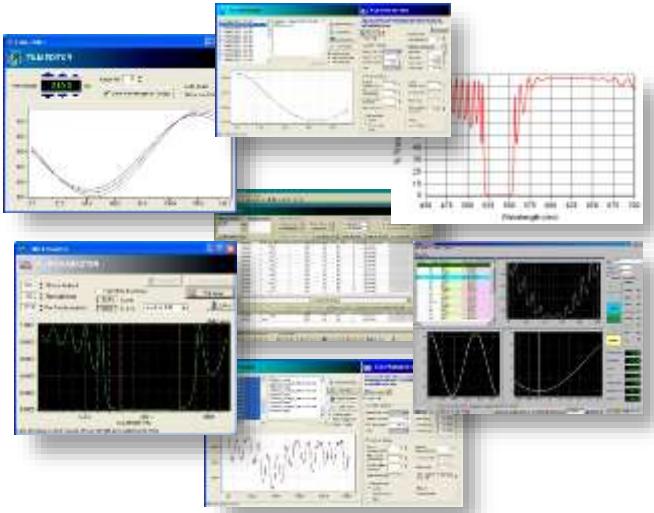


# Optical Monitoring: Delivering High Precision & Yield to the Manufacture of Optical Coatings

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



# Why Use Optical Monitoring?

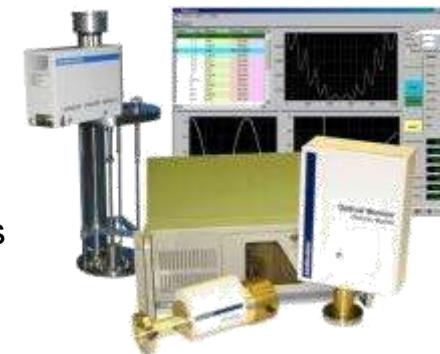


## The Challenges:

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



# Optical Monitoring Vs Quartz Crystal Example

## Target Specification

### ■ Product:

High Performance Steep Edge  
Notch Filter

### ■ Materials:

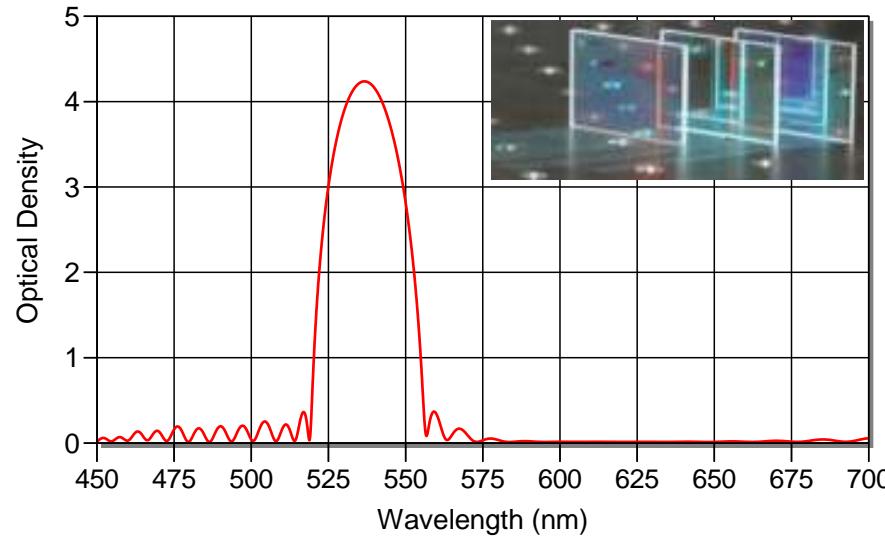
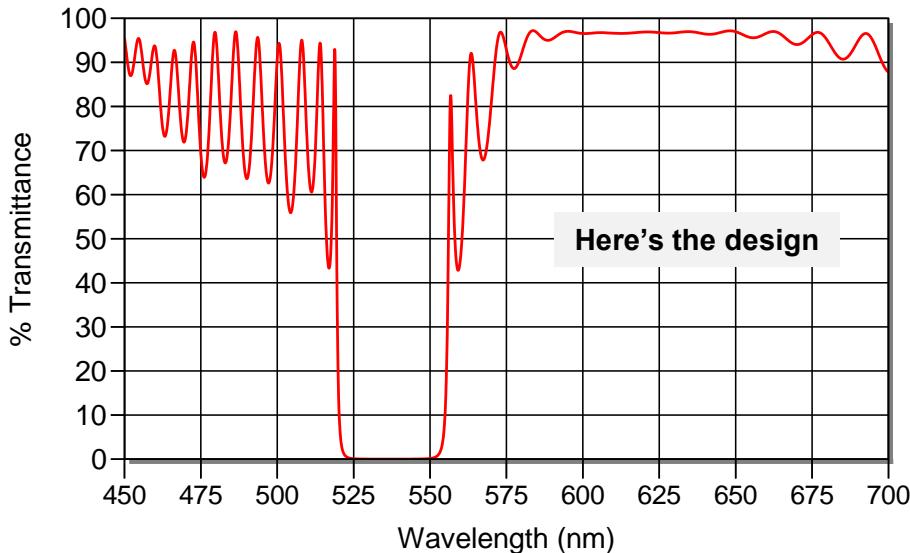
TiO<sub>2</sub> / SiO<sub>2</sub>

