

# FILM★STAR Optical Thin Film Software

## Introduction

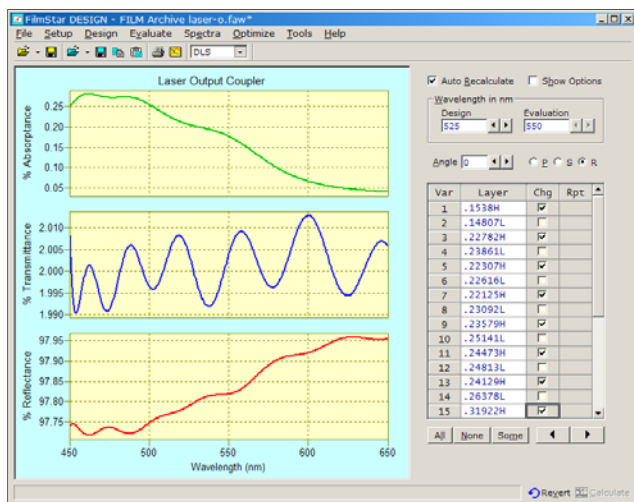
FilmStar™ includes programs for designing, measuring and monitoring optical thin film coatings: DESIGN & INDEX, MEASURE, MONITOR and CRYSTAL.

## Programs DESIGN & INDEX

**Thin Film Design** - Designs can contain virtually any number of layers defined by optical, physical or massive thickness. FilmStar supports evaluation and optimization in complex systems containing multiple substrates and spacers with films on all or some surfaces.

Design facilities include mathematical operations, Herpin replacement, optical to physical conversion, reverse design, inhomogeneous layer simulation, etc. Up to 999 film materials in a design. Design macros, with angle and wavelength matching, combine designs into filter assemblies. Program INDEX provides exceptionally convenient handling of filter glasses.

**Film Indices** - Indices are defined by constants, look-up tables or dispersive functions. Built-in functions include Cauchy, Lorentz, Sellmeier, Forouhi-Bloomer, Tauc-Lorentz, Bruggeman, Maxwell-Garnet, etc. User-defined models may utilize up to three dispersive materials (mixed films) and even include angle and polarization effects. Using inverse synthesis, coefficients are determined from measured spectral data.



DESIGN Interactor Screen

INDEX also includes the following abilities: 1. Calculate n,k from R&T for films of known thickness, 2. Calculate n,k from transmittance for slightly absorbing films, 3. Calculate filter glass dispersion from R&T data.

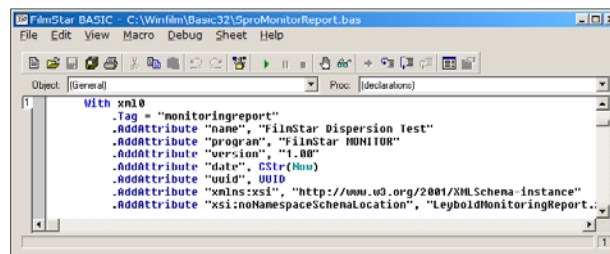
**Calculated Quantities** - Plot [%R, %T, OD, phase] vs. [wavelength (nm, microns, 1/cm, etc.), angle or thickness]. Other modes include E-field, total/partial/differential absorptance, CIE color, ellipsometry, dispersion (GDD etc.) and Herpin indices. The FSPlot Module generates web-ready and publication-quality graphs which may be printed in the FilmStar Report Generator (see Page 4).

**Optimization** - Optimization and synthesis methods include DLS, LM, simplex, gradient, needles, flip-flop and genetic evolution. Targets at multiple wavelengths and angles include %R, %T, phase, Psi/Delta, etc. User-defined targets are supported.

Supplementing the usual optimization targets, the powerful FilmStar Workbook (see Page 2) gives users unprecedented versatility in meeting complex system performance requirements. This capability is not found in other optical thin film software.

Optimization variables include thin and massive layer thickness as well as dispersive indices. Variables may be linked to preserve stack ratios. In inverse synthesis, targets are measured spectra; the starting design is the ideal design and the final design gives indices and thicknesses. A special mode enables users to correct deposition tooling factors.

