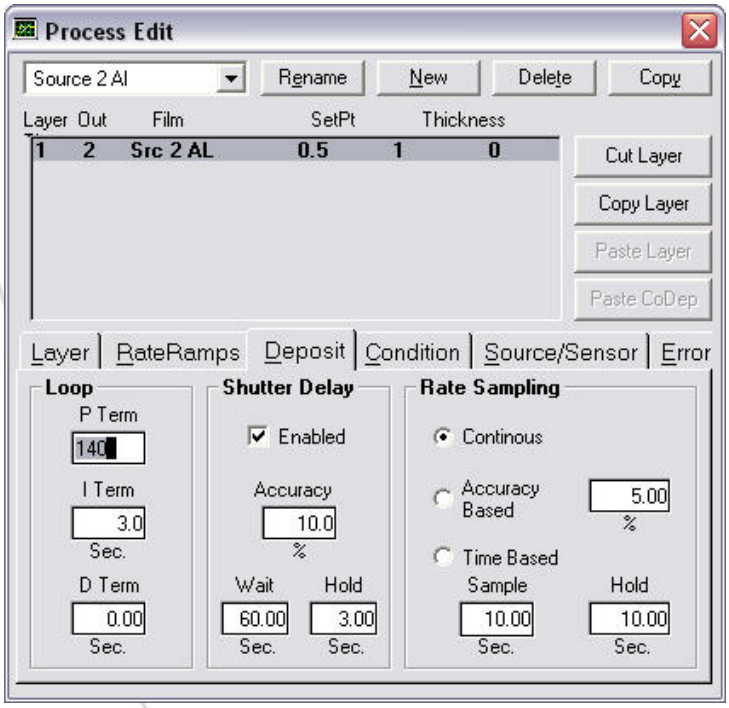
The layer tab in the Process edit is shown in the screen capture above. We have chosen our Film in the layer tab. Because we used a generic process the Output and Src/Pkt have the correct values of Output 2 and 2 for the Src/Pkt. This information is also provided on the Source Detail page of the control software. Because we are running a thermal deposition the Sweep Indexer for the e-beam will not be used. The Gas Recipe Indexer is also not used in this example. The other fields are typically as they are shown.

Rate Ramps

The rate specified on the Layer tab is always considered the initial rate, as we have the ability to change the rate at various thickness values throughout the deposition. This is accomplished using the Rate Ramps tab. The user chooses a new rate, a time to achieve this new rate, and the thickness at which the rate ramp is started. This feature can be used for example when depositing aluminum as a cathode on top an organic material. Many users believe that the rate of the aluminum should be low for an initial thickness to prevent damaging the organic material, however they don't want to wait for the time the deposit will take to complete at a low rate for the entire thickness of the cathode. The feature can be used in other ways as well. You can start a material at nearly zero for a rate and ramp it up while ramping another material down to create a gradient. During a co-deposition one material can be ramped to zero allowing the second material to cap the co-deposited material without creating an interface between the two layers as with a two layer sequential process.

A rate ramp will be used as shown in the example. Our initial rate on the Layer tab is 0.5 Å/s. At 100 Å (0.100 kÅ) accumulated thickness we ramp up over 45 seconds to a new rate of 4 Å/s. The process will complete our 1000 Å thickness at this rate.

