Doc. Number	E-beam evaporator (TECPORT) Manual	Internal

Revision	Date	Initiator	Reviewer Signature	Approver's Signature
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NATIONAL NANO FABRICATION CENTRE

CENTRE FOR NANO SCIENCE AND ENGINEERING

Indian Institute of Science, Bangalore

Electron Beam Evaporator
(Tecport)

Training document

Contents

Chapter 1
Descriptions and Specifications

Electron-beam evaporation, frequently called "e-beam," uses a focused beam of electrons to heat the metal for deposition. A controlled deposition of thin-films is achieved. Both dielectrics and metals can be deposited using solid sources. The material is kept in a water-cooled crucible and exposed to the electron beam, causing it to vaporize and condense on the wafers / samples. Oxygen gas can be bled into the system during deposition to maintain the stoichiometry during deposition. Planetary substrate rotation provides uniform deposition. Radiant heaters are provided for substrate heating. Option for Ion Assisted deposition, co-deposition and Ion etching is also available.

Tool Specifications:

- Tecport assembled:
    - E gun Manufacturer: Temescal
    - One 4 pocket hearth and one 6 pocket hearth.
    - Pop-Top source
    - Max Power 10kW
    - Accelerating Voltage 4-8 kV
    - Beam deflection 270deg
    - Emission Current 0-1.5A
- Programmable sweep controller.
- Temescal Crucible indexer.
- Substrate holder {6, 4, 3, 2 inch diameter}.
- Planetary rotation with four holders.
- Inficon IC6 deposition controller.
- Ultimate Pressure ~2E-7 Torr.
- Process Control using Symphony software provided by Tecport
- Deposition rates from 1 Å/s to 199 Å/s.

Location: IISc, CeNSE, NNFC, Thin Films bay.

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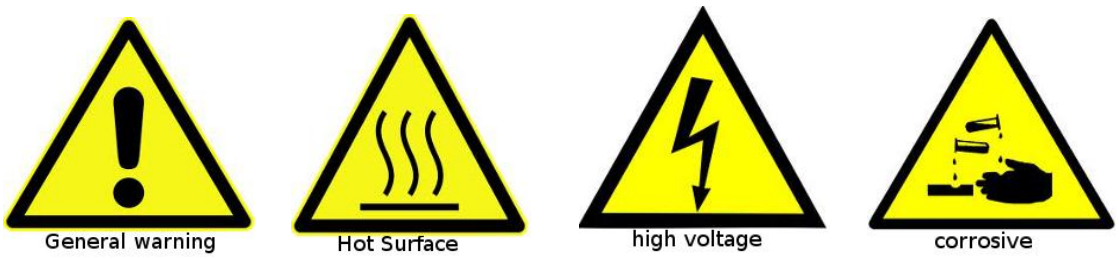
Chapter 2: *Safety.*



2.1 Safety Instructions

- Read all relevant instructions before you operate any accessories of the E- beam evaporator.
- Potentially lethal voltages may exist within this system, even with the main power switched off. Failure to observe all safety precautions can result in personal injury.
- Operators shall not enter areas intended for service access only.
- HIGH VOLTAGE WARNING and caution signs are posted in conspicuous locations.
- DO NOT WORK ALONE!
- Remove rings, watches, bracelets, and any other metal jewelry before working around high voltage.
- When turning on the e-gun, make sure that the e-beam is centered on the source material. Do not allow the e-beam to sweep onto the copper hearth.
- Intense light will be emitted from the evaporation materials. Always use dark safety glasses / filter window when you look in the chamber.

2.2 Health Hazard

- The condensates deposited on the tank walls of a vacuum system are generally in the form of extremely fine particles.
- Inhaling fine particles (powder) may cause damage to the lungs. To help prevent this, wear a protective respirator mask with fine filter.
- Some substances are toxic and inhaling them should be avoided. Take steps to ascertain whether or not the material being deposited is a known toxic substance. Refer to the Material Safety Data Sheets covering the evaporant (s) in question.
- Certain powders (titanium, for instance) can cause flash fires when exposed to oxygen or other oxidizers. Therefore, when opening the chamber door after a deposition cycle, exercise extreme caution and allow time for the coating surface to oxidize. Breakage of some of the more reactive condensates may be hazardous, even when the above precautions are observed. In this situation, fire-protective clothing should be worn.

2.3 Special Notes

- You must be qualified by NNFC Technologist/Tool owner to use this tool.
- Wear clean lint-free gloves when you handle components in the chamber to prevent contamination of the evaporation materials and its accessories.
- Do not over fill the hearth/crucible with evaporation materials. If you do, molten materials can spill out of the crucible, crack crucible liner and contaminate the e- beam source.
- Do not continue the evaporation when source material is out. Continue to evaporate when source material ran out will crack crucible liner. After evaporating for a while, if evaporation rate slows down quite a bit. Stop the evaporation here! It is possible that the metal source is running out.
- Only vacuum compatible materials are allowed in the system
- When you are done with your work, always leave the chamber under vacuum.
- Minimize the time the chamber is left at atmosphere, by preparing your samples in advance (i.e. before or while venting). This should be done in order to reduce contamination and moisture accumulation on chamber walls.
- The color code for all the GUI screens is GREEN: ON or satisfied and GREY: OFF or not satisfied. Set value is displayed in YELLOW and the present value in BLUE
- Substrates will be exposed to secondary radiation as there may be production of X-rays due to the high voltage electron beam. Radiation can damage MOSFET and Silicon based devices
- Enter all the parameters in log book
- In case of any complaint with the tool, enter in maintenance log as well as inform NNFC staff.