Ebeam deposition and IAD

### ■ Film Stack Design:

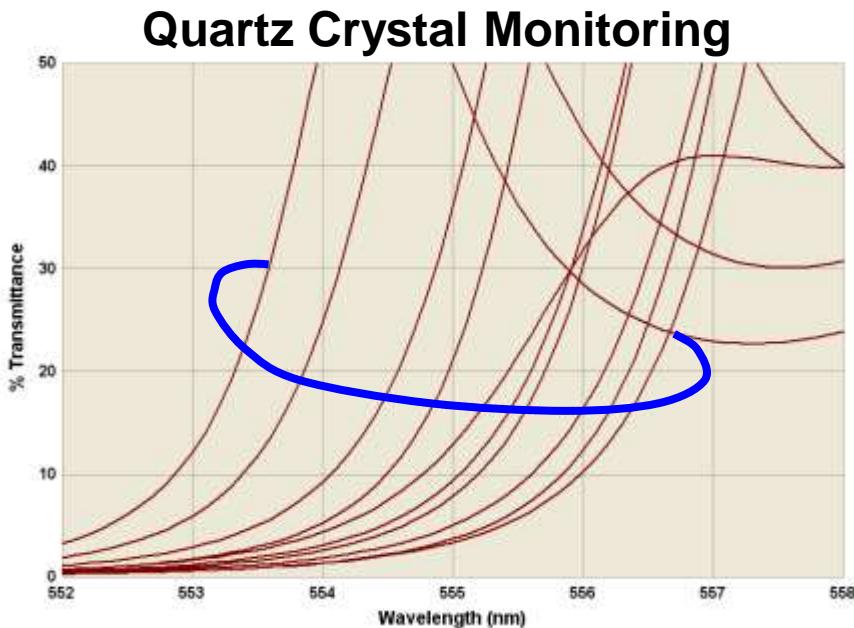
Demanding 34 layer film stack  
with non-QW termination

