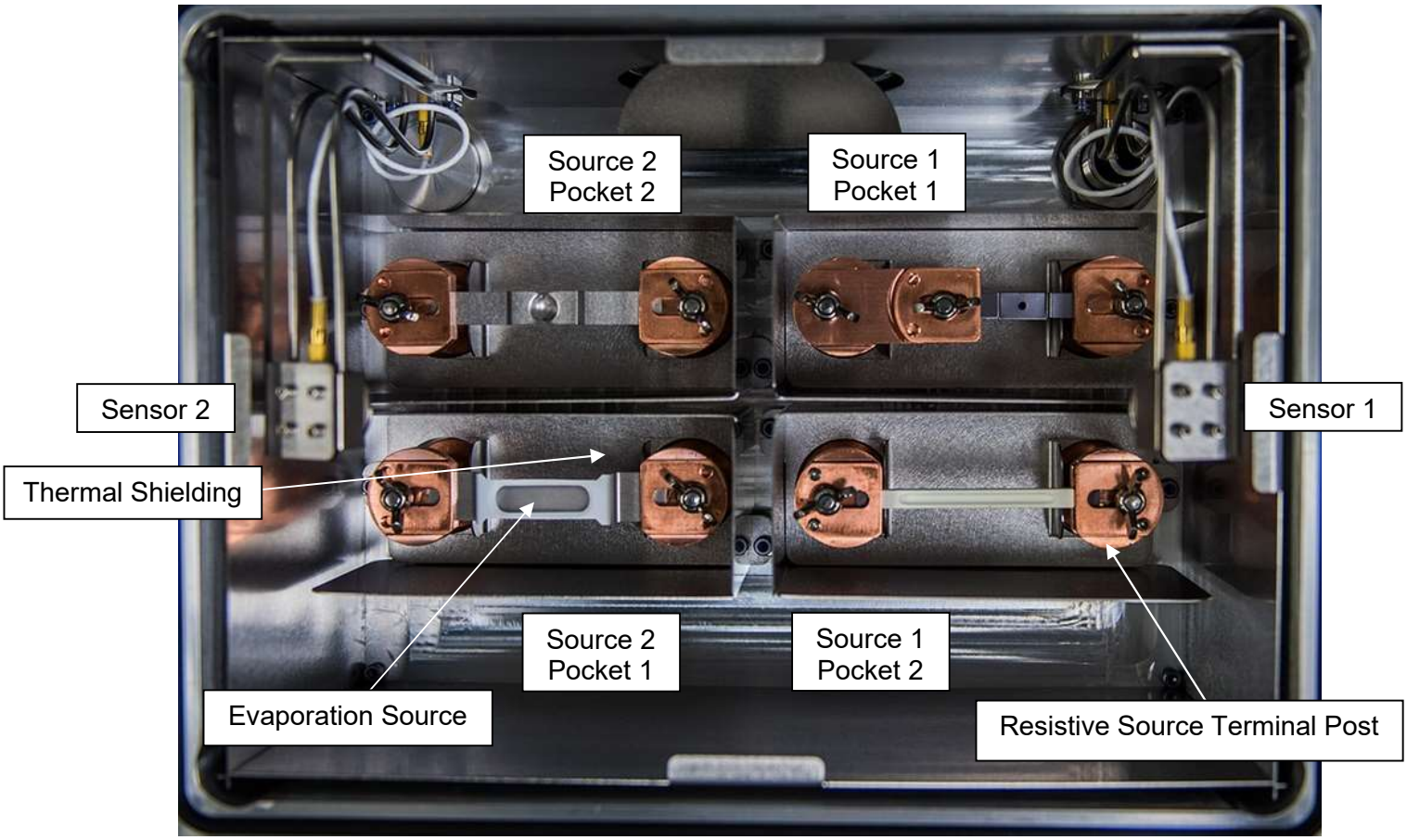
Angstrom Engineering COVAP Thermal Evaporator

The Angstrom COVAP thermal evaporator has four material sources. It is capable of both multilayer and two source co-evaporation.

