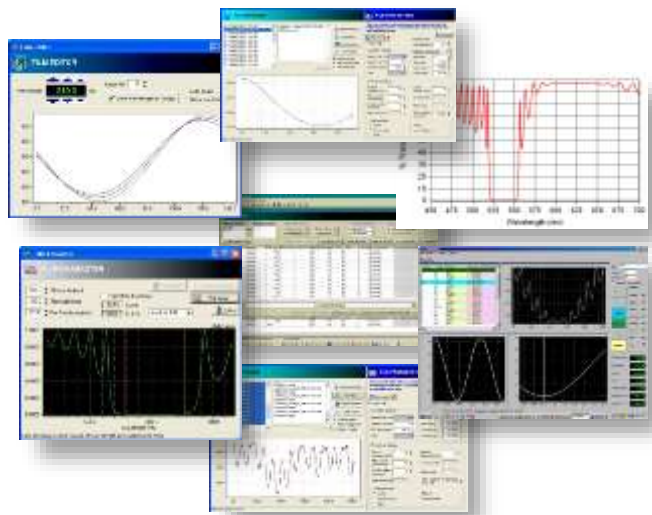


# Optical Monitoring: Delivering High Precision & Yield to the Manufacture of Optical Coatings

Intellemetrics Global Ltd  
[www.intellemetrics.com](http://www.intellemetrics.com)



# Why Use Optical Monitoring?



## The Challenges:

Complexity ↑

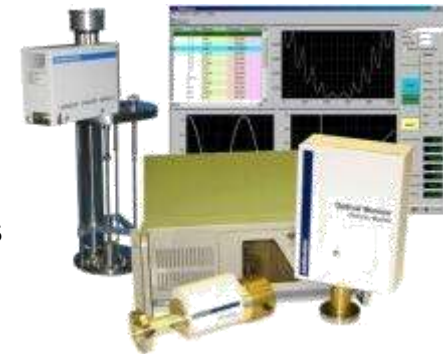
Precision ↑

Volume ↑

Cost ↓

## The Solution:

- Quartz crystal measures the **Deposited Mass**
- Optical Monitoring measures the true **Optical Thickness**
- Inherent error compensation in optical monitoring
  - Film stack errors can **decrease** as layer thickness and complexity increases

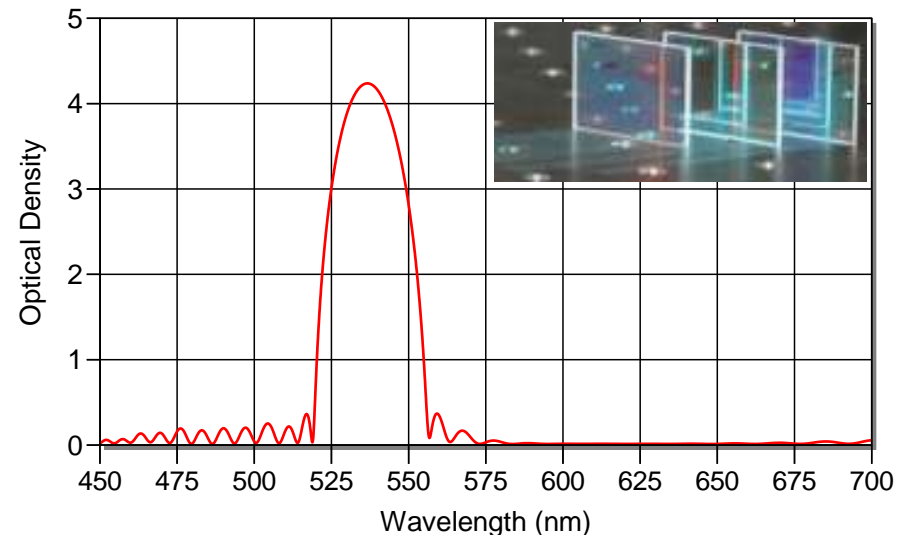
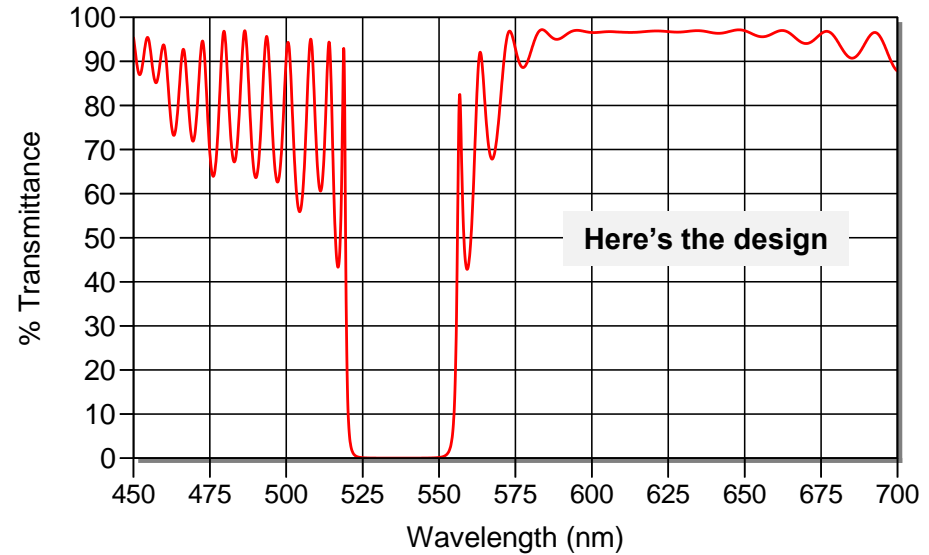


intellemetrics

# Optical Monitoring Vs Quartz Crystal Example

## Target Specification

- **Product:**  
High Performance Steep Edge Notch Filter
- **Materials:**  
TiO<sub>2</sub> / SiO<sub>2</sub>  
Ebeam deposition and IAD
- **Film Stack Design:**  
Demanding 34 layer film stack with non-QW termination
- **Band Edge Position Spec: ± 0.3nm**

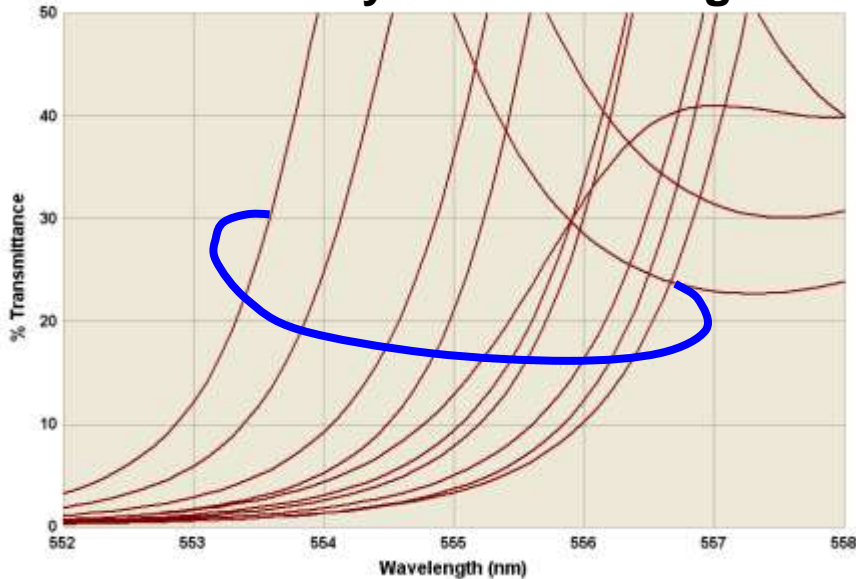


# Optical Monitoring Vs Quartz Crystal Example

10 back-to-back growth runs...

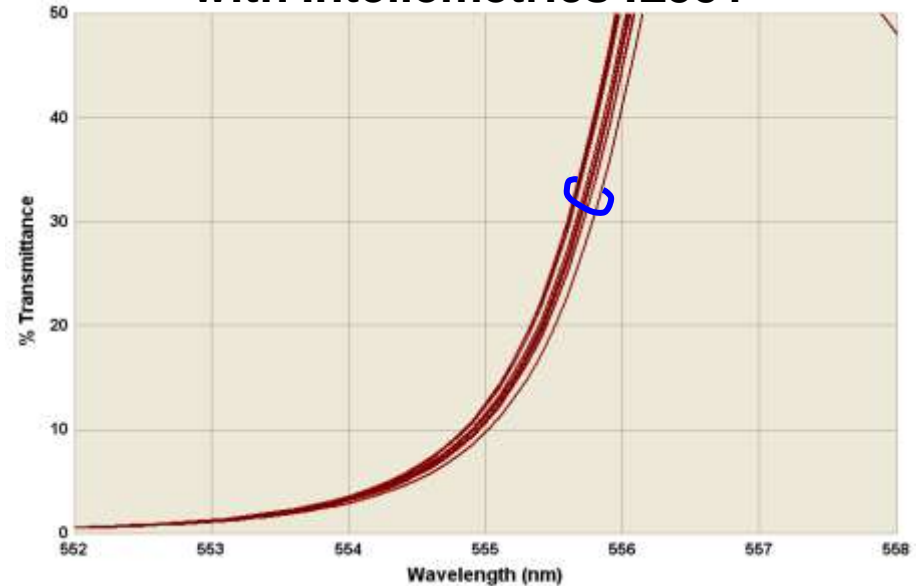
(Band Edge Position Spec:  $\pm 0.3$  nm)

## Quartz Crystal Monitoring



**Band Edge Spread > 3.3 nm**  
**Poor Yield**

## Optical Monitoring with Intellemetrics IL551



**Band Edge Position  $\pm 0.1$  nm**  
**Very High Yield**

In-direct optical monitoring process in back face reflection mode with 2 test glasses.  
Results shown above are from the coated product.