**FilmStar BASIC** - FilmStar supplements its user-friendly menus and dialogs with VBA-compatible FilmStar BASIC. FilmStar is object-compatible with MS Office and other popular programs. These capabilities are not found in other thin film software.



FilmStar BASIC Development Environment

Fully supported source-code examples include OTFE (Optical Thin Film Exchange with other programs), cone-angle compensation, design export to Code V and Zemax, process export to Maxtek, spectra import from Shimadzu and Woollam, bandwidth plots, Excel (see Page 4) and Word interfaces, etc. Programs can be encrypted for security and assigned to macro keys.

For further information please visit [www.ThinFilmSoftware.com](http://www.ThinFilmSoftware.com)

**FilmStar Workbook** - The built-in Excel-compatible Workbook provides users with calculation and optimization facilities beyond other design programs.

This screen shot illustrates a beamsplitter optimized over an angle range and including a wavelength-dependent weighting function. P/S energy must be maximized. This is difficult, if not impossible, to set up with the usual optimization targets.

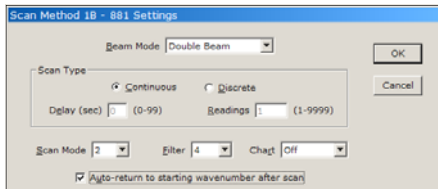
	A	B	C	D	E	F
4	Weighting	Macro - pres <F8>		DP	TP	RS
5	5.93E-04	Angle 38 p, Calculate	440	0.39039	0.60961	0.97365
6	6.38E-04	Angle 38 s, Calculate	442	0.40548	0.59452	0.98105
7	7.19E-04	Angle 38 p, Calculate	444	0.41659	0.58341	0.98935
8	6.65E-04	Angle 38 s, Calculate	446	0.42349	0.57651	0.99338
9	9.03E-04	Angle 40 p, Calculate	448	0.42638	0.57362	0.99535
10	9.52E-04	Angle 40 s, Calculate	450	0.42557	0.57443	0.99641
11	1.31E-03	Angle 42 p, Calculate	452	0.42144	0.57856	0.99702
12	1.49E-03	Angle 42 s, Calculate	454	0.41431	0.58569	0.99738

Optimization in the FilmStar Workbook

**FilmStar Free Version** - Prospective users are invited to test the FilmStar DESIGN Free Version. The Free Version has restricted indices, but values are realistic and even include dispersive Ag and Al.

## Program MEASURE

*Optical films must be measured - not just designed.* Optional program MEASURE controls and acquires data from spectrophotometers. It is highly integrated with DESIGN and provides optics users an alternative to the unsuitable chemists' software supplied by instrument manufacturers. No other coating software directly controls spectrophotometers.



MEASURE Scan Method for PE 881

Currently supported instruments include PE Lambda 2-950/URA (Lambda 19 Win XP!), PE 580-983, Cary, Agilent 8453, Hitachi U-3210/3410, OOI and Zeiss. Contact us for information about other instruments.

**Program Modes** - Transmittance (optical density), 'V' and 'VW' reflectance. Wavelength units: Ångstroms, nm, μm, 1/cm. Data types: Sample, Baseline (blocked sample beam, usually 0%), Reference (usually empty sample compartment or known reflector), and Standard files. Files may be loaded from disk or scanned as appropriate. Spectral data can be utilized in DESIGN for inverse synthesis.

**Scan Range** - Scan Range is defined by minimum, maximum and interval wavelengths (wavenumbers). A Wave List can also be specified. This is useful when measuring optics with differing characteristics

in different bands, ie. blocking regions and transmission regions. A Wave List is useful for optics whose specifications are defined at particular wavelengths.

**Digitizer** - SummaSketch graphics tablets may be used for digitizing strip-charts. This makes it possible to generate computer files from old data.

**Additional Features** - MEASURE includes FSPlot, the Workbook, FilmStar BASIC, and Report Generator. Users with reasonable programming skills can automate QC procedures and measurements.

MEASURE supports the FilmStar Database (see Page 4). This link to the FileMaker Pro application provides means to store spectra in secure password-protected files. Records created by MEASURE can be retrieved and analyzed in DESIGN.

MEASURE also includes OCX versions. This enables advanced users to quickly develop their own scanning applications. This is most appropriate in situations where the same measurement procedures are repeated over and over.

