MONITOR Version 2.52

FILM★STAR

for Microsoft Windows

Advanced Optical Thin Film Technology from

FTG Software Associates

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User Guide

Getting Started

FilmStar MONITOR converts thin film designs into practical optical monitor settings. Manual monitors are supported with user-configurable coating run-sheets. Support for automatic monitors includes Eddy LMC-10, Balzers GSM-420, Leybold Leycom IV and SYRUSPro, Intellemetrics and Cutting Edge Coatings. A simplified mode creates crystal monitoring run-sheets.

MONITOR is used in conjunction with FilmStar DESIGN and INDEX and is normally installed on the same computer. It may, however, be installed on a separate computer (not recommended). MONITOR is a complex program with numerous options. This is unavoidable due to the wide variety of monitoring techniques utilized in actual practice.

Installation

FilmStar requires a PC running Microsoft Windows. A password is required. Windows XP/Vista/7-10 users need Administrator privileges. Setup will not overwrite previous data files.

Complete installation as well as update files can be found at

https://www.ftgsoftware.com/updates.htm

Please visit this page often to keep your software up-to-date. If you have initial problems installing or running the software your solution may be already be at the Technical Issues page

https://www.ftgsoftware.com/issues.htm

A MONITOR-enabled Security ID Module must be attached to the parallel or USB port. Using codes supplied by e-mail, modules can be remotely upgraded.

> *When installing with USB ID Module for the first time, DO NOT plug in the module until installation is completed! Windows will automatically locate the new device.*

FilmStar provides an extensive set of Help screens. Press **<F1>** from any menu item or dialog box for context-sensitive help. The help system is identical to this manual's Reference section.
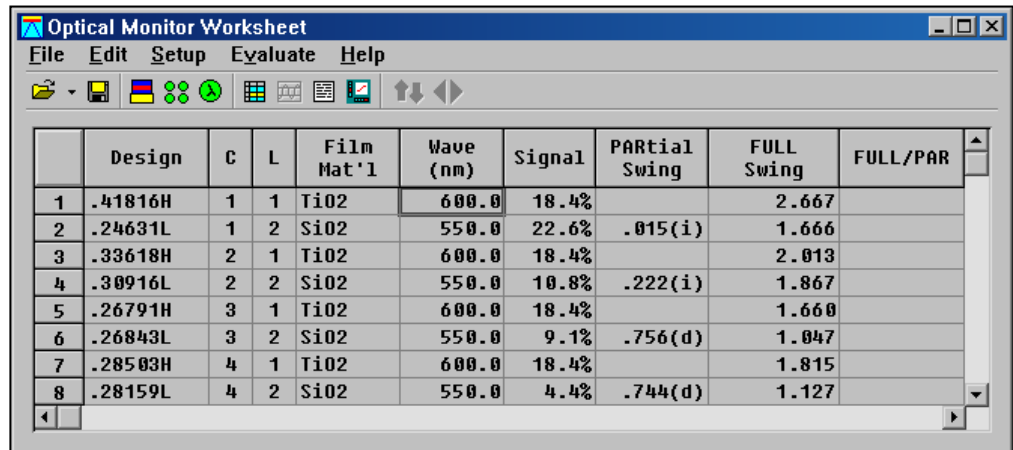
Tutorial

Introduction

FilmStar MONITOR converts thin film designs into optical monitor settings. It is intended for typical single wavelength reflection or transmission monitors such as those manufactured by Balzers, Eddy, Leybold, and Intellemetrics. Output includes printed run-sheets with graphical strip-chart simulation. Eddy LMC settings can be uploaded via the serial port. In other cases files are exported to the manufacturer's control software. FTG also offers FilmStar CRYSTAL for Inficon IC/5 deposition controllers.

A widely accepted approach utilizes reflectance or transmittance *ratios* rather than absolute values. Because these ratios are nearly independent of angle of incidence for 0-30°, calculations can be performed at normal incidence. FilmStar uses a combination of the matrix method and Rouard's method, which replaces a film stack with an effective Fresnel coefficient.

Starting MONITOR

Start MONITOR from **Start…Programs** or click the desktop icon. You should eventually see a screen similar to the one below. (If there are no entries in the *Wave* column assign defaults with **Setup...Wavelengths <Ctrl+A>**.)

Optical Monitor Worksheet

File   Edit   Setup   Evaluate   Help

	Design	C	L	Film Mat'l	Wave (nm)	Signal	PARtial Swing	FULL Swing	FULL/PAR
1	.41816H	1	1	TiO2	600.0	18.4%		2.667	
2	.24631L	1	2	SiO2	550.0	22.6%	.015(i)	1.666	
3	.33618H	2	1	TiO2	600.0	18.4%		2.013	
4	.30916L	2	2	SiO2	550.0	10.8%	.222(i)	1.867	
5	.26791H	3	1	TiO2	600.0	18.4%		1.660	
6	.26843L	3	2	SiO2	550.0	9.1%	.756(d)	1.047	
7	.28503H	4	1	TiO2	600.0	18.4%		1.815	
8	.28159L	4	2	SiO2	550.0	4.4%	.744(d)	1.127	

Inactive worksheet loaded from disk or pasted from clipboard

The worksheet (see page 37) provides means to assign monitor wavelengths for each layer on a chip. When loaded from disk, the worksheet is inactive. Click the Recalculate Worksheet icon or **Evaluate...Recalculate All <Ctrl+R>** and adjust Worksheet Calculation Options as shown below..
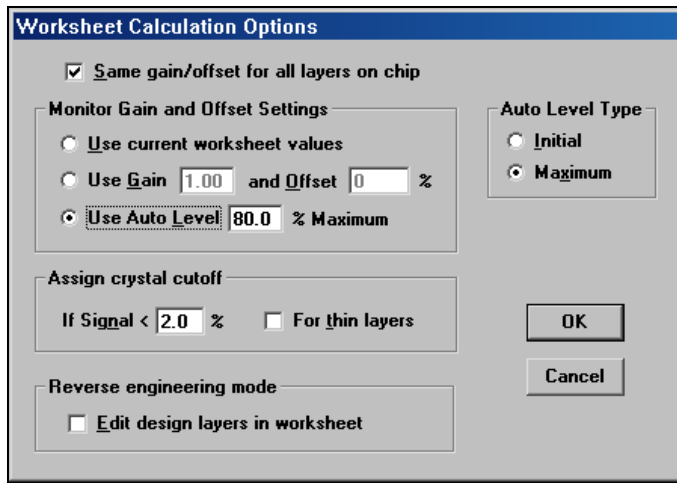
The worksheet re-appears with odd and even chips delineated with cyan and yellow background. The worksheet is now active (connected to its underlying data) and wavelengths can be edited. The Worksheet Options box can be activated without recalculation via **Evaluate…Calculation Options <Ctrl+O>**.

Active worksheet allowing wavelength changes

Click **Evaluate...Strip Chart <F8>** to view the Strip-Chart Simulation window. The red worksheet 'warning' cell color emphasizes that monitor wavelengths are not well chosen. While signal is adequate for both layers, selectivity is poor because both layers are near quarter wave peaks. In most cases we prefer to cut layers on the flat sloping part of the curve.
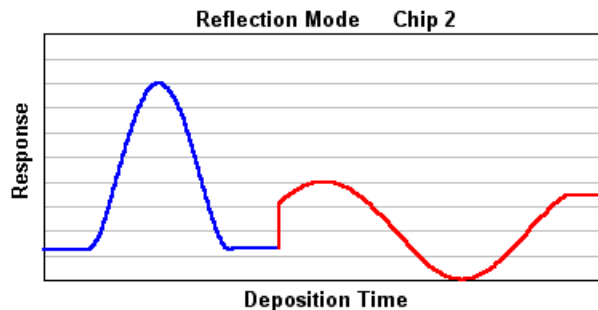
Return to the worksheet by clicking on it (or typing **<Ctrl+W>)** and change the wavelength of design layer 3 (Chip 2/Layer 1) to 550 and design layer 4 (C2/L2) to 460. Wavelength values can be typed or incremented with **Edit…Decrease <F4>**

and **Edit…Increase <F5>**. Most conveniently, wavelengths can also be changed in the strip-chart by clicking at the right and left of the plot or using **<F4>** and **<F5>**. (Adjust the magnitude of change in **Edit…Increment**.) Similarly, witness chips can be navigated by clicking at the top and bottom of the plot or using **<PgUp>** and **<PgDn>**.
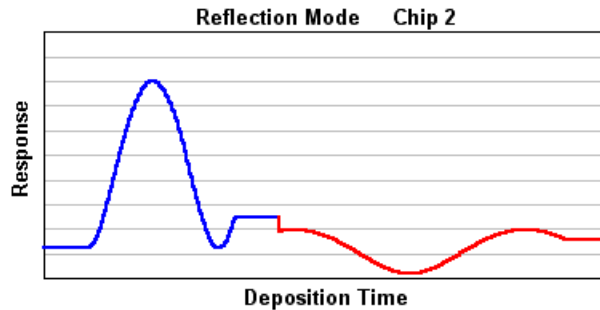
While design layer 4 (C2/L2) has good selectivity, a higher gain setting will be beneficial. Click **Edit…Options <Ctrl+O>** to bring up Worksheet Calculation Options (no need to leave the strip-chart dialog!) and uncheck *Same gain/offset for all layers* to enable variable gain settings (different values for different layers on a chip) and note that *Use current worksheet values* option is now enabled. Finally, change *Auto Level Type* to Initial.
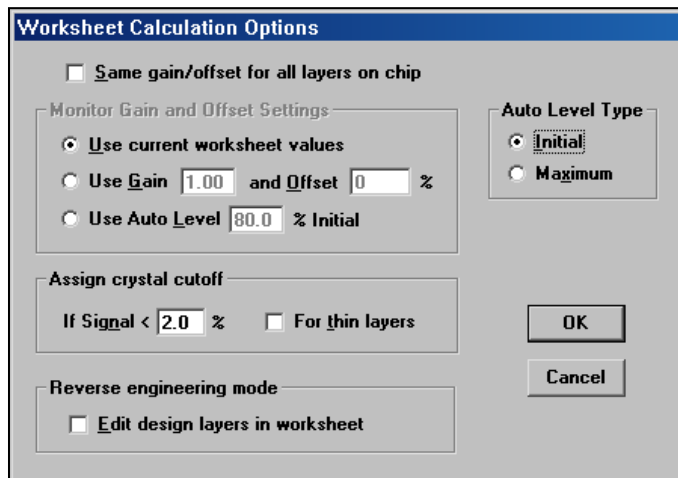
Return to the chart with **<F8>** and select **Setup...Single Layer <Ctrl+L>**. Press **<PgUp>** or **<PgDn>** to arrive at C2/L2. **Edit...Gain <Ctrl+G>** brings up the Monitor Gain dialog. Enter *Initial Level=60*,click **Set** to calculate gain/offset, and click **OK** to replot the curve.

You should now see the following:
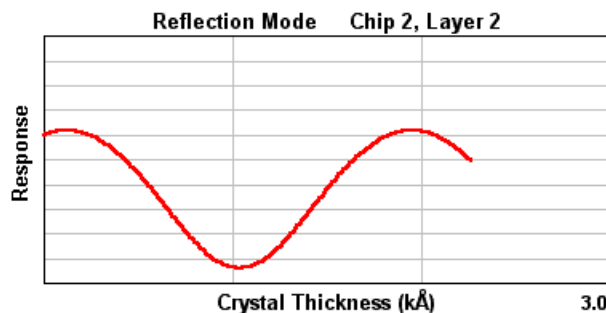
Return to the chart and click **Setup…All Layers <Ctrl+A>**. The following graph appears:
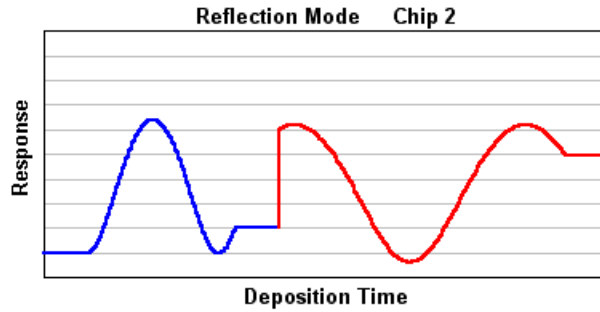
Let's assume that we've cycled through the entire design and are satisfied with selected wavelengths. We now need to create a coating run-sheet document for use in the coating shop. Click **Evaluate...Run Sheet <Ctrl+S>** to convert the worksheet into a printable and editable document. Later you can edit the worksheet's template and modify the document for the particular requirements of your coating department.
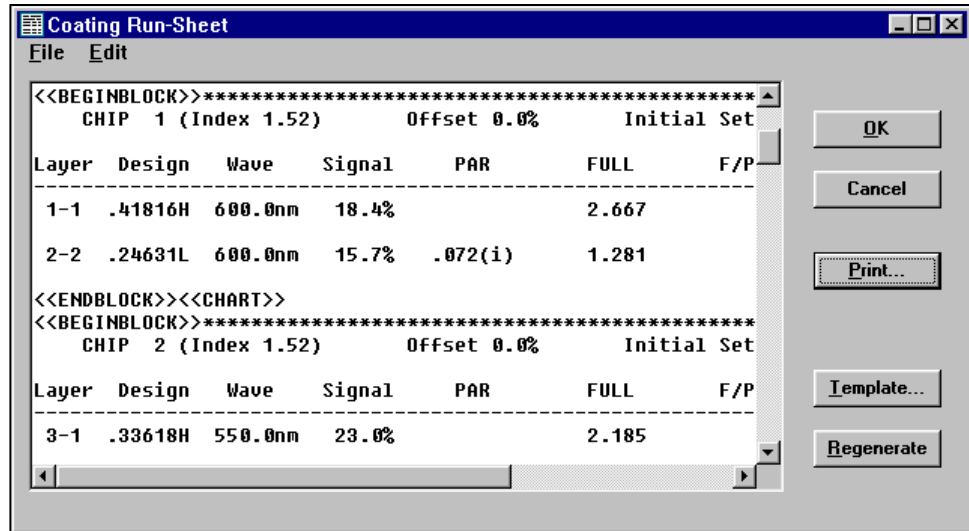
Click Print to preview and print the run-sheet. Notice how strip-chart images are automatically incorporated into the document.
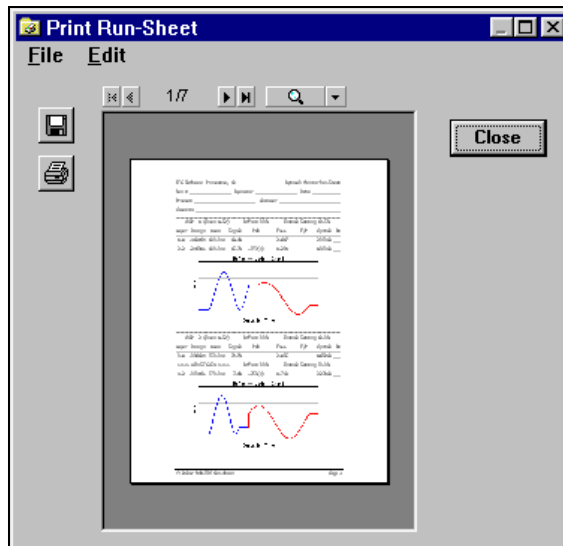
Evaluating a New Design