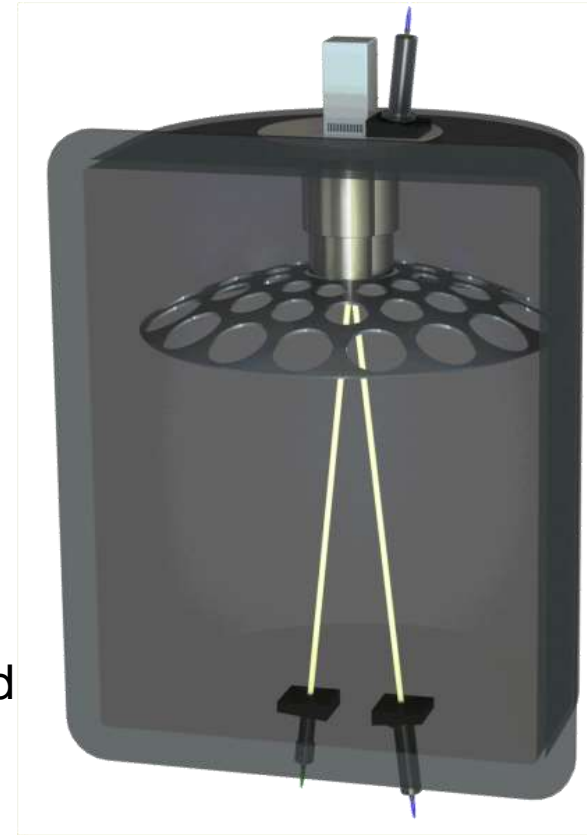
# Advanced Measurement System

## Optical & Electrical Noise

- Electron beam guns including sweep controls
- Plasma sources
- Heaters
- Arcing

## Solution

- Dual beam system
- Four phase chopper (light / dark / reference / dark)
- Time demultiplexed common optical path
- High speed digitisation and DSP within detector head
- High off axis rejection optics
- Rugged optical mounts
- High EMF / EMC immunity



## Result – High Quality, High Precision Data

e.g. Noise as low as 0.002% T or R,  
Calibration accuracy as low as 0.002% T or R

# In-Direct Optical Monitoring – Test Glass

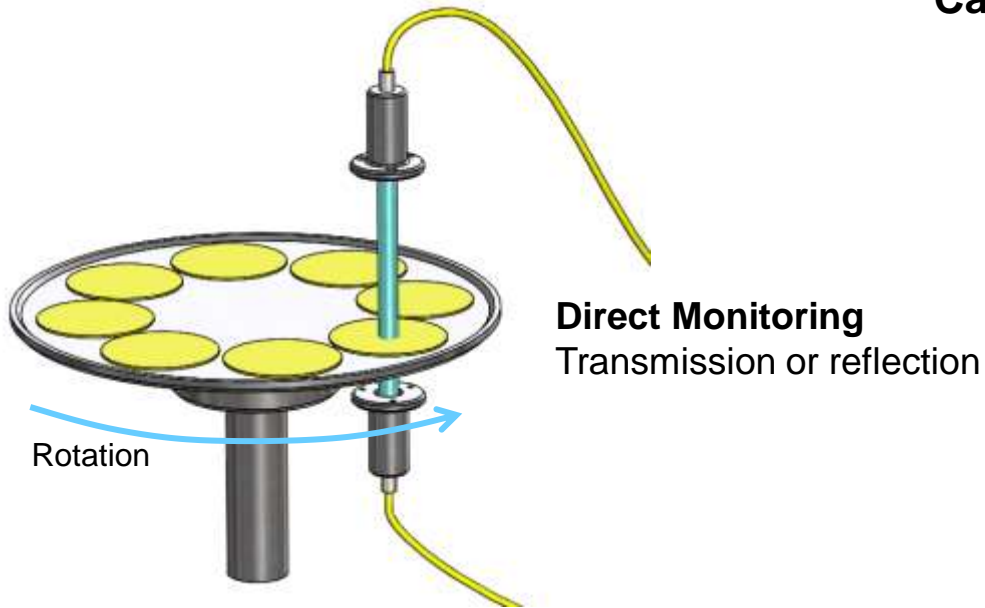
- Process flexibility & complexity
- Dynamic range
- Superior S/N
- Standard test piece – independant of product
- Result – Higher precision, yield, performance





# Direct Optical Monitoring

- Monitor the actual product or a witness piece at the same location
- No tooling factors
- Sample once per rotation
- Fast acquisition time (3ms)



## Ebeam Chamber Direct Monitoring on the Rotating Calotte



# Optimised Products for Different Wavelength Ranges

## Standard Product Range

- IL570-1 300 - 800nm
- IL570-2 400 - 1100nm
- IL570-3 550 - 1650nm
- IL570-4 800 - 2200nm

BW = 2.2 – 6.5nm

All optical coatings except extreme NBFs (i.e. DWDM)

## Combined Product Range

- IL570-1-3 300 - 1650nm
- IL570-1-3 400 - 1650nm
- IL570-1-4 300 - 2200nm
- IL570-2-4 400 - 2200nm

BW = 2.2 – 6.5nm

All optical coatings except extreme NBFs (i.e. DWDM)

## Enhanced Product Range

- IL570-DUV-ES 230 - 800nm
- IL570-DUV-3-ES 230 - 1650nm
- IL570-1-3-ES 300 - 1650nm
- IL570-3-ES 550 - 1650nm
- IL570-1-4-ES 300 – 2200nm

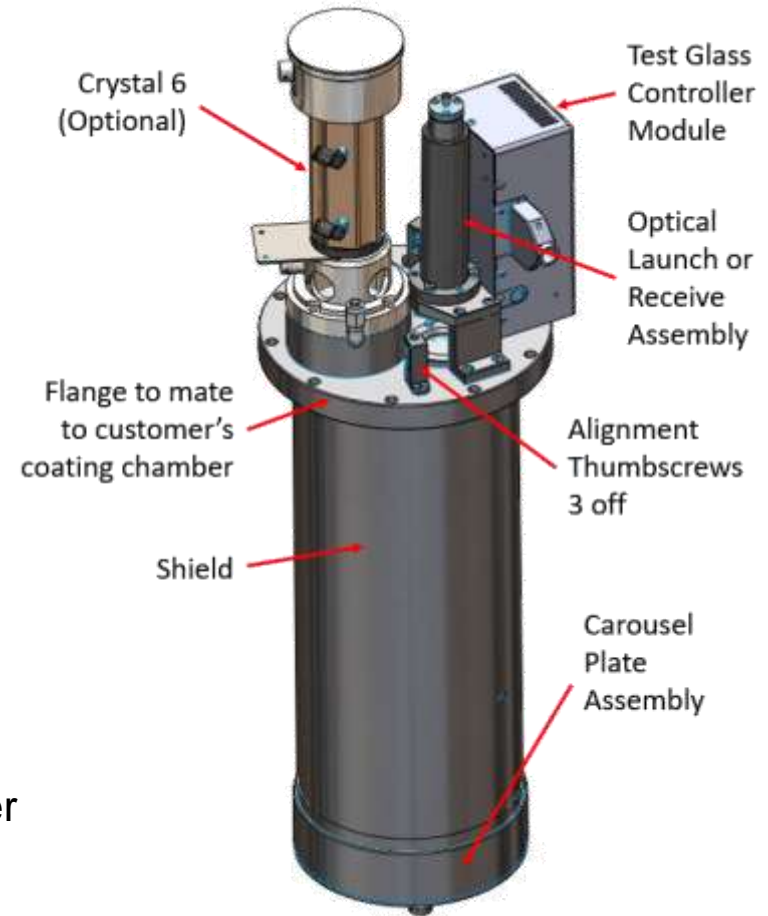
Deep UV capability down to 230nm.





# Accessories: Test Glass Changers

- In-house designs. Customised for your chamber geometry.
- Driven from IL570 OMS for true integration and automation.
- Intelligent interface knows which carousel position is being used, which test glasses have been coated, handles error checking, etc.
- Optional Integrated Multiposition Crystal Changer, thermocouples, etc.
- Suitable for front or back face reflection and transmission optical monitoring modes.
- Optical alignment from outside the chamber, i.e. under vacuum.
- Extremely high uniformity from test glass to test glass.
- Up to 16 test glass carousel system dependant upon chamber geometry.



# Powerful Software

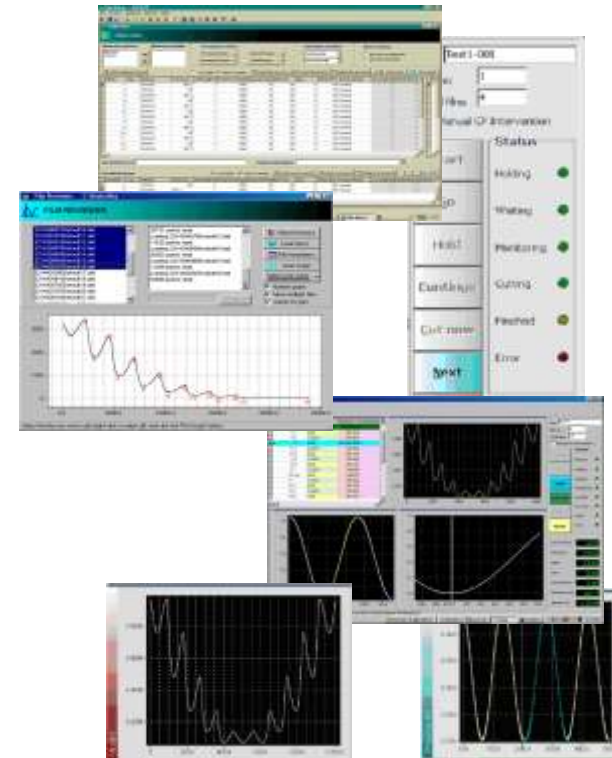
- Intellemetrics' Optical Monitors give thin-film engineers the tools to decrease process development time & manufacturing costs AND increase yield & product performance.
- The system combines advanced optoelectronic hardware with a suite of powerful software packages including

- **FilmMaker2**

- **FilmBuilder**
- **FilmModeller**
- **FilmEditor**
- **FilmSimulator**
- **FilmCharacters**
- **FilmReviewer**

- **FilmDirector2**

- Provide a single complete integrated solution.
- Windows 7, 8 and 10, 32bit and 64bit



# Film Stack Design → Optical Monitoring Scheme

## FilmBuilder

### Film Stack Design

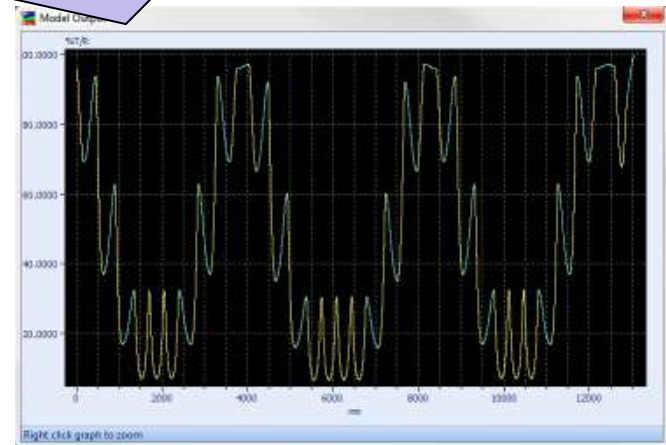
Import from  
FilmStar, TFCalc,  
Essential MacLeod,  
Optilayer, etc.