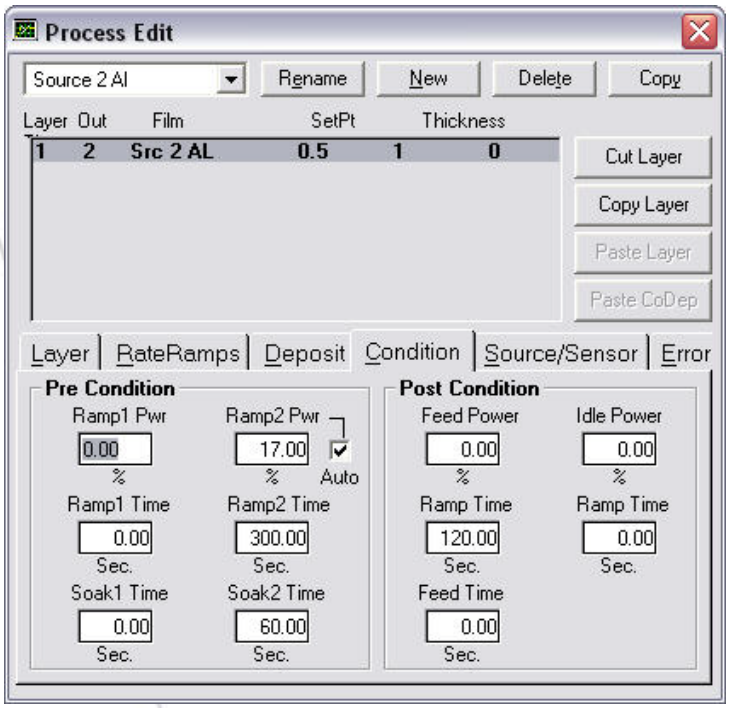


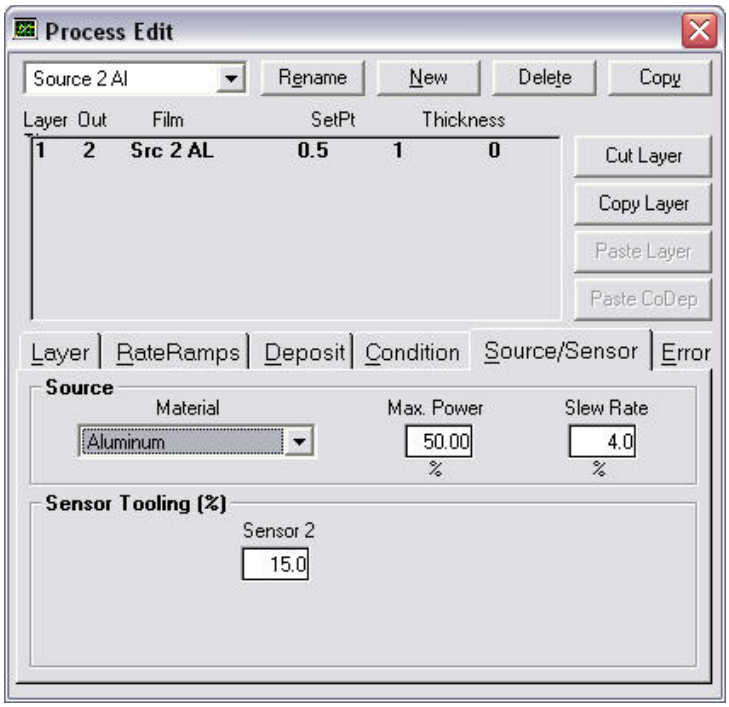


The Deposit tab contains PID values for tuning the process. The optional shutter delay phase is on this tab as well. Rate sampling is always continuous in that shuttered sensors are rarely used. The values entered should work well for our process. Note that the default accuracy for shutter delay is 5% and it has been increased to 10% because our initial rate is low at 0.5 Å/s.

PID

PID is an acronym for Proportional, Integral and Derivative. PID is used to control the rate of deposition using a closed loop that includes the a quartz crystal monitor for input, a setpoint in the control software to compare the input to, and the control signal out that controls the power to the transformer that operates the source. There are a number of informative sections within our manual including an appendix section on adjusting PID values for optimal control. In general the P term can be considered the power term, and it represents how aggressively the software will increase power to achieve the setpoint. The I term is the time constant of the system. It represents how long the system takes to respond to a change in input. The D term is a second derivative that helps correct for slight offset in desired rate to actual rate when the rate nears the setpoint. We typically use zero for the D term, or up to 10% of the I term at most. For lower temperature materials like organics that take longer to respond because the temperature is relatively low we recommend starting with P values of 90-110 and I values of 8-12 seconds. For mid temperature materials like salts and some organic compounds we recommend 110-125 for P values and I values ranging from 5-8 seconds. For high temperature materials like metals the P values are typically 125-150 and I values are 3-5 seconds.



