SID-242
Thin Film Deposition Controller

SQS-242
Deposition Control Software

Version 3.00

User's Guide

Sigma
instruments

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Safety Information

Read this manual before installing, operating, or servicing equipment. Do not install substitute parts, or perform any unauthorized modification of the product. Return the product to Sigma Instruments for service and repair to ensure that safety features are maintained.

Safety Symbols

WARNING: Calls attention to a procedure, practice, or condition that could possibly cause bodily injury or death.

CAUTION: Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

Refer to <u>all</u> manual Warning or Caution information before using this product to avoid personal injury or equipment damage.

Hazardous voltages may be present.

Earth ground symbol.

Chassis ground symbol.

Equipotential ground symbol.

Warranty Information

This Sigma Instruments product is warranted against defects in material and workmanship for a period of 2 years from the date of shipment, when used in accordance with the instructions in this manual. During the warranty period, Sigma Instruments will, at its option, either repair or replace products that prove to be defective.

Limitation of Warranty

Defects from, or repairs necessitated by, misuse or alteration of the product, or any cause other than defective materials or workmanship are not covered by this warranty. NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. UNDER NO CIRCUMSTANCES SHALL SIGMA INSTRUMENTS BE LIABLE FOR CONSEQUENTIAL OR OTHER DAMAGES RESULTING FROM A BREACH OF THIS LIMITED WARRANTY, OR OTHERWISE.

Return Policy

The purchaser may return this product in new condition within 30 days after shipment for any reason. In case of return, purchaser is liable and responsible for all freight charges in both directions.

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1.0 <u>Introduction</u>

This manual covers both the hardware and software associated with the SID-242 Thin Film Deposition Controller. The SID-242 consists of four main elements, integrated into a complete deposition control system:

> SRC Series Rack-mount Computer
> SQM-242 PC Card(s)
> SQS-242 Windows CoDeposition Software
> PLC for Digital I/O (option)
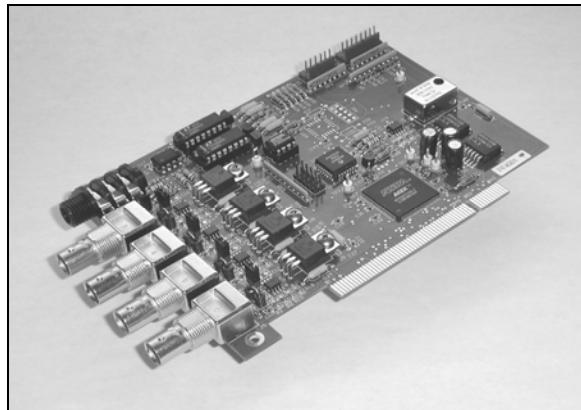
While the focus of this manual is on the SID-242 Controller package, it also covers each of these components separately. If you have purchased only the SQS-242 Software and/or the SQM-242 Card, we suggest that you also review Chapters 1 and 2 of this manual for important information.

1.1 <u>SRC Series Computer</u>

Sigma's SRC Series computers are Celeron (or better) class computers running the Windows® operating system. The SRC computer series uses standard off-the-shelf components and Sigma's custom rack-mount chassis to provide a compact, low cost instrument.

Included in the 5.25" or 7" high rack-mount chassis are an LCD Display, a TouchPad pointing device, a setting Knob, and six SoftKeys. A keyboard is provided for initial setup, but is not necessary for normal operation of the SQS-242 deposition control software. An optional rack-mount keyboard is also available.
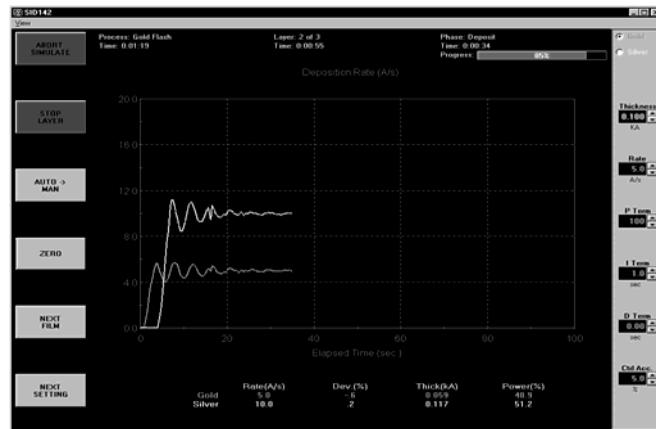
1.2 SQM-242 Deposition Control Card

Sigma's SQM-242 is a PCI expansion card for use in computers running the Windows operating system. Each card measures up to four quartz sensors via BNC inputs, and supplies the control signal for two evaporation sources via a dual phone plug output. Up to two cards can be installed in a computer, creating an eight input, four output, codeposition controller.

The SQM-242 card is supplied with demonstration software written in Visual Basic and LabView, including complete source code. The SQM-242 card and a Windows based computer form a basic deposition control system (without digital I/O capabilities).

1.3 SQS-242 CoDeposition Control Software

Included with the SID-242 is Sigma's SQS-242 software, a Windows-based program that provides all of the functions required for an eight sensor, four output, codeposition controller. It is optimized for use with the Setting Knob and six SoftKeys of our SID-242 controller. However, it will run on any Win98 or later system with our SQM-242 card installed.

The six SoftKeys provide easy access to the common operating functions. A single tabbed dialog box provides all of the settings required for a thin film process. Material parameters, sensor/source setup, pre/post conditioning, and error conditions are all visible on a single screen. Process settings, numeric data, and graphical displays are displayed during all phases of deposition.

The SQS-242 software stores process parameters in a Microsoft Access compatible database. This provides virtually unlimited access to desktop tools for building and analyzing thin film processes.

The SQS-242 software can be controlled from another computer using the RS-232 or Ethernet command protocol.

1.4 Digital I/O

Digital I/O for the SID-242 is provided through an inexpensive, external, programmable logic controller (PLC). This allows the PLC, and the associated I/O wiring, to be placed in a convenient location in a wiring cabinet. A single, serial communications cable runs to the SID-242 computer. The PLC provides electrical isolation, fail-safe operation, and extensive I/O processing capabilities through its ladder logic programming.

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2.0 <u>Introduction</u>

This section covers the minimum system connections and initial setup required to run the SID-242 Deposition Controller. Consult later chapters of this manual for more detailed setup and operational instructions.
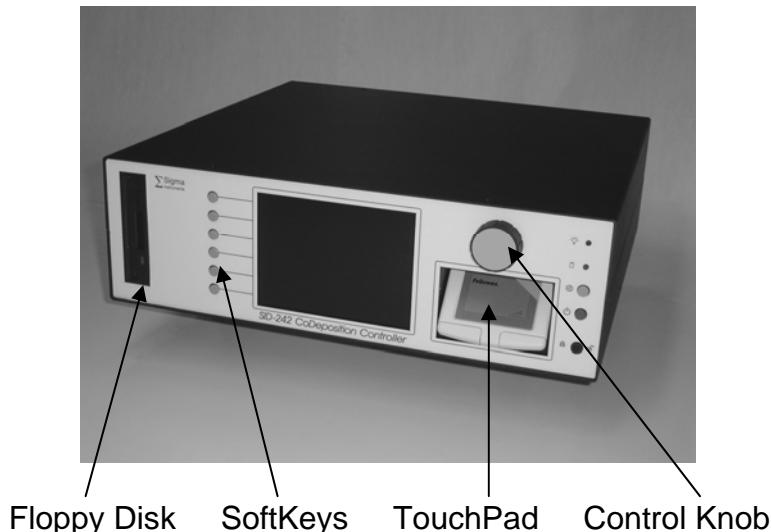
2.1 <u>Installation</u>

All electrical connections to the SID-242 are made at the back panel of the instrument.

<u>WARNING</u>: Care should be exercised to route SID-242 cables as far as practical from other cables that carry high voltages or generate noise. This includes other line voltage cables, wires to heaters that are SCR-controlled, and cables to source power supplies that may conduct high transient currents during arc down conditions.

Rack Installation	The SID-242 occupies a 5.25" high (4U) rack space. Install the unit in a 19" rack with the supplied hardware.
Power Connection	*<u>WARNING</u>*: Verify that the Voltage Selector Switch, located next to the power switch, matches your mains supply voltage.
	<u>WARNING</u>: Verify that the power cable provided is connected to a properly grounded mains receptacle.
Sensor Input Connections	Connect the BNC cables and oscillators from your vacuum chamber feedthrough to the desired SQM-242 Card Input(s). Refer to Chapter 4 for detailed instructions on system hookup to the SQM-242 card(s).
Source Output Connections	Connect the dual phone plug from the SQM-242 output jack to your evaporation supply control input. Refer to Chapter 4 for detailed instructions on wiring the SQM-242 output phone plug.
Digital I/O Connections	Digital I/O is not required for initial operation of the SID-242. Perform initial setup and checkout of the SID-242 before connecting your digital I/O. Refer to Chapter 5 for detailed information on wiring the SID-242 for digital I/O.
Keyboard Connection	A keyboard is supplied for initial user setup of Windows. Attach the keyboard to the keyboard input jack on the rear of the SID-242. Once Windows is setup, use of the keyboard is optional.

2.2 Front Panel

Floppy Disk   SoftKeys   TouchPad   Control Knob

Front Panel Controls

KeyLock	Insert key and turn clockwise to enable the power and reset buttons. Turn counterclockwise to disable the power and reset.
SoftKeys	Provide basic instrument operations within the SQS-242 deposition program. The SoftKeys are functional only in programs written specifically for the SRC computer.
TouchPad	Provides mouse functions in all Windows programs, including the SQS-242 software. Move your index finger along the touchpad surface to move the cursor. Press the left or right buttons below the touchpad surface to "click."
Control Knob	Used to adjust values within the SQS-242 software. Pushing the control knob stores the current setting, and moves to the next setting. Functional only in programs written specifically for the SRC computer.
Floppy Disk	1.44 MB floppy disk for upgrades, backup, and data storage/transfer.
Keyboard (not shown)	Required for Windows data entry, and useful during initial SID-242 setup. Not required for SQS-242 software operation. The F1 through F6 keys on the keyboard provide the same functions as the six SoftKeys on the front panel.

2.3 <u>Program Startup</u>

This section will start the SID-242 and run the SQS-242 deposition control program.

Power On the Computer	Insert the and turn clockwise to enable the power and reset buttons. Push the power button to start the computer.
Start the Program	The SID-242 will boot Windows from the internal disk and start the SQS-242 deposition program. If the SQS-242 program does not start automatically, use the touchpad to double-click the desktop icon.
User Login Screen	*<u>Note</u>: If you are prompted to register the software, just press Cancel for now.* *<u>Note</u>: The SID-242 ships with one pre-assigned user. The user name is Super, with no Password.* The SID-242 displays a progress bar during program startup, then a User Login screen. Select a User Name from the drop down box, enter the Password, then click OK. See Chapter 3 for more information on users, passwords, and access levels and registartion.
Process Database	The SID-242 normally starts with the last active process database. If that database is not found, a Database Open dialog will be displayed. Use the touchpad to navigate to the desired database.
Main Display	The main display shows a set of labels associated with the function of the six SoftKeys. As you operate the SID-242, these labels will change to display appropriate functions. Along the top of the display is a menu of less commonly used functions. This menu is available only when the SID-242 is stopped (i.e. not running a deposition process).
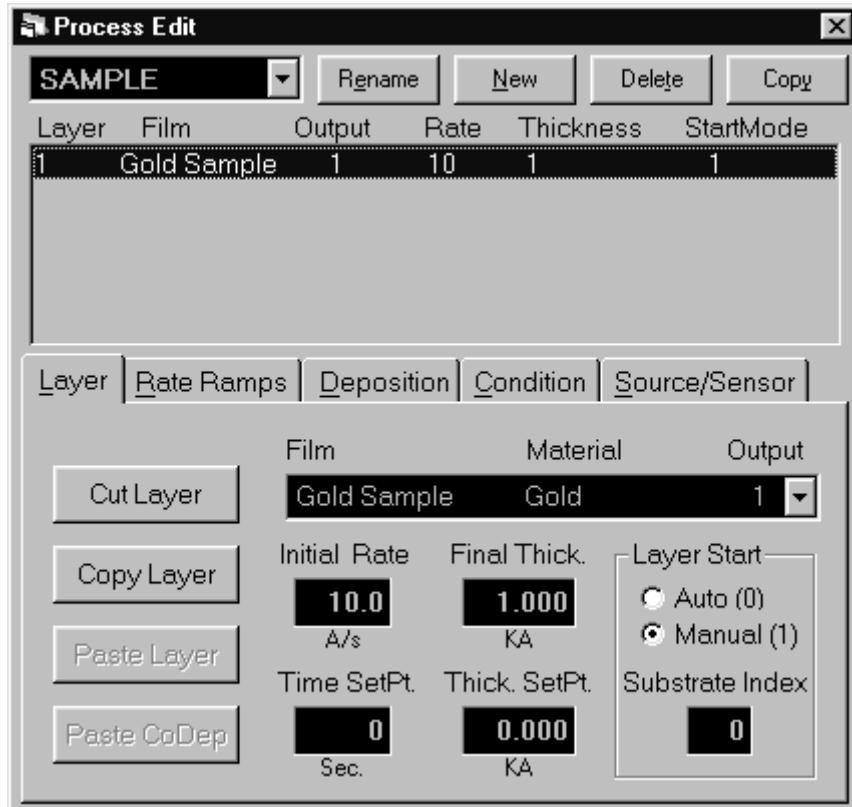
Simulate Mode   Simulate mode allows you to familiarize yourself with SID-242 operation, and test process recipes. If the first SoftKey is labeled "START SIMULATE" then the Simulate mode is active.

If the first SoftKey is labeled "START PROCESS" then normal mode is selected. Use the touchpad to select the Setup menu, then click System. On the SQM-242 tab, click the Simulate option button. Click the "Save" SoftKey label, or press the top SoftKey to activate Simulate mode.
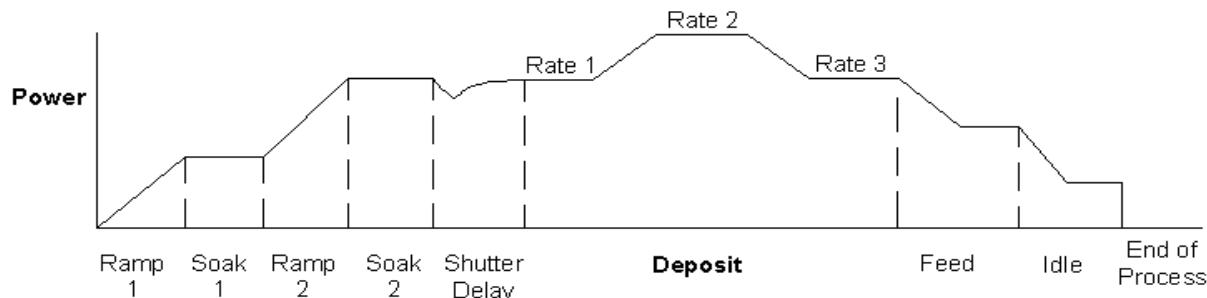
2.4 <u>Single-Layer Process Setup</u>

A thin-film deposition process consists of one or more layers of material evaporated onto a substrate. Let's build a simple single-layer process.

Open Process Edit	Use the touchpad to click on the "Edit" menu selection along the top of the display, then click "Process." The Process Edit dialog will display the setup for the last process run. To better understand process setup, see section 3.4.1.
Add A New Process	Click the "New" button in the dialog box. An on-screen keyboard appears, displaying the next numbered Process. Click "Backspace" several times to delete the name. Now "type" a new Process name using the touchpad and on-screen keyboard. Click "Enter" to save the new name.
Edit Film	Click the "Layer" tab to assure the layer parameters are displayed. Select "Gold Sample" in the Film dropdown box.
Edit Rate and Thickness	Click the "Initial Rate" setting, and then use the Control Knob to adjust the Initial Rate to 10 Å/s. Adjust the "Final Thickness" to 1.000 kÅ.

The diagram below illustrates a complete deposition cycle for a single layer. Refer to this diagram as we set the remaining process setup parameters.
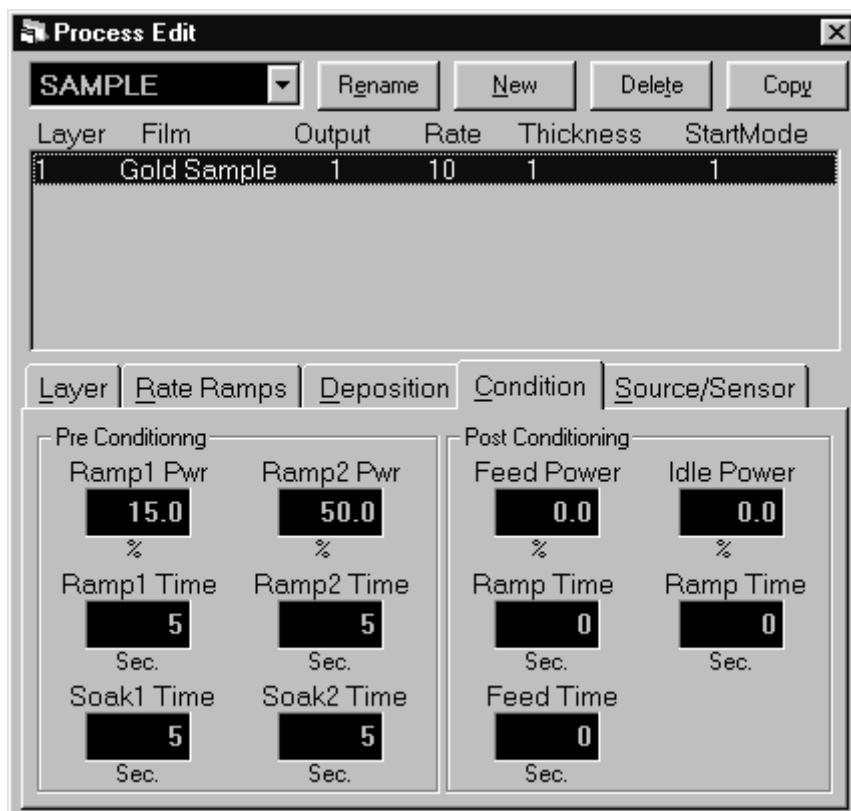
Edit
Rate Ramps

It may be desirable to vary the deposition rate during a layer. For example, to deposit slowly at first, then more quickly once the initial material is deposited. Click the "Rate Ramps" tab, then click "Insert Ramp." Adjust the "Start Thickness" to 0.400 kÅ, "Ramp Time" to 5 seconds, and "New Rate" to 15 Å/s.