The screenshot shows the FilmBuilder software interface. The main window displays a table of film stack layers. A red box highlights the 'Show materials' column and the 'Material' column, with a red arrow pointing to the text 'Import from FilmStar, TFCalc, Essential MacLeod, Optilayer, etc.'. Another red box highlights the 'FilterOutOff' column, with a red arrow pointing to the text 'Optical Monitoring Scheme Design'. A large purple arrow points from the bottom of the red boxes towards the graph in the next slide.

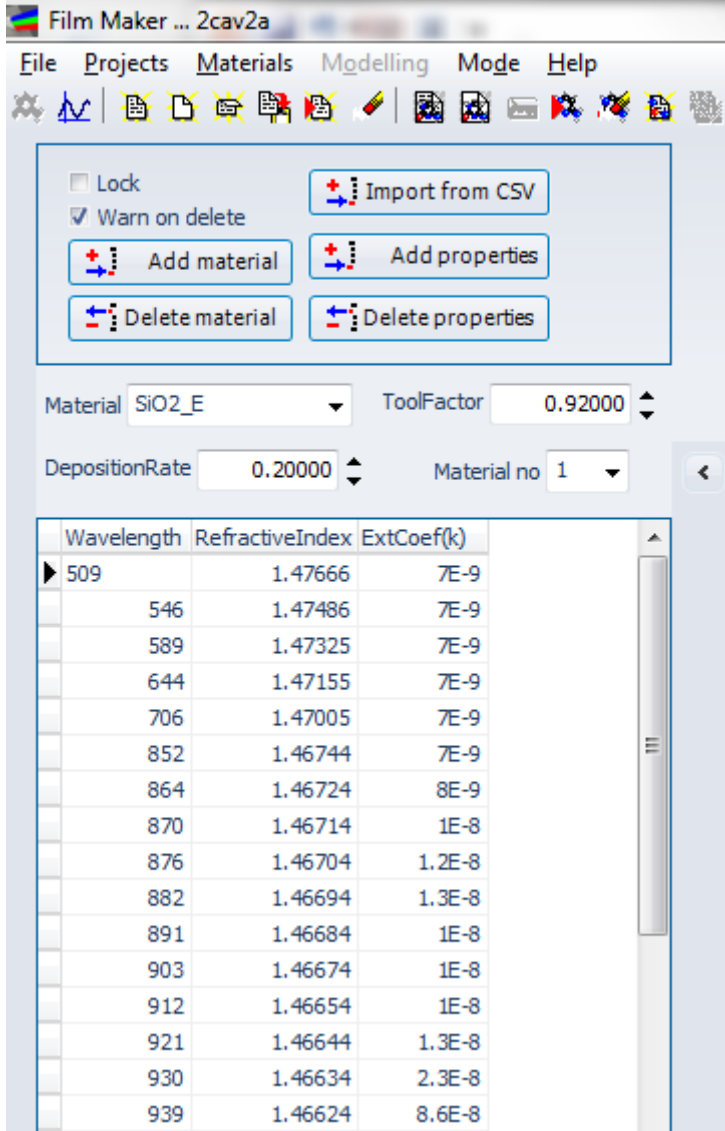
Order	Tag	Material	Thickness	QWThickness	CutPThickness	CutPortCyclic	Probewavelength	QWTime	QWFactor	SkipThickness	Gen	FilterOutOff	AnalysisMode	CrossingLanc	FilterOutOff	Fit
1		TKO2	175.055	1	175.055	1	1600	291.758	1	0	0	20	filter-1	1.5	50	
2		SiO2	276.026	1	276.026	1	1600	394.323	1	0	0	20	filter-1	1.5	50	
3		TKO2	175.055	1	175.055	1	1600	291.758	1	0	0	20	filter-1	1.5	50	
4		SiO2	276.026	1	276.026	1	1600	394.323	1	0	0	20	filter-1	1.5	50	
5		TKO2	175.055	1	175.055	1	1600	291.758	1	0	0	20	filter-2	1.5	50	
6		SiO2	276.026	1	276.026	1	1600	394.323	1	0	0	20	filter-2	1.5	50	
7	cov	TKO2	1050.33	6	1050.33	6	1600	291.758	1	0	0	20	normal	1.5	50	
8		SiO2	276.026	1	276.026	1	1600	394.323	1	0	0	20	filter-2	1.5	50	
9		TKO2	175.055	1	175.055	1	1600	291.758	1	0	0	20	filter-2	1.5	50	
10		SiO2	276.026	1	276.026	1	1600	394.323	1	0	0	20	filter-1	1.5	50	
11		TKO2	175.055	1	175.055	1	1600	291.758	1	0	0	20	filter-1	1.5	50	
12		SiO2	276.026	1	276.026	1	1600	394.323	1	0	0	10	filter-1	1.5	50	
13		TKO2	175.055	1	175.055	1	1600	291.758	1	0	0	10	filter-1	1.5	50	
14	coup	SiO2	276.026	1	276.026	1	1600	394.323	1	0	0	5	normal	1.5	10	
15		TKO2	175.055	1	175.055	1	1600	291.758	1	0	0	10	filter-1	1.5	50	
16		SiO2	276.026	1	276.026	1	1600	394.323	1	0	0	10	filter-1	1.5	50	
17		TKO2	175.055	1	175.055	1	1600	291.758	1	0	0	20	filter-1	1.5	50	
18		SiO2	276.026	1	276.026	1	1600	394.323	1	0	0	20	filter-1	1.5	50	
19		TKO2	175.055	1	175.055	1	1600	291.758	1	0	0	20	filter-2	1.5	50	

### On a layer-by-layer basis, specify

- Monitoring wavelength
- Filter parameters
- Cut algorithms
- Cut on optical monitor, crystal or time
- Calibration scheme
- and many other parameters



# Material Properties



The screenshot shows the 'Materials' tab in the Film Maker software. The interface includes a menu bar (File, Projects, Materials, Modelling, Mode, Help) and a toolbar. A control panel contains options for 'Lock', 'Warn on delete', 'Import from CSV', 'Add material', 'Add properties', 'Delete material', and 'Delete properties'. Below this, the 'Material' dropdown is set to 'SiO2\_E', 'ToolFactor' is 0.92000, 'DepositionRate' is 0.20000, and 'Material no' is 1. A table displays the material's properties across various wavelengths.

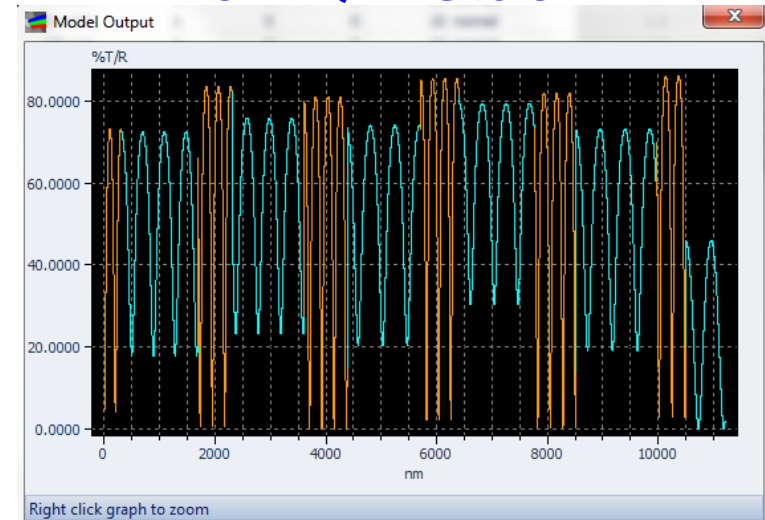
Wavelength	RefractiveIndex	ExtCoef(k)
509	1.47666	7E-9
546	1.47486	7E-9
589	1.47325	7E-9
644	1.47155	7E-9
706	1.47005	7E-9
852	1.46744	7E-9
864	1.46724	8E-9
870	1.46714	1E-8
876	1.46704	1.2E-8
882	1.46694	1.3E-8
891	1.46684	1E-8
903	1.46674	1E-8
912	1.46654	1E-8
921	1.46644	1.3E-8
930	1.46634	2.3E-8
939	1.46624	8.6E-8

- Unlimited number of custom materials
- Define n and k at unlimited number of wavelengths
- Define deposition rate for each material
- Define tooling factor for each material
- Read in data from CSV files, export to CSV
- Create Public or Private materials databases

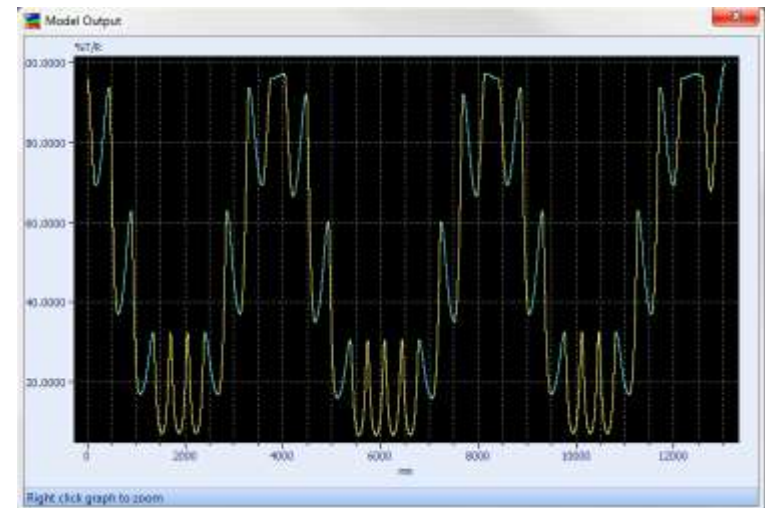
# FilmModeller

- Automatically reads a *FilmBuilder*® file
- Calculates and displays the expected Optical Signal as a function of Deposition Time
- Includes effects of wavelength changes and test glass changes
- Rapidly see the effect of your model design
- Provides guide to signal compression
- Provides guide to number of films per test glass.
- Suggests optical monitoring scheme options to try in *FilmSimulator*®