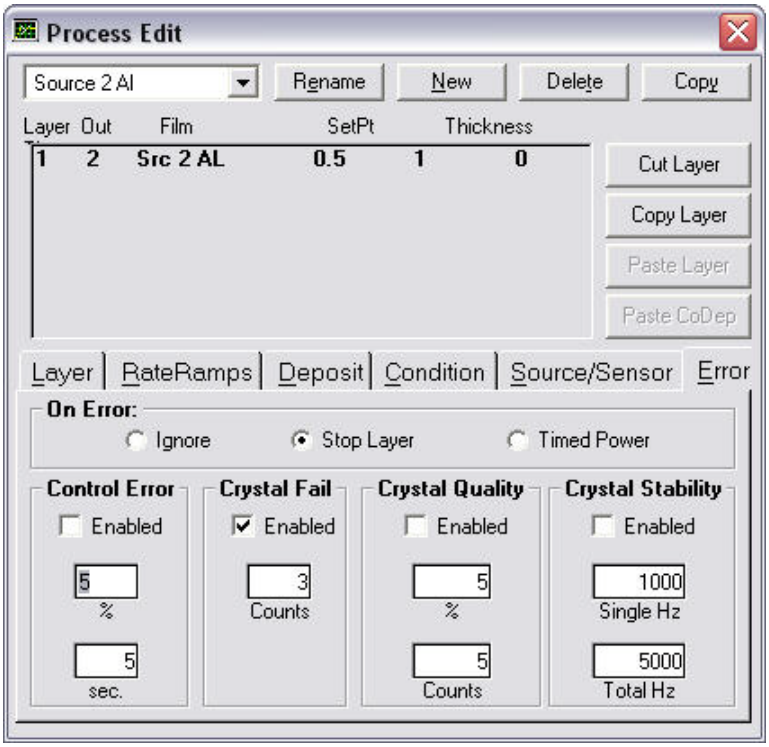


For most depositions only one pre-condition ramp is used. If one ramp is used it should be ramp 2. The auto checkmark should not be used where the deposition utilizes a rate ramp as this power value is saved at the end of the deposition to be used as the ramp 2 precondition power value the next time the recipe is run. In this case the power would be a little high, as the rate at the end of the example is much higher than the initial rate. The post condition helps to reduce stress on the source. In the Source/Sensor tab the Max. Power is typically set about 20% higher than what the normal power will be during the deposition. The slew rate is the maximum change in power in percent per second allowed. This value will not typically interfere with PID control at 1-2% and will catch large power fluctuations if the source spits material on to the sensor causing short term high readings. The PID can react to these readings and create an out of control condition without the Slew Rate to slow the response. Verify the tooling factor appears correct and correct sensor is shown for the source location. This can be verified on the Source Detail page in the control software.

Phases of a Process

When a process is performed in auto the deposition software works through the process in phases. The first phase is indexing. This phase is primarily a timer phase that can be used to allow a crucible indexer to rotate an e-beam hearth to the correct pocket, or gas control to achieve a stable pressure before igniting the plasma during a sputter process. With resistive depositions this phase is not used and the time is set to zero. The next phase is pre-condition. There are two ramps available to warm up the source and create some rate before the substrate shutter opens to deposit material on the substrate. In pre-condition the ramps control power and time only. The software does not control by rate. Typically only one ramp is used and when this is so ramp 2 should only be utilized to ensure the transition to the next phase is smooth. If a source shutter exists for the active source it will open during the pre-condition phase, however the substrate shutter remains closed until the deposit phase. The next phase is an optional phase called shutter delay. When selected this phase uses PID control to attempt to achieve the desired rate within a specified percentage of deviation. The rate must remain stable within the deviation range for a specified period of time before the phase ends and the substrate shutter opens for the deposit phase. The deviation percentage is plus or minus the desired rate. If the rate fails to remain within the deviation range during the shutter delay for the time specified the process aborts and an alarm is shown. Because the deviation is a percentage of the desired rate and the resolution is fixed the user should be aware that for smaller rates typically less than 1.0 Å/s the resolution is such that a small percentage in deviation like 3% may be difficult to achieve. A larger percentage deviation such as 10% may be more appropriate at smaller rates.
The deposition phase follows pre-condition and the optional shutter delay phase if selected. During the deposit phase source shutters for sources running will have their source shutters open. The substrate shutter is open during the deposition phase and closes when final thickness or time setpoint is achieved. An optional post condition phase follows the deposition phase where the source can be allowed to ramp down slowly in power to reduce thermal shock. This is essential with e-beam and sputter deposition. All source and substrate shutters are closed during this phase. After the post condition completes the deposition ends.