Edit Pre/Post
Conditioning
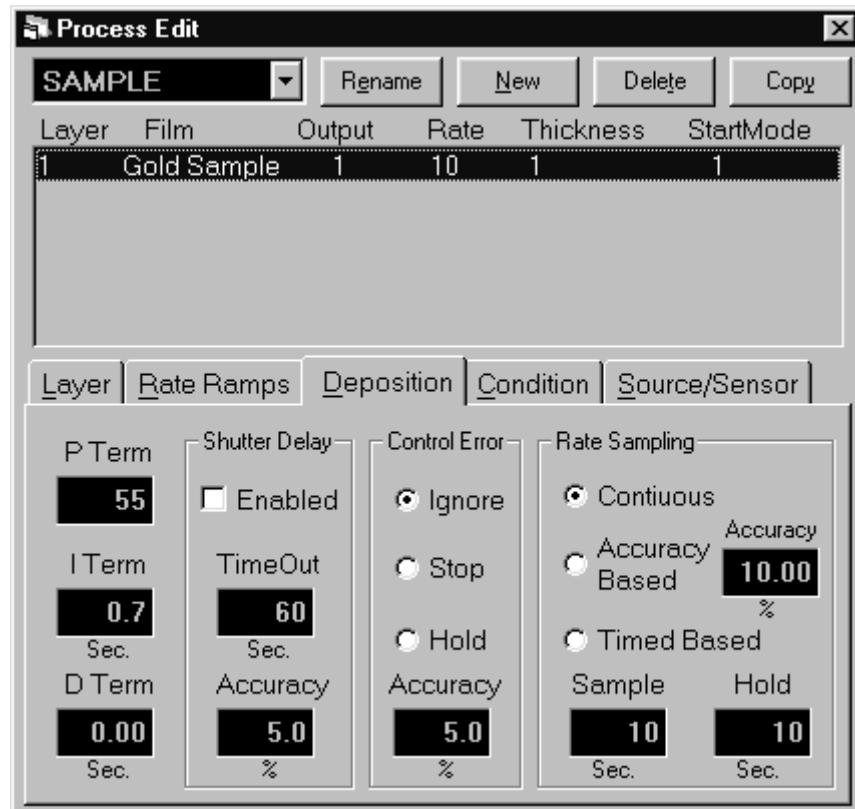
Before deposition begins, the source material is often brought to a ready state by raising the evaporation source power. Select the "Condition" tab and set each parameter to the values shown below.

**Edit
Deposition**
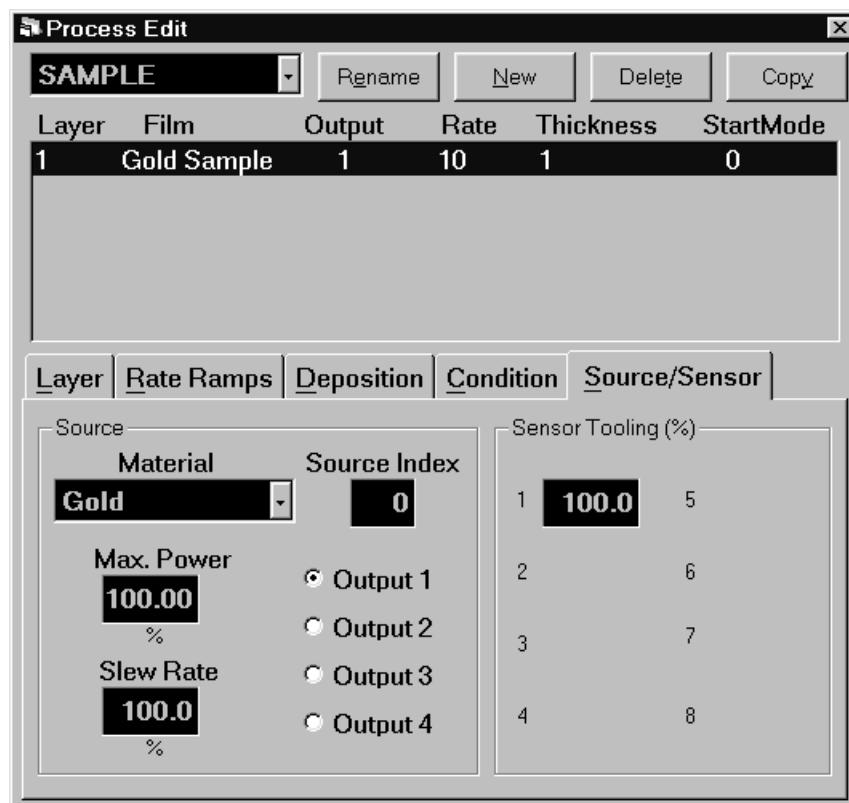
Select the "Deposition" tab. This tab establishes the gain (P Term), time constant (I Term), and dead time (D Term) for your process. Set these values to 55, .7, and 0 respectively.

Be sure Shutter Delay Enabled is <u>not</u> selected. Select Ignore for Control Error, and Continuous for Rate Sampling (see picture below).

Edit Source/Sensor
Select the "Source/Sensor" tab. This tab contains parameters associated with the physical layout of your evaporation system. For now, be sure that "Output 1" is selected and "Max Power" and "Slew Rate" are set to 100. Set the "Tooling" value to 100. Leave the Source Index as it is.

Save Edits
Click "Close Form" or press the first SoftKey to save this one-layer process. If you are prompted "Do you want to change….," answer Yes to make this the current process.

Your new single-layer process is now the active process in the main window. Notice the process, layer, and time information above the graph.

2.5 <u>Single-Layer Process Simulation</u>

If you have followed this chapter, you are ready to simulate a deposition process.
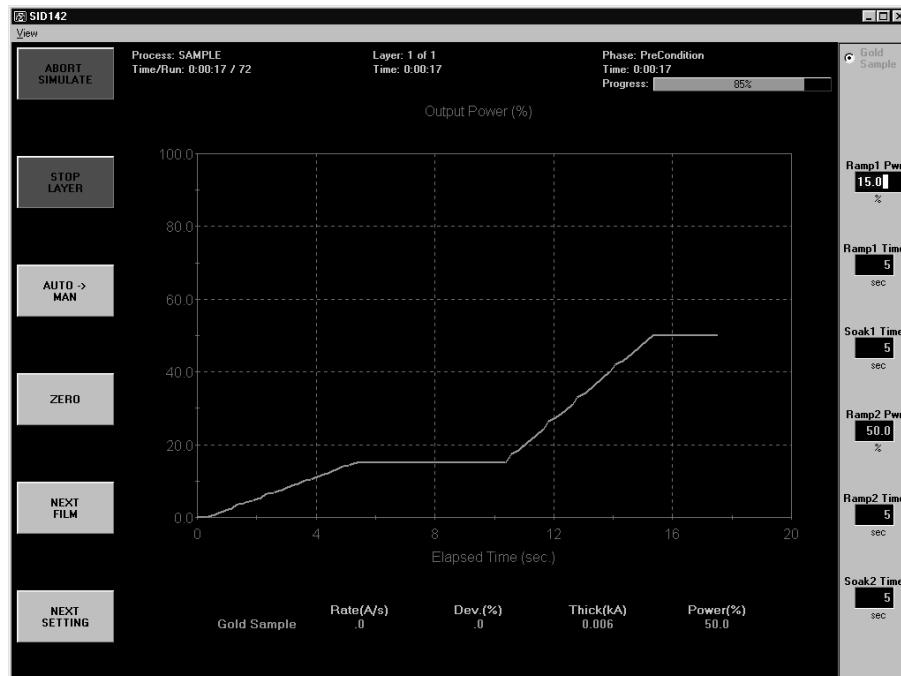
Setup Displays	Click the "View" menu and assure that these options are selected: Film Settings, Film Readings, and Automatic. Note that the settings "ribbon" along the right displays the pre-conditioning parameters you entered in the previous section.
Start Process	Verify that the top SoftKey label displays "START SIMULATE." If "START PROCESS" is displayed, follow the instructions at the end of Section 2.2 to enable simulate mode. Press the "START SIMULATE" SoftKey, or click the label, to start the process.
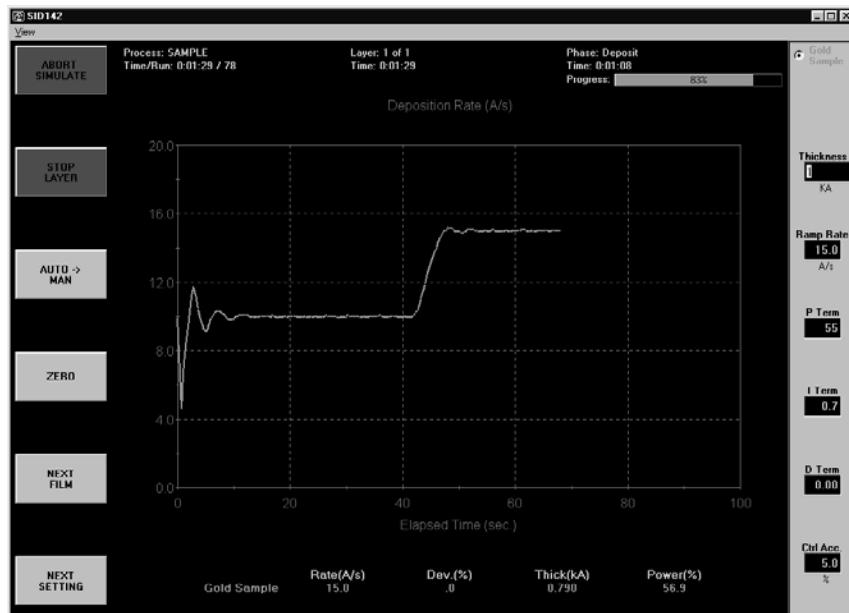
The process will start with preconditioning (i.e. Ramp1, Soak1, Ramp2, Soak2) as shown below. Once preconditioning is complete, the process will enter the Deposit phase. You may want to select "ABORT SIMULATE," then "START SUMULATE" several times to familiarize yourself with the on-screen displays during preconditioning. You may also want to use the settings ribbon to adjust parameters while the process is running.

<u>Preconditioning Phases</u>

Because we selected "Automatic," in the View menu, the graph displays Output Power during preconditioning, then switches to Rate during the deposition phase.

As shown below, the initial deposition rate was 10 Å/s until a thickness of .400 kÅ. Then the deposition rate was ramped up to 15 Å/s, and held until the desired final thickness of 1.000 kÅ is achieved. At this point, this single-layer process is finished.

Deposition Phase with one Rate Ramp

You should adjust the PID parameters on the setting ribbon, then Start/Stop the process several times to become familiar with their effect on control loop response.

2.6 <u>SoftKey Functions</u>

As you have seen, the SoftKey functions remain constant during deposition. Spend a few minutes to become familiar with each of these SoftKey functions.

**START
PROCESS**

Starts the first layer of a process when START is pushed. If AUTO->MAN is shown on the third SofKey (AUTO Mode) the process starts PreConditioning. If MAN->AUTO is shown on the third Softkey (MANUAL mode) the process immediatly starts Deposition under PID loop control.

**ABORT
PROCESS**

Aborts the process. The process can only restart at the first layer.

**START
LAYER**

Starts a stopped layer, or a layer that has been designated "Manual Start" in the process database. Starts the layer based on the state of the AUTO->MAN SoftKey as described above.

**STOP
LAYER**

Stops the current layer. Also changes the function of the first SoftKey to NEXT LAYER.

**NEXT
LAYER**

Abandons the current layer and moves to the next layer in the process. If it is the last layer of a process, the same as pushing ABORT PROCESS.

AUTO->MAN

When AUTO->MAN is pushed, the source output is set to manual control.. You may adjust the output using the settings ribbon. Because the PID loop is not running, you can manually set the output power to different levels and observe the associated deposition rate.

MAN->AUTO

Returns the output to PID loop control. If the process is running (ABORT PROCESS and STOP LAYER shown on the first two SoftKeys) depsoition continues. If the process is stopped, sets the output to zero and awaits a start command.

ZERO

Resets the thickness reading to zero.

**NEXT
FILM**

Sequences the setting ribbon through each Film in a codeposition layer.

**NEXT
SETTING**

When the settings ribbon is shown, sequences the setting knob action through each of the displayed parameters.

2.7 Multi-Layer CoDeposition Process

Our final example builds on the previous sections. If you have modified the setup of your process, return to Section 2.4 and adjust the process to those values. When your single-layer process matches Section 2.4, complete these steps:
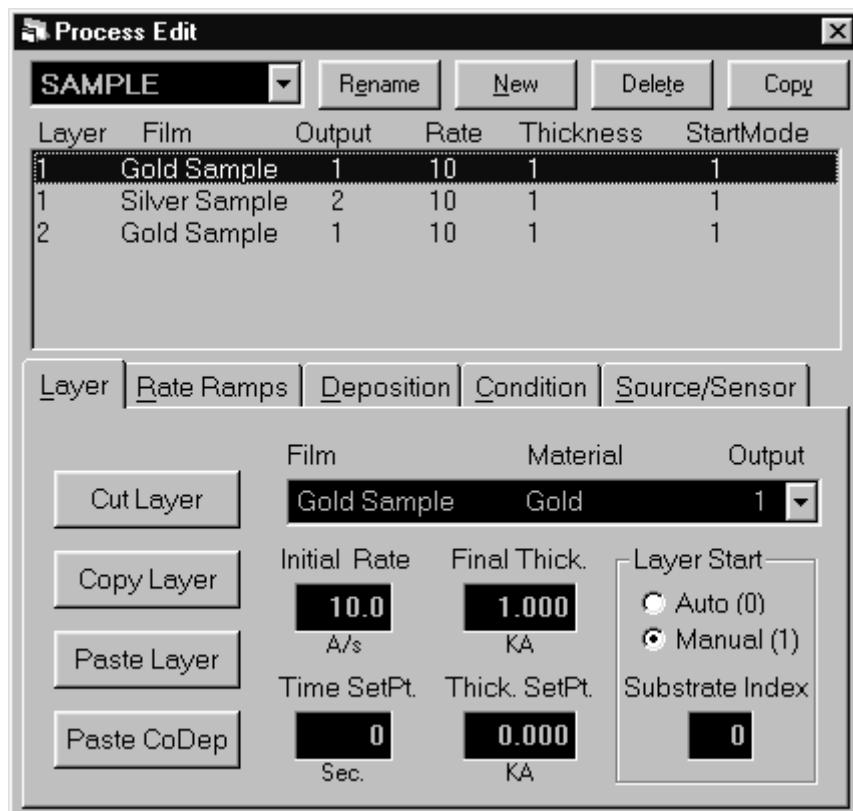
Duplicate a Layer	Open the Edit Process dialog. Click on Layer 1, click the "Layer" tab, then click "Copy Layer." Now click "Paste Layer." A duplicate Gold Sample film will be added as Layer 2. Click "Paste Layer" again to add a third Gold Sample layer.
Select a CoDep Film	Select Layer 3 in the layers list. Now select "Silver Sample" in the films dropdown. The layers list will update to show the new Silver Sample film assigned to Layer 3.
Add a CoDep Layer	Select Layer 3 in the layers list, then click "Cut Layer." Now select Layer 1. Click "Paste CoDep." The Silver Sample film will be added below Gold Sample as a codeposition layer. (Your setup should match the picture below.)
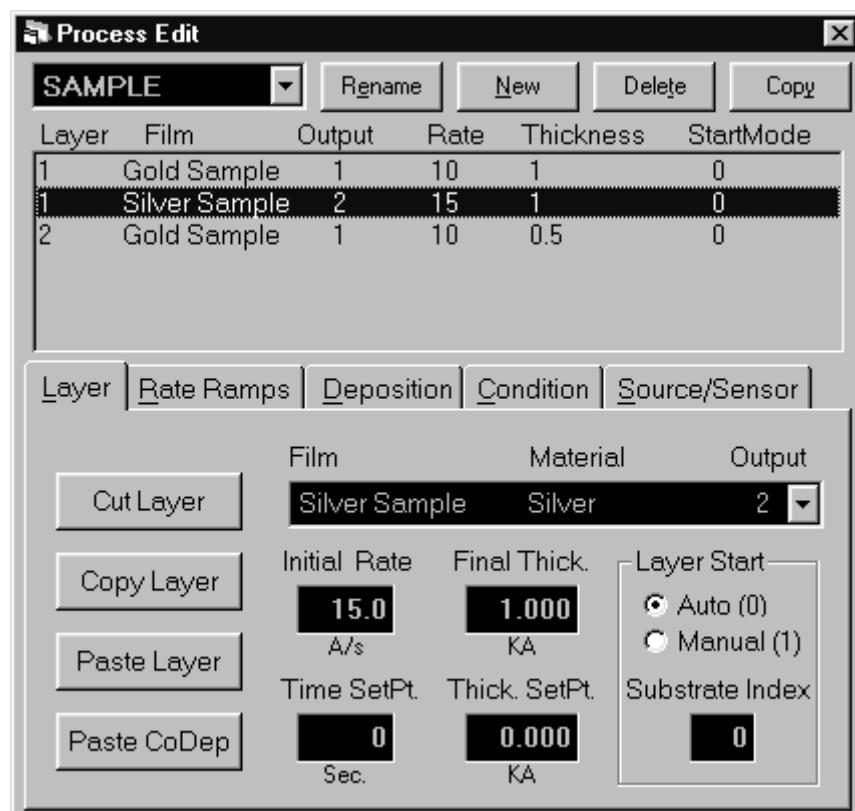
We now have two layers in our process. Layer 1 has Gold being deposited from source Output 1 and Silver is being codeposited on Output 2. Layer 2 is Gold alone.

__Hint:__ It's usually best to copy a layer, then paste several temporary layers of that type. Next, assign the films that you want to each of the pasted layers. When selecting films for codeposition, remember that each film in a codeposited layer must be assigned to a different source output! Now use "Cut Layer" on the temporary layers, and "Paste CoDep" to assign the film to the desired codeposition layers. Review this example until you are comfortable with these concepts.