### ■ Band Edge Position Spec: ± 0.3nm



# Optical Monitoring Vs Quartz Crystal Example

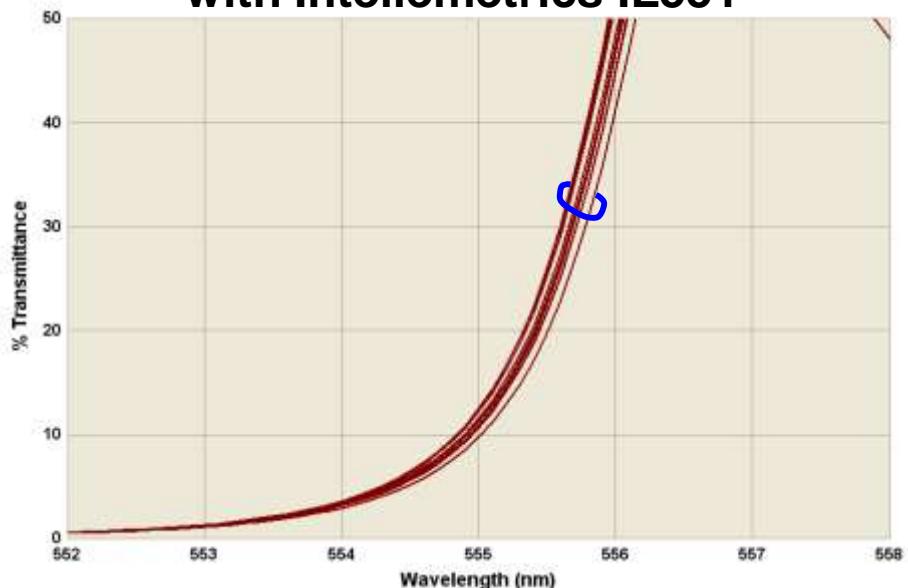
10 back-to-back growth runs...



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

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

**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

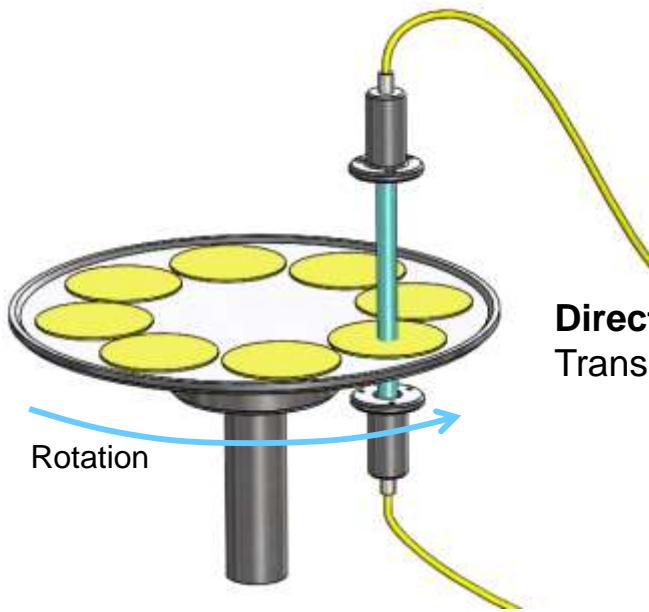
# In-Direct Optical Monitoring – Test Glass

- 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)



**Direct Monitoring**  
Transmission or reflection

**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	BW = 2.2 – 6.5nm
■ IL570-3	550 - 1650nm	All optical coatings except extreme NBFs (i.e. DWDM)
■ IL570-4	800 - 2200nm	

## Combined Product Range

■ IL570-1-3	300 - 1650nm	
■ IL570-1-3	400 - 1650nm	BW = 2.2 – 6.5nm
■ IL570-1-4	300 - 2200nm	All optical coatings except extreme NBFs (i.e. DWDM)
■ IL570-2-4	400 - 2200nm	