Chapter 3: Operating Manual

3.1 Start Up

- Check the logbook to verify if the last entry was okay.
- Turn on the utilities required for the system
    - Water lines -First outlet then inlet (on the back panel of the system)
    - Gas lines {Inlet for O2 and Ar (on the back panel of the system)
    - System electrical power ON switch (on the right panel of the system)
- Switch ON the UPS on the control panel of the system by pressing the power on button for 3 sec
- Once the LEDs are all powered up (wait for 10 sec) switch ON the computer CPU
- Once logged in the system, right click and open the SYMPHONY software on the desktop
- This will also open IC6 window, which should be closed
- After booting we have the welcome screen of the software Click on the symphony logo to get a pop-up menu
- Select the login option there, you will get a login window
- Enter your username and password
- After logging in the software again click on the Symphony logo and turn the control power ON
- Switch ON IC6
- Now the system is ready for loading

3.2 Substrate Loading

- Please make the time of system being open to atmosphere minimum, by preparing your samples in advance (i.e. before venting).
- Press the `Vent' button in the symphony window to vent the chamber.
- The chamber will unlock itself with notification through a buzzer.
- Clean the chamber using vacuum cleaner and IPA.
- Place your samples/substrates onto the wafer carrier baskets, remove the baskets only if necessary.
- Make sure that the required materials are loaded in the correct pocket of the EB gun pocket.
- Close the chamber door and hold it in that position for some time, i.e. till you hear the door clamp being activated from inside.
- Select the required recipe from process window on left side and load it to IC6.

3.3 System evacuation

- Press the play button which is on the bottom of the window. You will get 3 confirmation windows, press yes in all and the pumping starts. It takes anywhere between 2 to 3 hours for complete pumping depending on the chamber health and the base pressure required.

3.4 Deposition

- As the pressure nears the deposition pressure, switch on E-beam power supply, I-gun power supply and IC6 is ON, as per the requirement.
- Once the required parameters are satisfied, the tool gives a buzzer and starts deposition.
- The elapsed time, layer no, material, thickness, power; deposition rate... is displayed on the ‘Process’ window on the left hand side.
- The E-beam position can be adjusted using the hand-held remote. The other parameters that can be changed are amplitude, frequency and waveform in both latitude and longitudinal direction. Change the set pattern only if it’s really required.
- Fill out Run-log sheet in logbook.
- The status of the deposition is displayed on INFICON IC6 (top-right).
- Once the deposition is over, the system automatically shuts down and will vent the chamber after the mentioned time delay.(main valve close delay, vent delay will be taken from the process parameter recipe).

3.5 Substrate Unloading

- Once the chamber is out of vacuum, remove the substrates out from the basket carefully and clean the chamber (using vacuum cleaner and then with IPA).
- Close the chamber door and hold it in that position for some time, i.e. till you hear the door clamp being activated from inside