Edit Layer 1 Rate & Thickness — Click Silver Sample in the list of layers. Set "Initial Rate" to 15 Å/s, "Final Thickness" to 1.000 kÅ. Click the Rate Ramps tab and adjust "Start Thickness" to 0.400 kÅ, "Ramp Time" to 15 seconds, and "New Rate" to 0 Å/s.
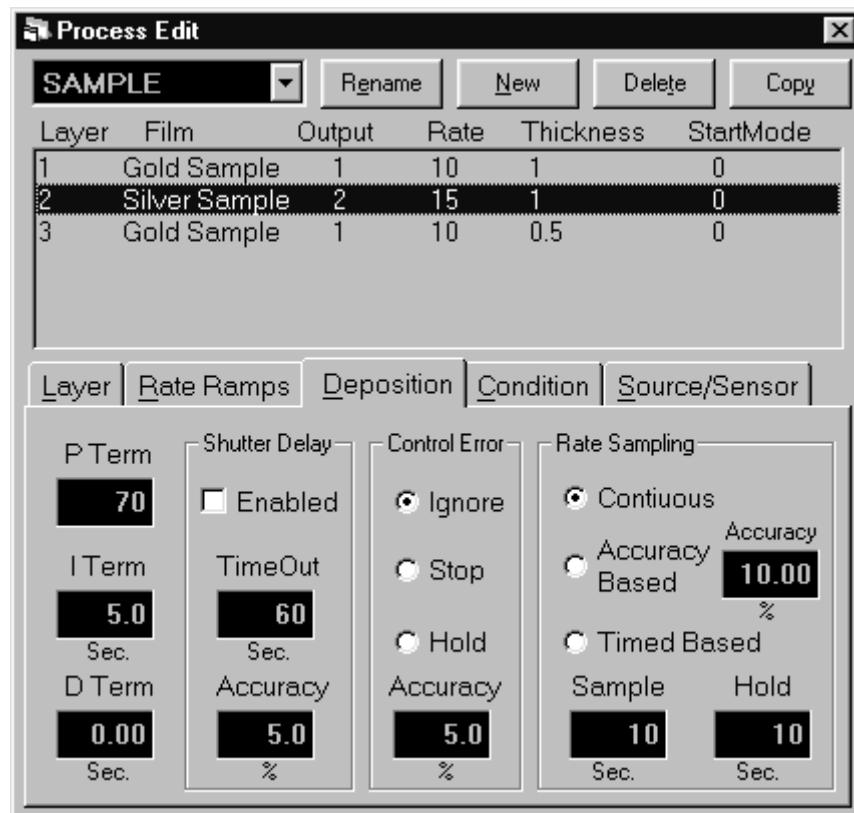
Edit Layer 2 Rate & Thickness — Click the Layer Tab, then click Layer 2. Set Final Thickness to .5000 kÅ.

Set Layers to Auto Start — At the end of deposition, you may choose to have the next layer wait for a Start Layer command, or to start automatically. Select each Layer in the layers list, then click Auto to set that layer to start automatically.
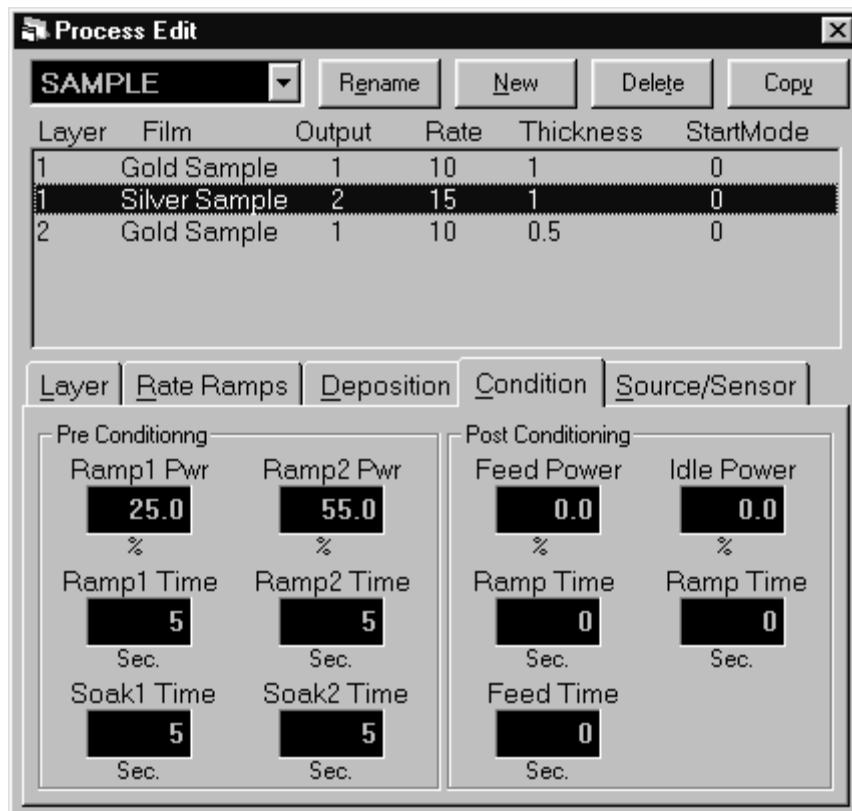
Verify that your process matches the one shown above.

Edit Silver Deposition — Select the "Deposition" tab and the Silver Sample layer. Set each parameter to the values shown below.

Edit Silver Conditioning

Select the "Condition" tab and the Silver Sample layer. Set each parameter to the values shown below.

Save Edits

Click "Close Form" or press the first SoftKey to save this two-layer codeposition process. Answer Yes if it displays the "Do you want to change…." message box to make this the current process.
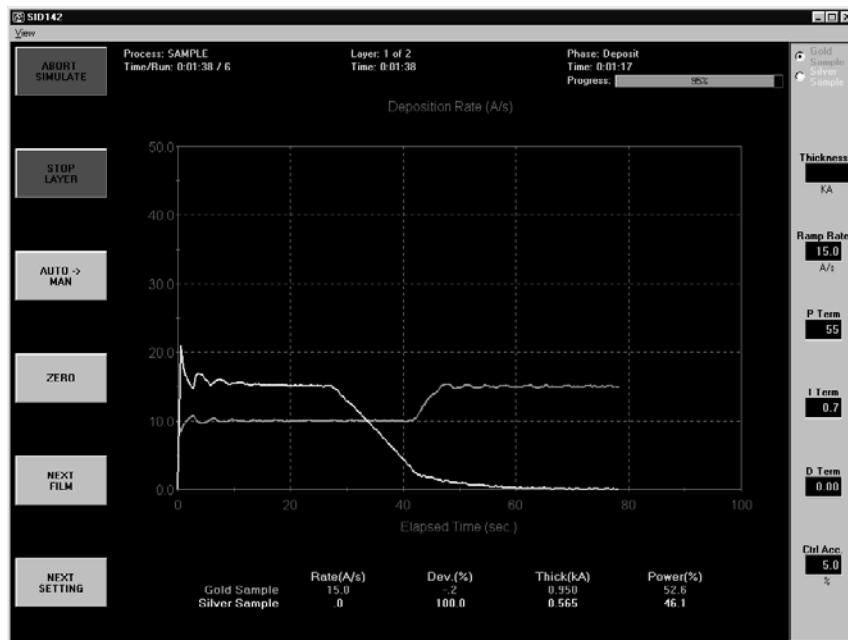
Start Process

Press the "START SIMULATE" SoftKey to start the first layer preconditioning phases. Note that two outputs are displayed for this codeposition layer.

Preconditioning of the two materials is entirely independent. If the preconditioning of one layer takes longer than the other, the start times are adjusted so that the end times coincide.

When preconditioning ends, codeposition of the two materials begins.

Your response should be similar to the graph shown below (your vertical scale may be slightly different). The slight ringing on the waveforms indicates some further tuning may be desired. However, this is an example of a reasonably well tuned loop.

At .400kÅ thickness, the Silver Sample deposition rate ramps down from 15Å/s to 0. Similarly, at .400 kÅ thickness the Gold Sample film ramps to a higher deposition rate of 15Å/s. Because the initial rate for Gold was set lower than the initial rate for Silver, Gold reached its .400 kÅ thickness rate ramp trigger later in the deposition cycle.

Try a P Term in the 25-30 range (less gain) for both Gold and Silver to decrease the loop susceptibility to noise. Increasing the I Term a little, say toward 1.0, will lessen overshoot during rate changes. The D term can be thought of as a "dead band" term. Most systems require little or no D term.

2.8   Conclusion

Once again, spend some time with this process to become familiar with its setup, and the effect of changes on deposition performance.

Because we selected Simulate Mode at the beginning of this Quick Start session, the SQM-242 card is "faking" an actual process. You can use the Simulate feature at any time to become familiar with SID-242 operation, and the effect of various settings on process performance. It is also a very useful feature for pre-testing your process setups. Return to the Setup menu, then select System and set the Mode to Normal to begin running your process with the SID-242 controller.

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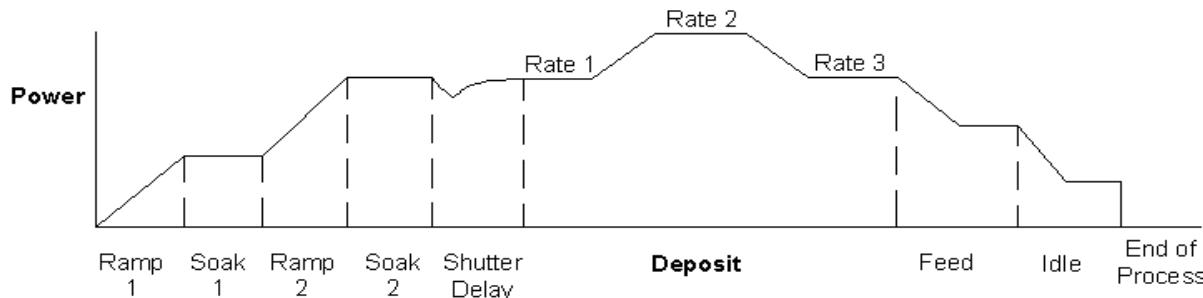
3.0 <u>Introduction</u>

The SQS-242 Deposition Control Software works with Sigma Instrument's SQM-242 Card to provide an inexpensive, yet powerful, PC based Thin Film Deposition Controller that can:

- Measure up to eight quartz crystal sensors simultaneously
- Control up to four deposition source supplies simultaneously
- Codeposit up to four films with preconditioning, multiple rate ramps, and feed/idle phases
- Graph deposition rate, rate deviation, or power output
- Store process, film and material parameters in Microsoft Access® database
- Use inexpensive PLCs for flexible and reliable external process controls

A typical deposition cycle for a thin film is shown below. The cycle can be broken into three distinct phases: pre-conditioning (ramp/soak), deposition, and post-conditioning (feed/idle). During pre-conditioning, power is supplied to prepare the source material for deposition. When pre-conditioning ends, material deposition begins. During deposition, the PID loop adjusts the evaporation source power as required to achieve the desired deposition rate. When the desired thickness is reached, the evaporation source is set to feed or idle power. At this point the process may be complete, or deposition of another film layer may begin. If desired, up to four separate films can be codeposited within a single layer. There is no limit to the total number of layers.

The SQS-242 software allows you to build the recipes and perform the operating functions required to control all aspects of multi-layer thin film deposition. Process recipes are stored in Microsoft Access format. There is no practical limit to the number of processes, films, or materials that can be stored in the database.
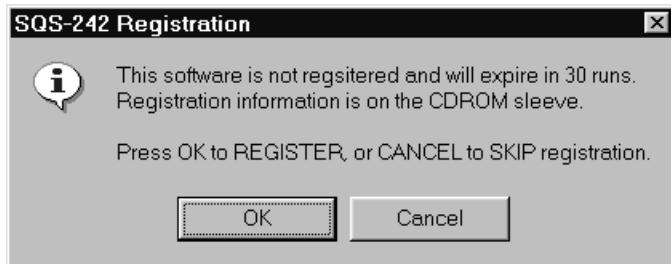
3.1 <u>Installation and Registration</u>

The SQS-242 install program is provided on CD-ROM. You can connect an external USB CDROM to the SID-242 for CDROM program installation. A 3 ½" diskette install is also possible by using another computer to copy the contents of each of the CD-ROM "Disk" subdirectories to blank 3 ½" diskettes.

To install the program, start Windows, then insert the disk or CD-ROM into your computer. Click Start, then Run, then type <d>:Setup (where <d> is the drive letter you are using). Click OK to begin installation, and follow the on-screen prompts. When installation is complete, you should restart your computer to load any new Windows DLL and OCX support files.
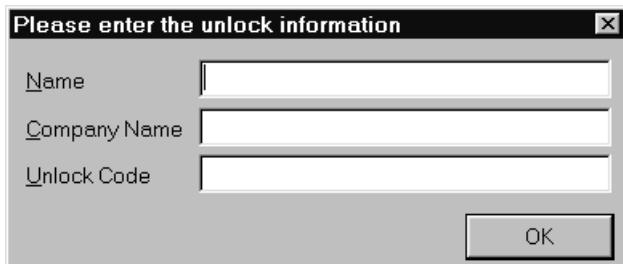
The SQS-242 software can simulate deposition for demonstration and tutorial purposes. However, an SQM-242 deposition controller card must be installed to actually read sensors and control a source supply. The SQM-242 card can be installed before or after the SQS-242 software. Consult the SQM-242 card User Manual for installation information.

To start the SQS-242 program, click Start, Programs, Sigma Instruments, then SQS-242. Until the software is registered, this Registration "nag" screen will appear.

Note: Press Cancel for full acces to the software for up to 30 runs. After 30 runs you must contact Sigma Instruments to start the program. There is no work-around!

Press OK to show the unlock screen. In some cases your unlock "Name" may actually be a number. If a valid Name and Unlock Code are entered, the program will start normally. Otherwise, after three tries the program will start and decrement the unregistered "run" counter.

Note: If you enter a name of DEMO and Unlock Code of 5A8CAC8E5586268 the software will be placed in Demo mode. All features of the software are permanently available, except that readings from the SQM-242 card are only simulated. The Demo mode can be disabled by entering a valid Name and Unlock Code later.

3.2 Operation
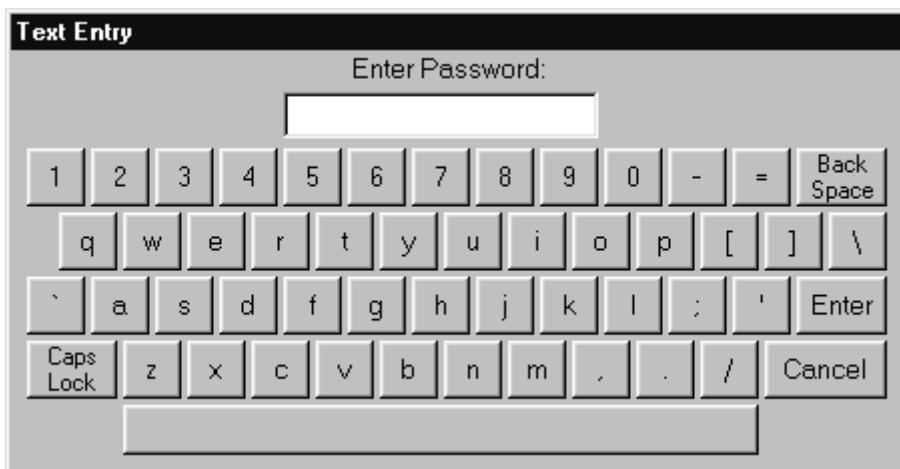
The SID-242 displays a progress bar during startup, then a User Login screen.

Note: The SQS-242 software ships with one pre-assigned user. The user name is Super, with no Password. Do not confuse this with the registartion Name and Unlock Code discussed in the previous section.

Select a User Name from the drop down box, type in the Password, and then click OK to start the program.

If your software is configured for keyboardless operation, an on-screen keyboard will appear as shown below. You can use your normal keyboard or mouse/touchpad to "type" the password, then click Enter. See System Setup, SQM-242 Setup later in this chapter to enable or disable the on-screen keyboard.

An Access Level is associated with each User Name. The Access Level controls which software functions are available to each user. For example, only users with an Access Level of Supervisor can assign users. See the Security section of this chapter for information on setting up users.

The remainder of this chapter covers the purpose and operation of each software function, arranged by menu selections. For a more "operational" approach, consult the previous Quick Start chapter.

Menus: The menus along the top of the main screen provide access to functions for building deposition processes, configuring the hardware for your vacuum system, and other less commonly used functions.

SoftKeys: The six switches to the left of the display are used for the normal operation of the instrument, and to navigate the setup programs (see below for the individual switch functions). Normally, you press the button that is adjacent to the labels on the SID-242 screen, but you can also use the mouse. Just move the cursor over the key label on screen and single click the mouse. You can also use the keyboard F1 to F6 function keys to simulate the front panel function switches. The SoftKeys change during operation to address different user input requirements.

Setting Knob: The knob to the right of the display is used by the SID-242 to set numeric data. A keyboard or the control's up/down arrows can also be used.
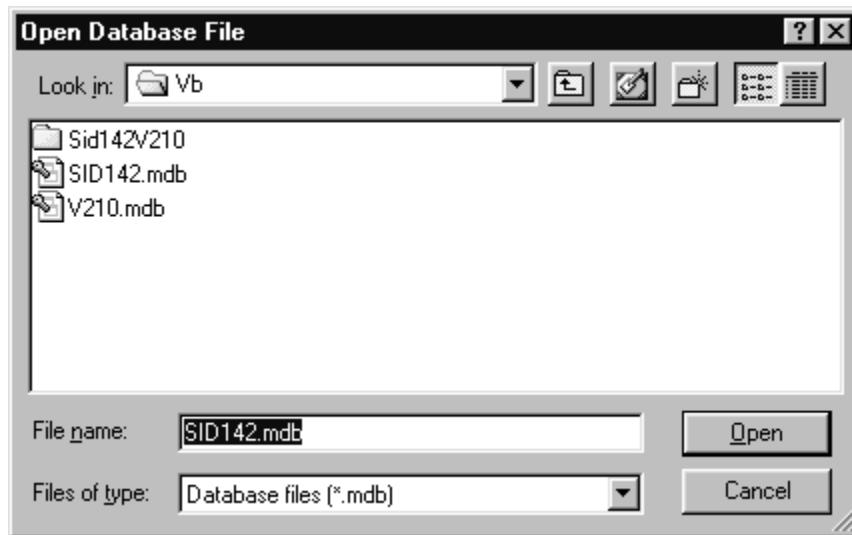
TouchPad: On the SID-242, a touchpad is located below the setting knob. The touchpad serves the same function as a normal mouse. Use the touchpad or mouse to access the menus, and for functions not available from the six function keys.

3.3 <u>File Menu</u>

Note: The current process must be stopped for the File menu to be available.

Process: Used to select a process from a list of all processes in the database. If the process selected is different than the current process, you are prompted to confirm the change.

Open Database: Selects a process database to be used for deposition. Remember, a single process database may contain an unlimited number of processes, films, and materials.
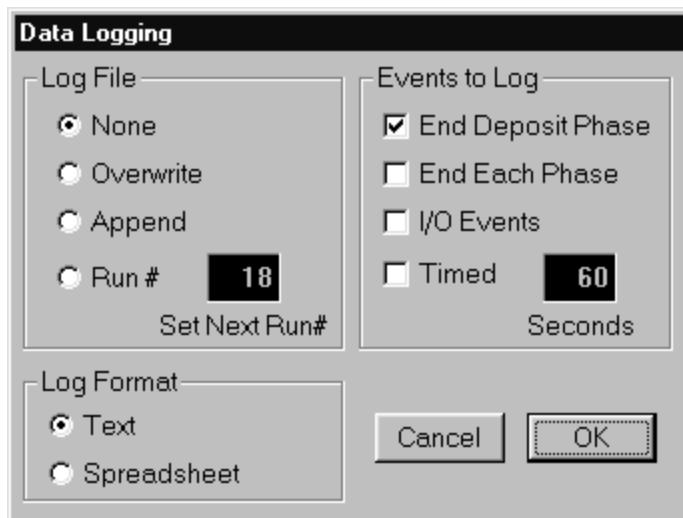
Save Database As: Saves the current process database to disk under a different name. This is useful for saving the process database to floppy disk (for backup!), or for making trial changes without affecting your working database.