When starting with a new design the following sequence is recommended:

1. Assign film indices.
2. Enter or edit calculation parameters.
3. Load, paste or edit a thin film design.
4. Configure witness chips.
5. Assign default monitor wavelengths, calculate an initial worksheet.
6. Interactively select optimum monitor wavelengths.
7. Print the final coating run-sheet

Click **Setup...Film Indices <Ctrl+I>** to access the Film Indices editor. As in DESIGN, enter index symbols (A-Z) in the **Symbol** column. There are three index types: *Opt* (optical), *Mtl* (metallic) and *Phs* (physical). *Mtl* slows calculations considerably and should only be selected if the material is a metal *Design* indices refer to values in the thin film design. *Monitor* indices refer to values achieved on the monitor witness chip *during* deposition.
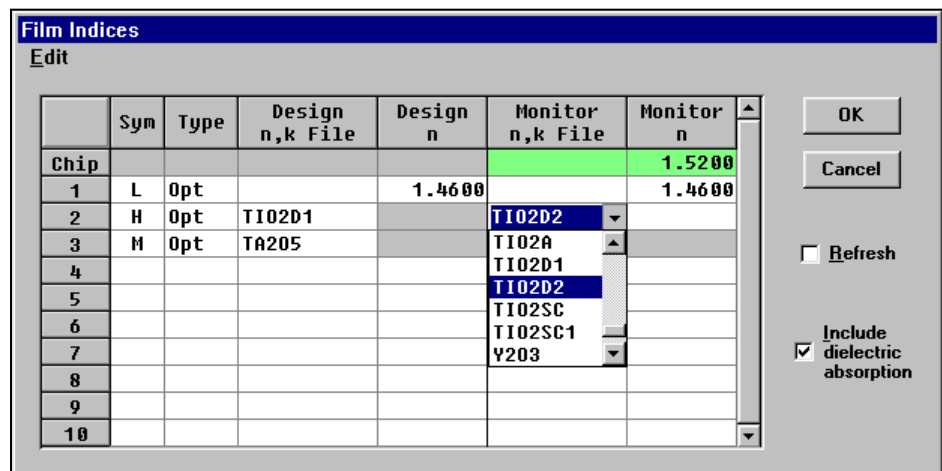
Hint: Type the first letter in the index file name for quick scrolling.

Type a numerical value under **n** or select a dispersive file name under **n,k File**. The scrolling list includes the names of tables created in FilmStar INDEX and stored in "..\winfilm\index". When a file name is entered any numerical index value is dimmed to show that the dispersive file name has precedence. Finally, only check **Include dielectric absorption** if monitoring in regions where absorption cannot be neglected (not recommended but sometimes unavoidable).

Monitor Calculation Parameters
Edit

| Preferences | Tooling | Response | Calibration |

Measured Spectrum
- Reflection
- Transmission

[Open...] [Paste] [Edit Peaks...]

Spectrum is ○ Continuous ● Peak positions

Sym	Film Material	Optical Mon/Sub	Crystal Mon/Sub	Rate Å/sec	Line Color
L	SiO2	1.680	1.950	5.60	12
H	TiO2	1.750	2.030	7.80	9
M	Ta2O5	1.710	1.970	3.20	14

[Compute M/S for Material L]

[OK] [Cancel]
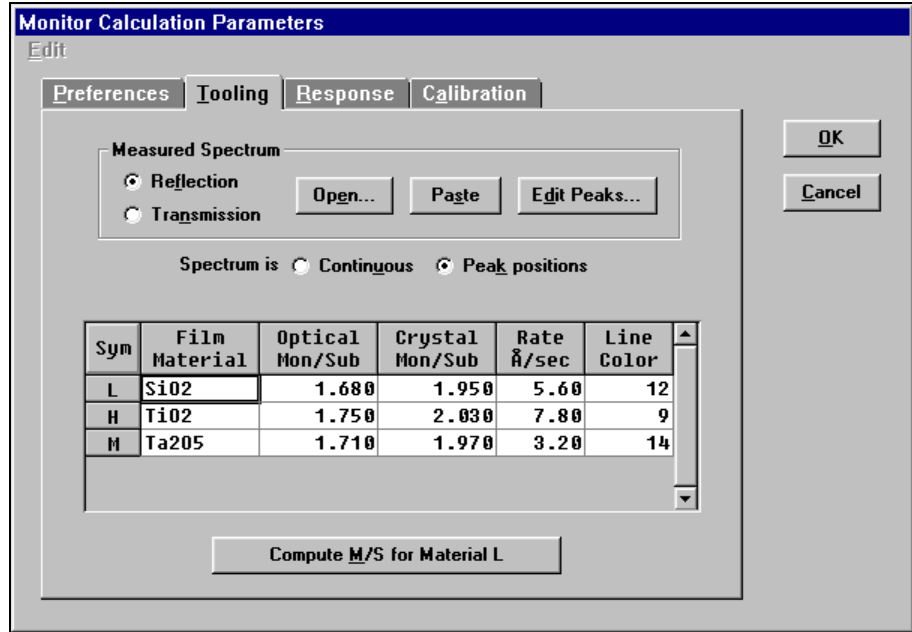
Materials listed in the **Film Material** column can be printed in the coating run-sheet. The **Rate** column helps MONITOR provide a more realistic strip-chart simulation graph. This grid also includes a **Line Color** column for assigning colors for the strip-chart simulation.

The **Response** tab specifies system response as a function of wavelength. These values are used in calculating signal strength and displaying the strip-chart simulation. While high accuracy is not important, it is crucial to realize that system response depends on many factors.

Monochromators used in optical monitors are more repeatable than accurate. The **Calibration** tab provides means to enter up to six calibration wavelengths for determining a quadratic correction function. Monochromator calibration is especially important for fabricating coatings, such as magenta filters, which must be monitored at widely separated wavelengths.

The ability to edit designs can be suppressed.

Click **Setup...Layers Editor <Ctrl+L>** for MONITOR's design editor. While the editor permits users to change designs, the capability should only be used for testing or for splitting layers that are too thick. Designs are normally loaded from disk with **File...Open...Design <Alt+Ctrl+D>** or **File...Open...Archive Design <Alt+Ctrl+A>**. For security the editor is disabled in FILM Archive mode. It can permanently disabled by a FilmStar Administrator.
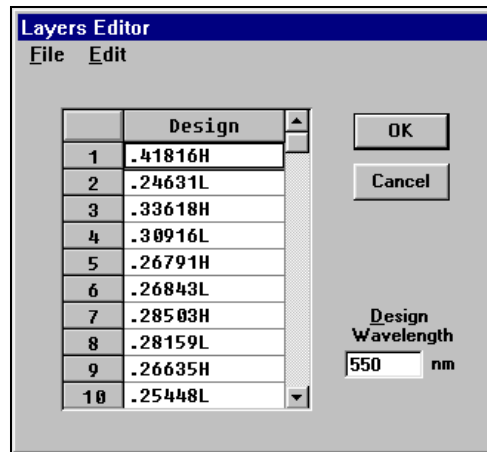
Layers are deleted with **<Del>** or by clicking **Edit...Delete Row <Ctrl+D>**. Rows are inserted with **Edit...Insert Row <Ctrl+I>**. A design text editor resembling DESIGN's groups mode editor is accessed via **Edit...Text <Ctrl+T>**.
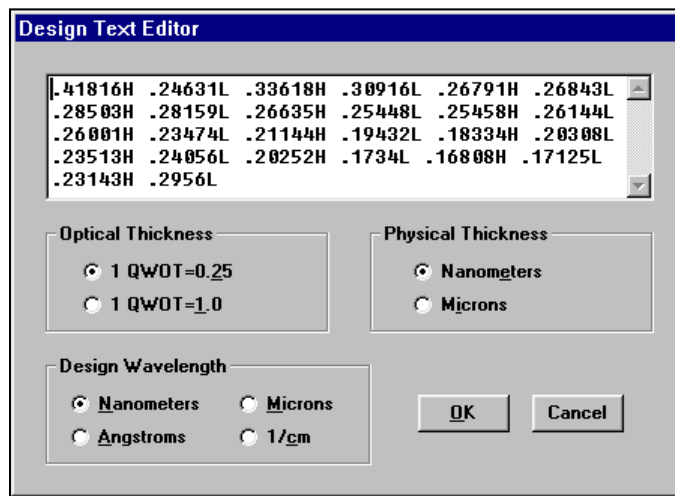
A design containing parentheses, *i.e.* `(.125H .25L .125H)10,` is 'exploded' into individual layers upon returning to the Layers Editor. Adjacent layers of the same type are combined when there are parentheses. That is `.125H .125H` becomes `.25H`. (Adjacent layers are NOT combined in the Layers Editor. This makes it possible to break up thick layers into thinner layers of the same type.)
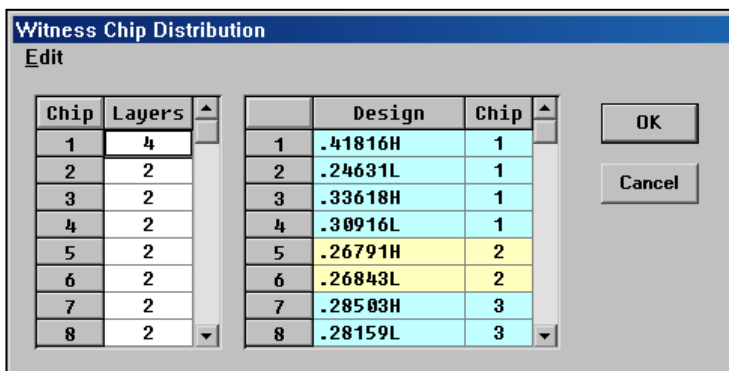
Click **Setup...Chip Distribution <Ctrl+H>** to specify or change the number of layers on each chip. (The dialog box is automatically activated after loading or

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editing designs if the number of layers has changed.) Note that there are several choices in the **Edit** menu. As the grid at the left is adjusted the grid at the right shows the updated distribution. If there are *too many chips* for the number of layers in the design, MONITOR will correct itself after you press **OK**. If there are *too few chips* an error message is issued.

Generally, the next step is assigning default monitor wavelengths with **Setup... Wavelengths <Ctrl+A>**. If these are not assigned, MONITOR will use wavelengths already in the worksheet. If you have no good guesses from previous run-sheets, just enter mid-range values, say 550nm for visible monitoring..

Sym	Film Mat'l	Wave (nm)
L	SiO2	550.0
H	TiO2	600.0
M	Ta2O5	575.0

OK   Cancel

Default Monitor Wavelengths
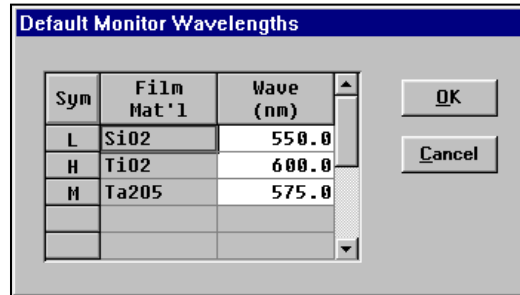
Returning to the Main Menu, click **Evaluate...Recalculate All <Ctrl+R>** to generate a worksheet based on new design, index and/or parameters values. When starting a new worksheet you will probably want to check *Same gain/ offset for all layers on chip* and try *Initial Level = 10%* (or *Initial Maximum = 80%* when specified in *Monitor Parameters - Advanced*) for reflection and *Signal Level = 70%* for transmission. Load some designs from disk and explore the way these are converted to worksheets.

Monitor Swings

You might prefer to use turning points and cutoff ratio (see next section).

Monitor swings are intensity fluctuations in reflected or transmitted light as typically observed on a strip-chart recorder. When the tooling factor is one, integral quarter waves at a given wavelength are equivalent to integral monitor swings. But fractional swings are not exactly the same. For example, 1.5H (QWOT = 1.0) could result in a monitor swing of 1.43.

Using MONITOR's default indices and parameters the following example illustrates the main ideas. If you have 'lost' the original default values and wish to use them, exit MONITOR, erase all 'work' files from ...\WINFILM\MONITOR and restart the program. Note that we are using a simple 4 layer design with 550nm design wavelength and all layers deposited on one chip. You should be able to reproduce the worksheet shown below.

	Design	C	L	Film Mat'l	Wave (nm)	Signal	PARtial Swing	FULL Swing	FULL/PAR
1	.25H	1	1	TiO2	600.0	18.4%		1.486	
2	.25L	1	2	SiO2	700.0	8.6%	.963(d)	.498	1.517
3	.325H	1	3	TiO2	625.0	21.2%	.526(i)	1.336	
4	.25L	1	4	SiO2	655.0	8.1%	.617(i)	.904	1+146.6%

The point is to locate monitor cut-offs with good selectivity and signal. Selectivity is highest when cutting on the slope. Generally, cut-offs at peaks and valleys should be avoided since these are the least selective points. Exceptions generally involve monitoring schemes where layer correction is possible.