## Program MONITOR

*Optical films must be manufactured - not just designed.* Optional program MONITOR converts designs to optical monitor recipes. MONITOR far exceeds the capabilities of monitoring curves typically provided in thin film design software.

**Coating Chamber Parameters** - These include tooling factors and spectral response. There are numerous options: vary wavelengths between chips or between layers on a chip; use previous turning points or previously coated chips; vary gain and offset for any layer. Wavelength calibration is included (very important when monitoring at widely separated wavelengths, but often neglected). As coating indices may differ from final values, two dispersive index files are utilized simultaneously.

Chip	Layers	Design	Chip
1	2	.41816H	1
2	2	.24631L	1
3	2	.33618H	2
4	2	.38916L	2
5	2	.26791H	3
6	2	.26843L	3
7	2	.28540H	4
8	2	.28159L	4
9	2	.26635H	5
10	2	.25448L	5
11	2	.25458H	6
12	2	.26144L	6
13	2	.26007H	7
14	2	.22474L	7
15	2	.21144H	8

MONITOR Witness Chip Manager

Film Indices and Calculation Parameters appropriate for manual or automatic monitoring modes are stored as Parameters files. Typically each coating chamber has its own file. Film designs may be loaded from

disk or pasted from the clipboard. Designs containing repeated layer groups, i.e. (.25H .25L)10 .25H, are converted into individual layers.

**Witness Chip Manager** - Users can assign or reassign any number of layers per chip. Different indices can be assigned for each witness chip.

**Calculated Monitor Quantities** - MONITOR calculates signal changes as typically observed on a strip-chart; crystal monitor settings.

**Interactive Worksheet** - Normally the user starts by calculating with default wavelengths. Wavelengths for each layer are subsequently adjusted for optimum sensitivity and selectivity. Any layer can be changed in any order and new layers can be inserted without affecting prior settings. Colors indicate whether monitor wavelengths are suitable.

Settings for thin layers can be based on turning points in previous layers on the same chip. MONITOR also supports optical monitors which allow re-use of previously coated chips.

**Coating Run-Sheet** - Once monitor wavelengths are determined, results must be translated into run-sheets, the actual instructions used by coating technicians. Run-sheets can be modified according to user-defined templates and printed in any language.

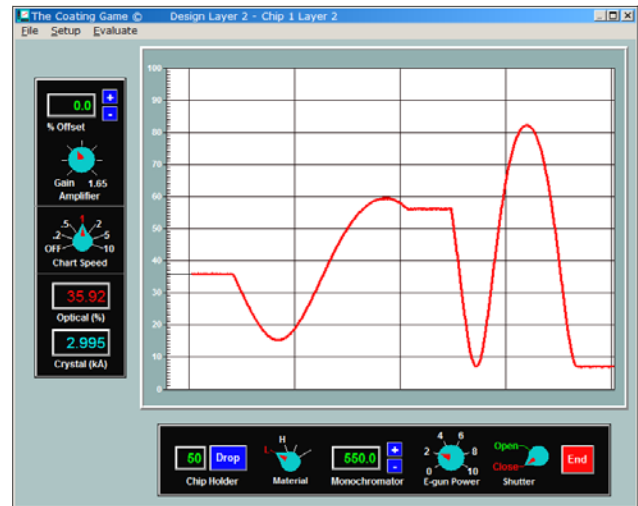
Design	C	L	Film Mat '1	Wave (nm)	Signal	Turn Pts	Cutoff Ratio	Crystal (kHz)	Initial Level
1	.41816H	1	1	TiO2	558.0	45.54	0.990	1.574	6.9%
2	.24631L	1	2	SiO2	558.0	28.4%	0.788	1.809	
3	.33618H	2	1	TiO2	558.0	45.54	0.423	1.266	6.9%
4	.38916L	2	2	SiO2	558.0	23.1%	0.926	2.271	
5	.26791H	3	1	TiO2	780.0	16.4%	0.255	1.809	7.3%
6	.26843L	3	2	SiO2	780.0	18.8%	0.538	1.972	
7	.28583H	4	1	TiO2	730.0	11.7%	0.268	1.873	7.4%
8	.28159L	4	2	SiO2	730.0	7.5%	0.595	2.069	
9	.26635H	5	1	TiO2	570.0	41.3%	0.811	1.003	6.9%
10	.25448L	5	2	SiO2	570.0	14.9%	0.322	1.869	
11	.25458H	6	1	TiO2	675.0	21.3%	0.228	0.958	7.3%
12	.26144L	6	2	SiO2	675.0	13.6%	0.553	1.921	
13	.26001H	7	1	TiO2	675.0	21.3%	0.255	0.979	7.3%
14	.23474L	7	2	SiO2	675.0	13.5%	0.385	1.724	
15	.21144H	8	1	TiO2	680.0	35.3%	0.158	0.796	7.1%
16	.19322L	8	2	SiO2	680.0	22.4%	0.268	1.927	
17	.18324H	9	1	TiO2	525.0	37.4%	0.172	0.699	6.7%
18	.28388L	9	2	SiO2	525.0	22.6%	0.566	1.492	