Once again, a pop-up keyboard may appear. If you want to browse or type in the database name, just select Cancel from the pop-up keyboard. Process databases are saved in Microsoft Access format.

Data Logging: Saves deposition data to a .LOG text file. If an option other than "None" is selected in the Log File section, data logging is activated. When the Start SoftKey is pushed, process data is saved in a .LOG file in the SQS-242 installation directory (typically: \Program Files\Sigma Instruments\SQS-242).

There are three options for file naming and logging. If "Overwrite" is selected, only the last run of the process is saved as ProcessName.LOG. Subsequent runs overwrite the log file. If "Append" is selected, each run is appended to ProcessName.LOG. If "Run#" is selected, each run of the process is saved as a separate file under the format ProcessName_Run#.LOG.

```
Data Logging

┌─Log File──────────────┐  ┌─Events to Log─────────────┐
│  ◉ None                │  │  ☑ End Deposit Phase       │
│  ○ Overwrite           │  │  ☐ End Each Phase          │
│  ○ Append              │  │  ☐ I/O Events              │
│  ○ Run #      18       │  │  ☐ Timed         60        │
│        Set Next Run#   │  │                  Seconds   │
└────────────────────────┘  └────────────────────────────┘
┌─Log Format────────────┐
│  ◉ Text                │      ┌─────────┐  ┌─────────┐
│  ○ Spreadsheet         │      │ Cancel  │  │   OK    │
└────────────────────────┘      └─────────┘  └─────────┘
```

A number of "events" can trigger a data entry in the log file. "End Deposit Phase" records process data (rate, thickness, time, etc.) at the end of each layer's deposit phase. Similarly, "End Each Phase" logs data at the end of each phase (conditioning, depositing, etc.). "I/O Events" logs data each time an external digital input or output changes. Finally, "Timed Logging" records data at the selected time intervals throughout the process.

There are two formats for writing data. If "Spreadsheet" is selected, each entry is a comma-delimited line of data. If "Text" is selected, the data is formatted for easy reading. The first few lines of the LOG file is a heading that illustrates the file format and content. Log files can be viewed using a word processor or spreadsheet program.

Print Process: Prints the parameters for the current process to the system printer. Select "Print to File" in the Printer Setup Menu to print the data to a file.

Print Setup: Selects and modifies the current system printer.

User Login: Displays the User Login screen so that a different user may log in. The existing user is logged off automatically. The user Access Level changes immediately to that of the new user.

Exit: Exits the SQS-242 deposition control program.

3.4 <u>Edit Menu</u>

3.4.1 Edit: Process

A process is a sequence of film layers. Multiple films deposited in the same layer are known as codeposition. A listing of each film in the selected process appears in the layers list box. Films in codeposition layers are listed with the same layer number, but a different output. Select a layer to edit its parameters in the tabbed dialog boxes.

The Edit Process dialog provides all the functions needed to develop a thin film deposition process from the database of existing films and materials. The Layer and Rate Ramp tabs specify the sequence of films to be deposited. The Deposition, Condition, and Source/Sensor tabs provide control over the individual films assigned to each layer.

Note: Edits to the Deposition, Condition, and Source/Sensor tabs will affect all processes and layers that use the selected film!

Process: A drop down box that selects the process to be edited. Defaults to the current process.

Rename: Edits the name of the selected process.
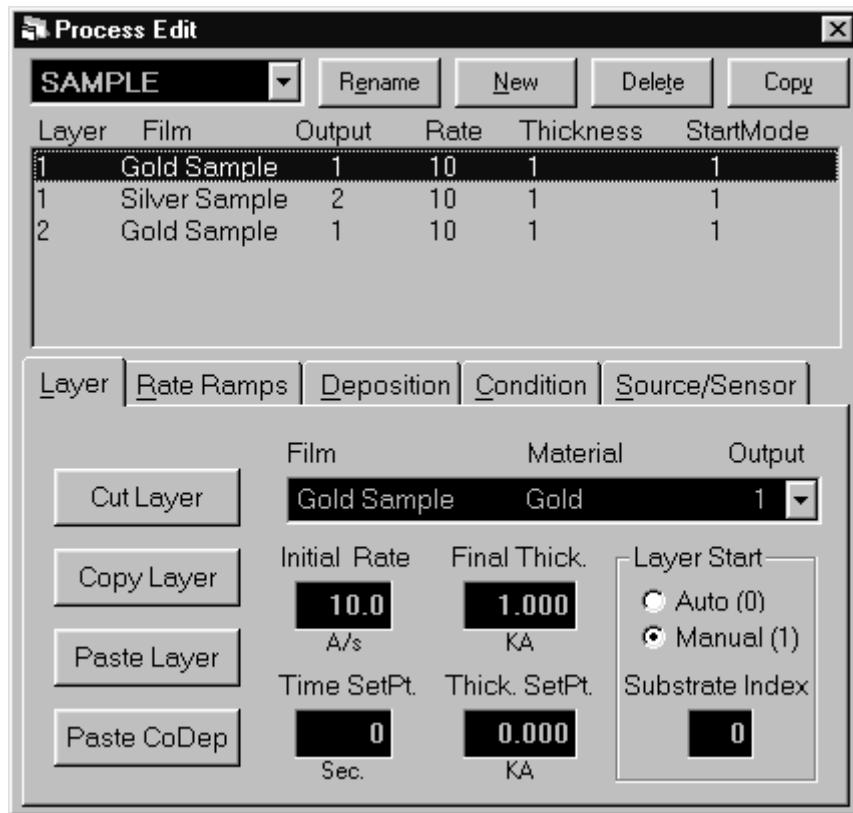
New: Creates a new process. Since every process must have at least one film, the first film of the currently selected process is used.

Delete: Deletes the currently selected process from the database. *There is no undelete!*

Copy: Creates a duplicate of the currently selected process.

Layer Tab

The layer tab provides the capabilities needed to add and delete process layers, as well as to edit the film, rate & thickness for each layer. Normally each film in a process is run sequentially, as layers. Codeposition represents different films that are deposited concurrently with other films, in the same layer.

Cut Layer: Removes the layer selected in the Layers list box from the process, and places the layer on the clipboard.

Copy Layer: Places the layer selected in the Layers list box on the clipboard, without removing it from the process.

Paste Layer: Inserts the clipboard layer above the currently selected layer in the Layers list box. Existing layers are shifted down.

Paste CoDep: Pastes the clipboard layer as a codeposition layer at the currently selected layer number. Films that use outputs already assigned to the selected layer are invalid.

<u>*Hint:*</u> To add layers to a process, it is easiest to click an existing layer in the layers list then click Copy. Click Paste to insert several temporary layers of that type. Next, assign the proper film to each of the layers, using the Film dropdown box.

When selecting a Film for a codeposition layer, remember that each film must be assigned to a different source output! To change an existing layer to a CoDep layer, highlight the existing layer and click "Cut Layer." Next click the layer desired for CoDep and click "Paste CoDep" to assign the selected layer. The Multi-Layer CoDeposition Process section of Chapter 2 illustrates this concept.

Film: Selects the film that is assigned to the selected layer. Changing a layer's film also changes the film related parameters for that layer (i.e. preconditioning, PID, material, etc.)

Initial Rate: Sets the initial deposition rate setpoint for the selected layer. If no rate ramps are defined for the layer, this is the rate setpoint for the entire layer.

Final Thickness: Sets the endpoint thickness for the selected layer. When final thickness is reached, deposition is stopped for that layer and the feed/hold phase is entered.

Time Setpoint: Sets an arbitrary time, after deposition begins, when the time setpoint relay is activated.
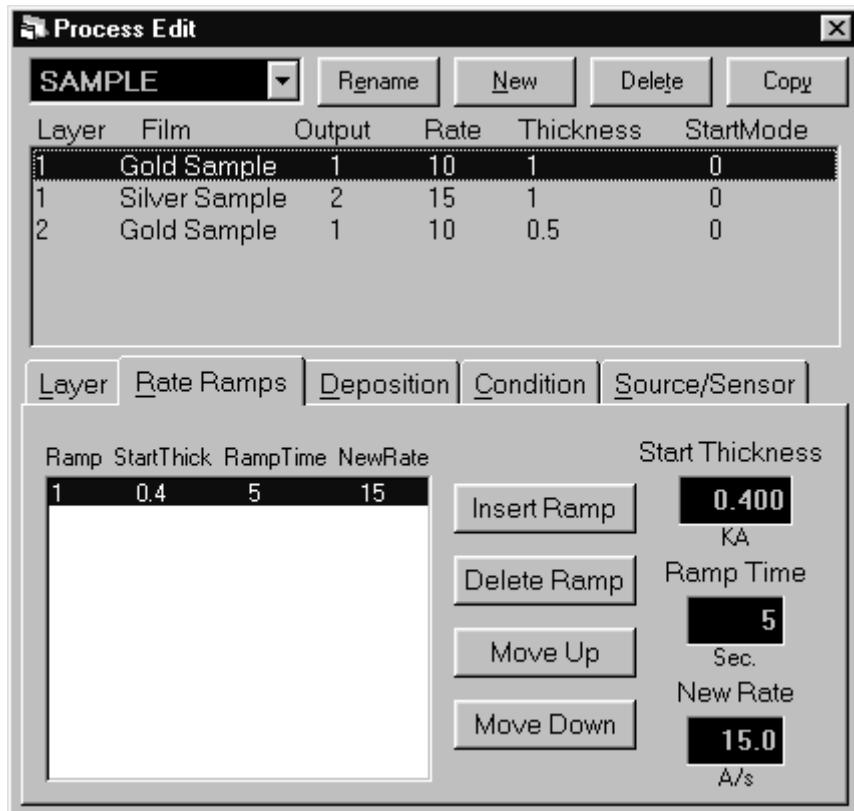
Thickness Limit: Sets an arbitrary thickness when the thickness limit relay is activated.

Auto/Manual Start: Determines whether a layer begins automatically upon completion of the previous layer. If Manual Start is selected, the previous layer ends at its idle power and waits for the user to push the Start Layer switch.

Substrate Index: If using a substrate indexer, assigns the substrate to a specific angle or placement value (0-15). These values are sent to the digital I/O PLC at the beginning of each layer for interfacing to a specific indexer. See System Setup and Digital I/O for other settings that pertain to the substrate index.

Rate Ramps Tab

Rate ramps cause changes to the deposition rate over time under PID control. Each rate ramp has a starting thickness, an elapsed time to ramp to the new rate, and a new rate setpoint. Each process layer can have an unlimited number of rate ramps.

Insert Ramp: Inserts a new rate ramp for the selected layer, at the selected position in the rate ramps list. Existing rate ramps are shifted down.

Delete Ramp: Deletes the selected rate ramp.

Move Up: Shifts the selected rate ramp up one position.

Move Down: Shifts the selected rate ramp down one position.
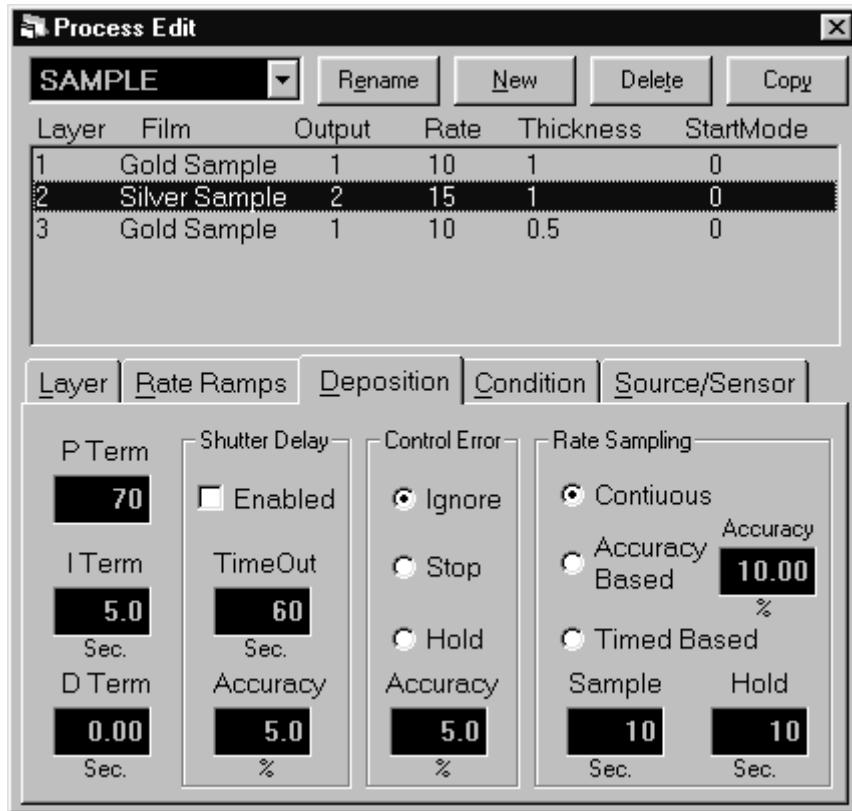
Start Thickness: The thickness that triggers a timed ramp to a new rate. (Start thickness should be greater for each subsequent ramp, and less than the final layer thickness, otherwise the rate ramp is skipped.)

Ramp Time: The time (in seconds) to ramp to the new rate. If the rate ramp is too fast, a PID control error may be generated.

New Rate: The new deposition rate setpoint for the selected layer.

Deposition Tab

The deposition tab contains parameters that directly affect the deposition phase of the process cycle.

P Term: Sets the gain of the control loop. High gains yield more responsive (but potentially unstable) loops. Try a value of 50, then gradually increase/decrease the value to respond to step changes in rate setpoint.

I Term: The integral term controls the time constant of the loop response. A small I term, say .5 to 1 seconds, will smooth the response of most loops.

D Term: The differential term causes the loop to respond quickly to changes. Use 0 or a very small value to avoid oscillations.
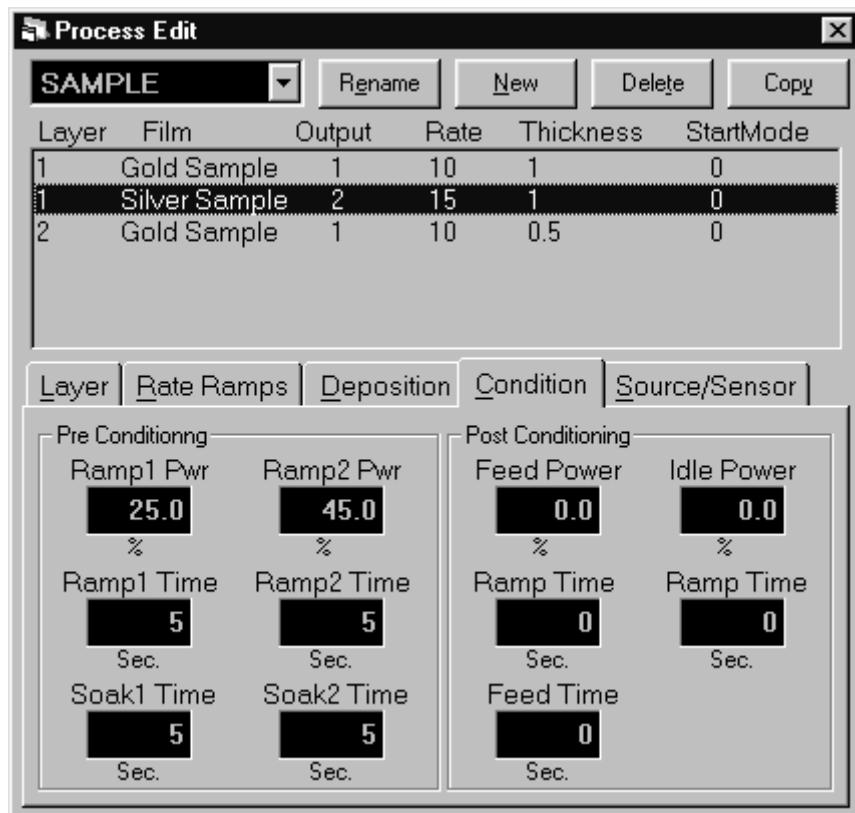
Shutter Delay: It is often desirable to assure stable process control before the substrate shutter opens. Enabling shutter delay requires that the system reach the programmed control accuracy, and maintain that accuracy for 5 seconds, before deposition begins. If the programmed accuracy is not reached, the process halts. If accuracy is reached, the substrate shutter opens and deposition begins once the accuracy has been maintained for 5 seconds. The Thickness reading is zeroed at the end of the shutter delay period. The time out function sets the length of time the system will wait for control before aborting.

Control Error: If the control loop cannot maintain the desired deposition rate, due to loss of source material, excess rate ramps, or equipment malfunction, a control error occurs. The error condition can be ignored, the process stopped (output power to 0%), or the output power held at the same level as when the error occurred. If hold is selected, PID control is abandoned, but the process will continue to be monitored for thickness setpoint. The control error accuracy is the value that must be exceeded for 5 seconds to trigger a control error. Use shutter delay accuracy to assure adequate process control before entering the deposition phase.

Rate Sampling: Rate sampling can extend the life of crystals. With rate sampling, the deposition rate is sampled for a period of time, then the sensor shutter is closed. Power is then held at the same level as the final power setting during the sample period. Continuous selects no sampling; the sensor shutter remains open during deposition. Accuracy Based sampling opens and closes the shutter at the rate required to maintain the desired accuracy during the hold phase. Time Based sampling opens the shutter for a fixed period of time then closes it for a fixed time.

Condition Tab

Before deposition begins, it is often necessary to precondition the source material. This places the system at the proper power level to achieve rapid PID control when deposition begins.