Reflection Mode   Chip 1
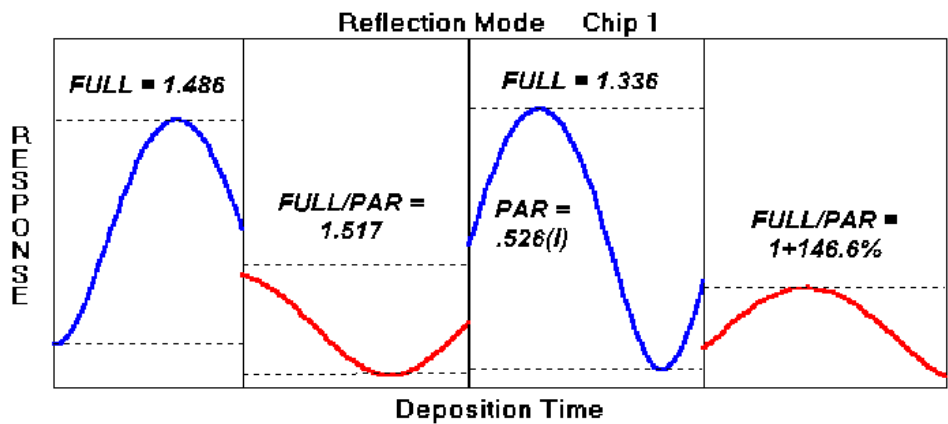
FULL Swing...An integral full swing encompasses the complete maximum to minimum excursion. Referring to the diagram, layer 1 response starts at the minimum value, rises to its maximum and finishes at some intermediate final value. In practice, the coating technician counts the number of chart divisions corresponding to the integral part of the swing. That number is multiplied by 48.6% and subtracted from the value at the maximum. That is

$$\text{cut-off} = \text{max} - (\text{max-min}) * \text{fraction}$$

or for increasing fractional swings as in layer 3

$$\text{cut-off} = \text{min} + (\text{max-min}) * \text{fraction}$$

Referring to the above diagram, if layer 1 starts at 14% and has its maximum at 77%, the technician should close the shutter at 46.4% [77-.486(77-14)].

PARtial Swing...Since layers are often too thin to produce a full monitor swing, cut-off points must be based on partial swings. Partial swings can be large (nearly indistinguishable from full swings) or small blips. In layer 2 the partial swing is 0.963...almost a full swing. '(d)' indicates that it is decreasing. The fractional full swing 0.498 is divided by 0.963 to give us 1.517. The placement of this number in the FULL/PAR column serves as a warning to the coating technician.

Layer 3 begins with a significant increasing partial swing of 0.526. The full swing of 1.336 is used to calculate the layer cut-off level. There is no problem here, except that the technician needs to be aware of the situation and have faith that the pen will not go off scale even though the layer starts at about 40%.

FULL/PAR...Layer 4 represents a condition which should be avoided if possible (and can be in this case). The fractional full swing exceeds the fractional partial swing. The technician is warned with the notation '1+146.6%'. If the layer starts at 10% and reaches a maximum of 29%, the cut-off is at 1.1% [29-1.466(29-10)]. This seems risky. If another wavelength can not be found, it is reasonable to increase amplifier gain for the last layer and start at 30% corresponding to a maximum of about 80% and a cut-off at 6.7% [80-1.466(80-30)].

There's one other situation. Increase layer 4 wavelength to 750nm. This makes the full swing smaller and partial swing larger. MONITOR now feels it is too risky to base the ratio on dividing a number by a much smaller number (< half). Instead it expresses layer cut-off as a number '2.365*Ini' to be multiplied by the initial level. If we once again adjust amplifier gain for an initial level of 30% the final cut-off will be at 71% [2.365*30]. The same notation is used for very thin layers where no ratios are possible.

Turning Points and Cutoff Ratio

This method offers better control for thin layers.

We now consider a different and recommended cutoff paradigm: turning points and cutoff ratio. Ratios can be improved by utilizing previous turning points. That is , the last two turning points are used to compute cutoff levels - even if the turning points are not within the current layer.

> **Previous turning points are used only when the current layer has the same wavelength and gain/offset as the previous layer. This does not, however, require that ALL layers on a chip have the same wavelength.**

Click **Setup…Program Mode…Run-sheet TPs** to place MONITOR in this mode. Then access **Preferences** in Setup Parameters and enter the following. (Note that checking **Use turning points** automatically checks **Same wavelengths**.)

☑ Identical witness chips for entire stack
☑ Use turning points from previous layers
☐ Same wavelengths for all layers on chip
☐ Re-use previously coated chips
☑ Neglect inital turning point < 5 % Threshold

When the previous design is recalculated we obtain the following:

	Design	C	L	Film Mat'l	Wave (nm)	Signal	Turn Pts	Cutoff Ratio
1	.25H	1	1	TiO2	640.0	14.7%	1	0.340
2	.25L	1	2	SiO2	640.0	12.5%	1	0.569
3	.325H	1	3	TiO2	570.0	9.0%	2	0.721
4	.25L	1	4	SiO2	570.0	15.1%	1	0.595
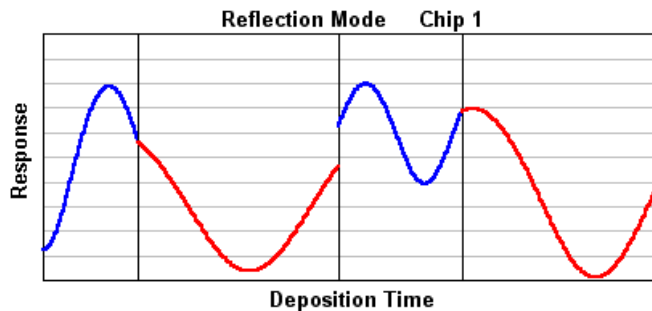
Note how the cutoff ratio for layer 2 utilizes the maximum value achieved by layer 1. There are two turning points for layer 3 but only one for layer 4. (If **Neglect initial turning point** is unchecked, layer 4 shows two turning points.

Once again setting program mode back to the previous *swing* notation, consider the following five layer design:

	Design	C	L	Film Mat'l	Wave (nm)	Signal	PARtial Swing	FULL Swing	FULL/PAR
1	.25H	1	1	TiO2	640.0	14.7%		1.340	
2	.25L	1	2	SiO2	640.0	12.5%	.926(d)	.754	1.814
3	.35H	2	1	TiO2	570.0	21.2%		2.199	
4	.15L	2	2	SiO2	570.0	10.3%	.216(i)	.388*Ini	
5	.1H	2	3	TiO2	570.0	33.5%	.076(d)	6.753*Ini	

Thin layers 4 and 5 are difficult to monitor. The situation is much improved by calculating cutoff ratios using previous layers. After recalculation the worksheet appears as below. The PAR column is replaced by **Turn Pts**. The FULL column is replaced by **Cutoff Ratio** and the FULL/PAR column is replaced by **Cutoff Level**. Cutoff Level is used when it is impossible to calculate a ratio. This occurs when the first layer on a chip is thin or if the Cutoff Ratio exceeds 3. Check one or more Use Level boxes to force MONITOR to print Cutoff Levels instead of ratios. Check the column title to check and uncheck all boxes.

Comparing results with the previous worksheet, the first layer on each chip is unchanged (despite the new notation). But since the second layer cutoff ratio is now based on the maximum in layer, its ratio has changed from 81.4% to 56.9%.

	Design	C	L	Film Mat'l	Wave (nm)	Signal	Turn Pts	Cutoff Ratio
1	.25H	1	1	TiO2	640.0	14.7%	1	0.340
2	.25L	1	2	SiO2	640.0	12.5%	1	0.569
3	.35H	2	1	TiO2	570.0	21.2%	2	0.199
4	.15L	2	2	SiO2	570.0	10.3%	1	1.119
5	.1H	2	3	TiO2	570.0	33.5%	1	2.120
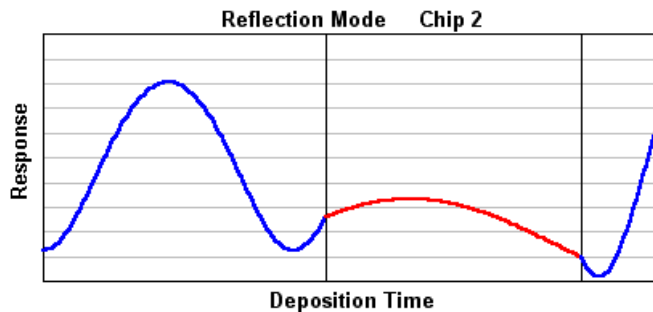
A far more dramatic change occurs in chip 2. The cutoff for layer 2 now utilizes its own maximum as well as the previous minimum from layer 1. The cutoff for layer 3 uses its minimum as well as the previous maximum from layer 2.

Several monitors use previous turning points and identical wavelengths on each chip (this can sometimes be disabled but it is not recommended). Monitors are selected through **Setup...Program Mode**. When gain and offset are fixed there is no need to display calculation options or gain adjustment menus.

When using previous turning points **FULL/PAR>100%** and **Monitor swing<1** warnings should be deactivated (**Evaluate...Warnings**) and a **Threshold** value should be utilized (try 5-10%). The latter warns the user that the turning point is too close to the start of a layer.

Generating Run-Sheets

Select **Evaluate...Run Sheet <Ctrl+S>** to view the coating run-sheet corresponding to the displayed worksheet. Click **Print** to preview the actual document. Run-sheets are not supported for most automatic optical monitors.

You will certainly want to replace *FTG Software Princeton, NJ* at the upper left with your own company name. Click the **Template...<Alt+T>** button to view the run-sheet template and edit the document as you wish. Templates (file extension .tpw) can also be edited in a text editor such as Notepad.

A run-sheet template includes regular text and field codes in curly brackets. There are two kinds of field codes: those that insert text (**{ChipNum;2}**) and those that indicate the beginning (**{BeforeChip}**) and end (**{End}**) of a section. In addition there are printer format codes (**<<Chart>>**). A complete list of codes is found in "Run-Sheet Template" on page 30.

Run-sheets are generated from displayed work-sheets...not from underlying designs or parameters. (Click **File...Configuration... Show All Columns** to view hidden columns.) New run-sheets can be generated from worksheets stored on disk without recalculation.

Export to Automatic Monitors

Output options depend on the monitor selected in **Setup… Program Mode**. Eddy settings are directly uploaded via RS-232. Leycom IV mode produces sequence files (*.seq); SYRUSPro settings are transferred in XML format via FilmStar BASIC program SproMonitorReport.bas. Intellemetrics settings are transferred to FilmMaker via BASIC program FilmMakerLink.bas.

Users should contact FTG Software for further details. This is especially recommended for SYRUSPro users.

Reference

File Menu

Four main files are utilized in MONITOR:

1. Monitor Calculation Parameters
2. Design
3. Template
4. Worksheet

A parameters file, design file and template file are associated with a worksheet file. When a worksheet is opened, associated files are also opened.

In addition the coating run-sheet itself may be stored on disk. Finally, spectral data files are utilized in calculating the monitor to substrate ratio.

Open Worksheet <Ctrl+F12>

Loading the worksheet automatically loads associated setup parameters, thin film design and run-sheet template. A design can be loaded from a Design file or from a FILM Archive file. A design can also be opened from a FILM Archive database.

Save As <F12>

This leads to the Save Files dialog box which provides Save and Save As functions for the worksheet and three associated files.

Open All

Quickly loads previous worksheet and associated *work files*. Use this to restore the program to a known state.

Save All

Quickly saves the worksheet and associated files as *work files*. These are the same files stored upon exiting MONITOR. This is useful for safely storing data while accessing other Windows programs.

Retrieve Run-Sheets

Load and print previously saved run-sheet print files (*.prt). These files are representations of printed forms and contain no other information. As such they can be printed in FilmStar DESIGN by clicking File…Retrieve Report.

Exit <Alt+F4>

Upon exiting configuration file "..\winfilm\config\design1.ini" is updated. Current data is saved in *work files* "work.*" (same as **Save All**)**.** These files are automatically loaded upon starting MONITOR.

Configuration - Directories
File...Configuration...Directories

Configuration changes are saved in "..\winfilm\config\design1.ini" upon exiting MONITOR. To keep changes respond **Yes** to *"Save new configuration?"*

User Name
The User Name can be automatically inserted into coating run-sheets.

Directories
Files are stored in three default directories. While files can be loaded from any directory, they can only be stored in the default directories. (Exception: spectral data files can be stored anywhere.)

Data
Calculation parameters (.mpw), template (.tpw), worksheet (.mww), and run-sheet (.run) files. Design file "work.dew" is also stored in this directory.

Designs
Thin film designs (.dew) or FILM Archive Files (.faw) created in DESIGN.

n,k Tables
Dispersion tables created in program INDEX (.itw).

Spectra
Spectral data files (.csv) in FilmStar comma-separated values format. This is the same format used by DESIGN and MEASURE. Spectral data is required for *Monitor to Substrate* (tooling factor) calculations.

Configuration - Preferences
File...Configuration...Preferences
Preferences are saved in design1.ini and common.ini.

Message box format
Message boxes display *OK Cancel*, *Yes No* and similar messages. There are two types: Windows (default) and FTG-style. Windows message boxes may be centered in the screen or in the active dialog. Windows message box buttons utilize local languages; FTG-style message boxes are dialog-centered and buttons are in English.

FTG message boxes can be set to *topmost*, thereby remaining visible when covered by other programs. This setting may be useful in BASIC or ActiveX automation.

Cancel warning
Issues a warning message if you modify a data entry in a dialog box and then click **Cancel** to close the box.

Overwrite warning
Issues warning when opening a new file or clicking the *Save* button after editing underlying data.

Display and save file descriptions
Check to save and list file descriptions (50 characters maximum). This facility is a carry-over from 16-bit Windows (8 character file names). The option adds **File…List** and **Spectra…List** commands.

The following changes, which are not included in menu selections, require that the user modify "..\winfilm\config\design1.ini" in Notepad or another text editor.

Enhance copied Worksheet

Check to add additional information (Properties and Materials) to a Work-sheet copied to the clipboard in **Evaluate…Copy Worksheet**.

File Shortcut Keys

The 'extra' file shortcut keys (*i.e.* **<Alt+Ctrl+P>** Parameters Open) can be sup-pressed by inserting the line

```
[Configuration]
ExtraKeys=0
```

The next time MONITOR (or DESIGN) is run the keys will be suppressed and the shortcut keys will not appear in the **File...Open** menu.