MONITOR Interactive Worksheet

Users may include design description, design file name, date, reflectance and transmittance values, etc. Run-sheets including helpful embedded strip-chart simulation plots following each chip may be printed directly from FilmStar MONITOR.

**The Coating Game** - Does the operator really understand the coating run-sheet? This module provides means to train operators before actual coating runs. A score compares *My Design* with the ideal. No other optical thin film software offers this feature.

**Automatic Monitors** - MONITOR supports several automatic monitors: Balzers GSM-420, Eddy LMC-10/20, Leybold OMS and SYRUS*pro*.



Coating Game Simulator

## Program CRYSTAL

Optional program FilmStar CRYSTAL converts thin film designs to deposition processes for Inficon IC/4+, IC/5 and Sycon STC-200/SQ controllers. Uploading is via RS-232 or IEEE-488. CRYSTAL eliminates the tedious and error-prone input of layer thicknesses.

**Parameters** - Film indices and calculation parameters appropriate for the specified controller are stored as Parameters files. Typically each coating chamber has its own file. Film designs generated by FilmStar DESIGN may be loaded from disk or pasted from the Windows clipboard. An Extended Materials manager supports up to 100 film materials.

**Layers Manager** - This dialog displays the number of layers stored in each process as well as the total number of new layers that may be added. Unused film processes can be stored on disk and deleted from the controller's memory.

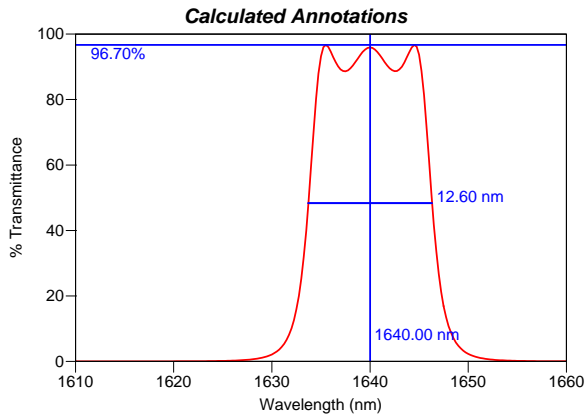
Film Design	Film Material	Indx 1-24	Rate Å/sec	Final Thick Å	Thick Limit Å	Time Limit min	Cruc 1-6h	
1	.41816H	TiO2	1	7.88	1.888	0.988	4.137	1
2	.24631L	SiO2	2	5.60	0.928	0.835	4.762	2
3	.33618H	TiO2	1	7.88	0.884	0.724	3.718	1
4	.38916L	SiO2	2	5.60	1.165	1.048	5.466	2
5	.26791H	TiO2	1	7.88	0.641	0.577	3.369	1
6	.26843L	SiO2	2	5.60	1.011	0.918	5.018	2
7	.28583H	TiO2	1	7.88	0.682	0.613	3.456	1
8	.28159L	SiO2	2	5.60	1.061	0.955	5.157	2
9	.26635H	TiO2	1	7.88	0.687	0.573	3.361	1
10	.25448L	SiO2	2	5.60	0.959	0.863	4.853	2