## 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

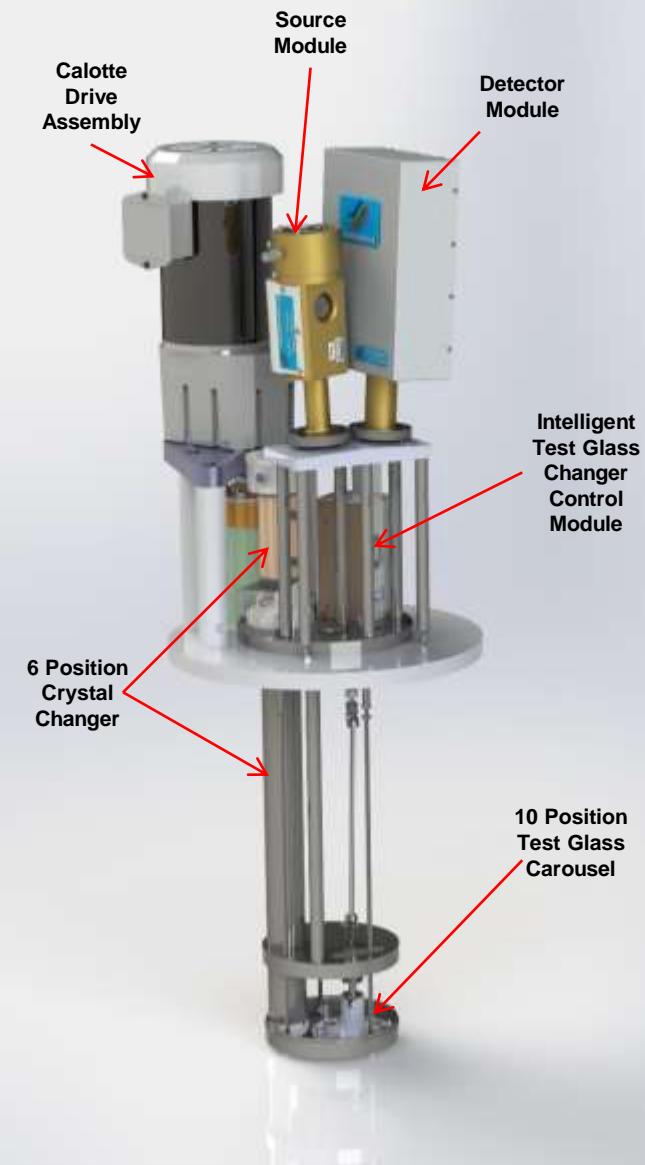
BW = 0.7 - 1.5nm

All optical coatings including extreme NBFs



# Accessories: Test Glass Changers

- In-house designs. Customised for your chamber geometry.
- Driven from Optical Monitor system 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.
- 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 or 250 glass drop glass system.



# Powerful Software

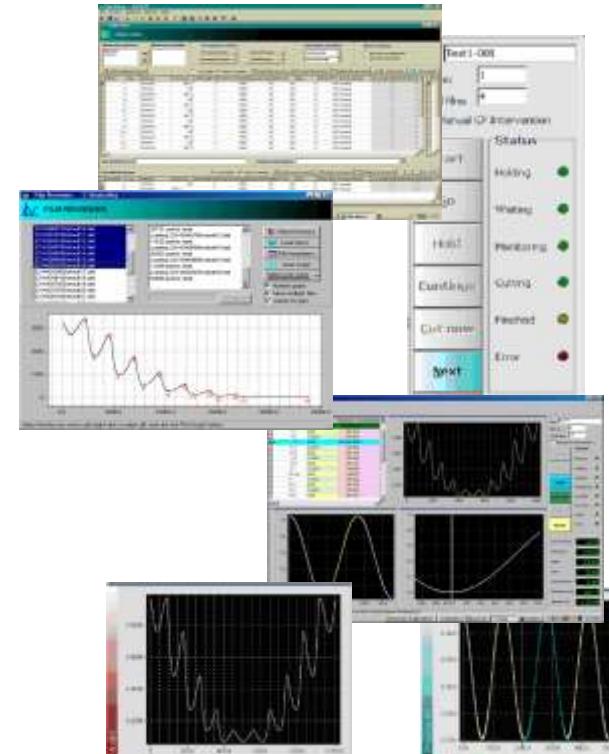
- Intellemetrics' Optical Monitors give thin-film engineers the tools to decrease process development time & manufacturing costs AND increase yield & product performance.
- The system combines advanced optoelectronic hardware with a suite of powerful software packages including