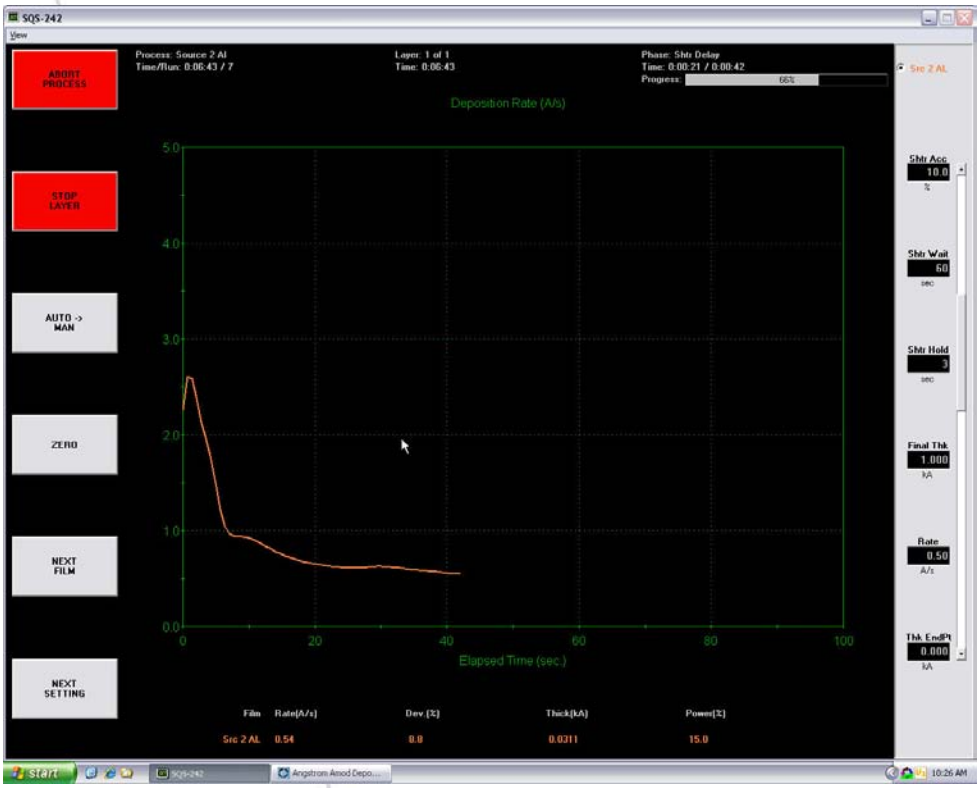
Options on the error tab can be used to ensure the deposition is within specific limits. The control error looks at percent deviation and can be used to stop a deposit if the source runs out of material. Maximum values are 30% for 99 seconds. Crystal fail ensures that the power does not ramp to the maximum value if the crystal does fail. Crystal quality and stability can be used where certain materials cause frequency shifts in the crystal oscillation.