Highlight Colors

Run-sheet highlight colors (normally blue and red) can be altered to enhance contrast.

```
[Monitor]
HighlightColor=0
WarningColor=1
```

Useful color codes are given below. Default values are 9 (highlight) and 12 warning).

```
0   Black            8   Dark Gray
1   Dark Blue        9   Blue
2   Dark Green       10  Green
4   Dark Red         12  Red
5   Dark Magenta     13  Magenta
```

Edit Menu

The Edit Menu provides several time-saving functions for entering and editing worksheet data. These are especially useful when there are repeated layers.

Insert & Delete Rows

These commands are useful for modifying worksheets without losing old data. It might be useful, for example, to split layer '.75H' into two layers '.375H .375H'. A blank line is inserted into the worksheet. Next the layers editor is accessed and the thick layer divided into two at the same position in the stack. This is followed by recalculation with option *Use current worksheet values*.

Increase/Decrease Wavelength <F4>, <F5>

Increase and decrease the wavelength by a wavelength increment. **<F3>** changes the increment. In filter wheel mode there is no increment and the next filter is selected.

Repeat Wavelength <F6>

This command repeats the wavelength from the previous row. That is, if the cursor is on row 4, it's wavelength is set equal to the one on row 3.

Spawn Wavelengths <Ctrl+F6>

This command changes all wavelengths on a chip to the wavelength in the active row. You can also force all wavelengths to be the same by clicking the appropriate box in the Advanced Parameters editor.

Copy Previous Chip <Shift+F6>

This command changes all wavelengths and gain/offset settings to those on the previous chip. The chips must have the same number of layers. This command is especially useful when monitoring a stack of repeated layers. This feature is not available in 'Re-use previously coated chips' mode.

Columns

Default restores columns and widths for the current monitor mode. *Show All* displays all columns including hidden ones not normally required.

Setup Menu

The Setup Menu varies numerous interrelated parameters. Some care must be taken in editing dialogs in the correct order: film indices before tooling factors, design before chip assignment, etc.

Program Mode
Setup...Program Mode

Crystal Only simplifies program operation by suppressing unneeded optical entries and modifying Film Indices and Parameters dialogs. *Eddy* operation utilizes serial communications to upload coating values. *TPs* = Turning Points. *Swings* refers to historic B&L practice.

Assign Default Wavelengths
Setup...Wavelengths <Ctrl+A>

Default wavelengths provide initial values for calculating the worksheet. If you have no idea what values to assign, just use the same mid-range value (visible: 600nm) for all layers.

To see what happens when no defaults are assigned (not recommended), clear and recalculate a worksheet. All entries to the right of the wavelength column will be blank.

Chip Distribution
Setup...Chip Distribution <Ctrl+H>

As the number of layers for each chip is entered in the left-hand *data grid*, the right-hand *status grid* shows layer distribution. When layers are assigned, gray rows in the status grid turn cyan (odd numbered chips) and yellow (even numbered chips). Upon exiting the dialog box with **OK** all layers must be assigned. If too many chips are specified, it is automatically corrected.

Users can easily change chip distribution after selecting monitor wavelengths. Upon returning to the worksheet, recalculate with *Same gain/offset for all layers on chip **disabled***. Then the only wavelengths that require adjustment are those in the changed chips.

Edit...Clear Grid

The status grid becomes completely gray. If rows are accidentally deleted click **Cancel** to exit the dialog box without retaining changes.

Edit...Auto Calculate

Normally Auto Calculate is checked and the status grid updates automatically when the data grid is edited. Constant updating could become annoying for large designs and can be suppressed. When Auto Calculate is suppressed click **Edit...Calculate Now <Ctrl+N>** to manually update the status grid.

The configuration is quite different when previously coated spots (as in Leybold TGW magazines) are utilized. The user specifies which layer goes on which spot. Row color is changed whenever a layer is not on the same spot as a previous layer. Although monitor spots are numbered in sequence, physical position may be different. Thus, spot #1 may actually correspond to physical position #5, etc. Click *TGW* to access a dialog for assigning physical position to spot number.

Design Text Editor
from Layers Editor: Edit...Text <Ctrl+T>

This dialog box makes it possible to enter and edit designs independently of DESIGN. Groups mode notation may be used. That is, designs such as

        .25H (.25L .25H)20 .125L

are supported. Upon returning to the Layers Editor these are 'exploded' into individual layers and adjacent layers of the same type are combined. That is `.125H .125H` becomes `.25H`. It is not possible to edit files loaded as FILM Archives.

When importing a design containing parentheses, MONITOR expands groups and combines layers of the same type: '1H 1H' -> '2H'. To prevent combining, before saving in DESIGN, expand the design in the Layers Editor with 'Edit.. Combine Layers' UNCHECKED. Then save the design or FILM Archive for loading into MONITOR.

Eddy Parameters
Setup...Eddy LMC-10/20 (IQ-145) <Ctrl+Y>

Program Number, *Chip Temperature*, *Overshoot* and *Noise Rejection* are discussed in Eddy documentation. MONITOR adds *Partial Swing Safety Factor*. While a coating technician counts PAR ~ 1 as an additional swing and ignores PAR ~ 0, an automatic monitor must have stringent rules for determining whether initial partial swings should be counted or ignored.

Depending on Overshoot, the LMC-10 counts an initial partial swing as a full quarter-wave when the monitor intensity level difference exceeds 10 times the Noise Rejection setting. MONITOR adds a Safety Factor and rejects layers with intensity level difference between Noise*10/Safety and Noise*10*Safety. In the worksheet these rejected layers are denoted by error message *Indeterminate Partial Swing*. A Safety Factor of 1.5 to 2.0 is reasonable. If the Safety Factor is too high, it may be difficult to locate suitable monitor wavelengths.

In LMC-10 operation, optical cutoff rules are ignored for layers selected for crystal monitor termination. (If your LMC-10 does not support this feature, contact the Eddy Company.)

> **LMC-10/20 users should be sure to select Software Revision.**

Film Indices
Setup...Film Indices <Ctrl+I>

The Film Indices editor lists materials used in the thin film design. There are two index sections: ***Design*** and ***Monitor***. 'Design' refers to the actual thin film design, while 'Monitor' refers to the indices in the chamber. The program converts design optical thickness to physical thickness and reconverts to optical thickness in the coating chamber. Film Indices are stored in the Parameters file.

> ***Materials must be defined before a thin film design can be loaded from disk. If you don't have separate Monitor index files for the coating chamber, just use Design values.***

To enter new index values:

1. Specify chip index in the ***Chip*** row. This row is present if ***Identical witness chips for entire stack*** was checked in the Calculation Parameters - Advanced dialog box. Otherwise chip indices are entered for each chip in the Witness Chip Distribution dialog box.

2. Define a symbol by entering a one letter index symbol 'A' to 'Z' in the **Sym**bol column.

3. Specify film thickness convention:

   a. ***Optical thickness***...Thickness units (QWOT = .25 or QWOT = 1) are set when the thin film design is loaded.

   b. ***Physical thickness***...Thickness units (nanometers or microns) are set when the thin film design is loaded.

   c. ***Metal thickness***...Thickness units (nanometers or microns) are set when the thin film design is loaded. Use this settings for metallic layers. Use Optical or Physical thickness for slightly absorbing (k<<n) dielectric layers.

4. Specify film indices for ***Design*** and ***Monitor*** sections:

   a. ***Constant***...Leave the **n,k File** column blank and enter constant values for n.

   b. ***Table***...Under **n,k File** insert the name of a dispersive Index Table previously stored in INDEX. Table names are inserted with the pull-down menu. Shortcut: type the first letter in the material to rapidly navigate the pull-down menu.

Refresh forces the reloading of dispersive index tables. Check this box if you altered index data in INDEX while running MONITOR.

Include absorption in dielectrics should be checked if monitoring at wavelengths where absorption is not negligible.

Layers Editor
Setup...Layers Editor <Ctrl+L>

This dialog box enables users to open, view and modify thin film designs. Designs containing parentheses are converted into separate layers. Unlike DESIGN, layers may then be split into adjacent layers of the same type.

File

The ***Open*** function is identical to the one in the Main Menu. The advantage here is that it can be immediately viewed.

Edit

> One row may be deleted or inserted at a time. Cut and paste operations are also supported with **<Ctrl+C>** and **<Ctrl+V>** keys.

It is possible to edit designs loaded as FILM Archives after **File…FILM Archive** is unchecked. The edited design may then be re-stored. This may be required, for example, if necessary to split a thick layer into thinner layers.

For security purposes, the ability to modify designs in MONITOR can be suppressed by modifying design1.ini (see *Security – Layers Editor* in "<u>Configuration - Preferences</u>" on page 16). The editor then becomes a viewer.

Parameters - Preferences
Setup...Parameters <Ctrl+P>…Preferences

Optical Mode

1. *Reflection*...Light is reflected from the front filmed surface. The rear surface is ground to eliminate reflections. This is the usual mode for reflection optical monitors.

2. *Transmission*...Light is incident on the front filmed surface and passes through the witness chip.

3. *Reflection + Side 2*...Light is incident on the front filmed surface. The rear surface is smooth and its reflection contribution is included.

4. *Reverse Reflection + Side 2*... Back side monitoring where light is incident on the uncoated surface. Since, in MONITOR Version 1.5, films are nonabsorbing at monitor wavelengths, results are identical with Mode 2.

5. *Transmission^2*...In this rarely used mode, monitoring light passes through the witness chip, strikes a mirror and returns to the optical detector through the witness chip.

> *In Eddy LMC-10 and IQ-145 operation transmission modes are not supported.*

Identical witness chips for entire stack

Most optical monitoring processes use identical witness chips throughout the deposition. Since there are cases where high index witness chips could be useful for depositing low index films, MONITOR also allows users to include different types of witness chips in the same coating run.

When witness chips are identical, chip index is entered in the first row of the Film Indices editor. When witness chips are not identical (box is unchecked) indices for each chip are entered in the Witness Chip Distribution dialog box.

Use turning points from previous layers

After calculating monitor swings, MONITOR computes ratios based on the last two turning points. If the current layer already includes two turning points, there is effectively no change. If the current layer has only one turning point MONITOR searches for one more; if the current layer has no turning points MONITOR attempts to find two. Previous turning points are only used if the layers have the same wavelength and gain/offset settings. This mode is automatically enabled in Balzers GSM-420 mode.

Same wavelengths for all layers on chip

When using previous turning points it is desirable that all layers on a chip have identical monitor wavelengths. If this box is checked all wavelengths on a chip are subsequently updated when one wavelength is modified.

Re-use previously coated chips

This mode is intended for optical monitors where it is possible to select a previous witness spot. An example is the six position monitor manufactured by Leybold.

Neglect initial turning point

By specifying a threshold value it is possible to neglect minor turning points. Applies to modes where Turning Points or Cycles (GSM-420) are displayed.

Parameters - Tooling
Setup...Parameters <Ctrl+P>…Tooling

Monitor to substrate ratios (tooling factors) for the index in the Film Material grid active row (containing the highlight) may be calculated from measured spectral data. A transparent substrate is mounted on the rotating or planetary fixture. A fairly thick film, say 15 monitor quarter waves at 550nm is deposited. Upon removing the substrate from the coating chamber its transmission is measured at normal incidence in a spectrophotometer. Normal incidence reflection spectra could also be used.

Since the calculation uses all the peaks and valleys in the spectrum, it might be best to avoid data at very short wavelengths where indices are more variable. For example, the spectrum for TiO2 from 500 to 900nm should work fine.

Film Material Grid

> *'Monitor' denotes the (stationary) witness chip, 'substrate' denotes the test optic mounted on the (rotating) fixture.*

Monitor to substrate ratios (tooling factors) and other material-dependent quantities are entered for films corresponding to index symbols (L, H, etc.) previously defined in the Film Indices editor.

> *DO NOT change the order of entries in the Film Indices editor (by interchanging L and H symbols, for example) after specifying tooling factors and other material properties in the Calculation Parameters editor!*

Optical Mon/Sub is the ratio of the *apparent* physical thickness on the optical monitor to the physical thickness on the substrate. ('Apparent' because thickness is computed from the number of quarter waves deposited on the monitor at the monitor angle of incidence.)

Crystal Mon/Sub is the ratio of the thickness reading on a quartz crystal monitor or deposition controller to the physical thickness on the substrate. This ratio is used in calculating the worksheet's **Crystal** column. It is also used in plotting strip-chart simulations for single layers. If you don't have a crystal monitor, set the ratios to one.

Rate provides more realistic strip-chart simulation curves and helps GSM-420 users establish the T-ALGO parameter. The rate refers to either the optical witness chip or crystal monitor as selected in the strip-chart window.

Delay comprises layer rise and soak times and is utilized in estimating run-time (Evaluate menu). Click the Chamber tab to include pumping and cooling times in the calculation.

Line Color is used in strip-chart simulations. Try to select colors which have good contrast when printed. Color codes are as follows:

```
0  Black          8  Dark Gray
1  Dark Blue      9  Blue
2  Dark Green     10 Green
3  Dark Cyan      11 Cyan
4  Dark Red       12 Red
5  Dark Magenta   13 Magenta
6  Dark Yellow    14 Yellow
7  Gray
```

Leycom IV Operation note

Film Material is renamed to *Layer Set*. This provides a default Layer Set for each material type. The maximum number of characters is 9.

Rate is entered in Å/sec. This will be converted to nm/sec and used to program the Leycom IV.

Open Spectrum

Load the spectrum from disk. Spectra are stored as FilmStar "*.csv" files. When examined with a text editor, the file will resemble the following:

```
"This is just an example"
5
400,.6,.1
450,.5,.2
500,.4,.3
550,.3,.4
600,.2,.5
```

The first line is an optional description (50 characters maximum); the line is included even if the description is blank. The second line is the number of spectral points. The third and subsequent lines are wavelength (nm), reflectance (0-1) and transmittance (0-1).

Paste Spectrum

Paste a spectrum from the clipboard. When using transmission data, reflection values can all be zero. When examined with a text editor, data appears as shown below (depending on tab settings):

```
400    .6    .1
450    .5    .2
500    .4    .3
550    .3    .2
600    .2    .1
```

The first column is wavelength (nanometers) followed by reflectance (0-1) and transmittance (0-1). When using transmission data, reflection values can all be zero. Columns are TAB (ASCII 9) delimited and lines are CRLF (ASCII 13 + ASCII 10) delimited:

```
400TAB2.676706E-02TAB.9732329CRLF
```

Spectrum Type

Specify whether **Reflection** or **Transmission** data is being used. Also select **Continuous** or **Peak** spectrum type. In the first case MONITOR locates the peaks in a continuous spectrum as might be acquired by MEASURE. In the second case the spectrum is defined only by its peak positions.