## ■ **FilmMaker2**

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

## ■ **FilmDirector2**

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

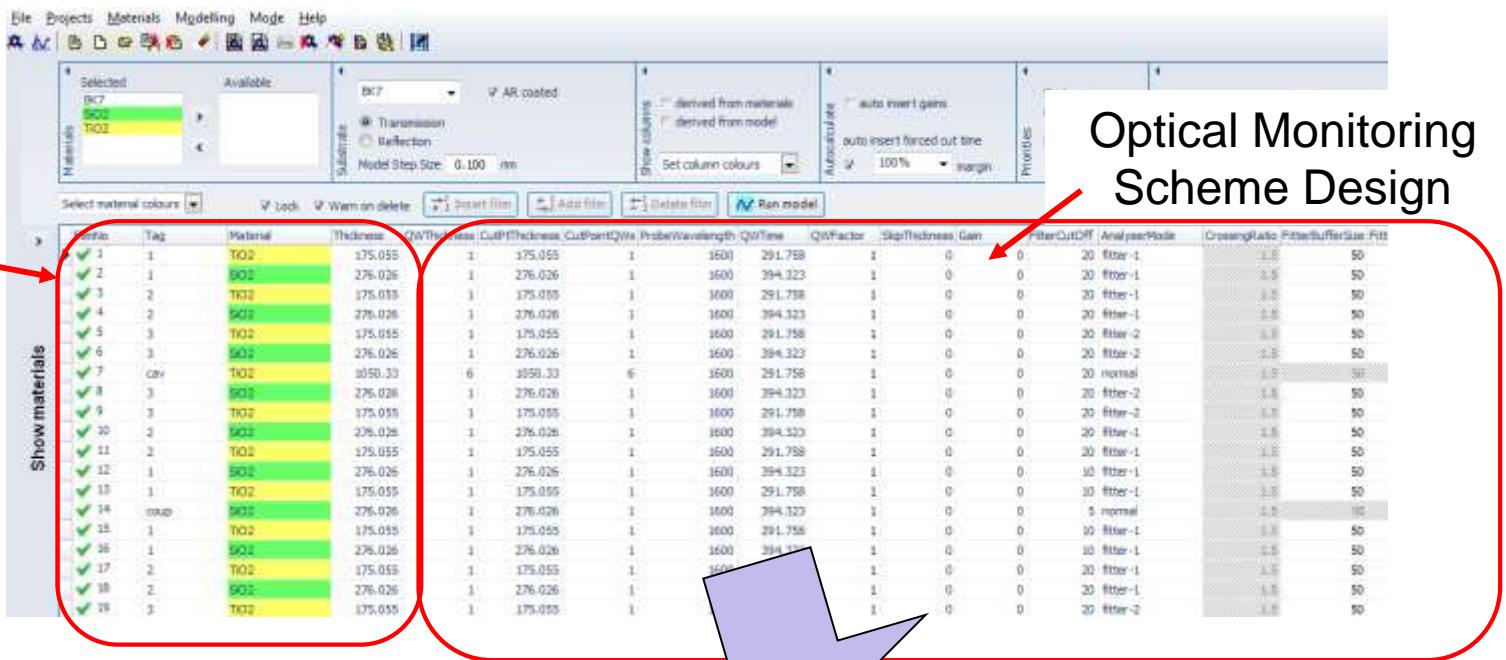


# Film Stack Design → Optical Monitoring Scheme

## FilmBuilder

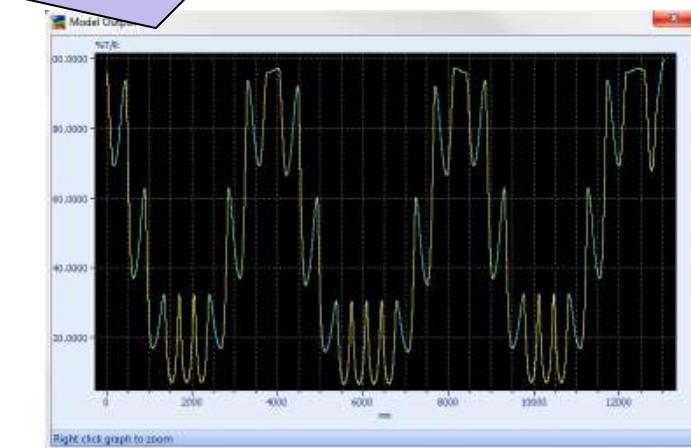
### Film Stack Design

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

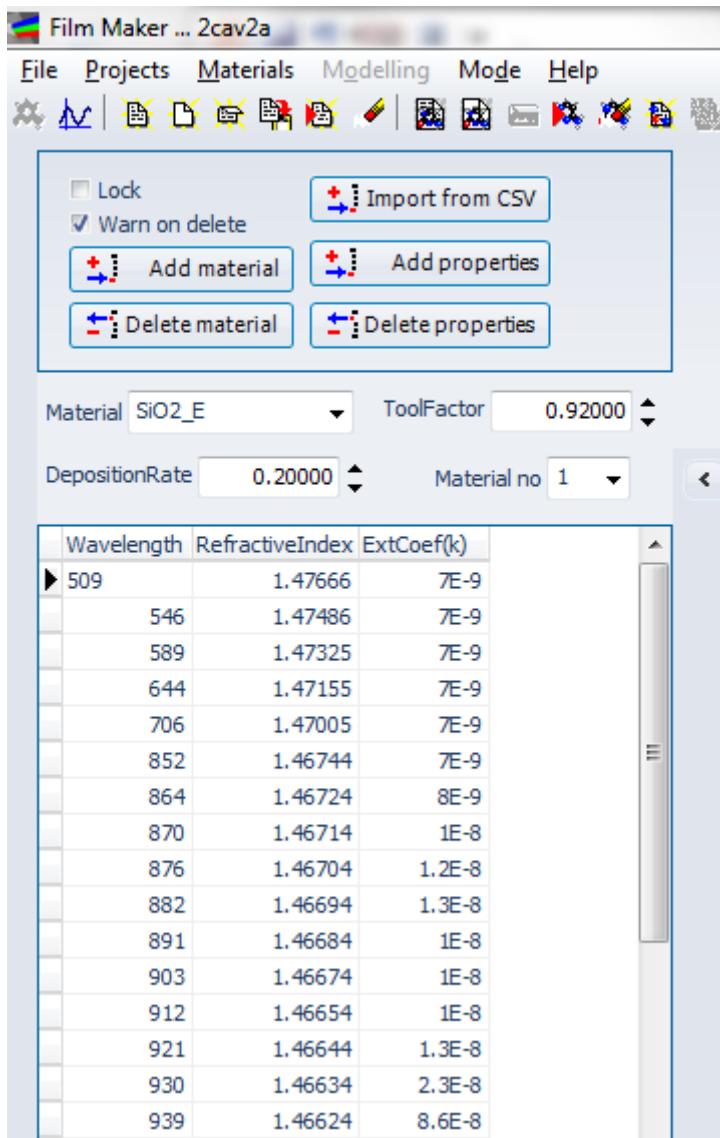