## Non QW stack



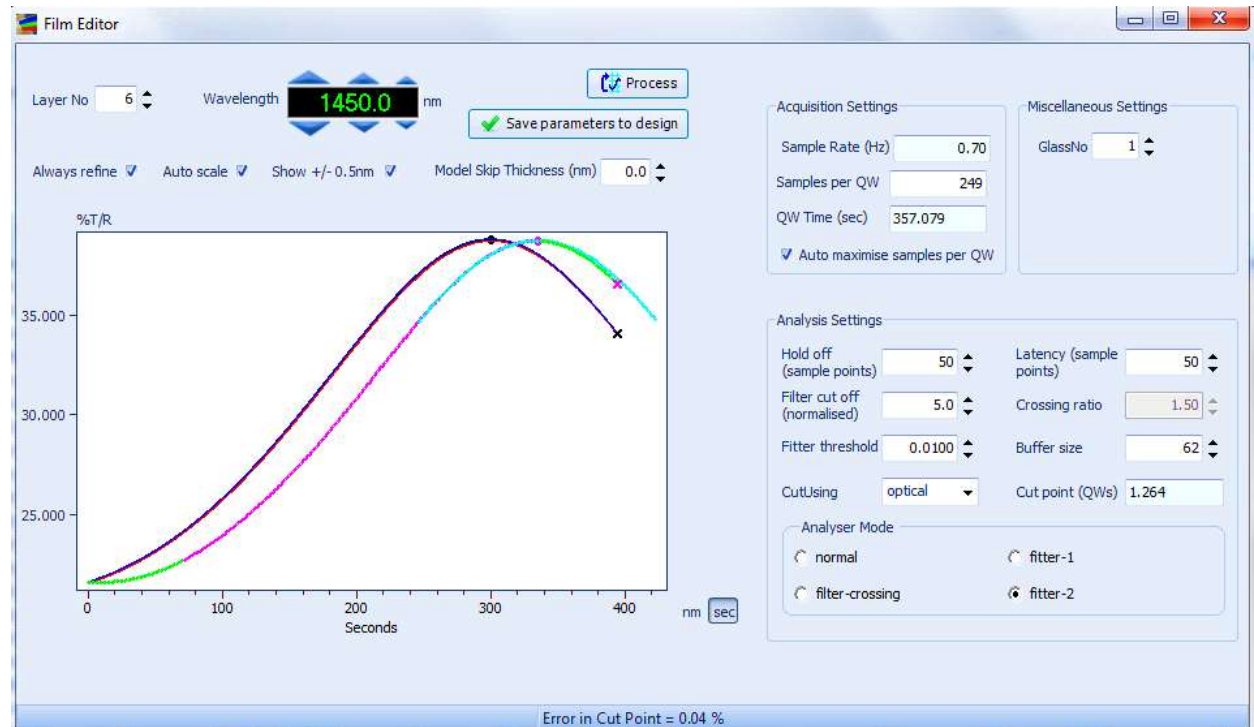
## QW stack





# FilmEditor

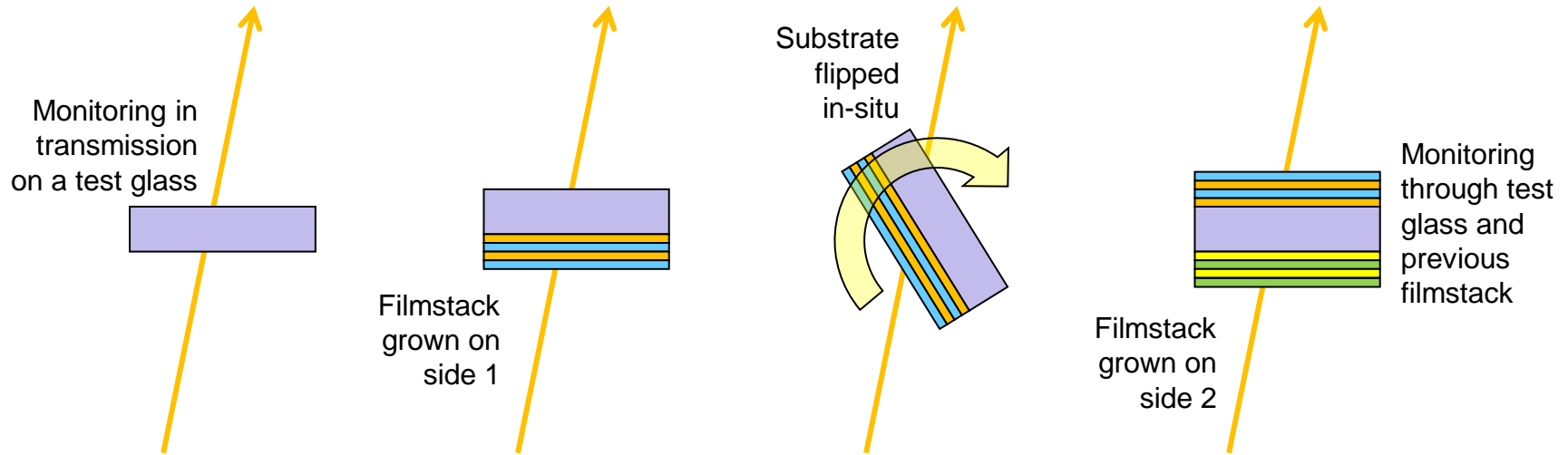
- Powerful, graphical intuitive process design & optimisation tool with instant visual feedback
- Inspect the waveform for any layer within the stack, BEFORE and AFTER Processing
- Change the following parameters to optimise waveform for that layer.
  - Wavelength, sample rate, test glass number, HoldOff, Latency, Filtering parameters, cut method, analyser mode.
- Automatically optimises waveform cutpoint depending upon parameters defined.
- Automatically shows sensitivity of each layer



**Improves cut point precision & manufacturing process stability / yield**



# Flip-Chip Coating Schemes



FilmMaker correctly models filmstacks on two sides of a test glass.

FilmDirector correctly calibrates on the bare test glass, and handles recalibrations after in-situ flipping of the test glass, enabling high precision monitoring of complex filmstacks on both sides of a substrate.

# FilmSimulator - Pre Coating Run

- Off-Line simulation runs including
  - Optical Model
    - Physical effects of Optical Monitoring hardware (bandwidth, wavelength, noise)
    - Physical effects of Customer's Coating Tool
      - E-gun noise (material dependent)
      - Gun dep rate control
      - Test glass changes

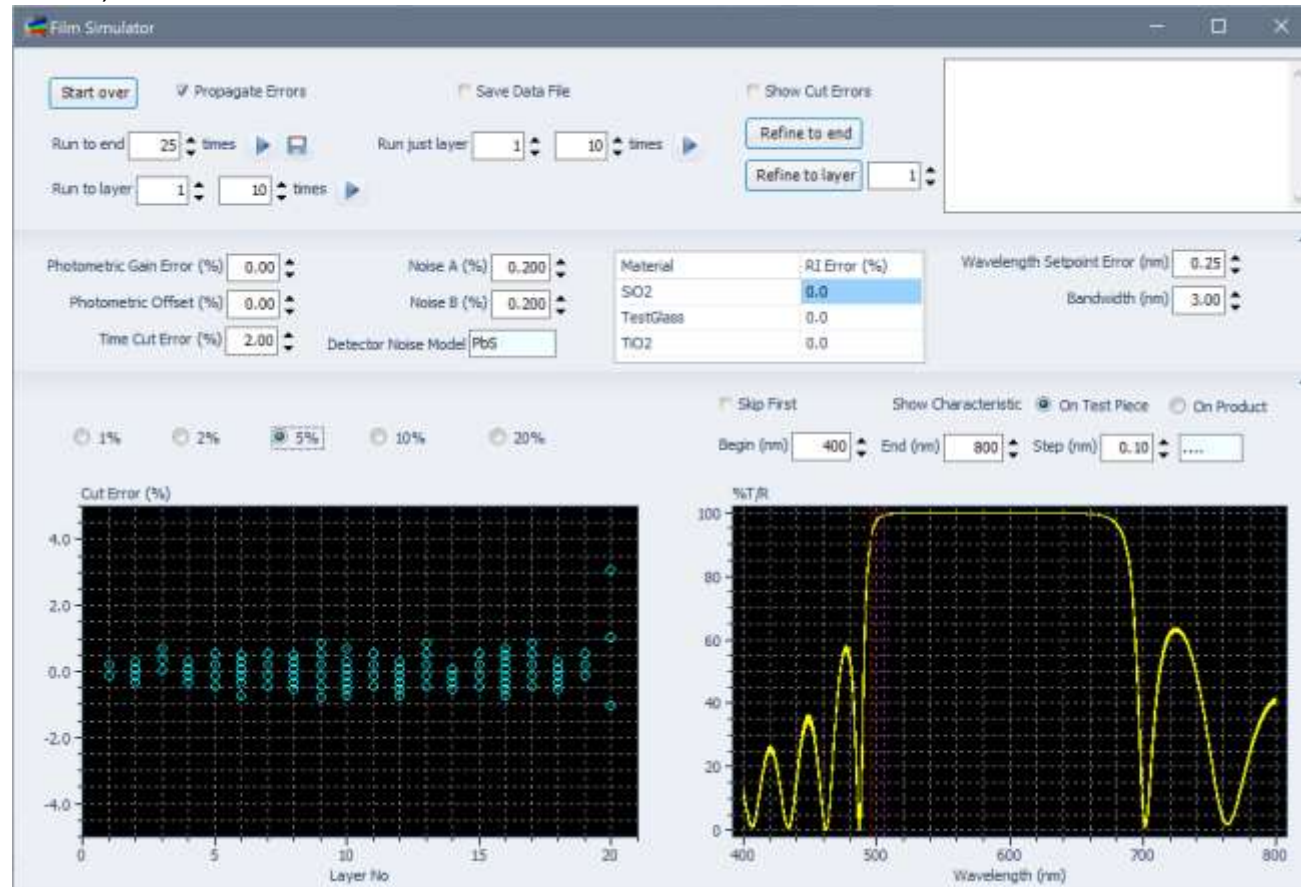
■ Calculates 'cut point' errors on a layer-by-layer basis

■ Builds a new stack each run.

■ Shows compensation effects.

■ Identifies problem layers.