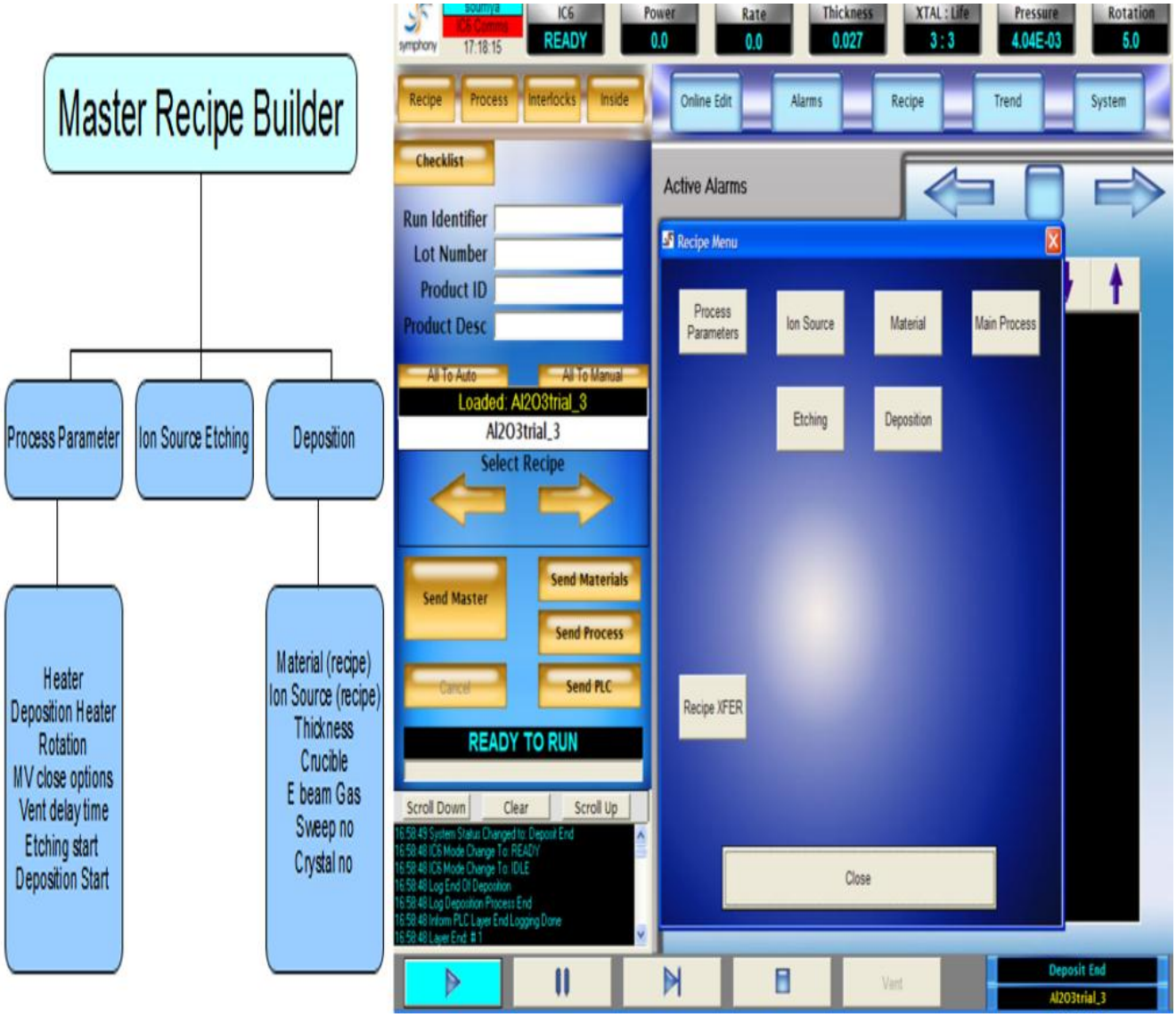
3.6 Shutting down the system

- Close the system door and again start pumping (the chamber should always be kept in vacuum (this is to prevent accumulation of moisture in chamber).
- Once the system reaches the rough vacuum of e-3 range, stop pumping.
- Turn the Control Power OFF from the symphony icon pop up list.
- Exit the software, from the symphony icon pop up list.
- Switch off the computer.
- Switch OFF IC6 deposition controller.
- Switch OFF KRI I-Gun discharge controller, Bias controller and Keeper Controller.
- Switch OFF the power supply for the E-gun.
- Turn off the UPS by long pressing the power button.
- Press EMO.
- Turn the system power switch to off position.
- Shut the water line, first inlet and then outlet.
- Turn off the gas lines.

Chapter 4: Process Recipe

The recipe menu includes

- Process Parameters
- Ion Source
- Etching
- Material
- Deposition
- Main Process

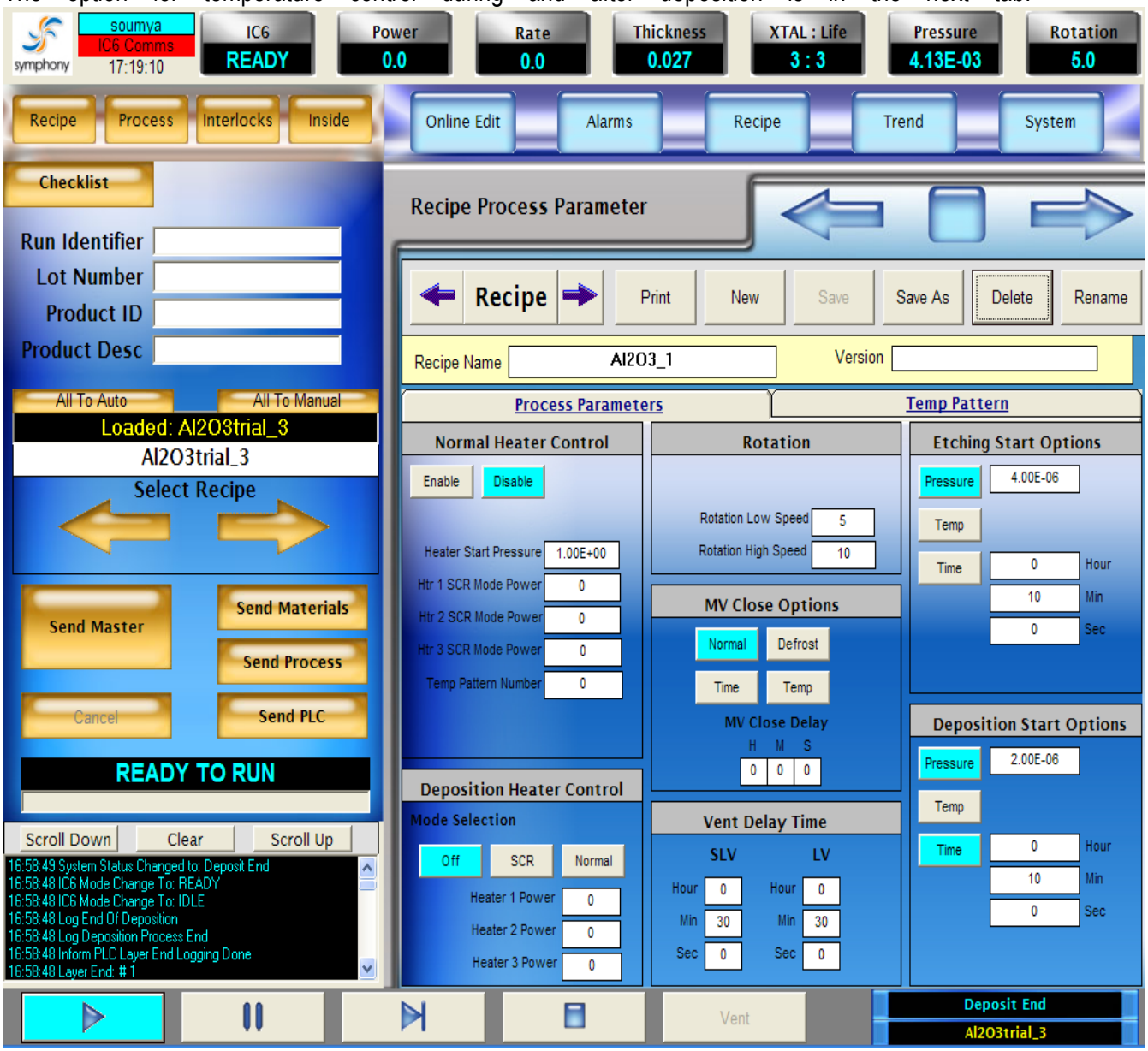


4.1 Process Parameters

The process parameters are included in this window. We have to enter the values for