CRYSTAL Worksheet

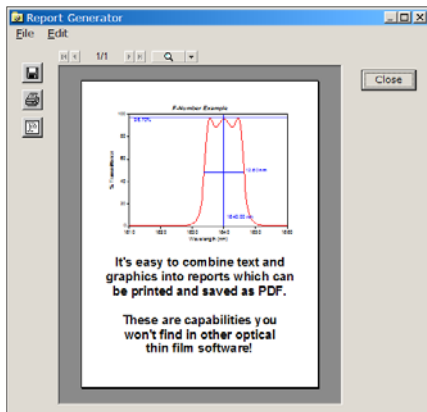
**Worksheets** - Worksheets may be loaded from disk, calculated from a design, manually edited, uploaded to the deposition controller, downloaded from the controller, and stored. Worksheets can be modified with FilmStar BASIC or transferred to Excel. Users can, for example, automatically adjust thickness settings to compensate for systematic errors. *This is a secret for success with crystal thickness monitors!*

## Additional Features

**FSPlot Module** - This powerful and flexible module is included in DESIGN and MEASURE. Annotations are graphic features distinct from axes and data. As illustrated in the following, these can be automatically calculated in FilmStar BASIC. A primary application is quality control where it is possible to show performance and specifications on the same plot.



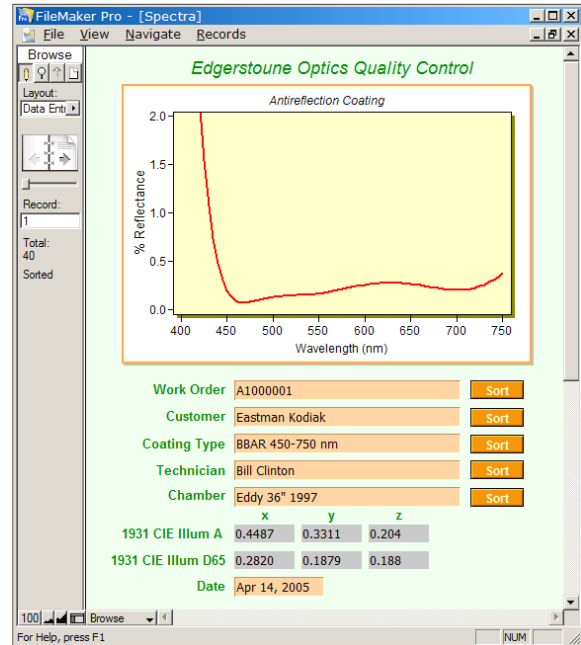
**Report Generator** - This module is also in DESIGN and MEASURE. It's useful for proposals, data sheets, catalogs, quality control, etc. Reports can be automated and include a logo, boilerplate text, etc. Reports can be stored as PDF files. The same technology is used to print run-sheets in MONITOR.



FilmStar Report Generator

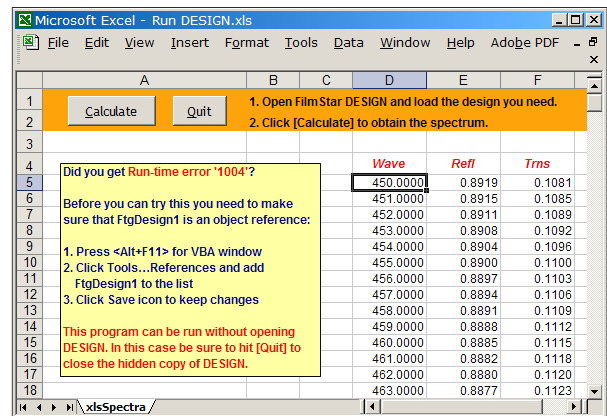
**Compatibility with Popular Software** - No coating program approaches FilmStar in combining specialized optical software with general purpose software.

Example: Nearly everyone has *Microsoft Excel*. With FilmStar it's easy to automatically (without opening Excel) create Excel files containing spectral data. This is far superior to manual copying and pasting.



Managing Coating QC with FileMaker Pro

The above screen shot shows how popular database software provides means to securely store, track, sort and recall thousands of curves or designs. Just click a button in FilmStar DESIGN to load the spectrum. As shown below, thin film calculations can effectively be performed directly in Excel.



Running FilmStar DESIGN from Excel

To learn more about FilmStar we suggest an on-line demonstration in the convenience of your own office.

To learn how this works and test your computer system for compatibility, please visit <http://ftgsoftware.com/glance.htm>.