Ramp 1: Ramp power sets the power level that is desired at the end of the ramp phase, in % of full scale. Ramp time sets the time to ramp with a linear rate from the initial power to the Ramp power. Soak time sets the time the output remains at the ramp power level.
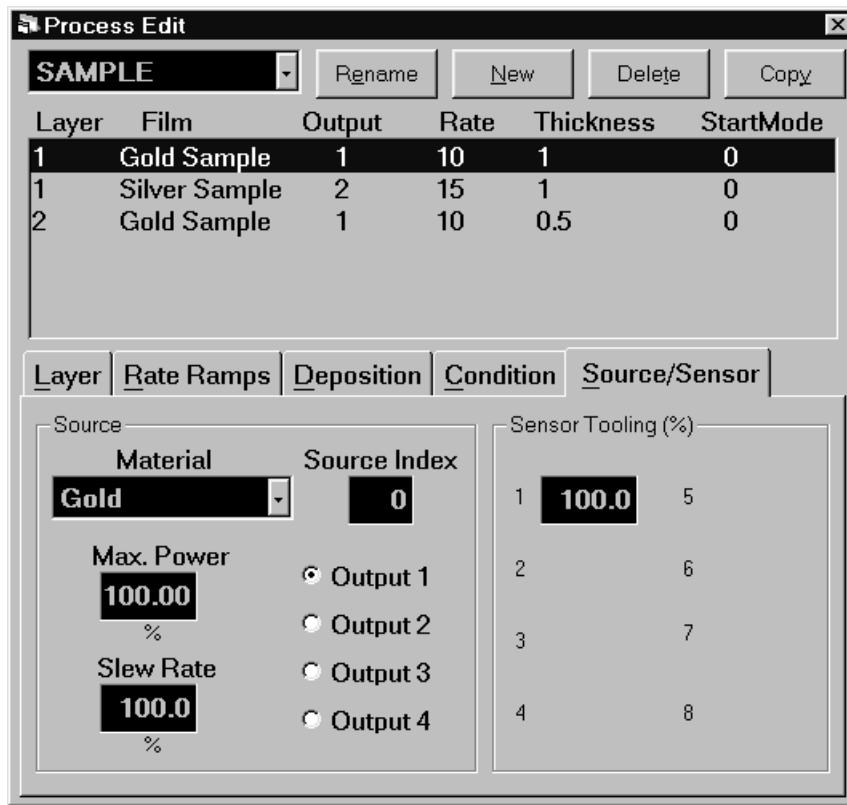
Ramp 2: Ramp 2 functions are the same as Ramp 1. Typically, Ramp 2 power is set near the power level required to match the desired initial deposition rate.

Feed: The feed phase holds output power at the level and time required to wire feed new material.

Idle: The Idle phase ramps the material to a state that is ready for deposition, typically the same as Ramp 2 power.

Source/Sensor Tab

The Source/Sensor tab controls the physical setup of the deposition system.

Material: Selects the physical deposition material

Max Power: The maximum output power allowed for the selected output. The full scale output voltage is a function of the deposition power supply input specifications, and is set in the SQM-242 setup. Max Power controls the maximum % of the full scale power that can be used by this process layer.

Slew Rate: The maximum power change allowed on an output, per second. If rate ramps or PID power requirements exceed this value, an error will occur.

Source Index: If using a source index, assigns each film to a specific pocket (one of 16 values). These values are sent to the PLC at the beginning of each layer. See the System Setup for other settings that pertain to the source index.

Output: Assigns the selected material to one of the source control outputs. When an output is selected, the Sensor Tooling panel changes to show only those sensors that are assigned to that output in the Edit, System dialog. The combination of a source output and its sensor inputs defines the deposition "control loop" for the selected material.
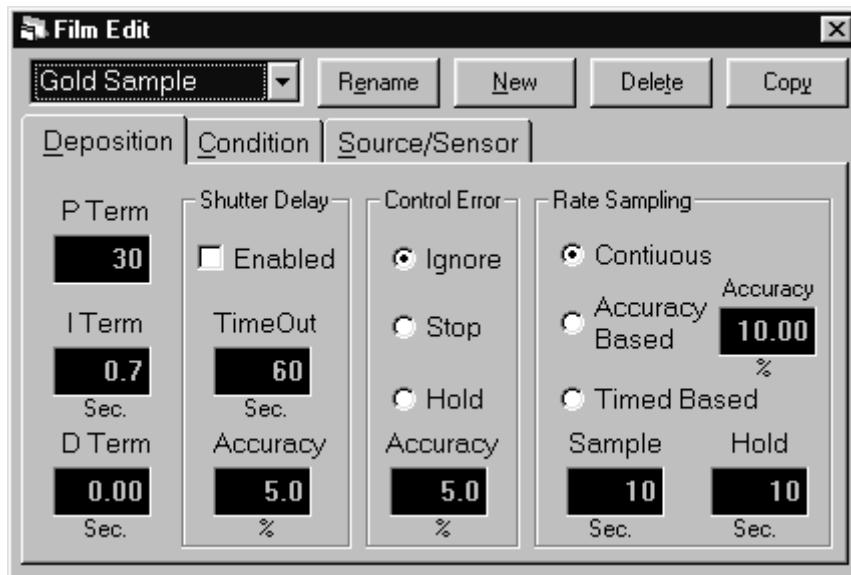
In codeposition, a layer may have multiple films, with each material using a different output and sensor(s) for control. However, no layer can have the same output assigned to more than one film. If you try to assign the same output to multiple films in a layer, an error message will be displayed. Reassigning a film to a different output to eliminate this error may impact other stored processes. If the change would create an output conflict in another process, an error message is displayed.

Sensor Tooling: Adjusts for sensor measured deposition rates that differ from the substrate deposition rate. A higher tooling value yields higher rates. For example, if the sensor sees only 50% of the substrate rate, set the value to 200%. Setting Tooling to 0% causes a sensor to be ignored for this film.

3.4.2 Edit: Films

The Edit Films dialog provides a subset of the functions of the Edit Processes dialog. The functions are those that pertain only to a specific film.

NOTE: Edits to a Film will affect all processes and layers that use that film!

Film: A drop down box that selects the film parameters displayed in the edit film dialog box. Defaults to the current process film.

Rename: Edits the name of the selected film.

New: Creates a new film.

Delete: Deletes the currently selected film from the database. A film cannot be deleted if it is used in ANY database process!

Copy: Creates a duplicate of the currently selected film.

The function of each Edit Films tab, and its associated controls, are identical to those detailed in the Edit Processes section. Please consult 3.4.1 for that information.

3.4.3 Edit: Materials

The Edit Material dialog provides the functions needed to build a materials database. In addition to the functions listed below, the main screen function keys provide capabilities to add/edit/delete materials.

Material: Selects a material to edit.

Density: Sets the density for this material. Material density has a significant impact on deposition calculations.
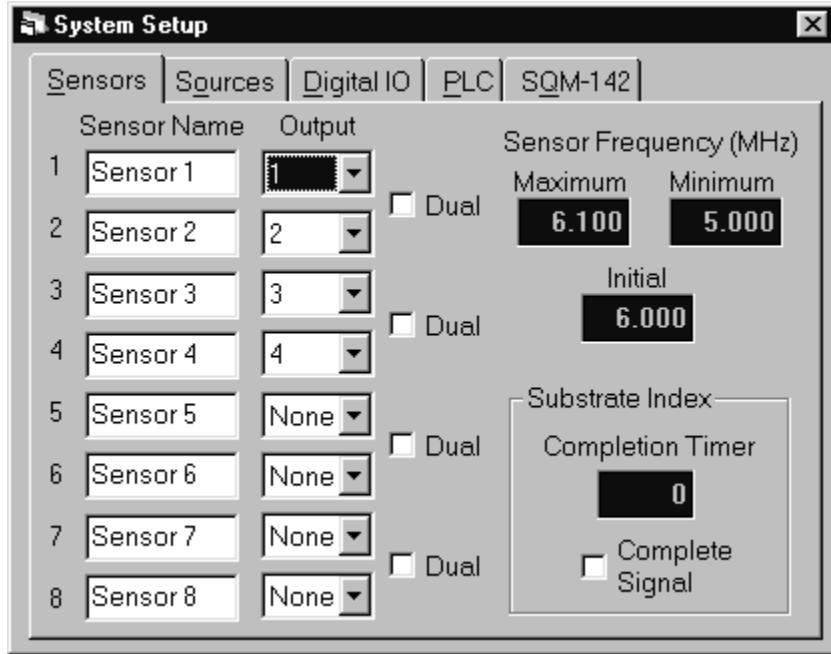
Z-Factor: Sets the Z-factor, an empirically determined measure of a material's effect on quartz crystal frequency change. Z factor has no effect on measurements when using a new crystal. If the Z Factor for your material is not known, using crystals with >80% life will eliminate the Z Factor term.

See the Appendix for a list of standard Material Parameters (Density and Z-Factor).

3.4.4 Edit: System

Sets the operation of system Sensors, Sources, Digital I/O, and SQM-242 measurement card(s).

Sensors Tab

Sensor Name: A meaningful name assigned to sensors 1 to 4 in single card systems; 1 to 8 in two card systems. For clear display, keep the name to less than 8 characters.
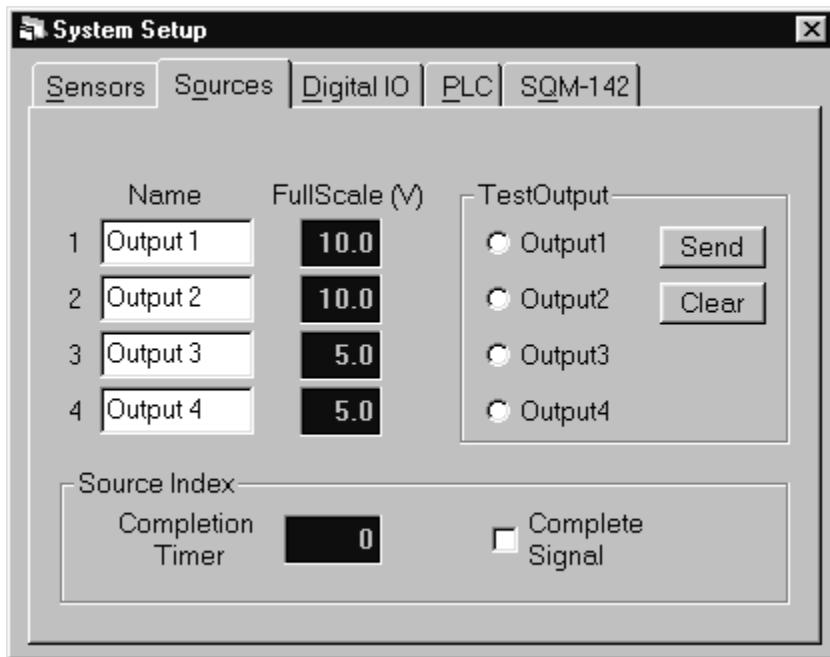
Sensor Output: The source output that a sensor is positioned to measure. Typically each sensor measures deposition from a particular source. If multiple sensors are assigned to a single output, the sensor readings are averaged when calculating rate and thickness. Setting a sensor's Tooling to 0% in Film setup can override this assignment and disable a sensor - see the Sensor Tooling section.

Sensor Dual: Indicates that a pair of sensors is setup as primary/secondary duals. When the primary sensor fails, the SQS-242 switches to the secondary sensor.

Max/Min/Initial Frequency: The frequency values for the quartz crystal sensors used as inputs to the SQM-242. Sensor readings outside the min/max values cause an error.

Completion Timer: If Complete Signal is checked, the process will halt if a move complete signal is not received within this timeout period. If Complete Signal is not checked, the process waits for this fixed time period before starting a layer.

Complete Signal: Check this box if your substrate index sends a signal designating that the move is complete and preconditioning can begin.

Sources Tab
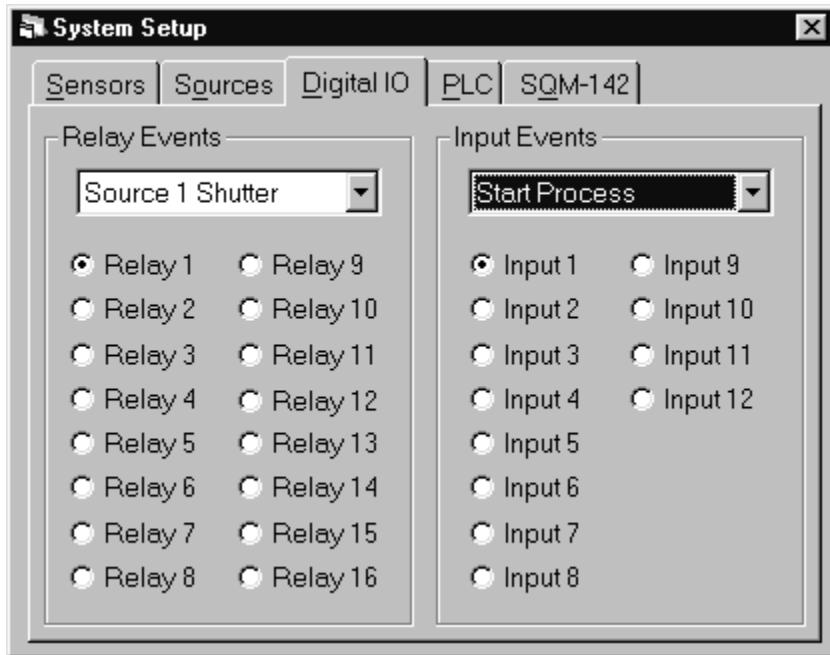
Output Name: A meaningful name assigned to SQM-242 outputs 1 and 2 in single card systems; 1 to 4 in two card systems. For clear display, keep the name to less than 8 characters.

Full Scale: The input voltage required by the deposition source power supply to produce 100% output power. Positive or negative full scale values are possible.

Completion Timer: If Complete Signal is checked, the process will halt if a move complete signal is not received within this timeout period. If Complete Signal is not checked, the process waits for this fixed time period before starting a layer.

Complete Signal: Check this box if your source index sends a signal designating that the move is complete and preconditioning can begin.

Test Output: Useful for testing source wiring and Full Scale voltage settings. Select an output, then click Send to set the SQM-242 card output to its Full Scale voltage. Click Clear to return the selected output to 0 volts.

Digital IO Tab

```
System Setup                                            [X]

 Sensors | Sources | Digital IO | PLC | SQM-142

 ┌─Relay Events──────────────┐  ┌─Input Events──────────────┐
 │ Source 1 Shutter      [▼] │  │ Start Process         [▼] │
 │                           │  │                           │
 │ ⦿ Relay 1   ○ Relay 9    │  │ ⦿ Input 1   ○ Input 9    │
 │ ○ Relay 2   ○ Relay 10   │  │ ○ Input 2   ○ Input 10   │
 │ ○ Relay 3   ○ Relay 11   │  │ ○ Input 3   ○ Input 11   │
 │ ○ Relay 4   ○ Relay 12   │  │ ○ Input 4   ○ Input 12   │
 │ ○ Relay 5   ○ Relay 13   │  │ ○ Input 5                 │
 │ ○ Relay 6   ○ Relay 14   │  │ ○ Input 6                 │
 │ ○ Relay 7   ○ Relay 15   │  │ ○ Input 7                 │
 │ ○ Relay 8   ○ Relay 16   │  │ ○ Input 8                 │
 └───────────────────────────┘  └───────────────────────────┘
```

The SID-242 uses an inexpensive PLC to provide digital I/O capabilities. The Digital I/O tab assigns deposition events (i.e. open shutter, start deposit, final thickness, etc.) to the available relays and inputs on the PLC.

Note: Omron CPM series PLCs number relays from 10.00 to 10.07, then 11.00 to 11.07. These correspond to Relays 1 to 16 on the Digital I/O tab. Similarly, inputs 0.00 to 0.11 on the Omron PLC correspond to inputs 1 to 12 on this screen.

Relay Events: The relay events dropdown box lists the deposition events that can cause a relay output to be activated. To assign a deposition event to a relay, click the Relay #, then select the desired event from the dropdown box. As you click each Relay#, the dropdown will change to show its currently assigned event. A description of each relay (output) event follows:

Source Shutter 1 and 2 (and 3-4 for a Dual Card System)
These 2 relays are used to control the Shutter that covers your deposition source. When you enter the deposit phase, the appropriate relay will close its contacts, which causes the shutter to swing out of the way. When the deposit phase finishes the shutter relay contacts open.

Sensor Relays 1 through 4 (and 5-8 for a Dual Card System)
These 4 relays are used to control sensor shutters. Their function depends on whether you have single or dual sensors.

If Dual Sensor is not selected (i.e. a single sensor), the relay contacts are closed when you are in a layer with the sensor enabled. As an example, let's say you have sensors 1 and 3 enabled for Film 1 and sensors 2 and 4 enabled for Film 2. When you start Film 1, the contacts for Sensor Relays 1 and 3 will close. When you start Film 2, these contacts open and the contacts for Sensor Relays 2 and 4 will close.

If you have the SQS-242 software configured for dual sensors, the operation of these relays is considerably different. Dual sensors use either Sensor Inputs 1 and 2, or Inputs 3 and 4. In this case, only Sensor Shutter Relays 1 and 3 have meaning, Relays 2 and 4 are always open. With the relay contacts open, Sensors 1 and 3 are selected. If a Crystal Fail is detected during the running of a film, the Sensor Shutter Relay's contacts will close for the duration of that film. This selects the second sensor in the Dual Sensor assembly for the remainder of the film.

Xtal All Good and Xtal All Fail Relays
These two relays provide an indication of the general health of your sensors. If the Xtal All Good Relay is closed, then all enabled sensors are returning a valid reading. If the Xtal All Fail Relay is closed, none of the enabled sensors are returning a valid reading.

Process Stopped and Running Relays
These relays indicate the overall status of the process. The Process Running relay closes as soon as Start Process is selected (by front panel or digital input), and opens when Abort Process is selected. Even if a layer is stopped within a process, the Process Running relay remains closed until the last film of a process has finished. The Process Stopped relay contacts behave in the inverse manner.

Process Active
This relay action is similar to the Process Running relay, except it will open if the process is temporarily halted for any reason, e.g. a Manual Start layer.

Layer Stopped and Running Relays
The Layer Running relay closes as soon as Start Layer is selected (by front panel or digital input), and opens when Stop Process is selected. The Layer Stopped relay contacts behave in the inverse manner.

Deposit Phase Relay
This relay indicates that you are in the deposit phase of a film. It is like having the two Source Shutter Relays connected in parallel. If you have shutter delay enabled, this relay will wait until the end of the shutter delay before going active.

Pre-Cond Phase Relay
This relay closes for the preconditioning phases (Ramp1, Soak1, Ramp2, Soak2) of a film.

Soak Hold Phase Relay
This relay closes for the Soak and Hold phases after deposition.

Manual Mode Relay
Closes when the program is placed in Manual mode.

Max Power Relay
Closes when any control voltage output is at the programmed maximum power level.

Thickness Setpoint Relay
This relay will become active when the Thickness Setpoint is reached. This is a programmable process parameter.

Time Setpoint Relay
This relay will become active when the Time Setpoint has been reached. This is measured from the beginning of the deposit phase, and is a programmable parameter.

Input Events: The input events dropdown box lists the deposition events that can be caused by an external digital input. To assign a deposition event to an input, click the Input #, then select the desired event from the dropdown box. As you click each Input#, the dropdown will change to show its currently assigned event. A brief description of each input event follows:

Start Process Input
Triggering this input is the same as pushing the Start Process button.

Abort Process Input
Triggering this input will abort the process.

Start Layer Input
Triggering this input will start or restart the current layer.

Stop Layer Input
Triggering this input will stop the current layer.