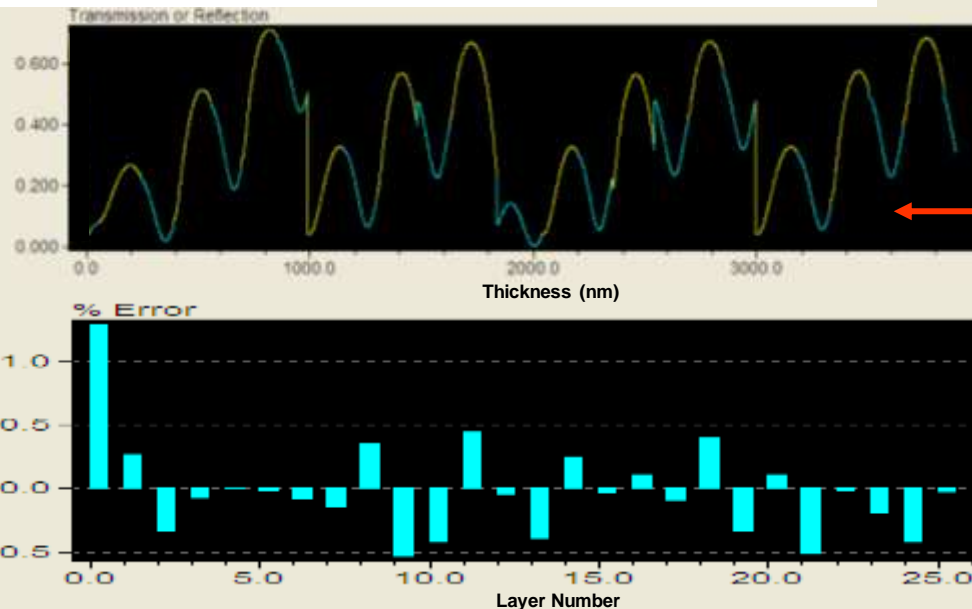
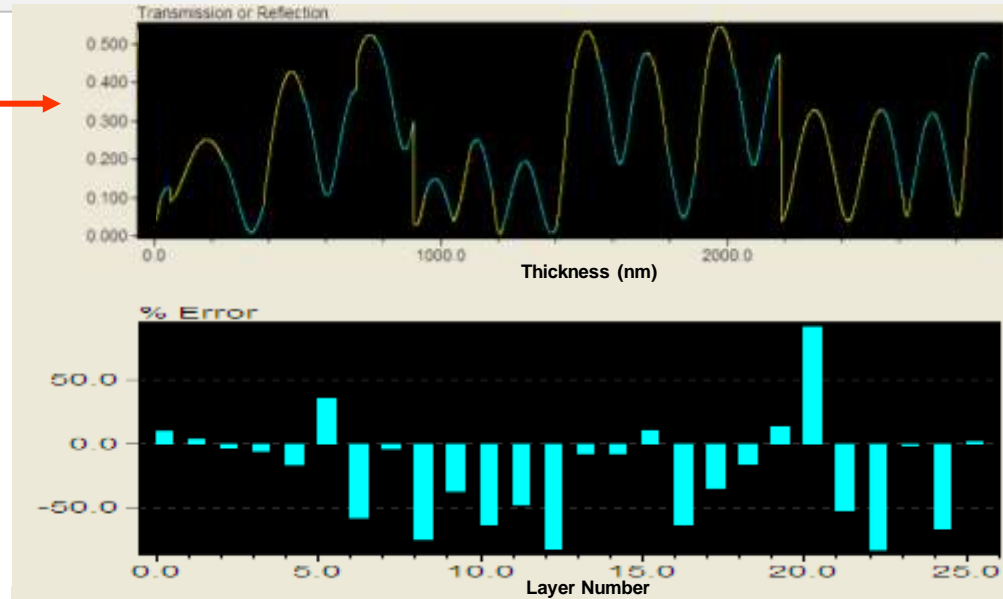
■ Shows effect on resultant spectrum.



# FilmSimulator in Action

- Complex 26 layer film stack
- Multiple Non Quarter Wave design
- FilmSimulator<sup>®</sup> indicates cutpoint errors > 50%
- Proof that the product will be extremely unlikely to meet specification

**Action:** Modify growth scheme and analyse impact with FilmSimulator<sup>®</sup>



Same film stack – different scheme

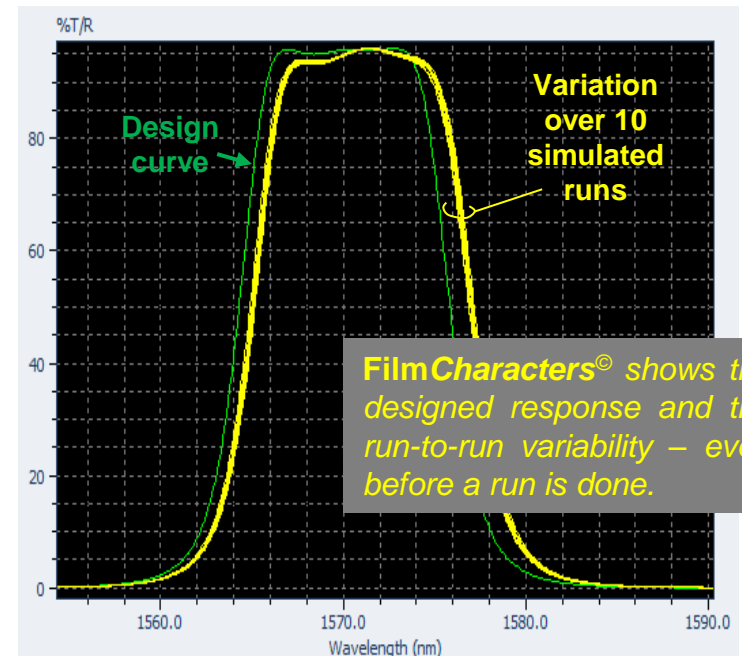
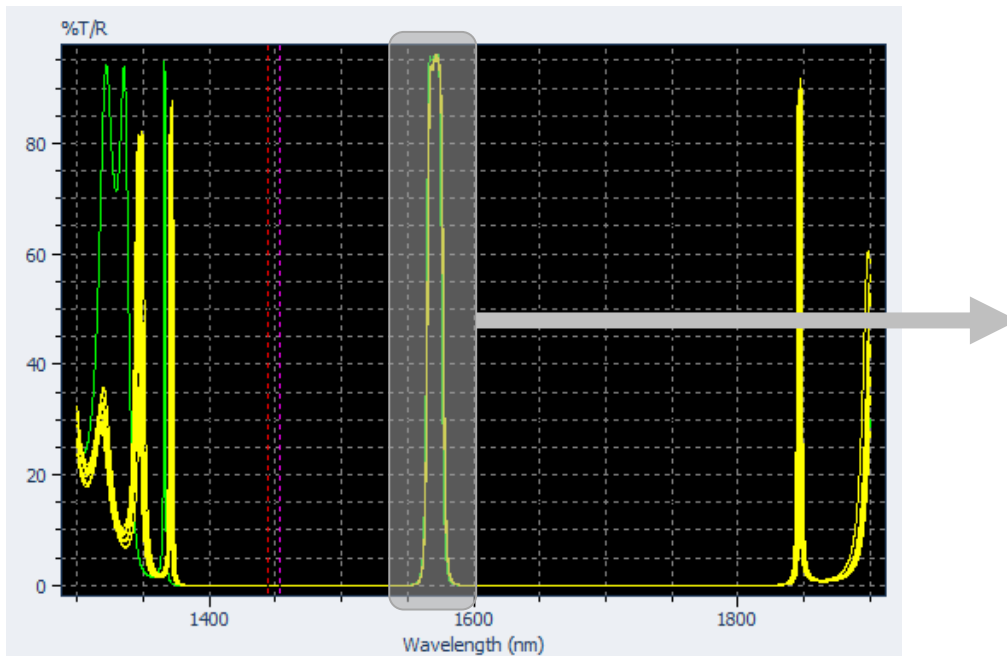
- Change monitor wavelengths
- Change Test Glass scheme
- Change filter settings