Introduction

This vacuum system has four thermal resistive evaporation sources. A substrate shutter is used to expose the substrate to the sources during the deposition phase.

Note sensor and pocket designation.

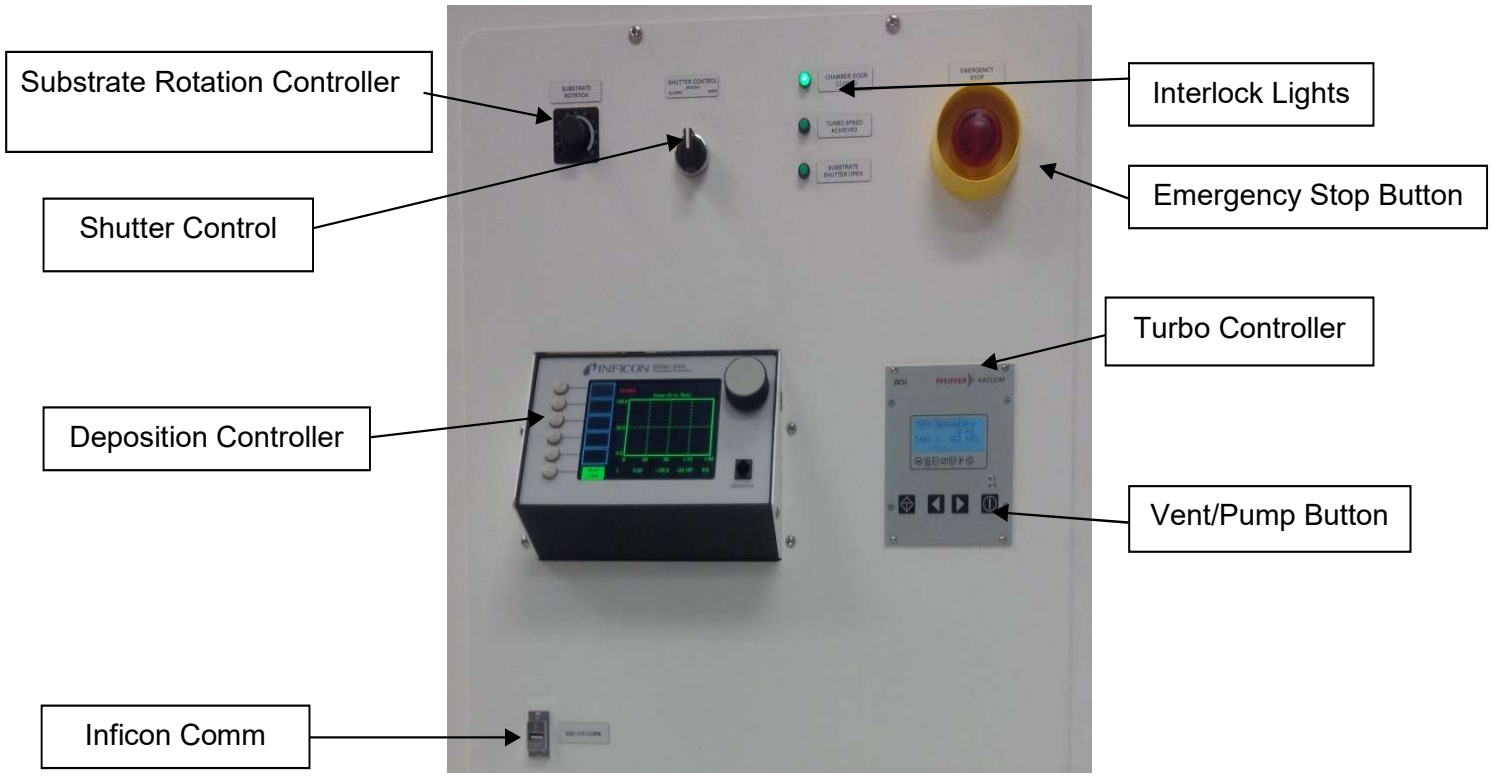


Basic Operation

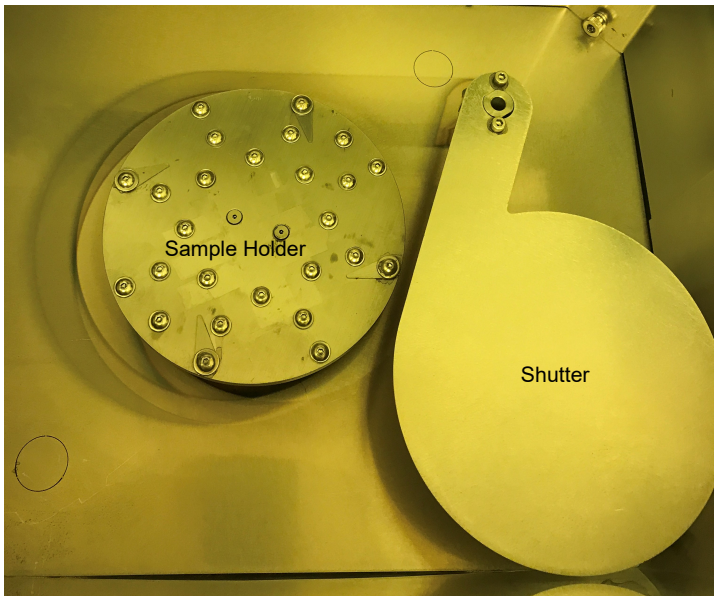
Controllers and display components are mounted on the front face of the system frame. All pumping and venting processes are controlled with relays, timers and the turbo pump controller. Ensure the required interlocks are satisfied before attempting to start venting. Interlock lights are used as visual indicators and will illuminate when interlock conditions are satisfied or true (i.e. Chamber Closed). The Emergency Stop Button will illuminate when pressed to stop the system.

Venting the Chamber

To stop the turbo pump and begin venting the chamber, push the 'Start/Stop' button on the turbo controller. Once the turbo pump rotational speed has dropped below the factory-established set point the turbo vent valve timer is initiated. The vent valve will remain open until the timer completes the timing cycle. Takes about 3 minutes to reach atmosphere. If the chamber does not vent, make certain that you are logged into FOM.



Open the chamber lid. Move the shutter manually to allow removal of the sample holder. Remove the sample holder by pressing, rotating and pulling to release. Mount your sample with the screws and washers provided. Make certain all holes are either covered or filled. Reinstall the sample holder with the push, lock and pull procedure again. Make certain it is locked or it will fall when the lid is closed. Move shutter to cover sample holder. Check the amount of material in the sources you are planning to use. Refer to the source sheet for current materials and their location. Close the lid and press the start/pump button.



The rough pump will immediately start roughing the chamber as the turbo pump begins to spool up to full rotation speed. The Turbo Speed Achieved interlock indicator light will turn on when the turbo pump is up to speed. Chamber pressure is displayed in hPa on the turbo controller. Allow the vacuum level to reach at least 9e-6 hPa.

Shutter Control

Make certain the shutter is in the *automatic* position. This will allow the deposition controller to open the shutters automatically during the deposit phase of a process.