Start Next Layer Input
Triggering this input will skip the current layer and start the next layer.
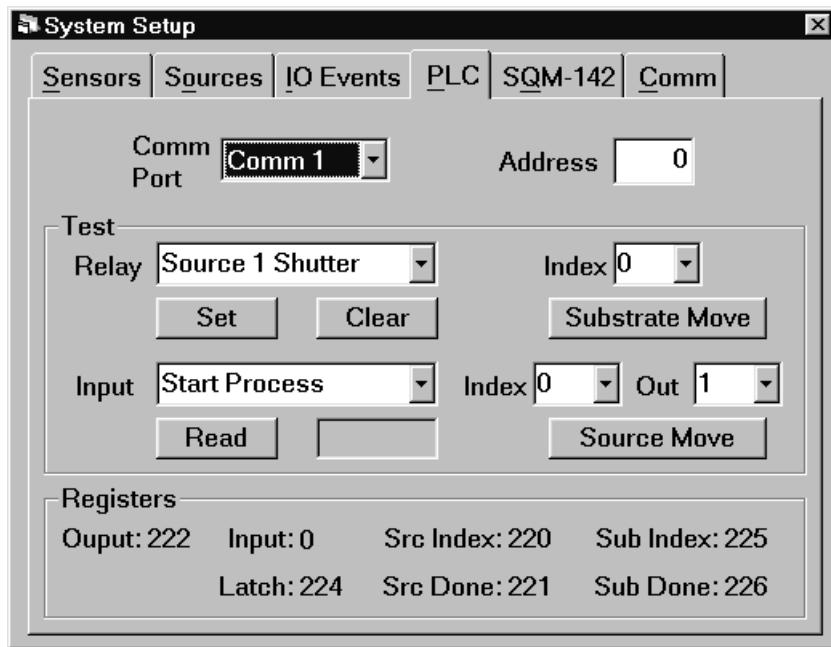
Zero Thickness Input
This will zero the thickness. It is identical to pressing the Zero Button.

Force Final Thickness Input
Triggering this input has the same as effect reaching Final Thickness setpoint.

PLC Tab
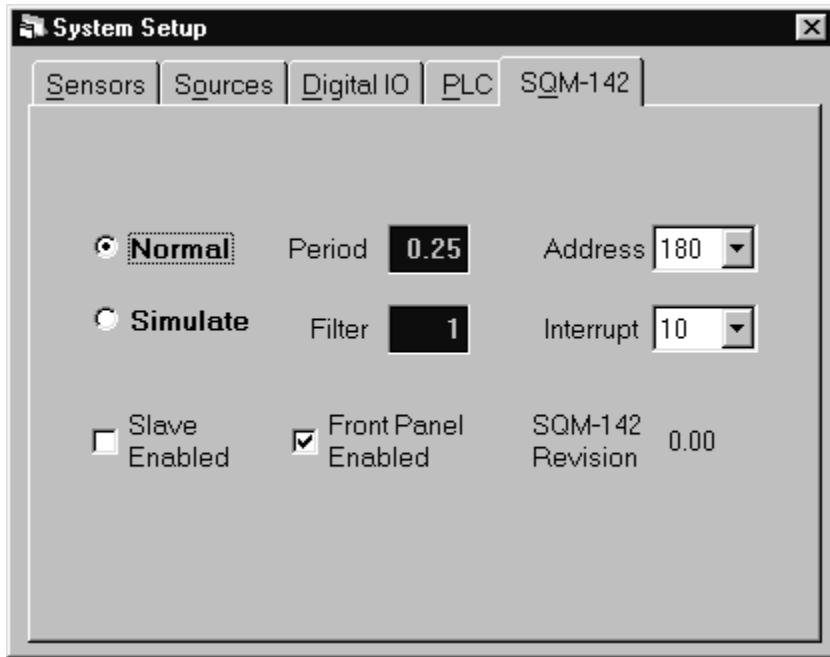
Comm Port: Selects the serial port used to communicate with the PLC. The Comm Port drop down lists the available ports. However, some of the ports may be used by other devices (modem, mouse, etc.). Select Disabled to prevent I/O from using the PLC.

Address: Several PLCs can be controlled from a single computer Comm Port by connecting their expansion ports. The slave address of each such PLC is usually set by a rotary or dip switch, and must be unique. Single PLC systems usually use Address 0. Consult your PLC User Manual.

Test: The Test section provides a simple means of testing your PLC communications and digital I/O wiring. To set a relay on the PLC, go to the Digital I/O tab and find which I/O event is assigned to that relay. On the PLC tab, select the same event in the Test Relay dropdown, then click Set. The assigned Relay# should close. Click Clear to open the relay. Use the Source and Substrate Move sections to test indexers.

To test a digital input, find the Input# that is assigned to an event on the PLC tab. Select the input event in the dropdown, then click Read Input to verify the state of the PLC input.

Registers: The PLC used for I/O runs a small monitor program that transfers relay and input states from the PLC connecting block to internal registers. The SQS-242 software reads/writes to those registers though the PLC's Comm port. The registers shown are those that have been programmed for your PLC. Because their redefinition is not a trivial task, these values cannot be changed in the SQS-242 program. Contact Sigma Instruments if you need to change the internal PLC register definitions.

SQM-242 Tab

Normal/Simulate: In Normal mode, the SQS-242 gets readings from the SQM-242 card(s). In Simulate mode, the SQS-242 generates simulated readings even if a card is not installed. Useful for testing new processes and learning the software.

Note: In Simulate Mode, a deposition rate is not "measured" until the output power exceeds 50%.

Period: Sets the measurement period between .2 seconds (5 readings per second) and 2 seconds. A longer period gives higher reading accuracy, especially at low rates.

Filter: Sets the number of readings used in the reading filter. A low setting gives rapid response to process changes, high settings give smoother graphs.
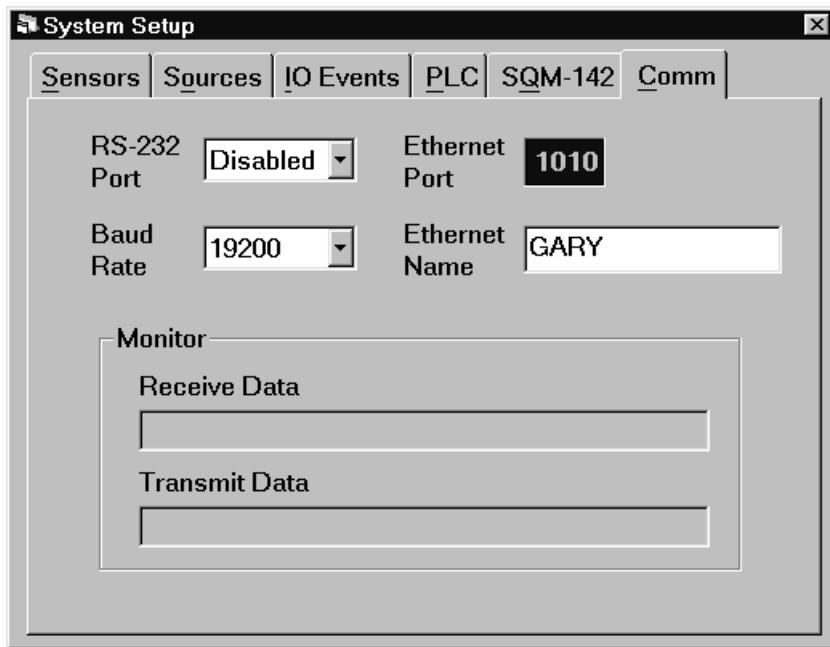
Address: Sets the address of the SQM-242 ISA card in the computer's address space. See the SQM-242 Chapter of this manual for detailed setup instructions.

Interrupt: Sets the interrupt used by the SQM-242 ISA card. See the SQM-242 Chapter of this manual for detailed setup instructions.

Slave Enabled: When a second SQM-242 card is present, it enables/disables sensors 5-8 and outputs 3 and 4.

Front Panel Enabled: When used with the SRC series computer, enables/disables the SQS-242 software to read the SoftKeys and setting knob.

SQM-242 Revision: Firmware revision of the SQM-242 card.

Comm Tab

RS-232 Port: Selects the comm port used for serial communications with another computer. This is NOT the same port used by the PLC for I/O. The Comm Port drop down lists available ports. However, some of the ports may be used by other devices (PLC, modem, mouse, etc.).

Baud Rate: Sets the baud rate used for serial communications.

Ethernet Port: Sets the TCP/IP port used by the SQS-242 software for Ethernet communications, 1001 is a typical value.

Ethernet Name: Sets the name of the external computer the software will be communicating with. The name is either an IP address (xxx.xxx.xxx.xxx) or the Name assigned in the Windows Network setup. It is NOT the name or IP address of the computer the SQS-242 software is installed on.

Receive Data: Displays the Query and Update requests received from the Comm and Ethernet port. See Appendix B for a description of the serial communications protocol.

Transmit Data: Displays the response to Query and Update requests received from the Comm and Ethernet port.

Note: The Monitor section does not show communications with the PLC.

3.4.5 Edit: Security

The Security menu assigns Users, their Password, and their Access Level. It also provides a flexible way to assign program functions to different Access Levels.

Note: The Security dialog is available only to users with Supervisor Access.

Users Tab

User: Drop down used to select an existing user, to edit their Access or Password. It is not possible to edit or add a user name in the User drop down. Use the New SoftKey to create a new User. Use the Delete SoftKey to delete the selected user.

Access: Assigns a program access level to the selected user. Generally speaking, Supervisor (SUPV) provides access to all program functions. Technicians (TECH) have access to a subset of functions. While User level access (USER) has access to only those functions needed to run deposition processes. See the Access Tab section to assign SUPV, TECH, and USER program capabilities.
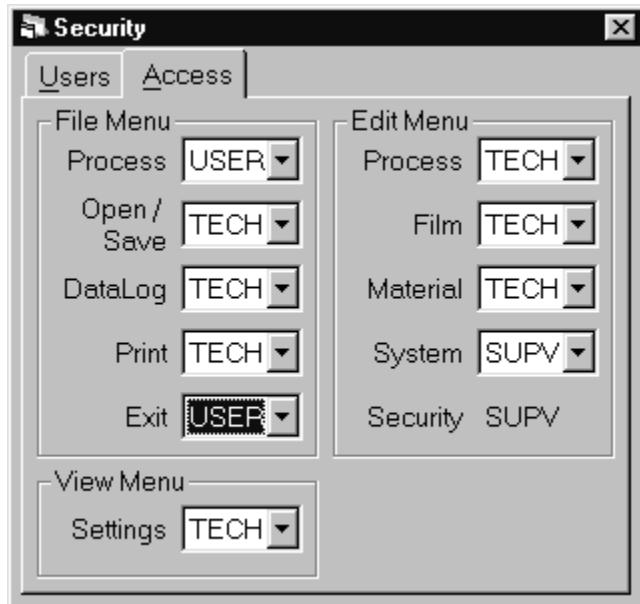
Password: Each user will typically have their own password. When a password is entered, a second box will appear for password confirmation. If the Password box is left blank, no Password is needed for that user to login.

Access Tab

The Access tab allows Supervisors to assign which menu selections are available to each of the three Access Levels. When a program menu is assigned to a particular access level, it is automatically available to higher access levels.

In the example below, every user has access to the File Process menu and the File Exit menu. Only Supervisors have access to the Edit System and Edit Security menus. The remaining menus are assigned TECH access. They will be available to TECH and SUPV users, but not to USER access users.

Those who login with USER access can select and run processes, but they cannot edit process parameters. TECH's can also select and run processes (because those functions are assigned to a lower level access). However, TECH's can also edit process parameters. Only Supervisors can change System Setup or Security assignments.

3.5 <u>View Menu</u>

The view menu controls the appearance of the main display.

Film Settings: Displays/hides a ribbon of commonly accessed process settings along the right of the screen. Additional process parameters are available in the Edit menu. When displayed, the settings ribbon allows the user to easily modify process settings during deposition without leaving the main screen. Changes are made to the current process and the process database immediately. In codeposition, first click on the desired film to display its parameters.

Film Readings: Displays/hides film deposition readings along the bottom of the screen. Readouts of Film, Rate, Deviation, Thickness, and Power are displayed simultaneously for each of the active outputs. The rate, deviation, and thickness readings displayed represent an average of the quartz sensors assigned to each film.

Sensor Readings: Displays/hides a pop up window of sensor rate, thickness, remaining life, and frequency readings. Unlike the main screen's Film Readings, this display is the raw data coming from each sensor. In addition, the output (i.e. PID control loop) that each sensor is assigned to is displayed. Sensor assignments are established in the SQM-242 Setup menu.

Rate Graph: Fixes the main graph to deposition rate. Deposition rate is useful during the shutter delay, rate ramp, and deposition phases. During other phases, the power output graph is usually more useful.

Deviation Graph: Fixes the main graph to display percent deviation from the rate setpoint. Rate deviation is useful for fine tuning the PID control loop.

Power Graph: Fixes the main graph at output power. Output power is directly adjusted during the preconditioning, feed, and hold phases. Output power is also useful during the deposition phases to detect error conditions, which cause oscillations. Be sure the Full Scale voltage is set properly in the SQM-242 Setup menu.

Automatic: Changes the main graph to display the most pertinent information for each deposition phase. During preconditioning, output power is displayed. During shutter delay, rate ramps, and deposition, the main graph displays deposition rate. During feed and hold phases, the graph reverts to output power.

3.6 Software Specifications

Display
  Graphs .... Rate, Deviation, Power
  Readouts... Rate,Dev,Thick,Power

Process Parameters
  Name.. 12 characters
  # Processes .... Unlimited
  # Layers .... Unlimited
  # Sensors (Dual) .... 1 to 8 (4 Dual)
  # Sources .... 1 to 4

Layer Parameters
  Start Mode.. Auto/Manual
  Rate.. 0.0 to 999.9 $\oplus$/sec.
  Thickness .... 0.0 to 999.9 $\oplus$
  Thickness Limit .... 0.0 to 999.9 $\oplus$
  Time Setpoint .... 0 to 30000 sec.
  # Rate Ramps .... Unlimited
  Rate Ramp Start... 0.0 to 999.9 $\oplus$
  Rate Ramp Time .... 0 to 1000 sec.
  New Rate .... 0.0 to 999.9 $\oplus$/sec.
  Substrate Index .... 0 to 15

Film Parameters
  Name.. 12 characters
  Ramp Time (1,2) .... 0 to 30000 sec.
  Soak Power (1,2) .... 0.0 to 100.0 %
  Soak Time (1,2).. 0 to 30000 sec.
  Shutter Delay Time... 0 to 200 sec.
  Shutter Delay Error... 0.0 to 30.0 %
  P Term .... 1 to 9999
  I Term.. 0 to 99.9 sec.
  D Term .... 0 to 99.9 sec.
  Control Error... Ignore/Stop/Hold
  Control Error Set .... 0 to 30.0 %
  Feed Ramp Time... 0 to 30000 sec.
  Feed Power... 0.0 to 100.0 %
  Feed Time .... 0 to 30000 sec.
  Idle Ramp Time... 0 to 30000 sec.
  Idle Power .... 0.0 to 100.0 %
  Tooling (Sensor 1 to 8)... 10.0 to 999.0
  Max Power .... 0.0 to 100.0 %
  Slew Rate.. 0.0 to 100.0 %/sec.
  Source Index (Pocket)... 0 to 15

Material Parameters
Name.. 12 characters
Density .... .0.40 to 99.99 gm/cm^3
Z-Factor... 0.100 to 9.900

Computer Interface
Type RS-232
Protocol .... Text string with checksum

Digital Inputs *(available only with PLC option)*
Start Process..
Stop Process...
Start Layer...
Stop Layer..
Start Next Layer ....
Zero Thickness..
Force Final Thickness ....
Substrate Index Complete
Source Index Complete

Relay Outputs *(available only with PLC option)*
Source Shutter .... 1 to 4
Sensor Shutter .... 1 to 8
All Crystal Fail ....
All Crystal Good ....
Process Running..
Process Stopped..
Process Active ....
Deposit Phase...
Pre-Cond Phase...
Feed/Idle Phase ....
Manual Mode ....
Max Power ....
Thickness Setpoint...
Time Setpoint ....
Final Thickness ....
Substrate Index Select .... 0 to 15
Source Index (Pocket) Select... 0 to 15

Security
User Name .... 16 characters
Password .... 8 characters
Access... 3 levels

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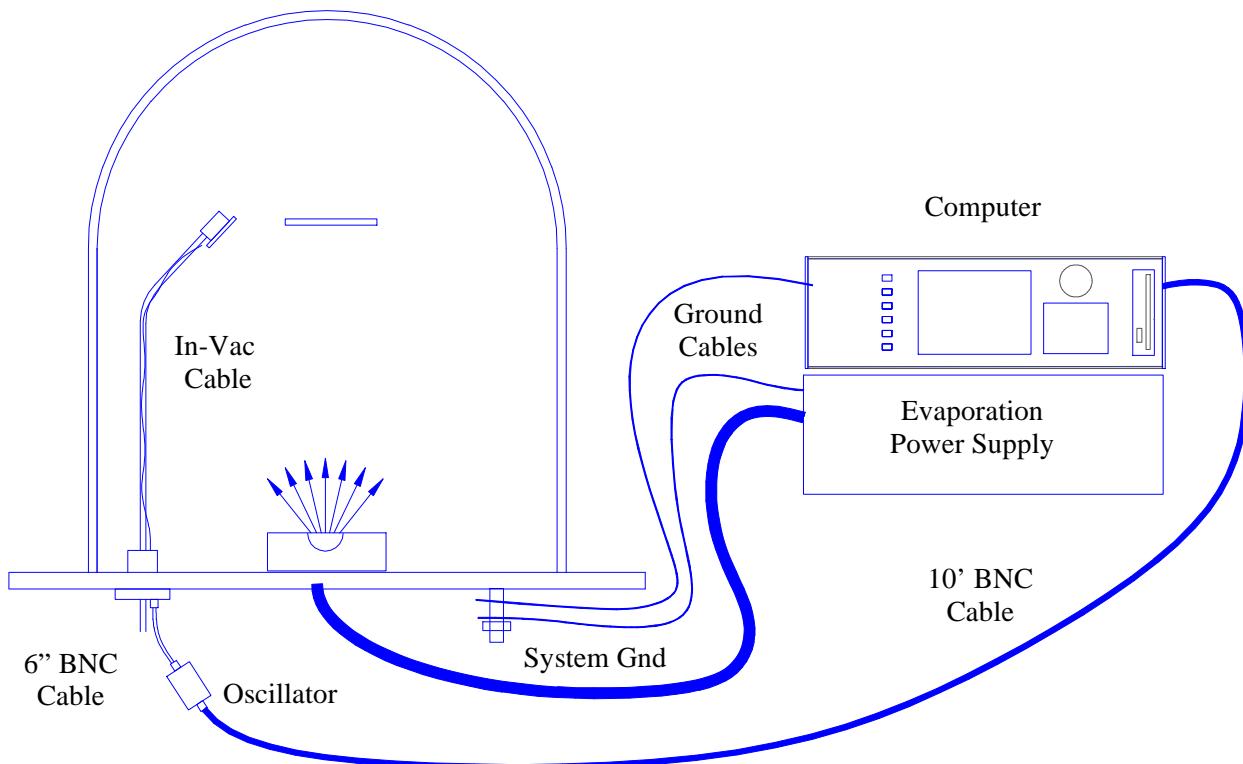
4.0 <u>Introduction</u>

This section covers installation, operation, and programming of the SQM-242 card.