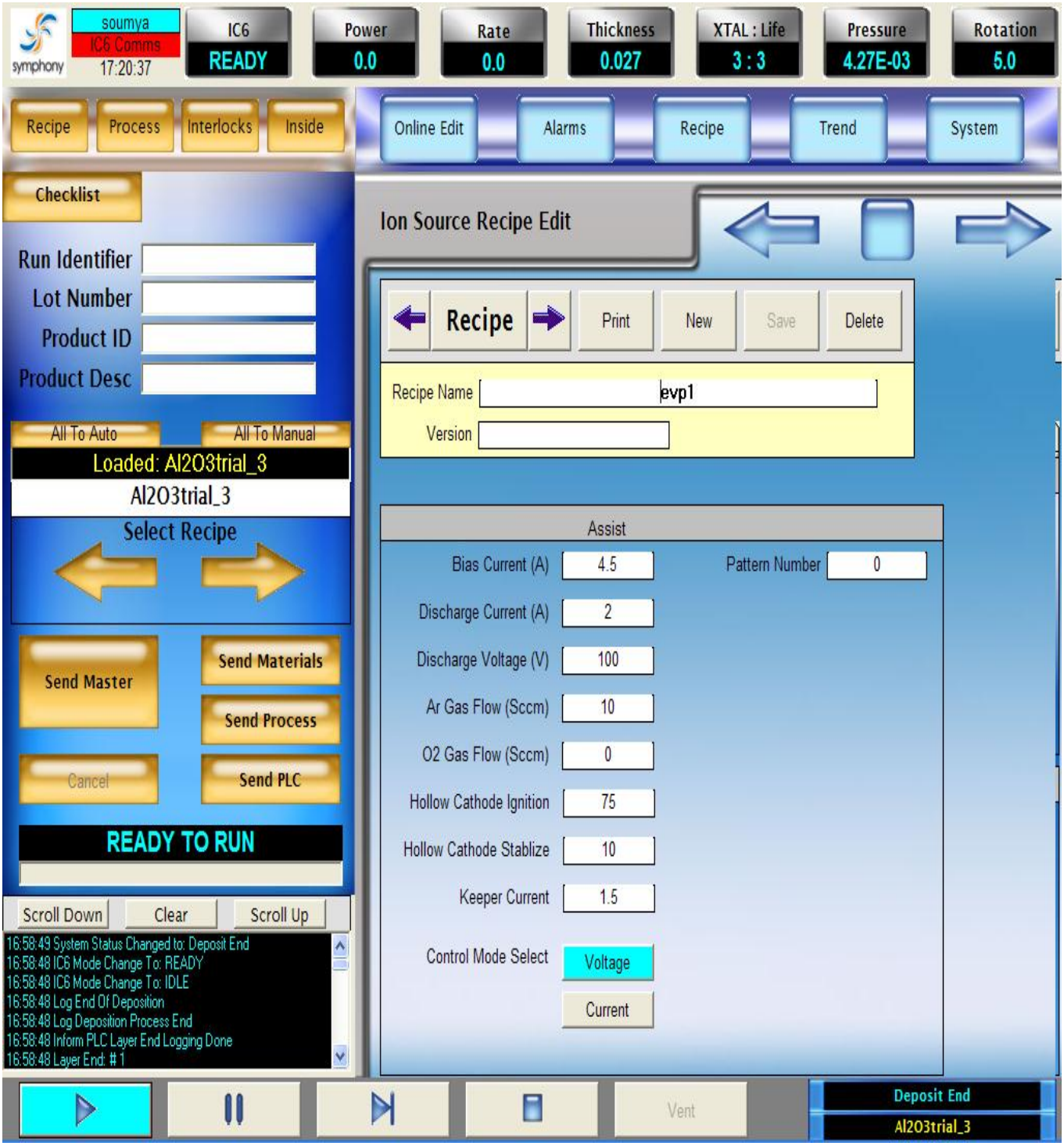
- Heater control during pumping down and during deposition
- The rotation speed
- Main valve close options
- Vent delay time
- Etching start options
- Depositions start options.

The option for temperature control during and after deposition is in the next tab.