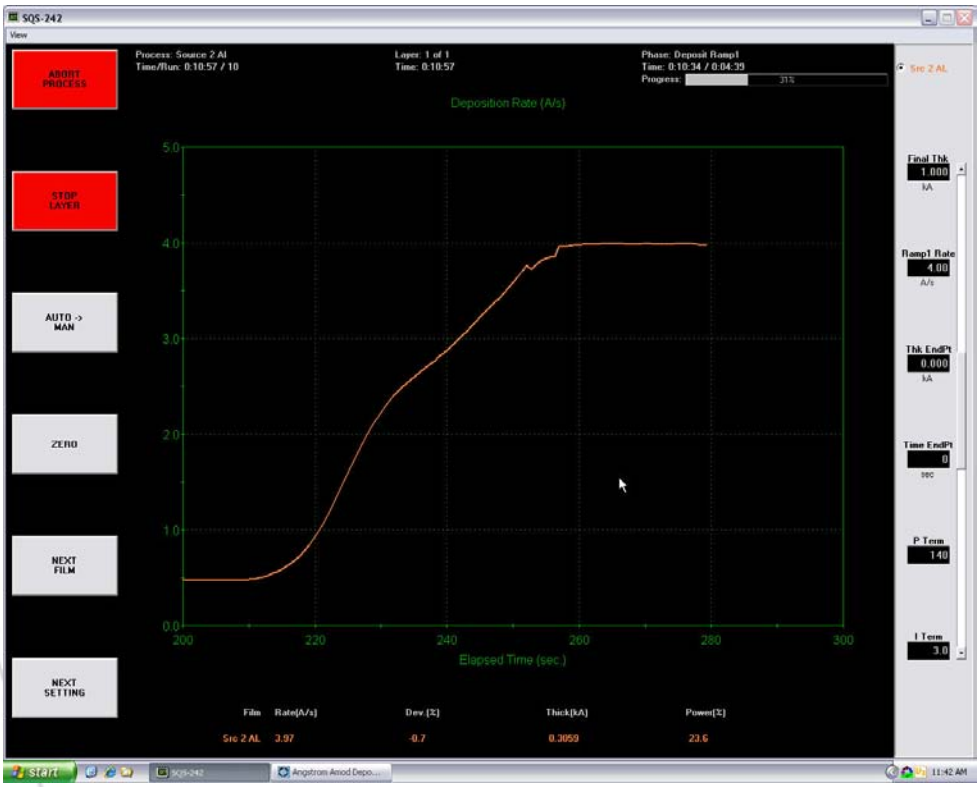
Running the Process

This process was first run in manual to get a better feel for the power needed in the precondition phase. A value of 17% was subsequently chosen for the ramp power. During the first run in auto the source broke during the ramp to the higher rate, so a less aggressive ramp time of 45 seconds was implemented instead of 30 seconds. The second run we ran out material before we reached final thickness. When this happens it is best to change the final thickness to a value less than the current accumulated thickness and allow the software to perform the post conditioning.

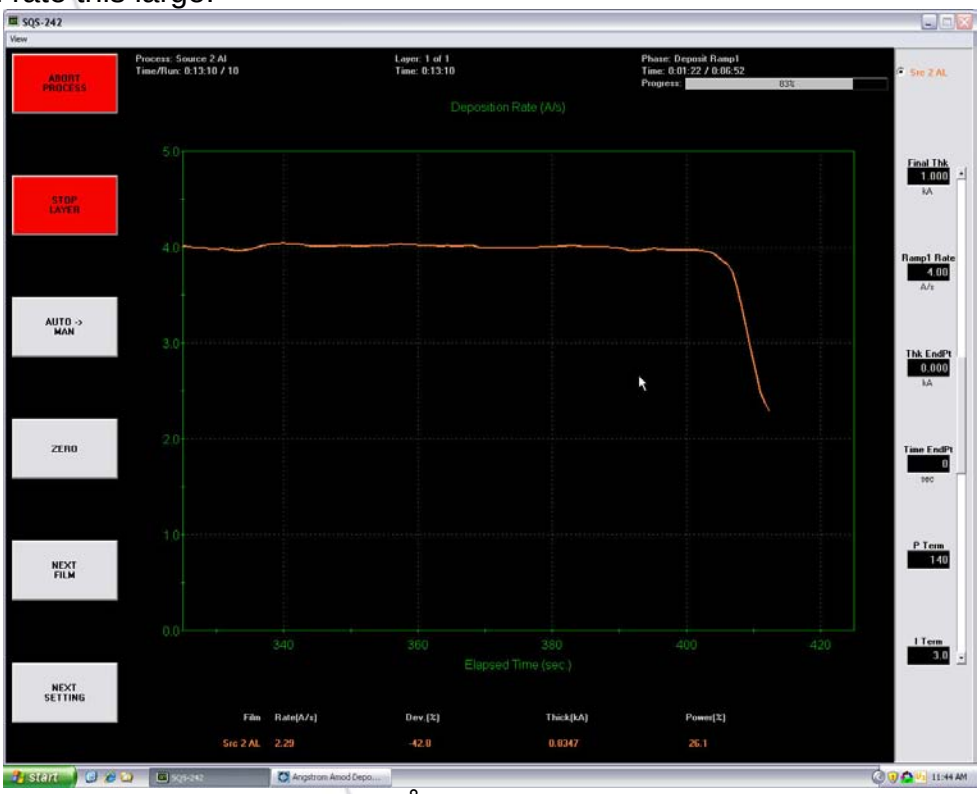
Soak 2 from second run at 17% power.



Shutter delay from the first run. Rate was high coming from precondition to shutter delay.



The rate ramp is shown here for second run. The time of 45 seconds worked well for a change in rate this large.



The Source ran out of material at 830 Å thickness.