Compute M/S for Material...

This leads to a series of three screens:

1. **Peak Verification**...Peaks are determined by examining series of points and looking for extrema. Since the algorithm can be fooled by noisy data which occurs when the wavelength spacing is too small, the dialog's **Spectrum** menu provides means to convert the spectrum. For example, transmission measured over the range 400-800 x .2 nm will have multiple spurious peaks which can be removed by converting the spectrum to 400-800 x –2 nm (-2 gives inverse spacing). If the data is really noisy (diode-array spectrometer?), try a smoothing algorithm, say Savitzky-Golay with order 2 and points 5.

2. **M/S Calculation Parameters**

   Optical Monitor...Enter the number of quarter waves on the witness chip. A quarter wave is one 'max to min' excursion. That is, if monitor signal starts at 30%, decreases to 10%, and returns to 30%, **two** quarter waves have been deposited.

   Crystal Monitor...Enter the crystal monitor thickness if applicable.

   Substrate Index...Enter the substrate's refractive index.

   Thickness Calculation...Enter a minimum number of quarter waves for starting the calculation. Error messages or erroneous results are possible if the number is too low.

3. **M/S Thickness Verification**...Calculated number of quarter waves on the substrate and estimated errors are given. **OK** inserts these values in the Film Materials grid. Click **Recalculate <Esc>** to return to the previous screen and adjust parameters.

Parameters - Response
Setup...Parameters <Ctrl+P>…Response

Response Grid

The worksheet **Signal** column is computed by multiplying the reflection or transmission swing (maximum - minimum) by the relative light monitor response at the specified monitor wavelength.

If using a monochromator enter an appropriate series of wavelengths, say 400 to 800 by 25nm. If using a filter wheel enter actual wavelengths. Response is measured by scanning or selecting filters and measuring the intensity for an uncoated witness sample. Setting the maximum to 1.0, enter relative response in the grid.

Note that the **Edit** menu is enabled when this grid is activated.

Select Wavelength

When **Monochromator** is specified , any wavelength between the minimum and maximum in the response grid may be utilized in the worksheet. When **Filter Wheel** is specified, only wavelengths specified in the response grid may

be utilized. In the latter case pull-down menus replace text entry boxes when adjusting wavelengths.

Monochromator Bandwidth (Halfwidth)

When *Use turning points from previous layers (Preferences)* is <u>unchecked</u>, it is possible to include 50% bandwidth (WH). This is useful when depositing many layers on a single witness chip (as in narrow band filters) or when monitoring IR stacks in the visible. It is not normally required for multiple witness chips.

Low Resolution averages 5 points (Gaussian distribution) in WH/2 intervals while *High Resolution* averages 13 points in WH/4 intervals. High Resolution is required as film thickness and/or bandwidth increases.

Users can verify results with DESIGN BASIC program MonitorWidth.bas.

Parameters - Calibration
Setup...Parameters <Ctrl+P>…Calibration

Monochromator Calibration Function

Monochromators used in optical monitors can be off by several nanometers. In order to compensate for these errors, enter a table of six actual wavelengths vs. monitor settings. This can be accomplished with a set of narrow band filters measured in a spectrophotometer of known accuracy or with doped glasses containing sharp lines. These are converted to a best-fit quadratic correction function when you press **OK**. Use the **Test** button to convince yourself that the correction works properly. Coefficients, along with entered wavelengths are stored with Parameters.

During calculation, MONITOR converts monitor wavelengths to corrected values. While MONITOR users need only be concerned with monitor wavelength settings (no matter what the real wavelength is), dispersive index tables set up in INDEX must cover the actual wavelength range.

Monochromator Grating Factor

If the visible grating in your light monitor monochromator was replaced by a IR grating, wavelength settings will be off by a factor of 2 or 3. Enter '2' if a monochromator setting of 500 nm corresponds to an actual wavelength of 1000 nm. If the conversion is not constant over the wavelength of interest (as is likely) use the calibration table (recommended) to generate a calibration function relating monochromator and evaluation wavelengths.

When a Calibration Function or non-unity Grating Factor is specified, the usual single wavelength column is split into *Mono* (monochromator setting) and *Wave* (evaluation wavelength) columns. One can adjust either and the other is automatically updated. In the main screen **Edit.. Wavelength Type** to select default column.

Evaluate Menu

This menu provides several functions (especially Calculation Options) that can strongly affect subsequent worksheet values.

Recalculate All <Ctrl+R>

This command recalculates the entire worksheet using wavelengths displayed in the *Wave* column. Rows are individually recalculated following any wavelength changes in the row.

Skip Calculation Errors

> ***This option should normally be left unchecked! It is only required in unusual circumstances.***

Calculation errors can occur under certain conditions. Such errors will stop the worksheet calculation at the offending layer. The user should then examine the data and discover the cause. In rare cases, such as layers where reflectance vs. thickness is flat and ratios cannot be computed, there must be a way to complete the Worksheet. (Such a layer would be monitored with crystal cutoff.) Click this option to cancel error-checking and permit calculations to proceed.

Copy/Paste Worksheet

The Worksheet is copied to or pasted from the Windows clipboard in Excel-compatible (tab separated) format. This could be useful if special printouts are required or if the user wants to store several runsheets in one large spreadsheet.

Properties and Materials are added to the bottom of a copied Worksheet by checking *Enhance copied Worksheet* in **File…Configuration…Preferences**. This facility provides means to transfer production settings to machine control software. The extra section is ignored by the Paste command.

Export Chip to DESIGN

Supporting reverse-engineering of coating processes, this advanced function exports and calculates the spectrum of the film stack on any witness chip (monitor spot). The exported design is the theoretical design (*Design* column) times Monitor/Substrate ratio. In order for this to work, DESIGN must be open. In DESIGN Film Indices substrate (*SUB*) index refers to the witness glass, not to the substrate utilized in the original design. Users should ensure that the required index symbols (LH, etc.) and appropriate index tables or functions are properly set up.

A particular chip is selected by moving the worksheet highlight to any row containing the required chip number. In some monitors, such as Leybold TGW, witness spots are all deposited on the same glass disk. Note, however, that TGW *chip number* and *chip position* can differ. That is, *Chip 1* can refer to physical *Position 5*. See *TGW Magazine* in the *Chip Distribution* dialog.

In monitors where chips are dropped on the bottom or otherwise collected, marking chips with a diamond scribe seems a reasonable way to keep track.

> ***It is assumed that the angle of incidence on the monitor is zero or very near zero.***

Calculation Options
Evaluate...Options <Ctrl+O>

When accessed directly this dialog box specifies gain/offset options for chips and layers. When accessed from **Evaluate...Recalculate All** the same options apply to the entire worksheet. These options are actually implemented when adjusting gain settings from the strip-chart simulation window. Note that this dialog box is not utilized in Balzers GSM-420 mode.

Same gain/offset for all layers on chip

Check this box to ensure that all layers on a chip use the same gain/offset settings. In the worksheet this is indicated by noting that ***Initial Level*** and ***Offset*** column entries are blank except for the first layer on a chip. Users

with reflection monitors may find this option adequate for all their coating requirements.

Use current worksheet values

Use current gain and offset settings.

> ***The two options listed below are available when 'Same gain/offset for all layers on chip' is selected.***

Use Gain and Offset

Use fixed gain and offset values. This is not generally as useful as the next option.

Use Auto Level

Compute gain and offset corresponding to user-set initial or maximum levels (reflection modes: specified by clicking menu **Auto Level**) or signal levels (transmission modes).

Initial level (reflection modes) refers to optical monitor response (0-100% for run-sheets and 0-1000 for Eddy LMC-10) when the chip is first loaded. Typically the coating technician loads a new chip, dials the correct monitor wavelength, and adjusts gain to bring the initial level to 10%. This mode is new and was not available in FilmCalc MONITOR.

Maximum level (reflection modes) refers to maximum monitor response (0-100% or 0-1000) for the chip. 70-80% seems to be a reasonable value. This helps ensure that the response does not go off-scale. This mode was included in FilmCalc MONITOR

Signal level (transmission modes) refers to the magnitude of the monitor response (0-100%) for the chip. When the signal level is 70%, gain and offset are computed so that the maximum is 85% and minimum is 15%. This mode was also included in FilmCalc MONITOR.

Calculation options may be changed during worksheet development. For example, the coating engineer might initially specify two layers per chip with initial level = 10%. It is later realized that chip capacity is exceeded and some chips will need to contain four layers.

The worksheet is then recalculated with initial level = 10%. Upon examining the strip chart simulation curves it appears that monitor response will exceed 100% for chip layers 3 and 4. The ***Same gain offset*** is now turned off. This allows the user to adjust gain and offset for layer 3. These values will apply to layer 4 unless that layer is also assigned new values.

Assign crystal cutoff if Signal less than

Enter a minimum ***Signal*** for optical monitoring. Crystal (physical thickness) monitoring may also be manually selected for each layer.

When a printed coating run-sheet is generated, the template entry ***{XLayer}*** is utilized rather than the optical entry ***{Layer}***. In Eddy LMC-10 operation, the number of quarter waves is set to zero, thereby causing the instrument to use the crystal cutoff rather than the optical cutoff. In this case MONITOR uploads crystal thickness. (If your LMC-10 does not support this feature, contact the Eddy company for an upgrade chip.)

Assign crystal monitor for thin layers

Check this box to automatically select (deselect) ***Crystal*** under ***Cutoff Type*** when layers are less than (more than) a quarter wave.

Edit design (reverse-engineering mode)

> Check this box to edit the design in order to determine thicknesses corresponds to actual monitor settings. This is intended for reverse-engineering layers which were terminated erroneously. It may be possible to reoptimize the remaining layers, redo the run-sheet and save a bad run.

Coating Run-Sheet
Evaluate...Run Sheet <Ctrl+S>

A coating run-sheet is a series of monitoring instructions used by the coating technician. Since every organization has its own requirements, users can customize run-sheets by modifying templates. The same worksheet can be used to generate run-sheets in different languages.

Upon activating the run-sheet window, the sheet currently in memory is displayed quickly; if there is no run-sheet in memory (the first time the window is activated) one is generated. Click the **Regenerate <Alt+R>** button at any time to calculate and display a new run-sheet according to any changes in the worksheet. This happens automatically after editing the run-sheet template.

> ***A run-sheet is generated from the displayed (active or inactive) worksheet, not from its underlying data.***

The displayed run-sheet now serves as a template for the MONITOR run-sheet print module and can be further modified with printer codes.

Using ComponentOne's VsPrint7.ocx the run-sheet print module combines text and strip-chart images. Run-sheet printouts may be saved in three formats: binary (.prt) for reprinting in FilmStar, Adobe Acrobat .pdf), and rich text (.rtf). Rich text may be opened in MS Word and resaved in .doc format. By resaving in Word format, .rtf files containing strip-chart images are reduced in size by a factor of about 100.

Cutoff Simulator
Evaluate...Cutoff Simulator

This facility is intended for bandpass filters. All layers (except for a few optimizing layers) are exact quarter waves and deposited on the actual filter. Ideally each layer is cut at a quarter wave peak. In reality, a small overshoot is necessary. The question is: what is the effect of different overshoot strategies. While an overshoot of 0.1% would obviously work better than 2.0%, the latter may be easier to implement with automatic monitors.

The Simulator requires that Program Mode be set to *Run Sheet TPs* and that the worksheet is active. In addition it requires that *Neglect initial turning point* in **Setup…Parameters** be checked; *5% Threshold* is suggested.

> ***Following the calculation the design is copied to the clipboard. This is easily inserted into DESIGN with macro DesignPaste.***
>
> ***Note that not all fields are recalculated by the Simulator. Click Recalculate All to update the worksheet.***

Overshoot

> Enter the required value (0.01 is 1%). The algorithm will attempt to convert all Cutoff Ratios to that value.

Resolution

This is the initial amount that the thickness changes as it searches for a solution. A smaller value is required for a smaller overshoot.

Max Iterations

The algorithm will quit if a solution is not found in the specified number of iterations. A larger value may be required if the resolution is made smaller.

Skip Layers

The algorithm automatically skips layers flagged for crystal cutoff. Non-quarter wave layers must be manually flagged. Typically these are a few outer layers which optimize passband transmittance. The format is a string of numbers separated by minus signs as follows:

```
-1-2-3-50-101-102-103-
```

Note that minus signs are required at the beginning and end.

Run-Sheet Print Setup

The options in this dialog box are the default format options for the report. Options can be changed throughout the document by using formatting field codes in the run-sheet template.

Header/Footer

Headers and footers are composed of three sections separated by pipe characters ("|"). The first section is left-justified, the second is centered, the third is right-justified. A page number field is embedded by including the code "%d" in the text; use code "%d/n" to add total number of pages (*i.e.* Page 3/7). In the following example the second section is blank:

```
FilmStar MONITOR Run-Sheet||Page %d/n
```

In the next example only the second section is used:

```
|FilmStar MONITOR Run-Sheet  Page %d/n|
```

Headers and footers use default report fonts which can be changed by clicking **Fonts**. In the header or footer fonts are printed italic if the default font is not italic, and vice-versa.

Margins & Line Spacing

Margins are in inches or mm. Line spacing is expressed as percent of font size. Margins should be the same throughout any document.

Metric Paper

When metric paper is selected, margins and some other length settings will be in mm instead of inches.

Color Printer

This toggles whether the print preview shows colors. Memory is saved by displaying monochrome graphics. It does not affect the actual printout.

Auto Preview

This toggles whether print preview is updated automatically whenever conditions are changed. When disabled a **Preview** button appears in the Print Run-Sheet main menu.

Show Graphics

This toggles whether graphics are displayed in the preview. When turned off graphics are shown as rectangles. This option saves memory and increases redraw speed. It does not affect the actual printout.

Run-Sheet Template
Evaluate...Run-Sheet...Template

Run-sheet templates make it possible to generate custom run-sheets from the currently displayed worksheet. Templates include placement codes (where to put the text), field codes (which data to extract from the worksheet), text and printer format codes. Placement and field codes are contained in curly brackets (**{ }**); printer format codes are contained in double arrows (<< >>).