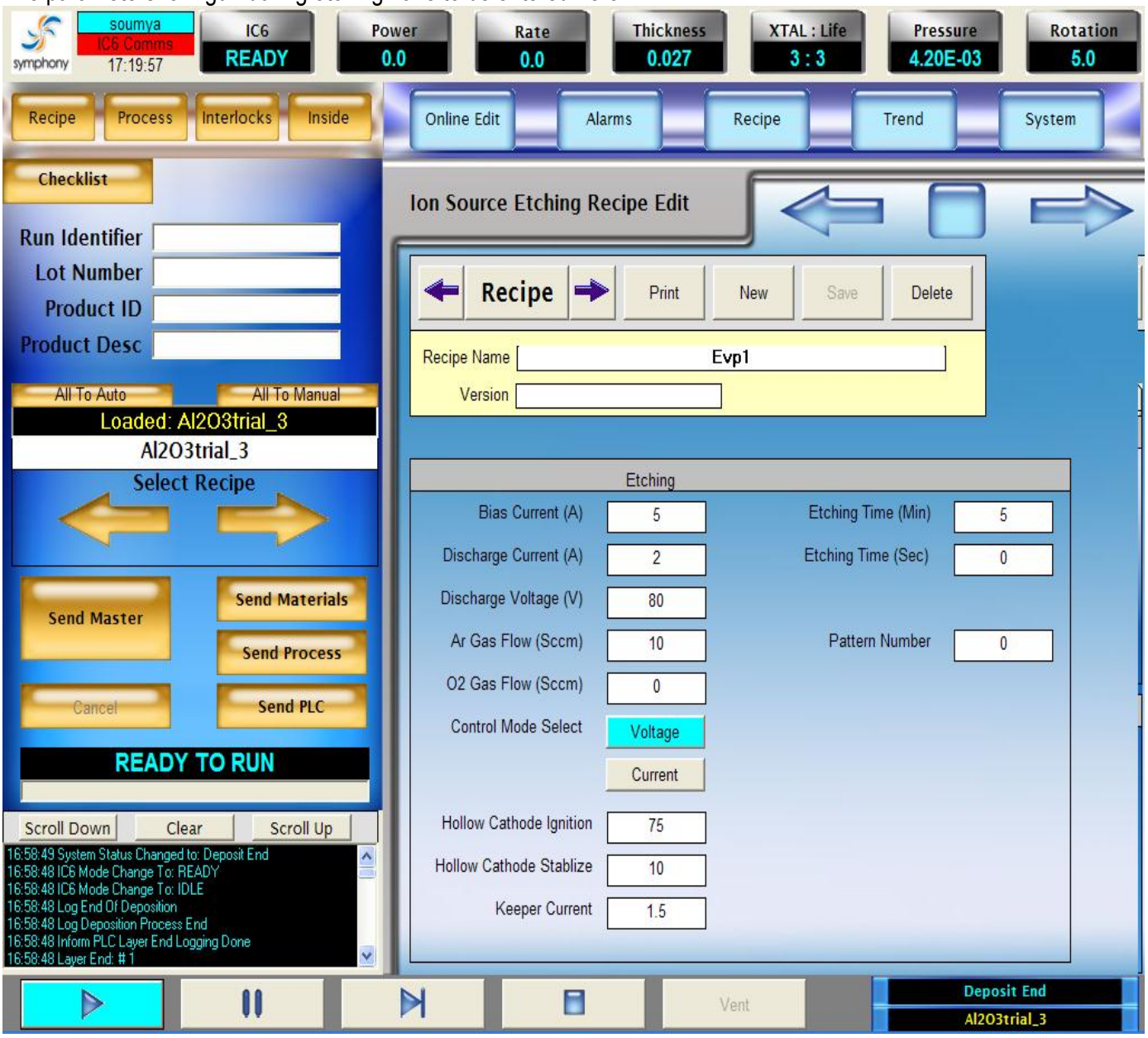
4.2 Ion Source

The parameters of Ion Gun during Ion assisted deposition have to be entered here



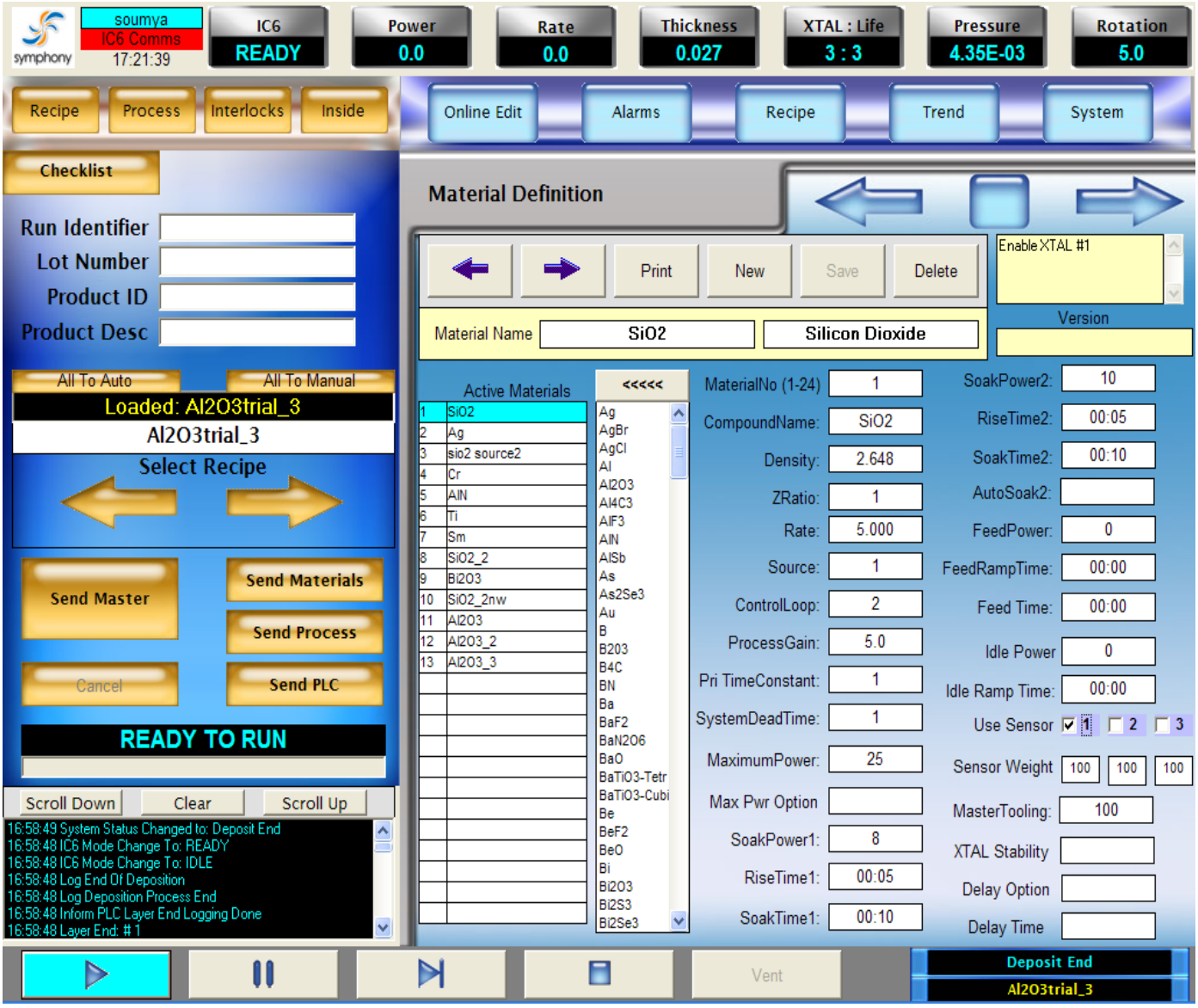
4.3 Etching

The parameters for I gun during etching have to be entered here



4.4 Material

Each material has a directory. The standard parameters will get automatically loaded as we select a material. The parameters included are



- MATERIAL NUMBER. This is the reference tag given for each material in IC6
- COMPOUND NAME. Name of the compound and this can be edited.
- DENSITY (0.100 to 99.99 gm/cc). The default value is 10.00. This parameter is specific to the material being deposited onto the Crystal. It is one of two

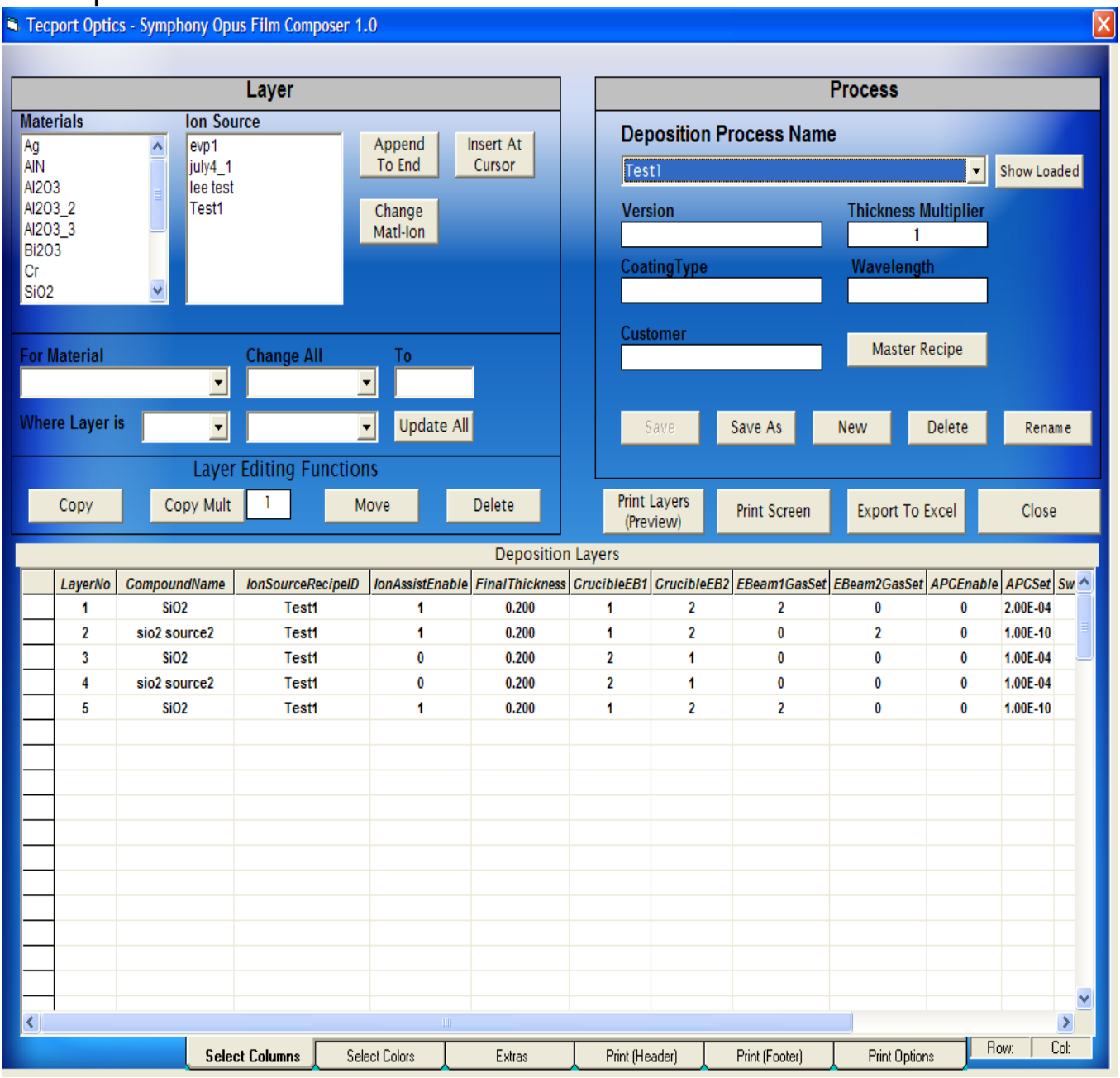
- parameters that relate the mass loading on the crystal to a thickness. Values range from 0.500 to 99.999. If a material is chosen from the Material Library the density is automatically entered. The default value is 10.00.
- Z-RATIO (0.100 to 15.000). This parameter is specific to the material being deposited. It is one of two parameters that relate the mass loading on the crystal to a thickness. Values range from 0.100 to 15.000. If a material is chosen from the Material Library the Z-ratio is automatically entered. The default value is 1.00. This parameter is superseded if Auto Z-ratio is selected in Source/Sensor Set-Up. CONTROL LOOP 0, 1, 2. This parameter establishes the control loop algorithms pertaining to either a slow responding source or a fast responding source. Permissible values are 0, 1, or 2. Select a 0 to choose the non-PID control loop, good for fast- and medium-speed responding systems with high noise levels (e.g., an electron beam gun with or without a liner, having large sweep amplitude of low frequency, 10 Hz or less). Select a 1 for the PI control loop, good for fast, medium, or slow systems with medium noise levels (e.g., an electron beam gun with medium sweep amplitude frequency, 20 to 100 Hz; also, sputtering and resistive sources). Select a 2 for the PID Control Loop, good for fast, medium or slow systems with low noise levels (e.g., an electron beam gun with sweep off or at a high frequency, 100+ Hz; also, sputtering and resistive sources).
- PROCESS GAIN (0.01 to 100.0 Å/sec/ % power). This parameter determines the change in % Power for a given rate deviation (dRate/dPower). The larger the process gain value, the smaller the change in power for a given rate error. Values range from 0.01 to 100.00. The default value is 10.00.