**Result:** massive decrease in cutpoint errors (< 1%)  
– the film stack performance is now achievable !

**10 minutes on FilmSimulator<sup>®</sup> saves many days of process development on the production line.**

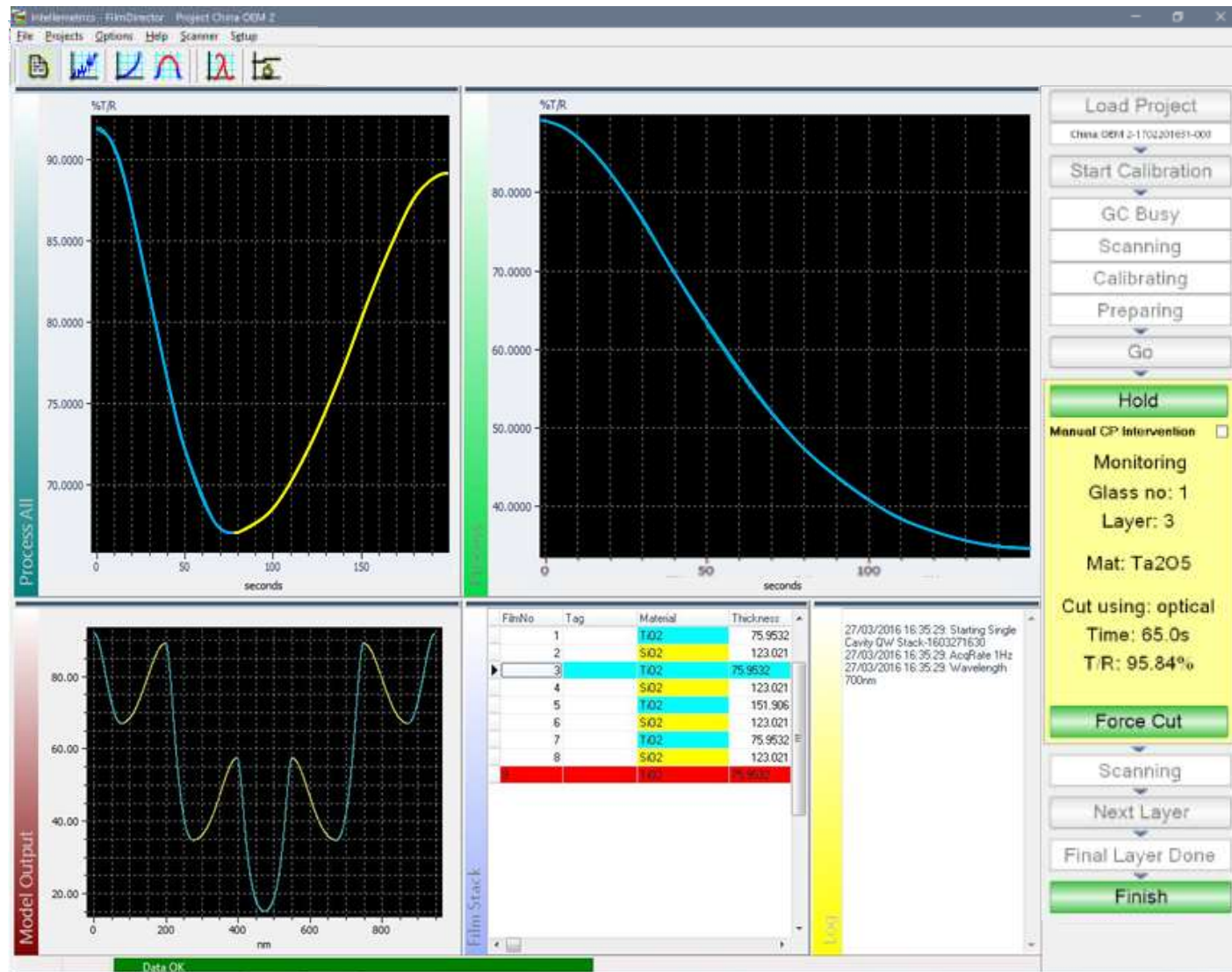
# FilmCharacters - Pre Coating Run

- Determine the Spectral Characteristics of the final film stack
- Compare the THEORETICAL DESIGN spectra with the 'REAL-LIFE' spectra from **FilmSimulator**®
- See the impact of 'cut point' errors on the performance of your final product !
- Powerful production process design tool
- Plot many simulated runs on the same graph
  - gain real information on process **YIELD – OFFLINE !**



# FilmDirector2

- Loads a project from **FilmMaker2**
- Performs the run under automatic or manual control as required
- Autocalibrates on start up
- Automatically changes the wavelength and the test glass
- Detects each cut and controls the deposition through an advanced I/O capability.

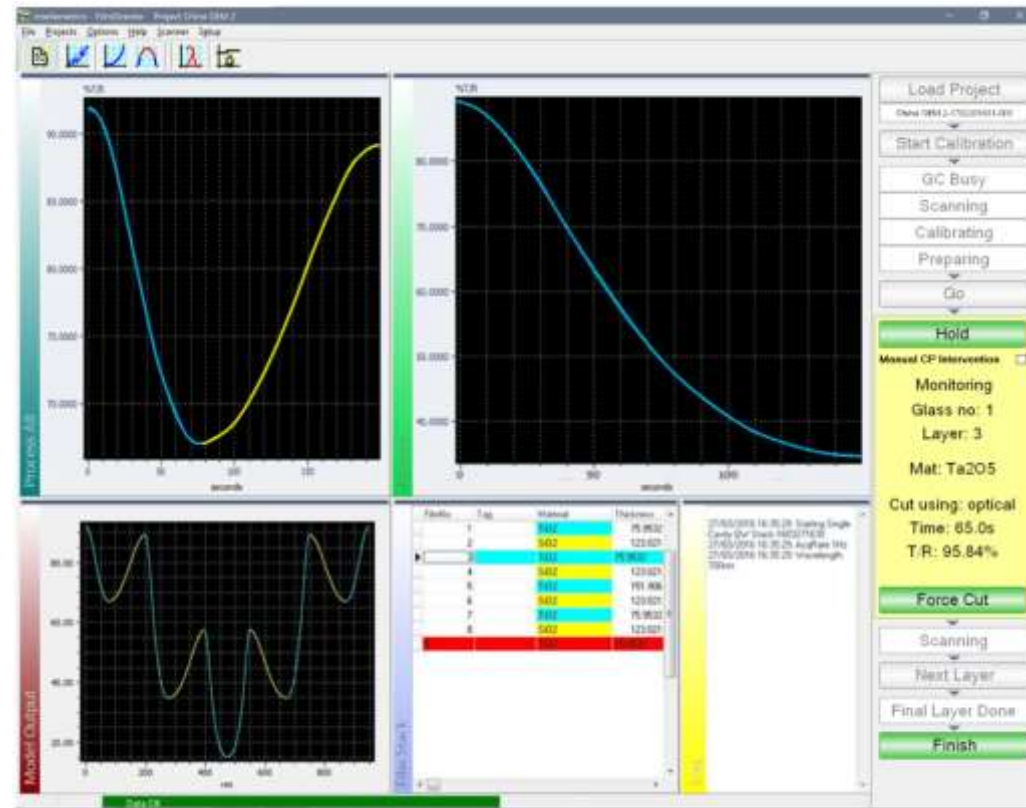




# FilmDirector2

## Key Features

- Incorporates advanced model fitting algorithms for cutpoint determination
- State machine based controller can recover/continue a process context even after a shutdown.
- Integrates seamlessly with **FilmMaker2**® design front-end.
- Freely configurable, panelled user-interface.
- Fully touch screen capable if required.
- After a run is completed, the data is logged for later analysis. Files can be exported in CSV format for analysis in your favourite program.





# FilmDirector2 – Wavelength Scanning

## Key Features

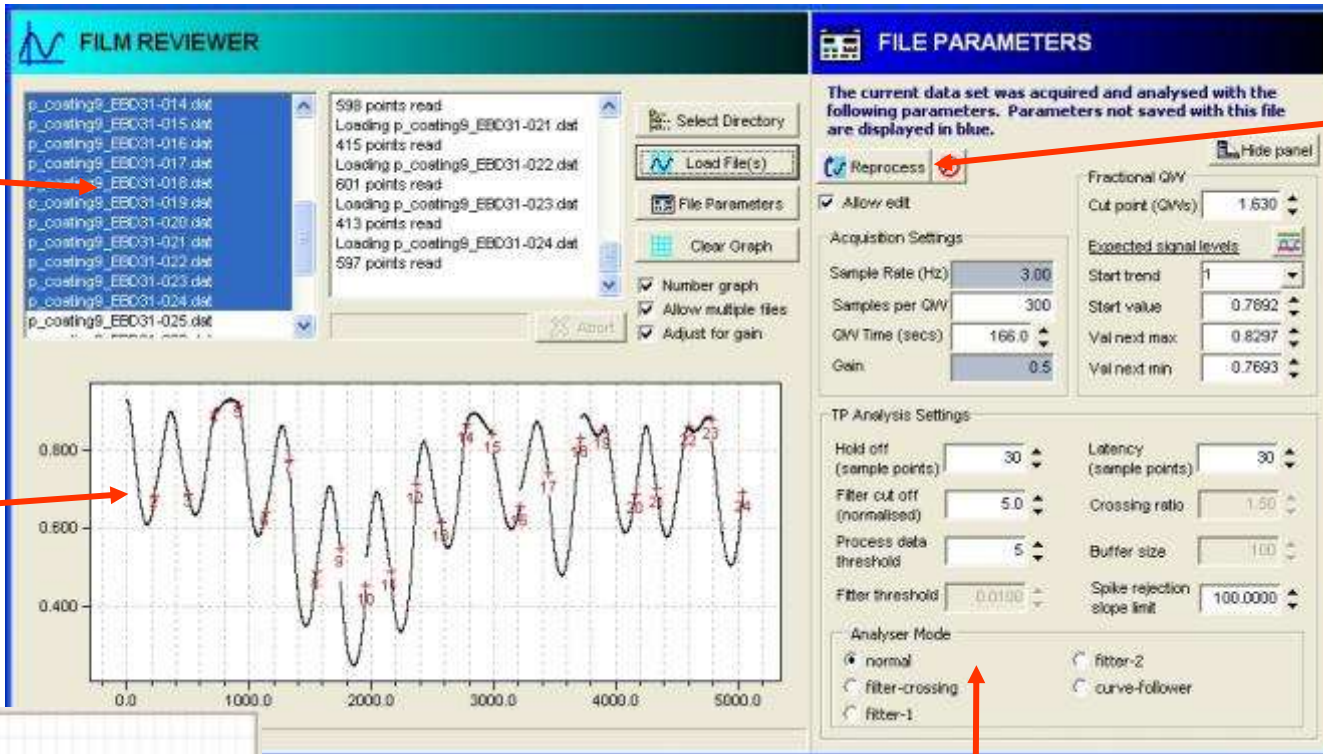
- Perform wavelength scan on bare substrate before coating.
- Perform wavelength scan after each layer, or at the end of the coating run.
- Automatic scanning can be preselected in FilmMaker2, or scans be done 'on the fly' as required.
- Displays theoretical scan as well as experimental scan for easy comparison.
- Auto saves scans to log files.



# FilmReviewer - Post Coating Run

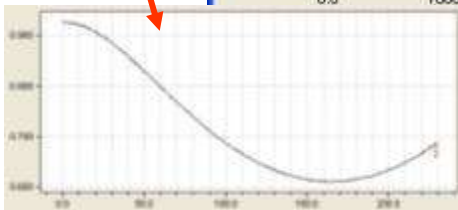
- **FilmReviewer**® is used to view, analyse and reprocess previous runs – for **OFF-LINE OPTIMISATION**.
- Take **REAL RAW DATA** from your coating system, and observe the effects of reprocessing it, changing the filtering parameters, the sampling rate, the latency and hold-off parameters and the termination algorithms.