The SQM-242 is a deposition controller on a PC card. Each SQM-242 card has four 1-10MHz quartz sensor inputs, and two 0-10V control outputs. Up to two cards can be installed in a computer.

The diagram below shows a typical single-sensor deposition system. The SQM-242 receives sensor inputs via a BNC cable from each sensor oscillator. It supplies a control voltage to the evaporation power supply (this connection is not shown in this diagram). The SQM-242's internal circuitry measures the sensor inputs, calculates the measured deposition rate against the desired rate, and updates the output voltage based on its PID control loop calculations. The evaporation supply adjusts power to the evaporation source based on the control voltage input.

Visual Basic and LabView demonstration programs allow easy setup and operation. A Windows DLL also provides user-written programs access to SQM-242 setup and readings.

4.1 Installation

4.1.1 PCI Model

Installation of the SQM-242 PCI card requires the driver disk supplied with the card. If the card is the second of two SQM-242 PCI cards, a jumper must also be placed on the bottom two pins of JP5 of the card before installation.

    Driver Installation
        1. Insert the Sigma Instruments Utilities CD-ROM.
        2. In Windows select Start, then Run.
        3. Browse to the \SQM-242 Card\Driver Install folder on the CD-ROM.
        4. Run the Setup program.
    SQM-242 PCI Card Installation
        1. Power down the computer and install the SQM-242 in an available PCI slot.
        2. Power up the computer.
        3. If desired, check Windows Device Manager for proper card installation.

4.1.2 ISA Model

The SQM-242 ISA card uses a hardware interrupt (IRQ) to communicate with the SQS-242 software. Before installation, your computer BIOS and Windows operating system must be configured to accept the SQM-242 ISA card.

Identify an Unused Interrupt	<u>WIN 9X/ME</u>: Open Control Panel, System, Device Manager, Properties.
	<u>WIN NT</u>: Open Administrative Tools, NT Diagnostics , Resources
	<u>WIN 2000</u>: Open Accessories, System Tools , System Info, Hdwe Resources
	Find an unused IRQ. The default SQM-242 setting is IRQ 10.
Set SQM-242 Jumpers	Set JP2 to an available IRQ.
	JP3 sets the I/O address. The default address (180) will work on most systems.
	Note*: A slave card requires no IRQ jumper, and an address 400 above the primary card address. See address settings below:*

Card:

                                                                        Primary
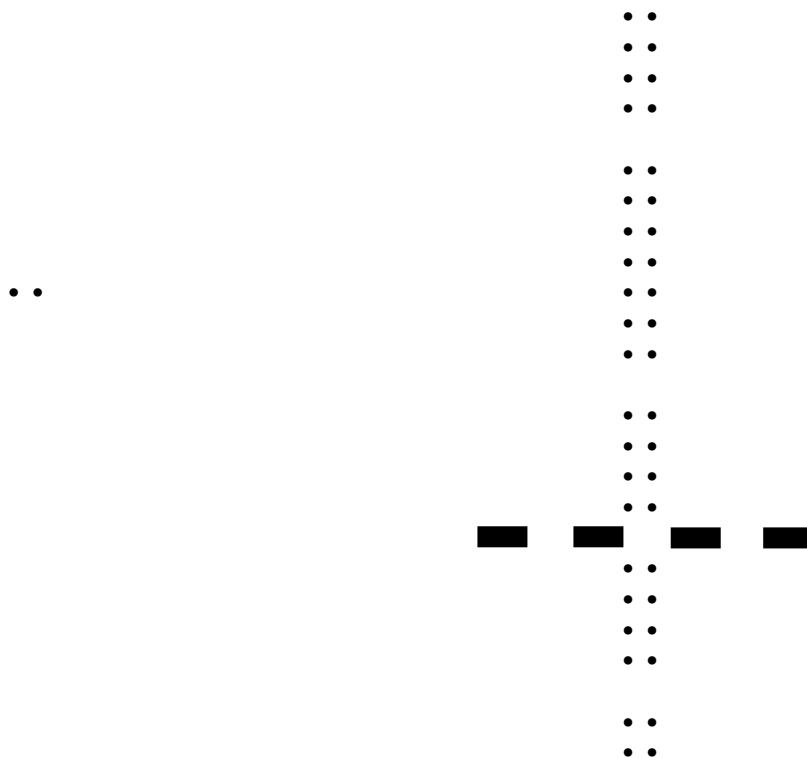
                                                                        Slave
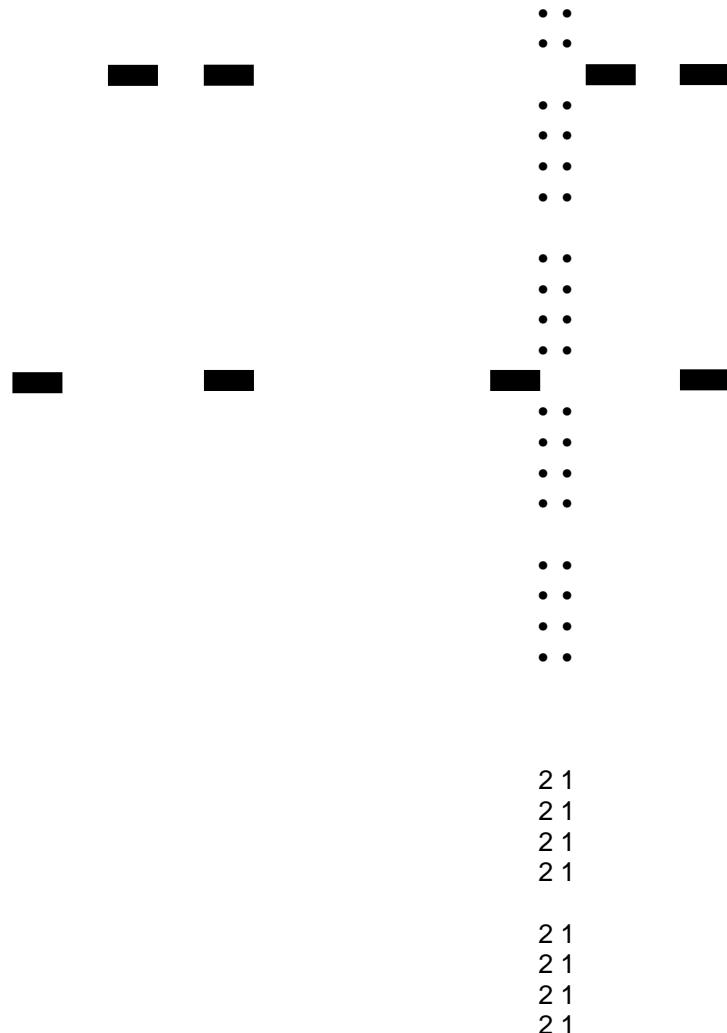
Address:

                                                                        180
140
1C0
220

580
540
5C0
620

JP3:

2 1
2 1
2 1
2 1

2 1
2 1
2 1
2 1

Reserve IRQ in the BIOS

The computer BIOS is usually accessed by pressing a key during startup - consult your computer manual. In the BIOS, reserve the IRQ selected on JP2 of the SQM-242 for an ISA card. Be sure to save changes on exit.

Reserve IRQ in Windows

WIN 9X/ME: Open Control Panel, System, Device Manager, Properties. Select Reserve Resources and reserve the IRQ selected on JP2 of the SQM-242.

WIN NT/2000: An NT Patch program is included on CD-ROM with the SQM-242 card. Follow these three steps for NT/2000 systems:
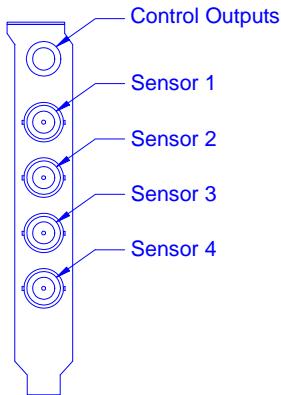
   1. Run the SETUPNT.EXE program.

   2 If IRQ 10 is NOT the selected interrupt, edit the \windows\sqm32swnt.inf file (a standard text file) to the proper interrupt.

   3. Execute the \windows\sqm32swnt.reg file to setup the registry keys.

Install Card

Power down the PC and remove the cover. Insert the card into any available 16 bit (long) ISA slot.
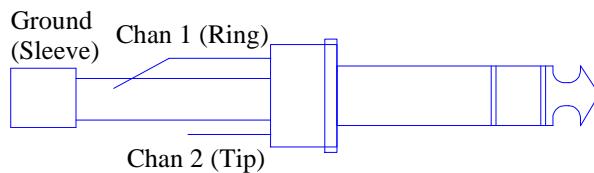
4.2 Sensor Connections

Once the SQM-242 is installed in the PC, connect the cable from the sensor oscillator to the BNC jack on the SQM-242 card. Refer to the drawing in Section 4.0. Avoid running the sensor wires near high voltage or noisy lines.

Control Outputs

Sensor 1

Sensor 2

Sensor 3

Sensor 4

4.3 Power Supply Connection

The connection to your evaporation power supply is done through a 1/4" Stereo Phone Jack on the SQM-242 card. There are 2 control voltages on this connector, as shown in the figure below. The ground is common to both channels. Power supply input connectors vary. Consult your power supply manual.

Ground
(Sleeve)

Chan 1 (Ring)

Chan 2 (Tip)

4.4 Troubleshooting

Defective crystals or improper software setup causes most SQM-242 problems. Follow the procedures below to identify and correct common problems.

4.4.1 No Readings, or Erratic Readings from Sensors:

Disconnect the deposition source supply. This eliminates the possibility that a noisy source, or poor loop tuning, are causing an unstable PID loop. Verify that the sensors, oscillator and cabling are connected as shown in Section 4.0.

Replace the quartz crystal. Crystals sometimes fail unexpectedly, or exhibit erratic frequency shifts before total failure. Depending on the material, crystals may fail well before the typical 5MHz value. If you find that crystals consistently fail early, you may want to set Min Frequency (see below) to a value higher then 5 MHz.

In the SQS-242 software Edit, System menu, assure that Simulate Mode is OFF, and Frequency Min/Max are set properly for your crystals (typically Freq Min=5.0 MHz, Freq Max=6.0 MHz). Some manufacturer's crystals exceed 6MHz when new. Setting Frequency Max to 6.1 Hz will correct that problem, with no effect on measurement accuracy. Assure that the proper sensors are enabled, and assigned to the desired output.

Close the Edit, System menu and select View, Sensors to show sensor frequency and % Life. While <u>not</u> depositing, observe the % Life display for each active sensor. The value should be stable, between 20% and 100%.

<u>If the % Life reading is zero or unstable</u>: Recheck the wiring from the sensor to the SQM-242, and verify that the system is properly grounded. Also check that the crystal is seated properly in the sensor head.

Swap the sensor to another SQM-242 input. If both SQM-242 inputs show zero or unstable readings, the problem is almost certainly a wiring or sensor problem.

<u>If the % Life is less than 50%</u>: Replace the crystal and assure that % Life is near 100%, very stable. If % Life is not near 100%, check the Frequency Min/Max limits.

<u>If the problem is not corrected</u>: Referring to Section 4.0, disconnect the 6" M/F BNC cable from the feedthrough. A test crystal and BNC barrel adapter is supplied with each Sigma oscillator. Attach the barrel adapter and test crystal to the 6" BNC cable as show below.

The Sensor Readings display should show 5.5 MHz, very stable. If not, contact Sigma Instruments technical support.

When a stable frequency reading is achieved with the test oscillator, reconnect the sensor and verify a stable reading.

When stable sensor readings are achieved without deposition, reconnect the source supply. Start the deposition process in Manual mode with 0% output. The % Life readings should remain stable.

Slowly raise the % Output until a rate reading is displayed in Sensor Readings. As material is deposited on the crystal, the % Life reading should remain stable, or drop slowly and consistently. If not, check your source supply for erratic output. Also assure that the sensor is not too close to the source (particularly in sputtering).

4.4.2 Incorrect Rate or Thickness Measurement:

First, complete the procedures in Section 4.4.1 to assure reliable sensor operation.

Set Tooling as described in the Edit Process section of Chapter 3. Incorrect Tooling values will cause consistently low or high rate/thickness values for a material.

Verify that the Material Density and Z-Factor values match those in the Materials Parameters Appendix. If the material is not listed, check a materials handbook. Density has a significant effect on rate/thickness calculations.

Z-Factor corrects for stresses as a crystal is coated. If readings are initially accurate, but deteriorate as crystal life drops below 60-70%, you need to adjust the Z-Factor or replace crystals more frequently. The relationship between Z-Factor and Acoustic Impedance is discussed in the Materials Appendix.

2.8.3 Poor Rate Stability:

First, be sure that a stable rate can be achieved in Manual mode, as explained in Section 4.4.1. Once a stable rate is achieved in Manual mode, follow the Loop Tuning procedures of Section 4.5.

4.5 Demo Programs

The CD-ROM supplied with each SQM-242 contains three demonstration programs:

SQS-242 Demo is a demonstration version of the SQS-242 software described earlier in this manual. It is fully functional with two exceptions: 1) it operates only in Simulate mode, it will not actually take readings from an SQM-242 card; 2) it will not communicate with a PLC for digital I/O.

SQM-242 VB (SQM32.EXE) is a basic deposition control program, complete with Visual Basic source code. Operation of SQM32.EXE is explained in the on-screen tool tips and help file.

SQM-242 LV is a LabView program that demonstrates techniques for communicating with the SQM-242 card using LabView.

4.6 SQM32C.DLL

SQM32C.DLL and VSQM32D.VXD are Windows programs that provide access to all SQM-242 card functions. Both files should be copied to your \WINDOWS\SYSTEM directory.

SQM32C.DLL can be used by C/C++, Visual Basic, and LabView. The CD-ROM that accompanies the SQM-242 contains a text file that gives the syntax for function calls to SQM32C.DLL

4.7 SQM-242 Specifications

Sensor Inputs .... 4 (BNC)
  Input Frequency .... 1 to 10 MHz
  Input Type .... Active Oscillator
  Sample Period... .1 to 2 sec.
  Thickness Resolution*.. .2⊕ @ .25sec.
                                          .025⊕ @ 2sec.
  Thickness Accuracy*... .5% + 1 count

Control Outputs.. 2 (dual phone jack)
  Output Voltage .... 0 to ±10VDC
  Output Resolution... 15 bits
  Output Impedance... 1 Kohm

- Density=1, Z-Factor=1, Sensor Freq.=6MHz

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5.0 <u>Introduction</u>

Digital I/O for the SQS-242 software is handled by an inexpensive Omron CPM2 series PLC. It is not necessary, however, to use external I/O with the SQS-242 software.

There are several benefits to using an inexpensive external PLC for I/O. First, noisy high voltage wiring can be placed near the control sources, rather than routed into the controller's equipment rack. Only a single serial cable runs from the PLC to the controller. The PLC also provides electrical isolation for the process controller. And finally, the PLC's ladder logic programming provides fail-safe process protection and allows I/O to be easily tailored to each end user's installation.

The PLC runs a small ladder logic monitor program that communicates with the SQS-242 software. The ladder logic program transfers relay and input states from the PLC connecting block to internal registers. The SQS-242 software reads/writes to those registers though the PLC's Comm port. If you need to perform logic functions on an I/O event, such as AND, OR, or INVERT, it can be easily accommodated by the PLC's ladder logic program using Omron's CX-Programmer software.

Contact Sigma Instruments for more information on programming your PLC.

5.1 PLC Installation

CAUTION: *The Omron PLC uses a special RS-232 cable as shown below. Do not use a standard serial cable. Damage to the SID-242 or the PLC could result.*

SID-142 Serial Port
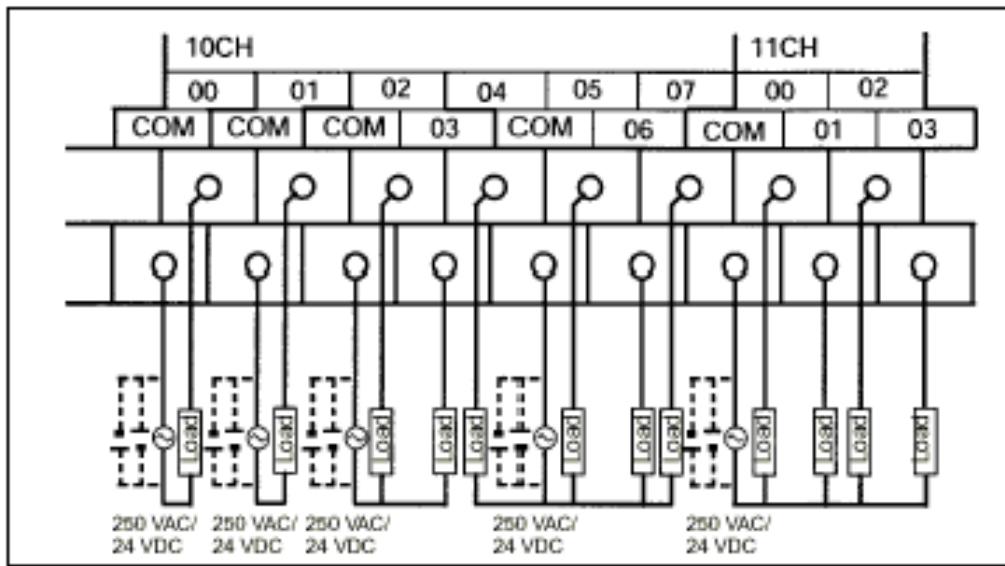
Signal	Pin No.
CD	1
RD	2
SD	3
ER	4
SG	5
DR	6
RS	7
CS	8
CI	9

PLC Port
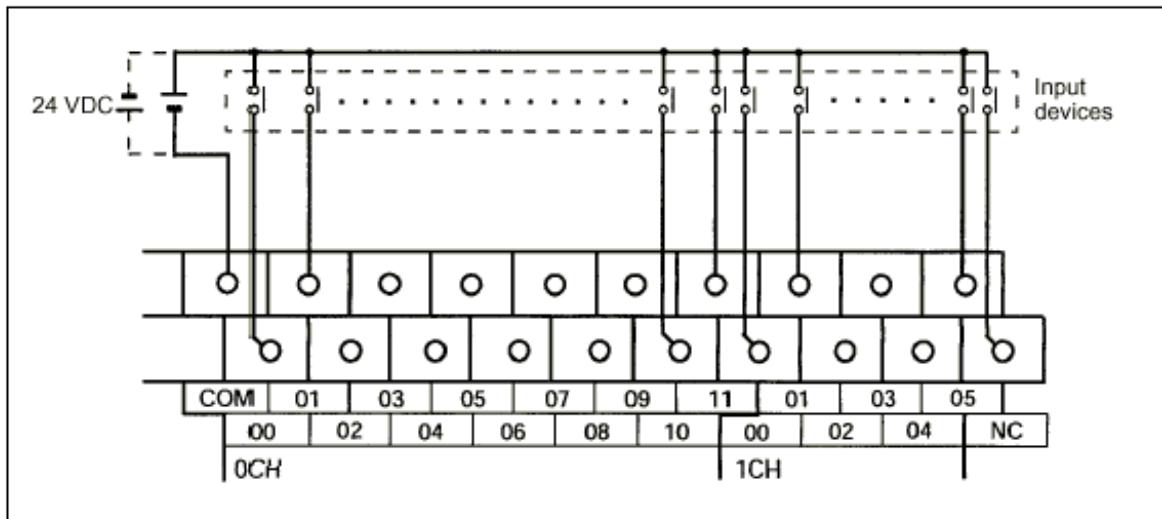
Pin No.	Signal
1/Cover	FG
2	SD
3	RD
4	RS
5	CS
6	--
7	--
8	--
9	SG

Mount the PLC controller near the devices it is controlling and sensing. Connect the PLC to a properly grounded power source. See the PLC User Manual on the SQS-242 CD-ROM for detailed PLC mounting and connection information. Connect the serial cable supplied from the PLC serial port to your computer serial port.