  PRIMARY TIME CONSTANT (0.010 to 200.00 sec). This is the evaporation source's time constant. This value is defined as the time difference between the actual start of a change in rate and the time at which 63% of the rate step is achieved. This value may be measured according to the above criterion or it may be determined empirically. Values range from 0.010 to 200.00 seconds. The default value is 1. This parameter is disabled if the CONTROL LOOP option parameter is set to 0.
- SYSTEM DEAD TIME (0.010 to 50.000 sec). This value is defined as the time difference between a change in % power and the start of an actual change in rate. Values range from 0.010 to 50.000 seconds. The default value is 1.0. This parameter is disabled if the CONTROL LOOP option parameter is set to 0.

- MAXIMUM POWER (0.0 to 99.9%). This parameter is used to set the maximum permissible % power level. The control voltage output will not exceed this limit. Values range from 0.0 to 99.9%. The default value is 90%.
- SOAK POWER 1 (0.0 to 99.9%). This parameter is usually set to the power level at which the source material just begins to melt. The instrument ramps the power level from zero to Soak Power 1 linearly over the time period Rise Time 1. Values range from 0.0 to 99.9%. The default value is 0.
- RISE TIME 1 (00:00 to 99:59 min:sec). This parameter provides the time period over which the source power is ramped from 0 to Soak Power 1. Values range from 00:00 to 99:59 minutes:seconds. The default value is 00:00.
- SOAK TIME 1 (00:00 to 99:59 min:sec). This parameter provides the time period for which the instrument holds at Soak Power 1. Values range from 00:00 to 99:59 minutes. The default value is 00:00
- SOAK POWER 2 (0.0 to 99.9%). This parameter is usually set to the power level at which the source material just begins to melt. The instrument ramps the power level from zero to Soak Power 2 linearly over the time period Rise Time 2. Values range from 0.0 to 99.9%. The default value is 0.
- RISE TIME 2 (00:00 to 99:59 min:sec). This parameter sets the time period in which the instrument linearly ramps the power level from Soak Power 1 to Soak Power 2. Values range from 00:00 to 99:59 minutes:seconds. The default value is 00:00.
- SOAK TIME 2 (00:00 to 99:59 min:sec). This parameter sets the time period for which the instrument holds the power level at Soak Power 2. Values range from 00:00 to 99:59 minutes:seconds. The default value is 00:00.
- AUTOS SOAK 2 (Y/N).
- FEED POWER (0.0 to 99.9%). This is one of three parameters used to affect a Feed Ramp. This value establishes the control voltage power level at which the source is maintained during wire feed. Values range from 0.0 to 99.9%. The default value is 0.
- FEED RAMP TIME (00:00 to 99:59 min:sec). This is the time interval for the source power to ramp linearly from the power level at the end of Deposit to Feed Power. The Feed Ramp relay is active during Feed Ramp Time. Values range from 00:00 to 99:59 minutes:seconds. The default value is 00:00.