Placement Codes as listed below; all these conclude with an {End} statement. Any number of lines can be used as text.

{BeforeRun}
    Text printed at the beginning of the run-sheet.
{End}

{BeforeChip}
    Text printed before a new chip.
{End}

{Layer}
    Text printed for each optically monitored layer on the chip.
{End}

{XLayer}
    Text printed for each layer specified as **Crystal** in **Cutoff Type**.
{End}

{ChangeGain}
    Text printed when gain/offset is changed in the middle of a chip.
{End}

{AfterChip}
    Text printed after each chip.
{End}

{AfterRun}
    Text printed at end of the run-sheet.
{End}

Field Codes are constructed as follows:

{FieldName;Width;*Justify;Leader;Trailer;Upper*}

Width...number of spaces the field will occupy (required)
Justify...0 left, 1 right, 2 center (default 1)
Leader...Character(s) added to the left of the field (default blank).
Trailer...Character(s) added to the right of the field (default blank).
Upper...0 lower case, -1 upper case (default no effect).

While parameters in *italics* are optional, extra semicolons must be used when specifying parameters towards the right. Examples:

{DesignName;10}............'   bbar'
{DesignName;10;0}..........'bbar   '
{DesignName;10;2}..........'   bbar   '
{DesignName;10;1;;;-1}.....'BBAR   ' *(note extra semicolons)*
{DesignName;10;1;-;;-1}....'-BBAR   '

```
{DesignName;10;1;(;);-1}...'(BBAR)      '
```

Field names and descriptions are given below. Placement codes in curly brackets indicate where fields are usually placed.

ChipIndex {BeforeChip}
   Witness chip index value or file name BeforeChip

ChipLayer {Layer}
   Layer number relative to chip (L column)

ChipNum {BeforeChip}
   Chip number (C column)

ChipPos {Layer}
   Chip position (Chip Pos column)

Crystal {Layer}
   Crystal thickness value (Crystal column)

Design {Layer}
   Thin film design for each layer (Design column)

DesignDesc {BeforeRun}
   Thin film design file description

DesignFile
   Thin film design file name

DesignPath
   Thin film design file name including path

DesignWave {Before Run}
   Design wavelength including units

Eval {Layer}
   Monitor evaluation wavelength (Wave column)

Full {Layer} (or Ratio or Cutoff)
   Full swing or cutoff ratio value (FULL or Cutoff column)

FullPar {Layer} (or Level)
   Full/Partial ratio (FULL/PAR column)

Gain {BeforeChip}, {ChangeGain}
   Gain setting (Gain column)

Index {Layer}
   Refractive index at monitor wavelength for Leycom IV

Initial {BeforeChip}, {ChangeGain}
   Initial level setting (Initial Level column)

LayerNum {Layer}
   Design layer number (left hand gray column)

LayerSet {Layer}
   Layer set description (Layer Set column) for Leycom IV

Material {Layer}
   Film material description (Film Material column)

Offset {BeforeChip}, {ChangeGain}
   Offset setting (Offset column)

Par {Layer} (or TurnPts or Cycle)
   Partial swing or Cycle value (PAR or Cycle column)

`ParamDesc {BeforeRun}`
Coating parameters file description

`ParamFile`
Coating parameters file name

`ParamPath`
Coating parameters file name including path

`Qwot {Layer}`
Quarter wave optical thickness for Leycom IV

`Rate {Layer}`
Deposition rate in nm/sec for Leycom IV

`RunSheetDesc {BeforeRun}`
Run-sheet file description

`RunSheetFile`
Run-sheet file name

`RunSheetPath`
Run-sheet file name including path

`RunTime`
Estimated coating run-time

`Signal {Layer}`
Signal strength (Signal column)

`TemplateDesc {BeforeRun}, {AfterRun}`
Template file description

`TemplateFile`
Template file name

`TemplatePath`
Template file name including path

`Today {BeforeRun}`
Today's date

`ToolCrystal {BeforeRun}, {AfterRun}`
Crystal tooling factors (mon/sub) for all materials

`ToolCrystalB {BeforeRun}, {AfterRun}`
Crystal tooling factors (mon/sub) for all materials (brief version)

`ToolOptical {BeforeRun}, {AfterRun}`
Optical tooling factors (mon/sub) for all materials

`ToolOpticalB {BeforeRun}, {AfterRun}`
Optical tooling factors (mon/sub) for all materials (brief version)

`UserName {BeforeRun}`
User name from Directories dialog box

`Wave {Layer} or Mono {Layer}`
Monitor monochromator setting (Wave or Mono column)

`WorksheetDesc {BeforeRun}, {AfterRun}`
Worksheet file description

`WorksheetFile`
Worksheet file name

`WorksheetPath`
Worksheet file name including path

```
yIni {Layer}
```
Initial R/T value (Refl/Trns Ini column)

```
yMin {Layer}
```
Minimum R/T value (Refl/Trns Min column)

```
yMax {Layer}
```
Maximum R/T value (Refl/Trns Max column)

```
yFin {Layer}
```
Final R/T value (Refl/Trns Fin column)

```
yIni%, yMin%, yMax%, yFin% {Layer}
```
As above in percent

Printer action commands insert text, graphics and page breaks.

<<BASBLOCK value>>...Value 0 to 15. Insert text block paragraph(s) created in FilmStar BASIC by assigning BasText$(0)...BasText$(15). See IndentFirst, IndentLeft, and IndentRight.

```
<<BasBlock 5>>    ' insert block text BasText$(5)
```

<<BASEXEC code>>...Run a FilmStar BASIC program expressed as a string. *For brevity, optionally omit 'Sub Main' and 'End Sub' when Sub Main is the only module.* The pipe character "|" (not shown here) separates lines.

```
<<BasExec BasText(0)=CStr(Now)>><<BasText 0>>
```

Since FilmStar adds 'Sub Main' and 'End Sub' as needed, the above sample code to insert date and time actually has three lines, not one. BasExec is best utilized for short code segments.

<<BASRUN name>>...Run a FilmStar BASIC macro. This provides means to include calculated values in run-sheets, for example total layer thickness.

```
<<BasRun c:\Winfilm\Basic32\TotThick.bas>>
```

While the macro could alternatively be assigned to a macro key, including the macro file name in the run-sheet template is more dependable. Note that the complete path must be given.

<<BASTEXT value>>...Value 0 to 15. Insert string created in FilmStar BASIC by assigning BasText$(0)...BasText$(15).

```
<<BasText 5>>    ' insert BasText$(5)
```

<<BEGINBLOCK>>...<<ENDBLOCK>>...This command pair is inserted in the {BeforeChip} and {AfterChip} sections to keep the printout for all layers on a chip on the same page.

```
{BeforeChip}
<<BeginBlock>>
{End}
{Layer}
   ...
{End}
{AfterChip}
<<EndBlock>><<Chart>>
{End}
```

<<CHART>>...Insert strip-chart simulation plot. This only works if the worksheet is active (not grayed).

```
<<Chart>>
```

<<PICTURE name, zoom>>...Insert a picture file with .bmp (bitmap) or .wmf (metafile) extension. Pictures are centered between current margins. Zoom is optional and is 100% if not specified. Picture is convenient for printing company letterheads and logos.

```
<<Picture d:\winfilm\ftglogo.wmf, 75>> 'zoom=75%
<<Picture d:\winfilm\ftglogo.wmf>>      'zoom=100%
```

<<SELECT min-max>>...This command is used in conjunction with *Selected Layers* (Chart Setup menu) mode. It selects the layers to be plotted in the next chart. Typically this is used in the production of narrow band filters where all layers are deposited with the same witness glass.

```
<<Select 4-8>><<Chart>>
```

Printer format commands supplement the formatting in the run-sheet print setup dialog box.

<<ALIGN type>>...Align text between margins.

```
<<Align 0>>       ' align left
<<Align 1>>       ' align center
<<Align 2>>       ' align right
<<Align 9>>       ' justify
```

Left alignment allows you to format words within a line. In center and right alignment the entire line will have the same formatting.

<<BOLD boolean>>...Font bold or normal.

```
<<Bold 0>>        ' following text is normal
<<Bold 1>>        ' following text is bold
```

<<BORDER value>>...Page border, values 0 to 7: 0 none, 1 bottom, 2 top, 3 top & bottom, 4 box, 5 columns, 6 columns & top & bottom, 7 all. If Border is not specified, a top border is drawn if there is a header and the bottom is drawn if there is a footer.

```
<<Border 4>>      ' draw box around each page
```

<<COLOR value>>...Color 0 to 15: 0 black, 1 blue, 2 green, 3 cyan, 4 red, 5 magenta, 6 yellow, 7 light gray, 8 dark gray, 9 blue, 10 green, 11 cyan, 12 red, 13 magenta, 14 yellow, 15 white. 1-6 are dark versions of 9-14.

```
<<Color 9>>       ' text is blue
```

<<DEFFONTS>>...Returns *Name*, *Size*, *Bold*, *Italic* and *Spacing* to default values.

```
<<DefFonts>>
```

<<DEFNAME font>>...Sets new default font name. *DefSize*, *DefBold*, *DefItalic* and *DefSpacing* are similar.

```
<<DefName Lucida Sans Typewriter>>
```

<<HDRBOLD boolean>>...Header and footer font bold or normal.

```
<<HdrBold 1>>     ' header/footer text is bold
```

<<HDRCOLOR value>>...Header/footer color. See Color.

```
<<HdrColor 12>>   ' header/footer text is red
```

<<HDRITALIC boolean>>...Header/footer font bold or normal.

```
<<HdrItalic 1>>  ' header/footer text is italic
```

<<HDRNAME value>>...Header/footer font name

```
<<HdrSize 10>>   ' header/footer size is 10 points
```

<<HDRSIZE points>>...Header/footer font size.

```
<<HdrSize 10>>   ' header/footer size is 10 points
```

<<INDENTFIRST length>>...Additional left indent for the first line of a paragraph in inches or mm (metric paper).

```
<<IndentFirst .3>>   ' first indent=.3"
```

<<INDENTLEFT length>>...Left indent in inches or mm (metric paper).

```
<<IndentLeft .75>>   ' left indent=.75"
```

<<INDENTRIGHT length>>...Right indent in inches or mm (metric paper).

```
<<IndentRight .75>>  ' right indent=.75"
```

<<INDENTTAB length>>...Tab spacing in inches or mm (metric paper).

```
<<IndentRight .75>>  ' right indent=.75"
```

<<ITALIC boolean>>...Font italic or normal.

```
<<Italic 0>>     ' following text is regular
<<Italic 1>>     ' following text is italic
```

<<LINECOLOR value>>...Line color used for borders. See *Color*.

```
<<LineColor 12>>    ' borders in red
```

<<LINEWIDTH points>>...Line width in points used for borders. The default is zero. This may be acceptable for 300 dpi printers but will be probably be too thin for higher resolution printers.

```
<<LineWidth 1.5>>   ' line width 1.5 points
```

<<MARGINS metric, left, right, top, bottom>>...Set English/metric units and margins. Any non-zero value for the first field sets metric paper. If utilized, Margins should be the first command in a template.

```
<<Margins 0,.75,.75,.5,.5>> ' English units
```

This command is useful for templates created and stored through BASIC. Users can then be sure that margins are correct even if the Graph Axes file was overwritten.

<<NAME font>>...Font name. This must correspond to your printer. See also Size, Bold and Italic.

```
<<Name Lucida Sans Typewriter>>
```

<<NEWPAGE>>...Insert page break. Page breaks are automatically inserted if a graph is too big for the page.

```
<<NewPage>>      ' insert page break
<<Page>>         ' alternative
```

<<SIZE points>>...Text font size in points (1" = 72 points)

```
<<Size 10>>
```

<<SPACEAFTER points>>...Extra space in points (1" = 72 points) to be added after paragraphs.

```
<<SpaceAfter 8>>    ' 8 point space after paragraphs
```

<<SPACING percent>>...Line spacing as a percent of the current font size. The default can be set in the Report Setup dialog box.

```
<<Spacing 120>>
```

<<UP lines>>...Move up the page. This is helpful when formatting commands have added unwanted white space between lines.

```
<<Up>>     ' move up one line
<<Up 2>>   ' move up 2 lines
```

Strip-Chart Simulation
Evaluate...Strip Chart

The strip-chart simulation screen is an important aid in understanding numerical results. It also provides the means to adjust monitor gain and offset.

Edit...Adjust Gain <Ctrl+G>
The Adjust Gain dialog box provides flexibility for different coating situations. Depending on monitor mode, gain and offset can be automatically computed from initial, maximum and/or signal levels.

The exact contents of this dialog box and whether or not it can be activated depend on program conditions. When *Same gain/offset for all layers on chip* is enabled, gain can only be adjusted when the chart includes the first layer on a chip. When *Use Auto Level* is activated, the dialog box is simplified and shows only the *Level* setting.

The best way to understand the role of gain and offset is to try a number of cases and observe the effects.

Layers or chips are selected with **<Up>**, **<Down>**, **<PgUp>**, **<PgDn>**, **<Home>**, **<End>**. Use **<Left>, <Right>**, **<Ctrl+Left>** and **<Ctrl+Right>** to increase/decrease wavelengths. You can also click the mouse on the graph axes.

Setup (Plot Mode)

Three plot modes are supported:

1. **Single Layer <Ctrl+L>**...Only one layer is shown at a time. This mode is very useful for specifying mid-chip gain settings. Any mid-chip setting also applies to the following layers on the same chip.

2. **All Layers on Chip <Ctrl+A>**...Probably the most widely-utilized mode.

3. **Selected Layers <Ctrl+S>**...Quite useful when a chip contains too many layers for a legible plot.

   Use this mode to delete unwanted mid-chip gain and offset settings. Suppose there are six layers on one chip, with mid-chip gain and offset settings starting at chip layers 3 and 5. The optical coating engineer then realizes that it is preferable to have the same gain and offset for layers 3 through 6. This is accomplished by highlighting layers 3 to 6, activating the strip-chart and assigning new values of gain/offset.

Setup...Layer Separator
Select *Horizontal* to emulate previous FilmCalc operation.