Load RAW DATA from previous runs on a layer by layer basis



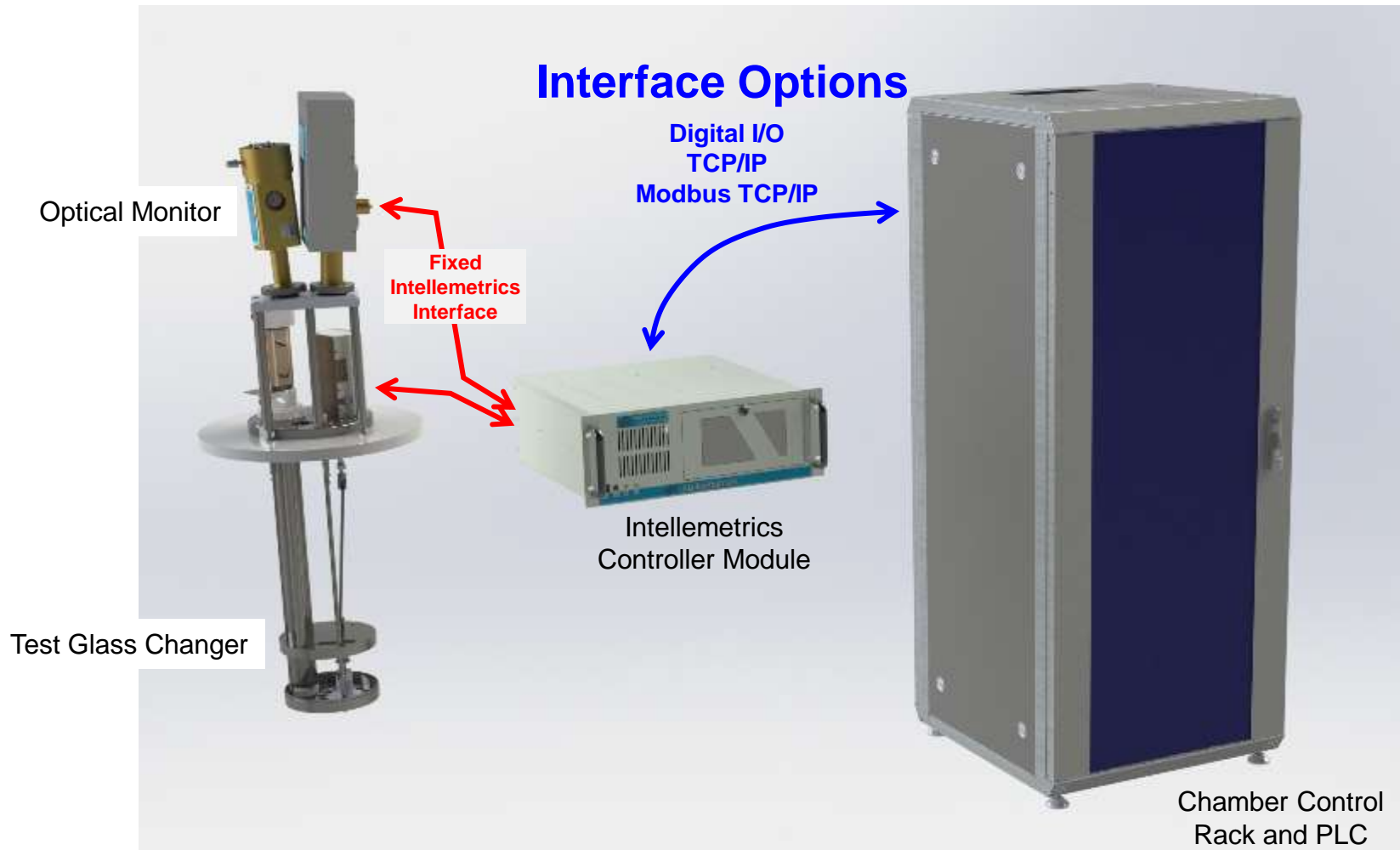
Reprocess the data on a layer by layer basis to optimise future runs

View the raw data for the whole stack or analyse a layer at a time



Change Acquisition Settings, Turning Point Analysis Settings and Analyser Mode and see the impact on accuracy of cutpoint determination.

# Integration into Your Coating System



Complete seamless integration for fully automated operation.

Customer can choose any one of the interfaces above, or use any combination of them.

Interfaces are fully specified and documented.

# Installation

Our skilled engineers will install and commission our monitor systems

directly onto your coating system ✓

at your facility ✓

and provide initial on-site operational training ✓



# Training & Support Products

## Remote Training

- ✦ FilmMaker and FilmDirector training
- ✦ Setup within 1 minute
- ✦ Fully interactive – you interact with the program under instruction
- ✦ Full VOIP for intuitive live instruction
- ✦ Either run FilmMaker & FilmDirector on your computer or on our computer



**Intellemetrics**

## Remote Support

- ✦ You invite us to log onto your optical monitor from anywhere in the world
  - You have full control of each log on event
- ✦ View Only
  - Diagnose problems
  - Provide training support
  - Provide process development support
- ✦ View and Interact
  - Diagnose and Fix
  - Install updates



**Manufacturing Facility**



**Optical Engineers**





# Installation Base

We have successfully integrated our Optical Monitor Systems onto coating systems made by the following manufacturers;



*and many more.....*





# Thank You

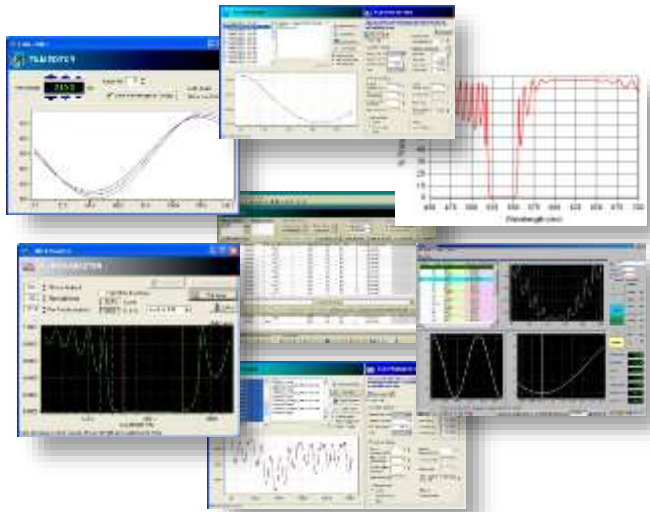
For further information & support, please contact

## Intellemetrics Global Ltd

Tel: +44 (0) 141 889 0700

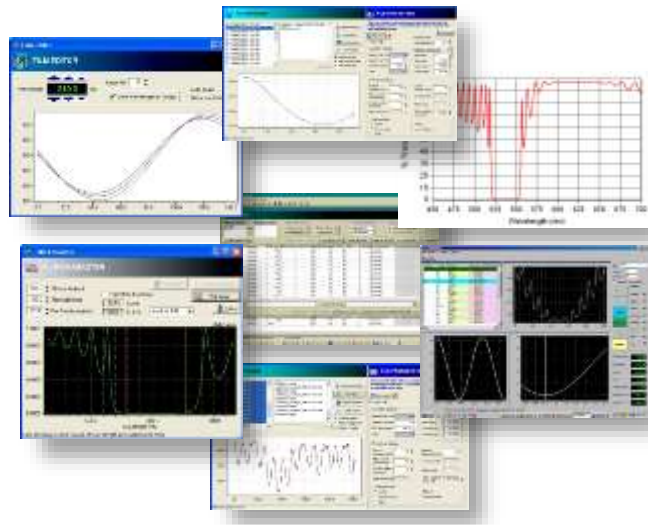
Email: [sales@intellemetrics.com](mailto:sales@intellemetrics.com)

[www.intellemetrics.com](http://www.intellemetrics.com)



# IL550 & IL560 Series Optical Monitors

## Customer Endorsements



# Tecport Optics - USA



**“Tecport Optics serve to serve again. We work vigorously and continuously with our customers and world class instrument manufacturers to provide state-of-the-art coating systems with cutting-edge technology processes. That’s why you will find Intellemetrics’ optical monitors integrated into our high precision coating systems.”**

*- Joseph Kim, General Manager,  
Tecport Optics Inc.*



# Oxford Instruments Plasma Technology - UK

## OptoFab 3000: High Precision Ion Beam Coating System



### IL563 Fibre Based Optical Monitor System

Direct optical monitoring in transmission mode on a fast rotating calotte.

Used for high quality AR and HR facet coating.

**“Oxford Instruments OptoFab3000 provides high performance optical coatings across a range of applications. We offer our customers high levels of precision and control and Intellemetrics’ optical monitor integrated with our patented holder is an important part of that.”**

*- Dr Mike Cooke, New Product Introduction Manager, Oxford Instruments Plasma Technology Ltd.*





## scia Coat 200 with integrated Intellemetrics IL570 OMS



**“scia Systems provides surface processing equipment for the MEMS, microelectronics and precision optics industries. For precise deposition of optical multilayers an in-situ optical monitoring is essential. The optical monitoring from Intellemetrics integrated in our scia Coat 200 ensures high quality and repeatable process results.”**

*- Marcel Demmler, Sales Director, scia Systems GmbH*





# Northumbria Optical Coatings - UK



**“In a demanding industry where precision, accuracy and repeatability matters the most, Intellemetrics have come up with a system that provides exactly that. We are very pleased working alongside Intellemetrics as they are always helpful and willing to offer a good service while continually improving their systems.”**