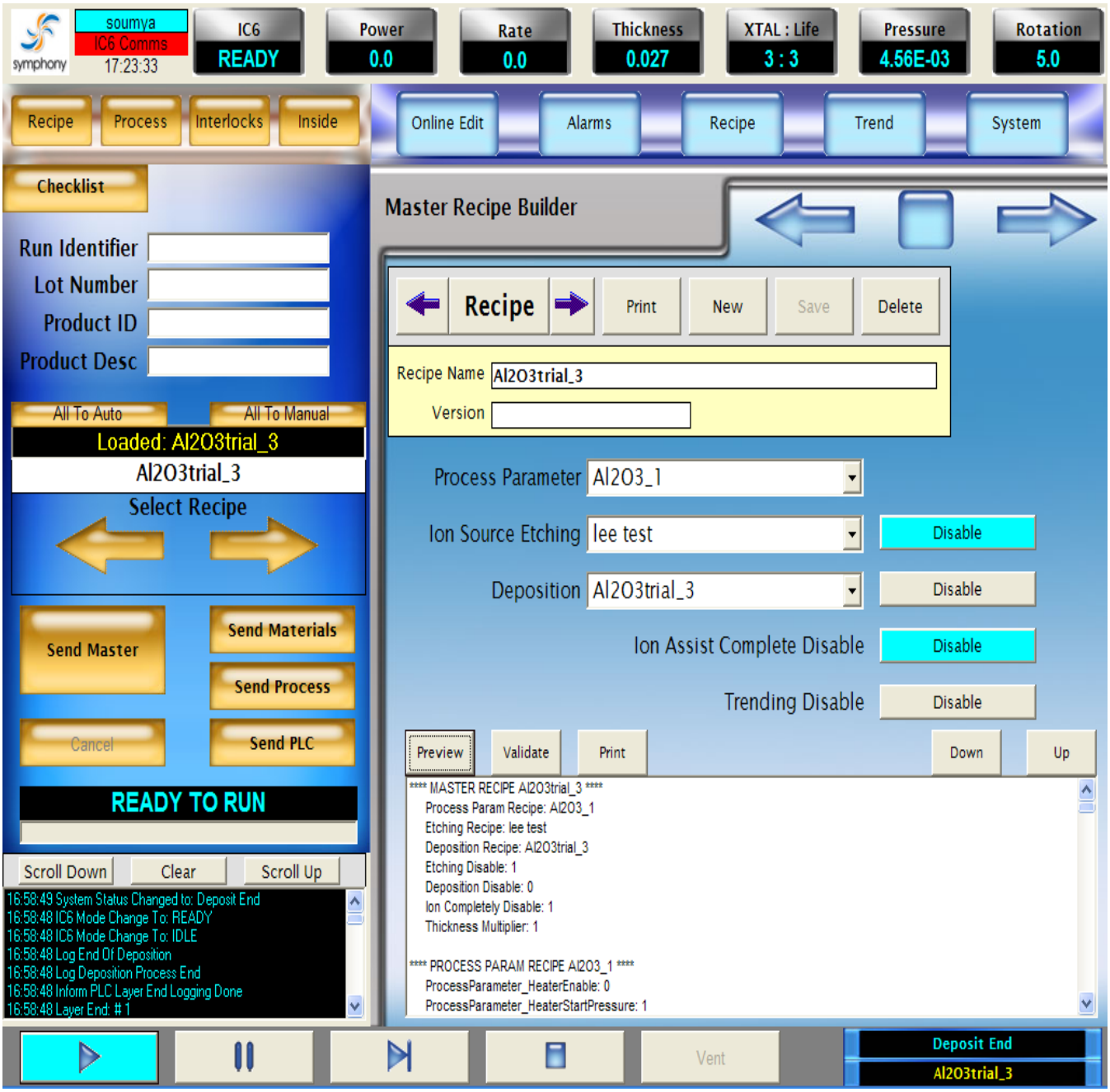
- FEED TIME (00:00 to 99:59 min:sec). This is the time interval for which the source power is maintained at Feed Power. The wires Feed relay is active during Feed Time. Values range from 00:00 to 99:59 minutes:seconds. The default value is 00:00.
- WEIGHT (1.0 to 400.0%). The Sensor Weight parameter is used to gauge the relative importance of each sensor's measured rate in calculating a weighted average 'aggregate' rate. The default value is 100%. If the WEIGHT parameter for a sensor is changed, the new WEIGHT for this sensor will be used for subsequent calculations of the aggregate rate, if the sensor's OPTION is non-zero. NOTE: This parameter affects the aggregate rate calculation. The aggregate thickness accumulated thus far is not re-scaled based on the change to the weighting factor.
- MASTER TOOLING (10.0 to 400.0%). This is a correction factor used for correlating the aggregate rate and thickness accumulation on the crystal with the thickness accumulation on the substrate. This thickness difference is due to the geometric distribution of material flux from the source.

4.5 Deposition



To include a process deposition recipe, click on New and enter the new recipe name. Select the material from the list of materials and the Ion source recipe and click on ‘Append to End’. This will insert one layer. Include all the layers required. The Ion assist enable, final thickness, crucible number, e-beam gas, sweep pattern number and crystal number has to be entered here. There are options to copy the layers as well.

4.6 Master Recipe



Master Recipe Builder is the final step in the recipe writing. Click on New and enter a recipe name. It will ask for Process Parameter, Ion Source Etching and Deposition. Select from the corresponding menu. We have the option to disable ion assist, ion etching, deposition and trending. Save the recipe, Validate and Preview. Now this will appear in the scroll down menu in the Recipe window in the left hand side.