Setup...Response Axis (GSM-420 mode)

Strip-charts in Balzers GSM-420 mode are different from those in other modes. Gain and offset settings are set to 1 and 0 because the GSM-420 provides its own corrections. The graph therefore represents 0-100% reflectance (transmittance) rather than overall system response. To display part of the graph and thereby enlarge the curve, select **Auto Scale** mode.

Setup...Thickness Axis

When plotting the response for a single layer, physical thickness and deposition time is continuously displayed as the cursor is moved over the graph. If **Crystal** physical thickness is specified the rate given in the Calculation Parameters dialog box refers to the deposition rate on the crystal monitor. If **Optical Chip** is specified, the rate refers to physical thickness on the optical monitor.

Warning Conditions
Evaluate...Warnings

Active worksheets indicate the quality of selected monitor wavelengths by displaying final ratios in 'good' (usually blue or dark green, but black may be better for monochrome monitors) and 'bad' colors (typically red).

Check one or more boxes and fill in minimum acceptable signal (say 5%) and fractional cut-off levels (say .15/.8) according to previous experience. Colors may be changed in design1.ini .

Threshold warning applies in two cases: 1. *Use turning points from previous layers* has been enabled, 2. Program Mode is *Run Sheet - TPs*. Extrema which are too near the beginning or end of a layer can cause difficulties with automatic optical monitors. Users should turn off 'FULL/PAR' and 'Monitor swing < 1' warnings when using previous turning points.

Worksheet

The worksheet is MONITOR's central feature and is always kept in memory. In addition to displaying information it is the storage area for several quantities. This is best appreciated by clicking **File...Configuration...Show All Columns**. Column widths can be manually adjusted if required.

Worksheets may be **active** or **inactive**. An active worksheet (displayed with alternating cyan and yellow bands), is connected to its underlying design and parameters files. Monitor wavelengths are edited directly, but other quantities can only be adjusted in auxiliary menus.

A worksheet is inactive (displayed entirely in gray) when loaded from disk or pasted from the clipboard. Cells cannot be altered, although rows can be inserted and deleted (not recommended). Select **Evaluate...Recalculate All** to generate an active worksheet using previous wavelength entries. This is the usual procedure when redoing old worksheets after the design has been changed slightly in order to compensate for spectral shifts. In such cases it is quite likely that previously selected wavelengths will require no adjustment.

Previous gain and offset settings are employed if **Use current worksheet values** is selected. These settings can be overwritten (still using previous wavelengths) with **Use Gain** or **Use Auto Level**. Click **Setup...Wavelengths** before recalculating if new wavelengths are required. This is the usual procedure when working with new designs.

While utilizing the worksheet the user follows four columns in the search for optimum monitor wavelengths:

1. ***Signal***...Relative signal strength: full-swing reflectance/transmittance change times monitor spectral response at the monitor wavelength.

   If the monitor spectral response is 0.8 at some wavelength and Rmax-Rmin = 25%, then the signal column shows 20%.

2. ***PARtial***...Partial or fractional swing. (d) indicates initial signal decrease, (i) denotes initial increase. From the coating technician's point of view a large partial swing will be counted as a full swing.

3. ***FULL***...Number of complete monitor swings.

   This column could also include a value like '5.687*Ini'. This indicates that the final level at cut-off is a multiple of the initial level. This occurs for thin layers or when FULL/PAR > 200%.

4. ***FULL/PAR (Full/Partial)***...Swing ratio based on a fractional max to min excursion.

   '1+101.5%' indicates that FULL>PAR. Care must be taken if these are used (cannot be avoided). If PAR is .75 and FULL is 0.8, FULL/PAR is '1+106.7%'. If PAR is 0.9 and FULL is 0.96 the same FULL/PAR is obtained. But (0.8/0.75) is preferable because FULL=0.8 is on the linear part of the strip-chart curve. FULL=0.96 is too close to the peak.

Utilizing the worksheet with ratios based on turning points in previous layers is somewhat different:

1. ***Signal***...Relative signal strength as above.

2. ***Turn Pts (Cycle)***...Number of turning points (extrema) in the current layer.

   > ***Turning points too near the beginning of a layer must be avoided in GSM-420 operation.***

3. ***Cutoff Ratio (GSM-420 RELative)***...Fraction (0-3.0) computed from the last two turning points. Previous turning points must have the same wavelength and gain/offset settings as the current layer. Otherwise the calculation begins anew at the point where the wavelength is changed.

4. ***Cutoff Level (GSM-420 ABSolute)***...Absolute cutoff level in %. Utilized when it is not possible to calculate a ratio (*i.e.* thin first layer on chip), or the ratio is >3.0, or the user has specified ***Level*** under ***Cutoff Type***.

Leycom IV Operation

1. ***Layer Set*** provides information about each material. Default Layer Sets are set up by checking ***Recalculate Layer Set column*** in Worksheet Calculation Options. The Layer Sets can then be edited manually or more conveniently via ***Edit...Layer Sets***. The maximum number of characters is 9. Multiple Layer Sets for each material make it possible to change e-gun crucible, etc.

2. ***Chip Position (TGW-6 only)*** is not the same as C*hip Number*. Chips are numbered consecutively, but it may be desirable to set up the Leybold TGW-6 in nonconsecutive order, *i.e.* position 1 for material A and position 4 for material B. A table relating Chip Position and Chip Number is found in the Witness Chip Distribution dialog in the Setup Menu.

3. **Rate** is in nm/sec is computed from the Rate entered into Setup Parameters in Å/sec. While **Cutoff** is not used to program the Leycom IV, it does provide a guide to selecting appropriate monitor wavelengths.

4. **QWOT** is quarter wave optical thickness (1 QWOT = 1.0) at the monitor chip. This is the value utilized by the Leycom IV.

5. **Film Index** is utilized by the Leycom IV.

FilmStar BASIC

FilmStar BASIC is a development environment for customizing FilmStar. Using Sax Basic, FilmStar BASIC adds the special commands and keywords discussed in this section. Two macro commands are supported: BasOpen and BasRun.

The FilmStar BASIC language is nearly 100% compatible with Microsoft VBA (Visual Basic for Applications). The IDE (Integrated Develement Environment) (**Tools…BASIC Editor <F6>**) provides means to edit and test BASIC programs.

The purpose of BASIC in MONITOR is to enable users to produce custom lists or files for integration with automatic optical monitors.

FilmStar MONITOR Extensions

Summary documentation for FilmStar extensions is provided in the BASIC editor (IDE). Click the Browse Object icon.

A number of functions and subroutines are supported. Other functions are supported by the Macro function described below.

Sub BasActivate()...Return focus to BASIC's IDE (integrated development environment).

```
BasActivate
```

Sub BasChain(file$)...Immediately run BASIC program from current program.

```
BasChain "c:\winfilm\basic32\eval1.bas"
```

Property BasText$(0)...BasText$(15)...Set text variables for use in the run-sheet with action commands *BASTEXT* and *BASBLOCK*. Text can be a fragment or a block of paragraphs.

```
BasText(0) = "Welcome to FilmStar MONITOR"
```

Sub Busy(k As Boolean)...Turn hourglass cursor on/off

```
Busy False  ' turn off hourglass cursor
```

Sub DefaultPath(Optional pParam$, Optional pDesign$, Optional pIndex$, Optional pSpectra$)…Change some or all default paths listed in Configuration dialog. pParam$ includes Worksheet, Template and Parameter files.

```
DefaultPath ,,,"c:\dwdm\test004"  ' change spectra path
```

Sub DispBox(text$, icon%, title$)...Display a message box without buttons. This is useful for status messages when no response is required. Use the following icon numbers: 16-Stop, 32-Question, 48-Attention, 64-Information. Use the BASIC MsgBox instruction when a user response is required.

```
DispBox "Waiting for stabilization", 48, "Heater"
Wait 10              ' wait 10 seconds
DispBox "", 0, ""    ' remove the box
```

Sub Display(text$, title$, wd%, ht%, FontName$, FontSize!, FontBold%)...
Display a multiline text box in a dialog box with width wd% (twips) and
height ht%.

```
Display "FTG Software Associates", "Princeton, New
Jersey", 5000, 3000, "Arial", 18, 1
```

Function FilmMatlFile$(kRow)...Returns dispersive film file name in row
kRow under *Monitor n,k File* in the Film Indices dialog.

```
s$ = FilmMatlFile$(2)
```

Function fMsgBox%(text$, icon%, title$)... Similar to BASIC's MsgBox but
utilizes the format set in the Preferences tab. MsgBox is screen-centered;
fMsgBox optionally centers in the active dialog window.

```
k% = fMsgBox("Do you want to proceed?", 36, "BASIC")
```

Sub MainActivate...Return focus to CRYSTAL's Main Menu.

```
MainActivate
```

Property MainEvents As Boolean....By default, running a program from the
BASIC editor (IDE) enables FilmStar keyboard and mouse events. By
default, running a program via macro command *basrun* disables FilmStar
keyboard and mouse events. This behavior may be changed in a BASIC
program by setting MainEvents true or false.

```
MainEvents = True  ' respond to keyboard/mouse
                   ' default in IDE
MainEvents = False ' do not respond to keyboard/mouse
                   ' default when run without IDE
```

Most importantly, setting *MainEvents = True* in a BASIC program run from
basrun adds an **Abort BASIC** menu command.

Property MonWaveUnit$...Returns N for nanometers and M for microns.
Utilized in SproMonitorReport.bas for Leybold OMS setup.

```
s$ = MonWaveUnit$
```

Property NumFilmMatls%... Get the number of film materials defined in the
Film Indices dialog.

```
k% = NumFilmMatls
```

Property NumLayers...Get the number of layers in the design

```
k% = NumLayers
```

Property OpticalMode%...Set monitor mode: 1 Reflectance (Side 1 only), 2
Transmittance (uncoated Side 2), 3 Reflectance (include Side 2), 4 Reverse
reflectance, 5 Transmittance squared, 6 Tranmittance (AR on Side 2)

```
OpticalMode = 1
```

Function PadString$(text$, length%, align%)...This function pads a string
with spaces to return a string of given length. Spaces are added to the left
(align=0) or right (align=2) or the string is centered (align=1). This function is
useful for generating reports.

```
BasText0$ = PadString$(format$(x!,"0.000"),8,0)
```

Property PgmExe$...Get the name of the FilmStar .EXE file.

```
s$ = PgmExe   ' returns "Monitor1"
```

Sub sMsgBox(text$, icon%, title$)... Similar to BASIC's MsgBox but utilizes the format set in the Preferences tab. MsgBox is screen-centered; sMsgBox optionally centers in the active dialog window.

```
sMsgBox "Get a cup of coffee!", 48, "Working Hard"
```

Property RunTime...Get estimated coating time in minutes

```
t! = RunTime
```

Property SubstrateFile$...Get dispersive substrate file name listed under *Monitor n,k File* in the Film Indices dialog.

```
s$ = SubstrateFile$
```

Property SubstrateFile$...Get dispersive substrate file name listed under 'Monitor n,k File' in the Film Indices dialog.

```
s$ = SubstrateFile$
```

Sub TurnPtAdjust(Mode&, Optional Ratio!, Optional Delta!)...Adjust Worksheet chip settings by rounding up near QWOT layers in the Cutoff Ratio column to QWOT. Default Ratio = 0.98; default Delta = .01. Mode: default = 0 (last layer only), +1 for all layers, +2 adjusts the Cutoff Level column in addition to the Cutoff Ratio column. *Note that TurnPtAdjust requires Program Mode = Run-Sheet - TPs.*

```
TurnPtAdjust     ' default setting, last layer on chip
TurnPtAdjust 1   ' all layers on chip
TurnPtAdjust 1, .96, .02   ' non-default values
TurnPtAdjust 3   ' all layers and Cutoff Level column
```

As there are numerous optical monitor strategies, users should report any anomalies. Hint: TurnPtAdjust can be assigned to a Calculation Macro in Tools.. Macro Commands. The simplest would be *BasExec TurnPtAdjust*.

Property UUID$...Returns UUID (Universal Unique Identifier) for use in Leybold XML files.

```
s$ = UUID$
```

Sub WriteIniString$(section$, key$, text$)...Store user-define initialization variables in design1.ini.

```
WriteIniString "Temp File", "LastFileName", "WW098909"
```

inserts/modifies the following entry in design1.ini:

```
[Temp File]
LastFileName=WW098909
```

Sub WsCopyAll(Optional Enhance as Boolean)...Copy entire worksheet to the clipboard. Useful for BASIC macros utilizing *Microsoft* Excel.

```
WsCopyAll          ' copy Worksheet
WsCopyAll True     ' copy Worksheet, adding Properties and
                   ' Materials information at the bottom
```

Function WsGetNum!(iRow%, iCol%)...Gets numeric value of the worksheet cell at iRow, iCol.

```
x! = WsGetNum(2, 5)
```

Function WsGetText$(iRow%, iCol%)...Gets text in the worksheet cell at row iRow, column iCol.

```
s$ = WsGetText(2, 2)
```

Sub WsSetNum(iRow%, iCol%, v as Variant)..Sets numeric value of the worksheet cell at iRow, iCol

```
WsSetNum 2, 5, 3.24
```

Sub WsSetText(iRow%, iCol%, s$)... Sets text at iRow, iCol.

```
WsSetText 2, 2, "Hello world!"
```

Function XLcell(iRow&, iCol%) As Variant...Extract data from the open workbook (worksheet specified in XLopen).

```
WaveUnit$ = Xlcell(1, 1)  'first row
Wave!(55) = Xlcell(56, 1)
```

Sub XLclose()... Close hidden workbook object

```
XLclose
```

Sub XLinfo(nRows&, Optional nCols%)... Returns number of rows and columns in an open worksheet. Sheet specified in XLopen.

Function XLnew(mRows&, mCols%, Optional ShtName as Variant, Optional Font$, Optional fSize!, Optional RefStyle%) As Boolean...Opens new hidden Excel workbook object for writing. If the workbook object is already open, a new worksheet is added with name ShtName. Default font = Verdana 9 pt. Set RefStyle (0, 1, 2) = 2 for R1C1. Remember to add one row for header.