*- Loukas Zampelis, Design Engineer,  
Northumbria Optical Coatings*

# MEYER BURGER (formerly Roth&Rau) - Germany

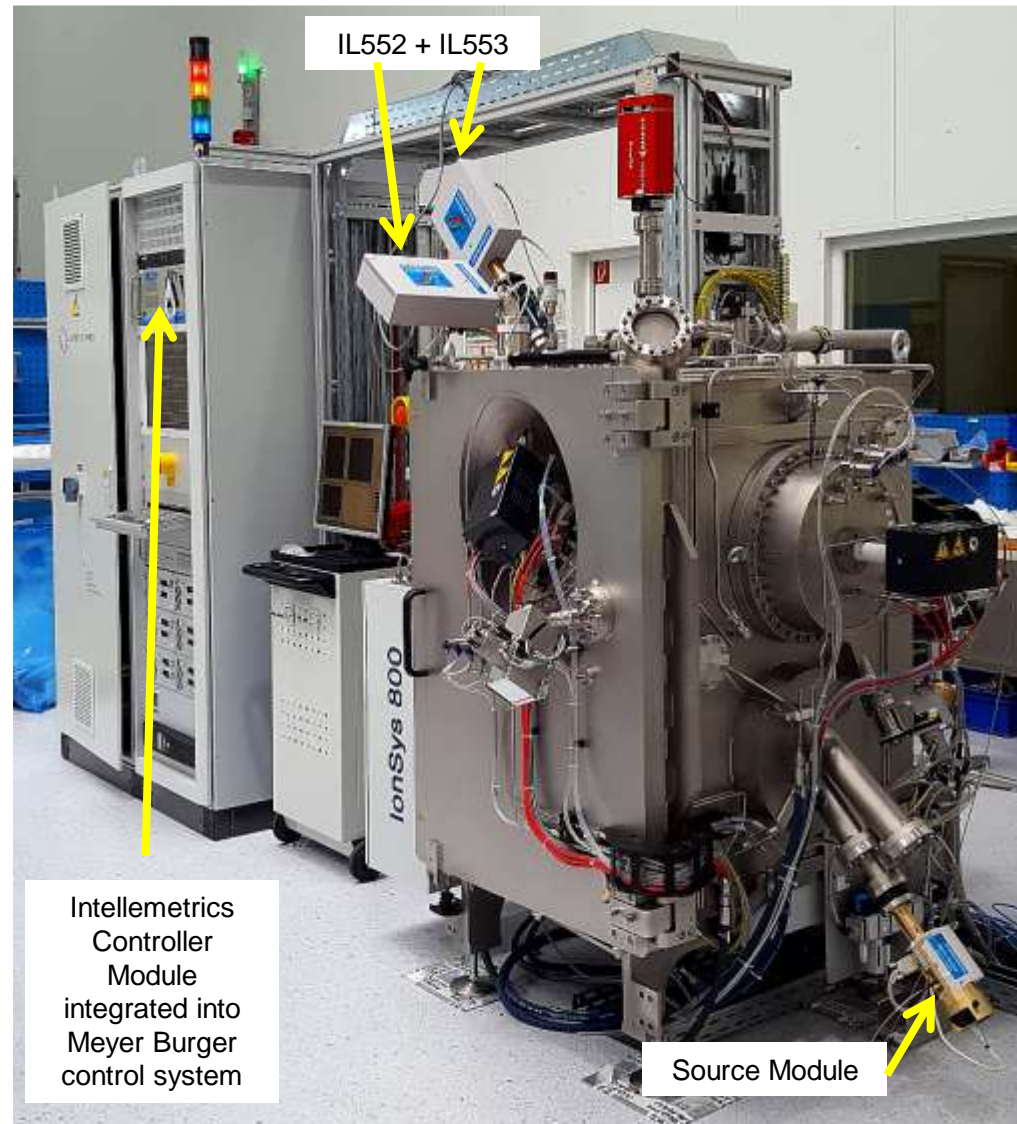
Meyer Burger is a leading global technology company specialising in innovative systems and processes based on semiconductor technologies and is employing around 1,600 people across three continents. Meyer Burger has integrated the Intellemetrics Optical Monitor into our range of coating systems for the production of precision optical coatings.



## IonSys 800 IBS Coater

For high precision optical filmstacks

Intellemetrics IL552+IL553 Optical Monitor for monitoring from 400 to 1650nm in transmission and reflection on rotating substrate.



Intellemetrics  
Controller  
Module  
integrated into  
Meyer Burger  
control system

Source Module

# Elettrorava - Italy



**“Elettrorava has delivered several optical coating systems using ion beam sources and electron beam source specifically designed to meet needs of major worldwide Institutions. The success of these systems has been enabled by the control of the process by the Intellemetrics Optical Thickness Monitor. Besides an outstanding user friendly software with associated hardware Intellemetrics offers on site assistance and round the clock remote assistance for the lifetime of the system”**

*Dr Paolo Rava, Managing Director,  
Elettrorava S.p.A*



# Kenosistec - Italy



**“Kenosistec is a dynamic Italian company with more than two decades of experience in designing, developing and manufacturing High Vacuum Systems and components for Thin Film Deposition and Research Applications. Kenosistec are pleased to integrate Intellemetrics optical monitors into our coating systems.”**

*- Paola Santilli, Senior System Engineer, Kenosistec.*





Plassys designs and manufactures equipment for thin film deposition and etching. For over 20 years many prestigious public and private research centers have relied on PLASSYS expertise in vacuum technology and application know-how.

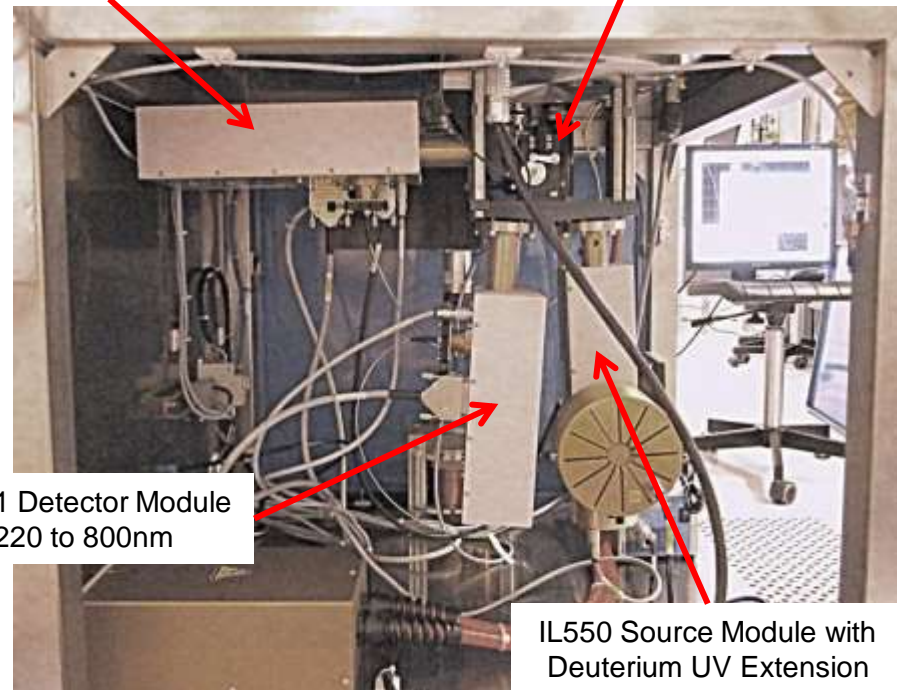
Ion beam deposition chamber with IAD installed at prestigious French research lab.

Intelmetrics optical monitor integrated for monitoring and control of a wide range of precision optical coatings.

Monitoring from 220nm to 2,200nm

IL555 Detector Module  
800 to 2,200nm

Mirror Block and  
chamber mounting  
accessories

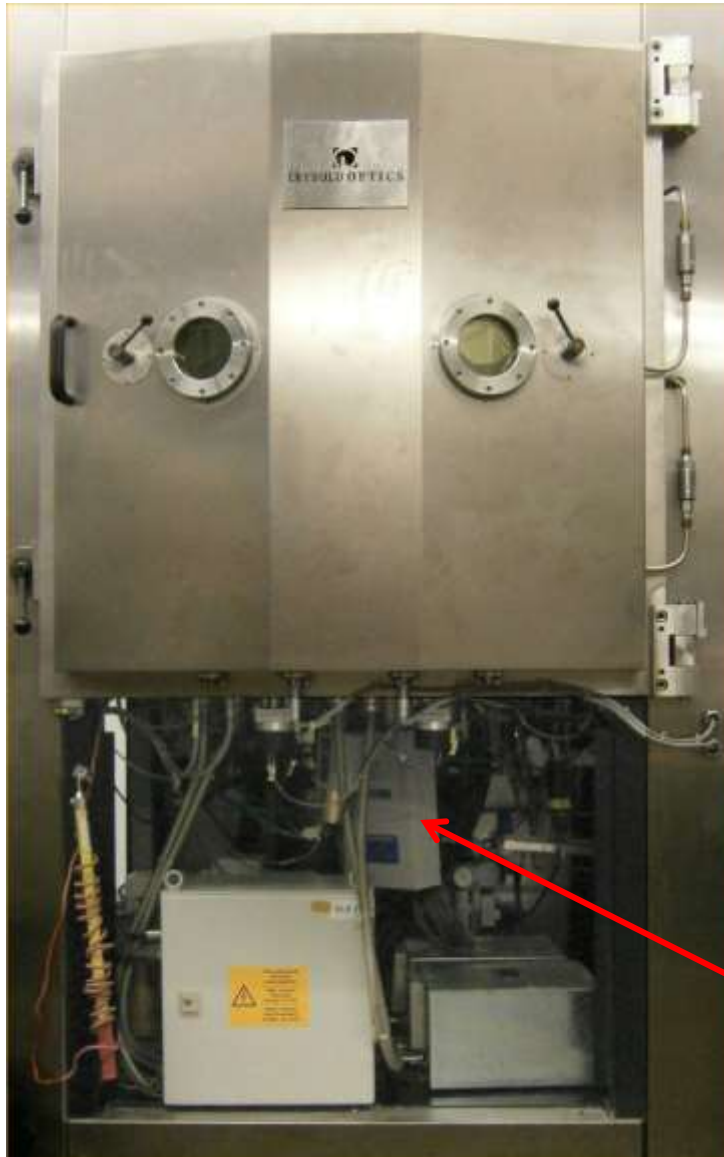


IL551 Detector Module  
220 to 800nm

IL550 Source Module with  
Deuterium UV Extension



# Leybold Optics - Germany



**Intellemetrics IL555 (800 to 2400 nm) in front face reflection mode on a Leybold LABplus 900 chamber.**

**System full integrated into the Leybold LabPC control system for complete automated operation.**

**Application: 3 – 5 $\mu$ m and 8 - 15 $\mu$ m  
Bandpass Filters  
Narrow Bandpass Filters  
Edge Filters**

**Source and  
Detector  
Modules**



# Korea Vac Tec Co Ltd – South Korea



Source Module  
mounted on top of  
the chamber



IL552 Detector  
mounted underneath  
the chamber



Korea Vac Tec's VTC-1000 PO Coater is designed for precise optical coatings on optical parts and similar products using electron-beam and thermal evaporation (with ion gun pre-cleaning and assistance) to create multilayer optical coating on the surface of substrates. VTC-1000 PO Coater runs in fully automatic mode.

# Hind High Vacuum Co Pvt Ltd - India

*“HHV is a leader in the field of vacuum technology including the manufacture of vacuum coating systems for the production of high precision optical coatings. We are pleased to integrate the Intellemetrics Optical Monitor into our systems thereby offering our customers enhanced precision and control.”*

*..... Prasanth Sakhamuri,  
Managing Director*



Images show:

Incorporating Intellemetrics IL56SX Optical Monitor from 400 to 1650nm in transmission and reflection.  
Intellemetrics Test Glass Changer  
Compact launch and receive optical assemblies mounted on top and beneath the chamber.



**intellemetrics**

# A selection of our End-Users.....





# Installation Base

We have successfully integrated our Optical Monitor Systems onto coating systems made by the following manufacturers;



*and many more.....*





# Thank You

For further information & support, please contact

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