Output Wiring: The 10.00 to 10.07 relays on Omron PLCs correspond to Relay# 1 to 8 in the SQS-242 software. These physical relays are mapped to relay events in the SQS-242 System Setup dialog. Omron PLC output wiring is illustrated below. Notice that some relays (i.e. 02/03 and 04/05/06/07 share a common terminal).

Input Wiring: The 0.0 to 0.11 inputs on Omron PLCs correspond to Input# 1 to 12 in the SQS-242 software. These physical inputs are mapped to input events in the SQS-242 System Setup dialog. Omron PLC input wiring is illustrated below.

```
24 VDC                                                          Input
                                                               devices

        O    O    O    O    O    O    O    O    O    O

          O    O    O    O    O    O    O    O    O    O

        COM  01   03   05   07   09   11   01   03   05
             00   02   04   06   08   10   00   02   04   NC
        0CH                          1CH
```

Other Digital I/O: Depending on the PLC model used, additional I/O pin definitions are available for other I/O function, such as source indexer operation.

PLC Model

                                                   PLC Pins

                                                   SQS-242

Function

900-004-8ER

                                                   Output 11.00-

11.07

                                                   Source Index

1&2, Pockets 1-4.

900-004-30/40   Output 11.00-

11.03

                                                   Source Index 1,

Pockets 1-4

                                                   Input 1.00

                                                   Source Index 1

        Done

900-004-40

                                                   Output 11.04-

11.07

Pockets 1-4   Source Index 2,

                                                           Input 1.01

                                                           Source Index 2
Done

5.2 <u>PLC Setup and Test</u>

In the SQS-242 software select Edit, Setup, then the PLC tab. Set the Address to match the PLC Address. Set the Comm Port to the serial port you are using.

The Test section provides a means of testing your PLC communications and digital I/O wiring. To set a relay on the PLC, go to the Digital I/O tab and find which I/O event is assigned to that relay. On the PLC tab, select the same event in the test dropdown, then click Set. The assigned Relay# should close. Click Clear to open the relay.

To test a digital input, find the Input# that is assigned to an event on the PLC tab. Select the input event in the dropdown, then click Read Input to verify the input state.

To move a source or substrate indexer, select the index (i.e. pocket) to activate, then click the appropriate move button. For source indexers, each indexer will move.

5.3 <u>PLC Programming</u>

The Omron PLC runs a small monitor program that converts RS-232 commands to the physical relay outputs and digital inputs wired to the PLC. Using Omron's CX-Programmer ladder logic software, the PLC monitor program can be modified to provide additional decision and control functions. The functions of the internal PLC registers used by the standard SQS-242 program are shown below. Contact Sigma Instruments for further information.

PLC Register   **SQS-242**
Function
200

                                                           Layer/Phase
Register
                        Bits 0-9 are BCD layer number running
                        Bits 10-15 are BCD Phase# as shown below
                          00   Application Startup   09
        ShutterDelay Phase
                          01   Program Initializing   10
        Deposit Phase

	02	Not Used
11	Layer Stopped	
	03	Not Used
12	Layer Starting	
	04	Process Stopped
13	Not Used	
	05	Ramp1 Phase
14	Feed Ramp Phase	
	06	Soak1 Phase
15	Feed Hold Phase	
	07	Ramp2 Phase
16	Idle Ramp Phase	
	08	Soak2 Phase
17	Idle Phase	

201

Sensors/Outputs Register (updated each layer)

Bits 0-7 are sensors used (1=used, 0=unused)
Bits 12-15 are outputs used, 12 is Out1, 13 is Out2, etc.

220

Source Index Register (updated each layer)

Bits 0-3 are BCD of Ouput1 source index

Bits 4-7 are BCD of Ouput2 source index

Bits 8-11 are BCD of Ouput3 source index

Bits 12-15 are BCD of Ouput4 source index

221

Source Done

Flag (read at start of each layer)

1= Source

Indexer Done, 0=Not Done
222

Outputs 1-16

Bit 0 is Relay 1,

etc.
224

Inputs 1-12

Bit 0 is Input 1,

etc.
225

Substrate Index

used by layer

Bits 0-3 are BCD

of substrate index
226

Substrate Done

Flag (read at start of each layer)

1= Substrate

Indexer Done, 0=Not Done

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6.0 <u>Introduction</u>

The computer interface capabilities of the SQS-242 program allow operation from an external computer via Ethernet or RS-232 serial communications. The active process can be selected, process parameters read or changed, operation controlled, and data collected.

Parameters may be read (Query commands) while the process is running, but can only be changed (Update commands) while the process is stopped. Changes to the "structure" of a process (e.g. add or delete layers) are not allowed from the computer interface.

6.1 <u>Serial Interface</u>

Connect a serial cable from the SID-242 serial port to a computer serial port. The cable required is a DB9 female to female with pins 2 and 3 crossed, commonly referred to as a null modem cable.

In the SQS-242 program select the Edit, System menu, then the Comm tab. Set the Comm Port to match the serial port the cable is connected to on the SID-242. Set the baud rate to match the baud rate of the host computer that will be connected to the SID-242. Communications format is No Parity, 8 bits, 1 stop bit.

6.2 <u>Ethernet Interface</u>

Connect a cable from the Ethernet card to your Ethernet network. In the SQS-242 program select the Edit, System menu, then the Comm tab. Set the Ethernet port to 1001, and the Ethernet name to the Network name, or IP Address of the computer you wish to communicate with.

6.3 SQS-242 Comm Program

SQS-242 Comm, found on the SQS-242 CDROM, is a simple Windows program to demonstrate SQS-242 computer interfacing concepts. With SQS-242 Comm you can easily send commands to, and read the responses returned by, the SQS-242 program. SQS-242 Comm is written in Visual Basic, and the source code is included as an example of programming concepts for computer interfacing.

Make an RS-232 or Ethernet connection from the host computer to the SID-242. Start the SQS-242 program on the SID-242 controller, and setup the RS-232 or Ethernet settings as detailed above. Leave the Edit, System, Comm tab displayed.

Run the Setup program for SQS-242 to install it on the host computer. Start SQS-242 Comm, then select the Utility tab. Set the Comm Port and Baud Rate for the host computer, or select Ethernet and set the Ethernet Port (typically 1001). Click the Version button under the SID-242 Controller heading. Click Send to send the query to the SQS-242 program.

The query string should show in the SQS-242 Monitor Receive Data, and the response in Transmit Data. The response should also show on the SerialComm Response display. The next section describes the Query/Update and Response strings in detail

6.4 <u>Protocol</u>

The SQS-242 program never initiates communications. It only responds to commands from the host computer.

SQS-242 computer Interface commands fall into two general categories. Query commands request data from the SQS-242 program. Update commands instruct the SQS-242 program to take an action. The SQS-242 responds to both Query and Update commands with a response that indicates the results of the command request.

Query Command:
        @<command>;<param1>;…;<paramn>;<Chksum><CR>

Query Example: Software Version Query
        @QU;11;44<CR>

        Description:
        @   Message start character
        ;   Separator
        QU   Query Utility command
        ;   Separator
        11   Parameter 11 (SID242 Software Version)
        ;   Separator
        44   Checksum (see section that follows on checksums)
        <CR>   Carriage Return (ASCII 13)

Response Example: Software Version Query
        @QU;<ACQ>;2.1.6;??<CR>   (Response to
Software Version query)

        Description:
        @;QU;<ACQ>;   Query Acknowledged (ASCII 06)
        2.1.6   Message (Software Version)
        ;   Separator
        0C   Checksum (actual checksum varies with different versions)
        <CR>   Carriage Return (ASCII 13)

Update Command:

  @<command>;<param1>;...;<paramn>;<data>;<Chksum><CR>

Update Example: Set Process

  @UP;11;MyProcess;44<CR>

Description:

@;UP;	Update Process command
;	Separator
01	Parameter 01 (Set Process)
;	Separator
MyProcess	Data
;	Separator
??	Checksum
<CR>	Carriage Return (ASCII 13)

Response Example: Set Process Completed

  @UP;<ACQ>;??<CR>

Response Example: Set Process Failed

  @UP;<NAK>;<ERR>;??<CR>   (Response to
Update Process)

ERR:	01	Illegal Command
	02	Illegal Parameter
	03	Illegal Format
	04	Checksum Error
	05	Request Denied
	06	Unknown Error

Checksum Calculation

  The sample code below calculates the FCS checksum of a string of characters. In the code, Message is a string that has been stripped of terminator and checksum characters before being passed to this routine

```
' XOR ASCII codes
For i = 1 To Len(Message)
    FCS = Asc(Mid$(Message, i, 1)) Xor FCS
Next i

' Convert FCS to two character hex string
If Len(Hex$(FCS)) = 1 Then
    CalcChkSum = "0" & Hex$(FCS)
Else
```

```
CalcChkSum = Hex$(FCS)
```

6.5 <u>Command Summary</u>

<u>Note</u>: Update Queries (except UP02-UP10) are only valid in Stop Mode

Query Process: **@QP;<param1>**
    (Query)

                                       **@QP;O6;Respo
nse**   **(ACK
Response)**

                                       **@QP;21;ErrNu
m**   **(NAK
Response)**
   <param1>
      01   Process Name
                   @QP;01
      (Query Process)
                   @QP;06;MyProc   (Process is
MyProc)
      02   Process Time
                   @QP;02
      (Query Process Time)
                   @QP;06;32:45   (Time is 32 min.,
45 sec.)
      03   Layer
                   @QP;03
      (Query Process Layer)
                   @QP;06;1
      (Layer is Layer 1)
      04   Layer Time
      05   Phase
          (Phase numbers are shown below)
                 00   Application Startup
      09   ShutterDelay Phase
                 01   Program Initializing
      10   Deposit Phase
                 02   Not Used
      11   Layer Stopped

	03	Not Used
12	Layer Starting	
	04	Process Stopped
13	Not Used	
	05	Ramp1 Phase
14	Feed Ramp Phase	
	06	Soak1 Phase
15	Feed Hold Phase	
	07	Ramp2 Phase
16	Idle Ramp Phase	
	08	Soak2 Phase
17	Idle Phase	

06   Phase Time
07   Run #
08   All Process Names (returns comma delimited list)
1n   Source Shutter, n=1 to 4
(0=Open, 1 =Close)

                @QP;12
(Query Source Shutter 2)
                @QP;06;0
(Source Shutter 2 is Open)

2n   Sensor Shutter, n=1 to 8
(0=Open, 1 =Close)
30   All Crystal Good
         (0=False, 1=True)
3n   Crystal n Good, n=1 to 8
(0=False, 1 =True)
39   All Crystal Fail
         (0=False, 1=True)

Update Process:
     @UP;<param1>;<data>   **(Update)**

                                              **@UP;O6;Respo
nse**   **(ACK
Response)**

                                              **@UP;21;ErrNu
m**

(NAK

Response)

  <param1>

    01   Set Process

                                          @UP;01;MyProc

    (Select MyProc)

                                          @UP;06;

    02   Start Process

                                          @UP;02

                                          @UP;06

    03   Stop Process
    04   Start Layer
    05   Stop Layer
    06   Start Next layer
    07   Auto Mode
    08   Manual Mode
    09   Zero Thickness
    10   Force Final Thickness
    2n   Output n Power (Manual Mode Only)

                                          @UP;21;50

    (Set Output 1 to 50%)

Query/Update Layer:

    @QL;<param1>;<layer>;<output>

                              @UL<param1>;<layer>;<output>;<value>

  <param1>

    01   Film Name   (Example: Set
Layer 1, Output 1 film to My Film)

    @UL;01;1;1;MyFilm
    02   Material
    03   Start Rate (A/s)
    04   Start Thickness (kA)
    05   Time SP (mm:ss)
    06   Thickness SP (kA)
    07   Start Mode (0/1)
    08   Substrate Index (0 to 15)
    1n   Ramp n Start Thickness (n=1 to 9)
    2n   Ramp n Ramp Time (n=1 to 9)
    3n   Ramp n New Rate (n=1 to 9)

Query/Update Film:

    @QF;<param1>;<layer>;<output>

@UF;<param1>;<layer>;<output>;<value>
<param1>

01	P Term
02	I Term
03	D Term
04	Shutter Delay Status (0/1)
05	Shutter Timeout
06	Shutter Accuracy
07	Control Error Status (0/1/2)
08	Control Error Accuracy
09	Rate Sampling Status (0/1/2)
10	Sample Accuracy
11	Sample Time
12	Sample Hold
13	Ramp 1 Power
14	Ramp 1 Time
15	Soak 1 Time
16	Ramp 2 Power
17	Ramp 2 Time
18	Soak 2 Time
19	Feed Power
20	Feed Ramp Time
21	Feed Time
22	Idle Power
23	Idle Ramp Time
24	Output (1-4)
25	Source Index
26	Max Power
27	Slew Rate
28	Material
3n	Tooling n (n=1 to 8)

Query Measurement: **@QM;<param1>**

1n	Output n Power (n=1 to 4)
2n	Output n Rate
3n	Output n Thickness
4n	Output n Deviation
5n	Sensor n Rate (n=1 to 8)
6n	Sensor n Thickness
7n	Sensor n Frequency
8n	Sensor n % Life

Query Utility: **@QU;<param1>**

01	SQM242 Version
02	SQM242 Mode (0/1)
03	SQM242 Period
04	SQM242 Filter
05	SQM242 Slave Enabled (0/1)
06	Front Panel Enabled (0/1)
11	SID242 Software Version
12	SID242 Operating System
13	SID-242 Computer Name

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A. <u>Material Parameters</u>

Material	Density	ZFactor	Material	Density	ZFactor
Aluminum	2.73	1.08	Magnesium Fluoride	3	1
Aluminum Oxide	3.97	1	Manganese	7.2	0.377
Antimony	6.62	0.768	Manganese Sulfide	3.99	0.94
Arsenic	5.73	0.966	Mercury	13.46	0.74
Barium	3.5	2.1	Molybdenum	10.2	0.257
Beryllium	1.85	0.543	Neodymium Fluoride	6.506	1
Bismuth	9.8	0.79	Neodymium Oxide	7.24	1
Bismuth Oxide	8.9	1	Nickel	8.91	0.331
Boron	2.54	0.389	Niobium	8.57	0.493
Cadmium	8.64	0.682	Niobium Oxide	4.47	1
Cadmium Selenium	5.81	1	Palladium	12	0.357
Cadmium Sulfide	4.83	1.02	Platinum	21.4	0.245
Cadmium Teluridium	5.85	0.98	Potassium Chloride	1.98	2.05
Calcium	1.55	2.62	Rhenium	21.04	0.15
Calcium Fluoride	3.18	0.775	Rhodium	12.41	0.21
Carbon Diamond	3.52	0.22	Samarium	7.54	0.89
Carbon Graphite	2.25	3.26	Scandium	3	0.91
Cerium Fluoride	6.16	1	Selenium	4.82	0.864
Cerium Oxide	7.13	1	Silicon	2.32	0.712
Chromium	7.2	0.305	Silicon Dioxide	2.2	1.07
Chromium Oxide	5.21	1	Silicon Oxide	2.13	0.87
Cobalt	8.71	0.343	Silver	10.5	0.529
Copper	8.93	0.437	Silver Bromide	6.47	1.18
Copper Sulfide	4.6	0.82	Silver Chloride	5.56	1.32
Copper Sulfide B	5.8	0.67	Sodium	0.97	4.8
Copper Sulfide A	5.6	0.69	Sodium Chloride	2.17	1.57
Dysprosium	8.54	0.6	Sulfur	2.07	2.29
Erbium	9.05	0.74	Tantalum	16.6	0.262
Gadolinium	7.89	0.67	Tantalum Oxide	8.2	0.3
Gallium	5.93	0.593	Tellurium	6.25	0.9
Gallium Arsenide	5.31	1.59	Terbium	8.27	0.66
Germanium	5.35	0.516	Thallium	11.85	1.55
Gold	19.3	.381	Thorium Fluoride	6.32	1
Hafnium	13.1	0.36	Tin	7.3	0.724
Hafnium Oxide	9.63	1	Titanium	4.5	0.628
Holnium	8.8	0.58	Titanium Oxide	4.9	1
Indium	7.3	0.841	Titanium Oxide IV	4.26	0.4
Indium Intimnide	5.76	0.769	Tungsten	19.3	0.163
Indium Oxide	7.18	1	Tungsten Carbide	15.6	0.151
Iridium	22.4	0.129	Uranium	18.7	0.238
Iron	7.86	0.349	Vanadium	5.96	0.53
Lanthanum	6.17	0.92	Ytterbium	6.98	1.13
Lanthanum Fluoride	5.94	1	Yttrium	4.34	0.835
Lanthanum Oxide	6.51	1	Yttrium Oxide	5.01	1
Lead	11.3	1.13	Zinc	7.04	0.514
Lead Sulfide	7.5	0.566	Zinc Oxide	5.61	0.556
Lithium	0.53	5.9	Zinc Selenide	5.26	0.722
Lithium Fluoride	2.64	0.774	Zinc Sulfide	4.09	0.775
Magnesium	1.74	1.61	Zirconium Oxide	5.6	1.001

Appendix
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Z-Factor is used to match the acoustic properties of the material being deposited to the acoustic properties of the base quartz material of the sensor crystal. Z-Factor is the ratio of the acoustic impedance of the sensor to that of the deposited material.

If you know the acoustic impedance of your material, it is easy to calculate the Z-Factor. The sensor is basically silicon dioxide, and has an acoustic impedance of 8.83. For example, Gold has an acoustic impedance of 23.18, so:

Gold ZFactor = 8.83/23.18 = .381