Function XLopen(file$, Optional sSheet as Variant, Optional bView as Boolean) As Boolean...Open Excel workbook (*.xls/*.xlsx); required before Function XLcell. Optional Sheet number or name for multi-sheet workbooks. ***XLclose required before XLnew!***

```
XLopen "C:\Winfilm\Data\WaveAngs.xls"
XLopen "C:\Winfilm\Data\WaveAngs.xls", , True
```

*Note: XLopen is an Excel-defined constant and consequently incompatible if establishing a COM reference to Excel. In that case use alias **XL_open**.*

Function XLsave(file$, Optional bProtect as Boolean) as Boolean...Save Excel workbook (*.xls *.xlsx *.tab *.txt). Tab-delimited saves the first sheet. If no extension then .xls or .xlsx is added.

```
Xlsave "c:\Winfilm\Spectra\Test.xls, True  ' Locked
Xlsave "c:\Winfilm\Spectra\Test.xls ' Unlocked
Xlsave "c:\Winfilm\Spectra\Test ' Adds .xls or .xlsx
Xlsave "c:\Winfilm\Spectra\Test.tab ' Tab-delimited
Xlsave "c:\Winfilm\Spectra\Test.txt ' Tab-delimited
```

Sub XLview(Optional file$)... Activate the built-in FTG Excel Viewer for inspecting .xls and .xlsx files. Excel is not required.

```
XLview ' No file specified, select with dialog
XLview "c:\Winfilm\Data\WaveAngs.xls"
```

Sub XLwrite(iRow&, iCol%, fCell As Variant, Optional Decimals%, Optional Justify%, Optional ForeColor&, Optional BackColor&)...Write number, text or math/text formula fCell to an open worksheet. Default decimal places = 2; default justification = 1 (right) for numbers and 2 (center) for text; left = 0. Decimals < 0 gives scientific notation. "|" in a column header is converted to a line feed, thereby allowing multi-line headers. *An fCell entry starting with = denotes a numeric formula; an entry starting with & denotes a text formula.*

Transfer Menu

This menu appears when Eddy IQ-145/LMC-10 operation is selected in **Setup...Program Mode**. Otherwise it is hidden.

Terminal Emulator
Transfer...Terminal <Ctrl+T>

The built-in terminal enables users to update and control Eddy light monitors from the computer.

IQ-145: Set *Capture* on to record everything shown on the screen in a text file. Click *File* to change file names. (You can reuse the current capture file; new data is appended.) A trick: To annotate data, type in a description (instead of 1-6) in response to the PLEASE TYPE prompt. The IQ-145 will issue the TRY AGAIN prompt.

LMC-10: When **Capture Mode** is unchecked, the terminal is used to manually create a coating program or update an old program. When Capture Mode is checked, the terminal displays the output of the LMC-10's printer port. Set *Capture* on to record everything shown on the screen in a text file. Click *File* to change file names. (You can reuse the current capture file; new data is appended.) A second serial port or a switch box is required to connect the computer with the LMC-10 *PRINTER* connector on its rear panel.

Upload Instrument
Transfer...Upload <Ctrl+U>

LMC-10/20 Programmer: This dialog replaces the old terminal uploader. When first activated a BASIC-52 program (LMC_COM.BAS or LMC_COM2.BAS for Eddy software revision 7.x) is sent to the light monitor.

The coating program in the main screen is initially displayed. The displayed program can be uploaded to the LMC, or a program in the LMC can be down-loaded, viewed, modified (tweak wavelengths or change chip drop) and uploaded. Chip drop for the first layer is changed by clicking the **Change Drop** button; chip drop for other layers can be changed in the Edit menu.

Edit…Tweak Wavelengths provides means to move coatings to slightly higher or lower wavelengths. This is recommended for quickly correcting coatings which have the correct shape but are displaced slightly in wavelength.

Program descriptions are stored in memory normally allocated to programs 37-40. (If necessary, click **Edit…Enable Descriptions** to regain use of these four coating programs.) Descriptions are stored on disk when the dialog is closed.

If you use the Eddy Programmer with several monitors (or not sure that descriptions are correct), click **File…Retrieve Descriptions** to download them from the

LMC. Click **File…Copy Descriptions** or **Copy Program** to copy grids to the clipboard. These can be pasted into Excel or a word processor for printing. You can delete a coating program (set its layer count to zero) by right clicking its row in the description grid.

After uploading the light monitor or using it in terminal mode, users can return to front panel operation by clicking *YES* in the *Enable front panel operation?* dialog box. Click *NO* to upload more coating programs or to manually edit current programs from the computer.

> **Enable front panel operation upon leaving the LMC Programmer if you intend to utilize terminal operation (and vice-versa).**

IQ-145: This dialog box displays the coating program before it is uploaded to the light monitor via terminal emulation. The displayed program is computed from the current Worksheet. You can also load a previous program from disk. The coating program number (1-40) can be changed.

If the *Q Waves* entry is less than one the *Cutoff* value is the optical monitor intensity (10-999). If the *Q Waves* entry equals zero the *Cutoff* value is the crystal monitor setting in Ångstroms.

Serial Port Select
Transfer...Serial Port

Change serial ports as required. Upon exiting MONITOR the selection is stored in Configuration file design1.ini. In LMC-10 Capture Mode the setting can be different from the one used during uploading.

The Coating Game©

The Coating Game simulates actual coating production. It is a tool for developing practical coating skills. After a coating is produced it can be automatically compared with the theoretical design.

Playing the Game

Start FilmStar DESIGN if it's not already running. This enables you to compare the theoretical design with the virtual coating that you produce. Since you won't actually need to run DESIGN it can be minimized.

In the main File menu click **The Coating Game**. You should see the strip chart move. Should you want to switch to another program such as a word processor we suggest you click **<F2>** to pause the game's master clock. You may also find this necessary if menus are 'sticky'. *The pause function is disabled if you are in the midst of depositing a layer.* Press **<F2>** again to resume coating operations.

Assuming that DESIGN is running check **Setup...Show Coating Spectrum** to activate the ability to graphically compare the theoretical design with the coating fabricated in the game. Next, load a Worksheet from disk. This sets up machine parameters as well as a previously defined coating requirement.

You should have the associated coating run-sheet at hand. If not, load it from disk with **File...Retrieve Run-Sheets**. When first starting (before opening the shutter), allow the strip chart to run until the pen line has moved off screen. This stabilizes the speed of program operation since speed is affected by the number of pixels to be updated.

During the game it may be necessary to calculate cut-off levels. Maximum and minimum positions need to be marked. This is accomplished by 'writing' on the strip chart. Click on the chart to obtain a blue labeled line at the cursor position. Hold the shift key for a red line. Continuous clicking erases the oldest line, leaving three lines on-screen. When all layers are deposited, click the **End** button. If DESIGN is running and if *Show Coating Spectrum* was activated, a graph comparing the design with your coating finally appears.

Obviously one wants to play the game as quickly as possible while still being able to calculate and judge cut-off levels. Adjust the **Coating Rate** knob (e-gun power) in conjunction with **Setup...Coating Rate Multiplier**.

Setting up the Game

A Coating Game requires a previously set up Worksheet as well as a printed run-sheet which can be loaded as a binary file and printed from the game. The Worksheet must use FILM Archive mode because the archive will be automatically loaded into DESIGN and used to compute a 'score'.

The score merit function is computed from Optimization Targets generated from the theoretical design. This is easily done as follows in DESIGN:

1. Evaluate the design.

2. Click **Optimize...Targets** and clear current targets by clicking on the upper left and pressing **Delete**.

3. Click **Generate**, select *Reverse Synthesis* mode and convert the spectrum into targets.

4. Store as a new FILM Archive file and later open this file in MONITOR to attach it to the Worksheet.

Since the merit function for one design will be different from another, a 'score' for one design will not be the same as another. Note that the Merit Function can be calculated in DESIGN by pressing **<Shift+F9>**.

The Coating Game reads the first four indices from the Film Indices list and lists material symbols (L, H, M, etc.) in its Materials selector switch (typically simulating a crucible selector). The game uses defined indices and monitor/substrate ratios. It utilizes monochromator calibration if enabled. If *Re-use previously coated chips* is enabled in *Monitor Parameters Advanced* the user is presented with a six-position *Witness Chip* selector rather than a *Drop Chip* button.

The game does not provide information about which layers to put on which chips at which wavelength. *In other words, there is nothing to prevent the player from destroying the coating.* There is no way to delete bad layers and start again. After all this does not occur in actual practice. It is permissible, however, to add more material to layers that are too thin.

A number of settings can be adjusted in **File...Configuration...Automation**:

The Coating Game has been set to allow 2000 points on the screen. If this is not sufficient, select a higher Chart Speed or reduce the physical width of the strip-chart. The number of points can be increased, but it appears that too many cause screen graphics problems.

The game communicates with FilmStar DESIGN via DDE (dynamic data exchange) . If using a slow computer it may be necessary to increase the DDE time-out interval. The Coating Game master clock sets strip-chart refresh rate. The default is 20 milliseconds. In practice the screen updates every ~250 ms

depending on processor speed and the graphics card. Check *Test Mode* to view actual screen update intervals.

DDE Strip-Chart

The DDE Strip-Chart (32-bit version only) extends *The Coating Game* to actual production and provides a path towards complete automation.

This facility requires that MONITOR acquire the strip-chart signal from an optical monitor or lock-in. In order to do this we have set up MONITOR as a DDE (dynamic data exchange) client. By using DDE we avoid problems that would certainly occur if we were to develop special versions of MONITOR for different hardware configurations.

The DDE Strip-Chart offers two major advantages over paper:

1. It is much easier to pick out and record turning point levels.

2. It is possible to mark the cutoff level.

Setting up a Server

The DDE Strip-Chart requires DDE server software. A sample program *Coater1.exe* with Visual Basic 6 source code has been provided in directory

..\Winfilm\Monitor\Vb6\Coater

Coater1.exe must be replaced with a DDE-compliant program which actually reads the signal from your monitor. If you don't know how to do this, contact programmers in your company or contact FTG Software for a quotation.

A DDE link requires a *topic* and an *item*. These are specified in the automation setup (**File...Configuration...Automation**). Default values corresponding to the supplied examples are "Coater1|Main" and "lblSignal".

Running the Strip-Chart

With *Coater1.exe* (or its replacement) running click **File...DDE Strip-Chart**.

In the strip-chart window click **Setup...Show Shutter Switch** to display the shutter switch. The Shutter label in *Coater1.exe* turn red and green as the switch is toggled. You can use this for actually opening and closing the shutter if you connect your DDE server to the shutter relay.

To keep a permanent record of the coating sequence, click **File...Open Log File** and enter a new or existing (appends data) file name. It is necessary to close the file before exiting the strip-chart window.

General

File Manager

FilmStar file commands will be familiar from other Windows applications, but there are some differences because of the number of file types utilized.

> *Files can opened from any directory but can only be saved in default directories.*

More...Delete <Ctrl+D>

Only a highlighted file can be deleted. The current file cannot be deleted.

More...List Files <Ctrl+L>

To create a master list of all files, use the **Copy** command and paste the text into Notepad with **<Ctrl+V>**. Repeat for other file types. Lists can be printed.

Keyboard Commands

Keyboard commands are generally identical with those in other Windows applications. The grid (spreadsheet) control warrants some explanation.

Cancel

Upon selecting **Cancel <Escape>** changes in the dialog box are lost. If you are constantly losing data in this manner try setting the cancel confirmation flag. See "Configuration - Preferences" on page 16.

Grid Control

The custom grid control makes it possible to edit large data sets within a dialog box. The control is quickly navigated with the mouse.

Mouse...Click on the required cell. A single cell is selected when highlighted by a box. Note that the box is sometimes a pull-down list. Multiple cells are highlighted in black by holding down the mouse button.

Keyboard...Use **<Arrows>**, **<Home>**, **<End>**, **<Ctrl+Home>** and **<Ctrl+End>** to move the focus and scroll the grid. Hold down the shift key to select multiple cells. **<PgUp>** and **<PgDn>** also work. **<Tab>** navigates to the next available cell and moves the focus to the next control if there are no more editable cells. Most grids will not let you enter data more than one row below the last row containing data.

Press **<Del>** or **<BkSp>** to clear an entry or a selected region. Note that rows can be deleted, inserted and sorted by wavelength. To edit a cell without replacing it (*i.e.* overwrite mode), press **<F2>** or **<Insert>**.

The program attempts to prevent erroneous data. In most cases the offending data cell is highlighted in yellow. Additional checks are performed upon clicking the OK button.

Shortcut Keys

There are a number of shortcut keys. Several dialog boxes and windows contain their own shortcut keys (not shown here). File Save **<Shift+Ctrl+k>** and Save As **<Shift+Alt+k>** sequences are not displayed in menus.

<F2>	DB Retrieve Design
<F3>	Change increase/decrease wavelength interval
<F4>	Decrease current monitor wavelength
<F5>	Increase current monitor wavelength
<Shift+F1>	Default column widths
<Ctrl+F2>	Retrieve column settings from disk
<Shift+F2>	Show all columns
<Shift+Ctrl+F2>	Keep (store on disk) column settings
<Shift+F3>	Hide current column
<Shift+F4>	Reduce current column width
<Shift+F5>	Increase current column width

<F6>	Repeat previous monitor wavelength	
<Ctrl+F6>	Duplicate wavelengths through current chip	
<Shift+F6>	Copy wavelengths from previous chip	
<F8>	Strip-chart window	
<F9>	Recalculate current chip (automatic in some modes)	
<Ctrl+F12>	Worksheet Open	
<F12>	Worksheet Save As	
<Ctrl+A>	Assign default wavelengths	
<Ctrl+G>	The Coating Game	
<Ctrl+H>	Edit chip distribution	
<Ctrl+I>	Film indices editor	
<Ctrl+L>	Layers design editor	
<Ctrl+M>	Communications	
<Ctrl+O>	Worksheet calculation options	
<Ctrl+P>	Monitor calculation parameters	
<Ctrl+R>	Recalculate entire worksheet	
<Ctrl+S>	Coating run-sheet window	
<Ctrl+T>	Eddy IQ-145, LMC-10 terminal emulator	
<Ctrl+U>	Upload Eddy IQ-145, LMC-10	
<Ctrl+Y>	Eddy IQ-145, LMC-10 parameters	
<Alt+Ctrl+k>	**Open**	
<Shift+Ctrl+k>	**Save**	
<Shift+Alt+k>	**Save As**	
k = D	Thin film design	
k = P	Monitor calculation parameters	
k = T	Run-sheet template	

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