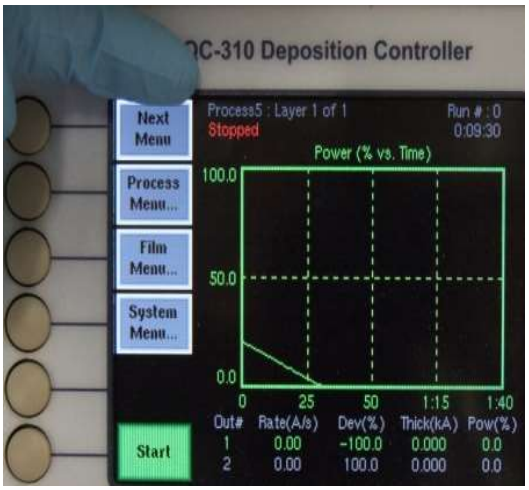
Deposition Control

The Inficon deposition controller is a self-contained unit capable of controlling up to four outputs. Two rate sensor inputs are provided and can be assigned to the outputs as required. Output 1 is connected to an SCR to control the power to Source 1 (Pockets 1 & 2) and Output 2 is connected to an SCR to control the power to Source 2 (Pockets 1 & 2). A quartz crystal rate monitor is located near each of the pocket pairs for rate monitoring control. This arrangement allows independently controlled deposition of materials from each of the 2 source locations simultaneously (in the *codep*).

Operating a Rate-Controlled Deposition

- All interlocks required for deposition must be met. These include Turbo Speed Achieved, Water Flow (where applicable), and Chamber Closed interlocks. The loss of any of these interlocks during deposition will disable all power supplies and interrupt the process.
- Choose film or layer you wish to deposit.
- Press the auto/manual soft key on the controller so that Auto is displayed on top.
- Select the process and press edit keys to set the rate and thickness of your desired film.
- Start the deposition using the start process soft key. After the pre-conditioning step the controller will utilize PID control for the output power to achieve the desired rate and will maintain the rate throughout the deposition until this final thickness is achieved.

Running the Process:
Press the Main softkey to return to the Main screen. The new Process will be the current process as displayed at the top of the screen. Load sample and pump down the chamber to below the base pressure setting, ideally in the 10-6 Torr range. With the controller in Auto, press the Start softkey to start the process. The process will ramp power and soak it there for a duration time then advance to the Shutter delay where the system will adjust the power to achieve the rate setpoint.



As soon as the Shutter delay is satisfied, the system will advance to the Deposit Phase, open the substrate shutter, zero the accumulated thickness and start depositing the Layer. Upon achieving a thickness set-point, the power will ramp down to 0% over a span of 30 seconds and the process will end. Allow 15 minutes for the source to cool and than press the vent button. Remove your sample, reinstall the sample holder and pump the system back down.

Additional Information

Tooling Factor

The standard equation for calculating tooling factor is:

New Tooling Factor = [Actual Thickness (measured) / the Theoretical Thickness (Inficon)] * the Original Tooling Factor

The tooling factor represents the percentage amount of material deposited on the substrate in comparison to what is deposited on the sensor used to monitor thickness and rate. A sensor mounted at the substrate height equidistant to the source/boat location would theoretically have a tooling factor of 100%. A sensor mounted closer to the source/boat, which is our typical geometry, will have a lower tooling factor as a larger quantity of material will be sampled than the quantity reaching the substrate. Typically, the tooling factor is estimated based on the relative distances and geometries between the source/boat and the sensor compared to the source/boat and the substrate. A good preliminary estimate for standard Covap systems is ~20%. For SQC-controlled systems the pocket-specific tooling factor is entered in the Film Tooling field under the Film menu. It should be noted that the SQC controllers have two other adjustments named: System Tooling in the System menu, as well as Crystal Tooling in the Sensors Menu. As these are global in nature, they should be left at the default value of 100%. On systems with adjustable substrate height, if substrate height is increased the tooling factor will typically decrease.

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/boat or style of source/boat must be used.
- The source/boat must be mounted in the same location in the clamps or not removed for loading material.
- The same source/pocket location and sensor must be used.
- A consistent amount of material must be in the source/boat.
- 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.

Films

The choice of which films to copy is 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. Pre-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 in the chamber. You can use a film for more than one source location; however, it is not recommended as slight differences could exist in tooling factor. If any parameters in a film are set, they are retained regardless which layer uses the film. If changes are made to the initial rate the pre-conditioning values will also likely require adjustment 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.

Rate Ramps

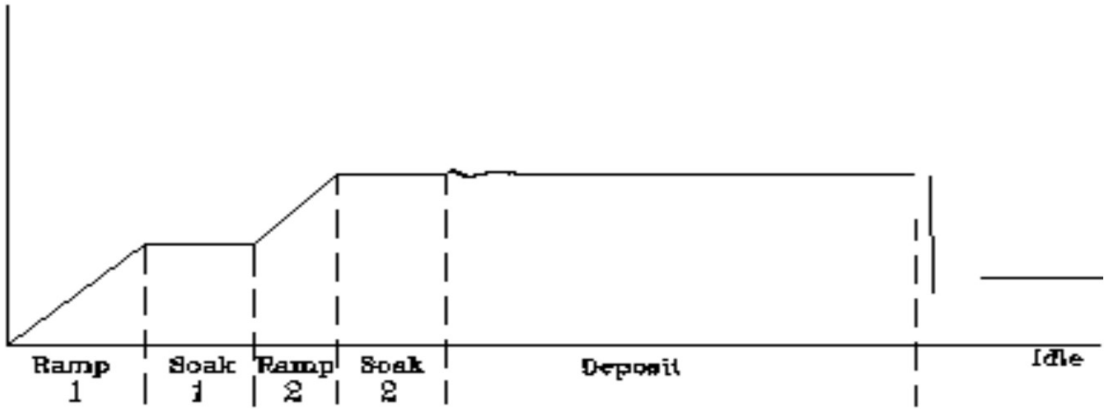
The rate specified in the Layer of the Process is always considered the Initial rate, as the rate can be modified at specified thickness values throughout the deposition. This is accomplished by enabling one or more Rate Ramps. The user chooses a new rate, a time to achieve this new rate, and the thickness at which the rate ramp is started. This feature can be used, for example, when depositing aluminum as a cathode layer on top an organic material. To prevent damage to the organic layer the user may want to deposit the aluminum cathode layer at a reduced deposition rate to start, and then deposit at a higher rate after a protective film is established. This feature can be applied in other ways as well. The user could begin depositing a material at a negligible deposition rate and ramp it up while ramping down for another material to create a gradient. During 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.

Quick edit

The quick edit feature can be used to modify process parameters during the active process. It can be used to change rate, thickness and PID settings.

Phases of a Process

When a process is executed automatically, the deposition software works through the process in phases. The first phase is indexing; this phase serves as 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 used to energize the appropriate source selection relay(s) and provide a power path to the source/ pocket location specified in the process. The next phase is pre-condition; there are two ramps available to warm up the source/boat and create some rate before the substrate shutter opens to deposit material on the substrate. During pre-condition, the ramps control power and time only. The software does not control by rate during this phase. Typically, only one ramp is applied, and it is recommended to use ramp 2 in those cases to ensure a smooth transition to the next phase. The next phase is an optional phase called shutter delay. When enabled, this phase uses PID control to attempt to achieve the initial rate within a specified percentage of deviation. The rate must remain stable within the deviation range for a user-defined period of 3 seconds before the phase ends and the substrate shutter opens for the deposit phase. The deviation percentage is plus or minus the initial rate. If the rate fails to achieve its target within the deviation range during the shutter delay 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 lower rates. The deposition phase is executed after the pre-condition and the optional shutter delay phase, if selected. The substrate shutter remains open during the deposition phase and closes when the final thickness or time setpoint is achieved. An optional post condition phase is executed after the deposition phase, wherein the power supplied to the source can ramp down slowly to reduce thermal shock. This is an essential step when depositing with e-beam and sputter sources, it is recommended in some cases for resistive sources as well. After the post condition ramp is finished a user-defined Idle time is available (to allow solidification prior to indexing for the next layer) if required. The substrate shutters remain closed during the post conditioning phase. After the post condition completes, the process will end.



Phases of a Process Courtesy of Inficon