### On a layer-by-layer basis, specify

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



# Material Properties

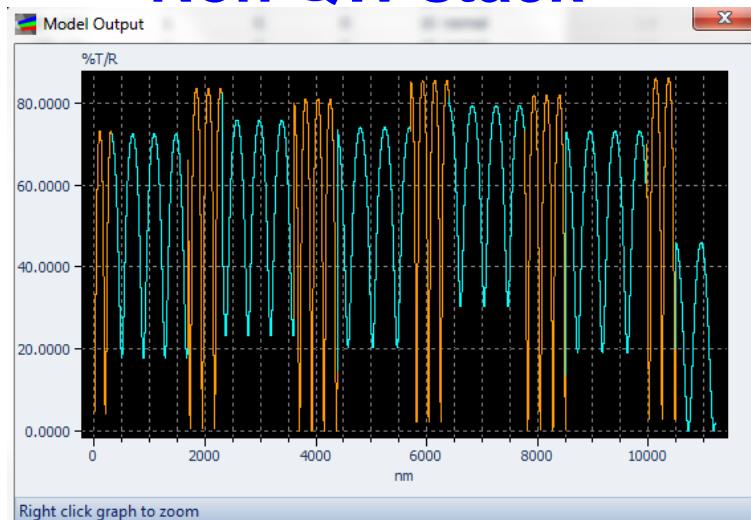


- Unlimited number of custom materials
- Define n and k at unlimited number of wavelengths
- Define deposition rate for each material
- Define tooling factor for each material
- Read in data from CSV files, export to CSV
- Create Public or Private materials databases

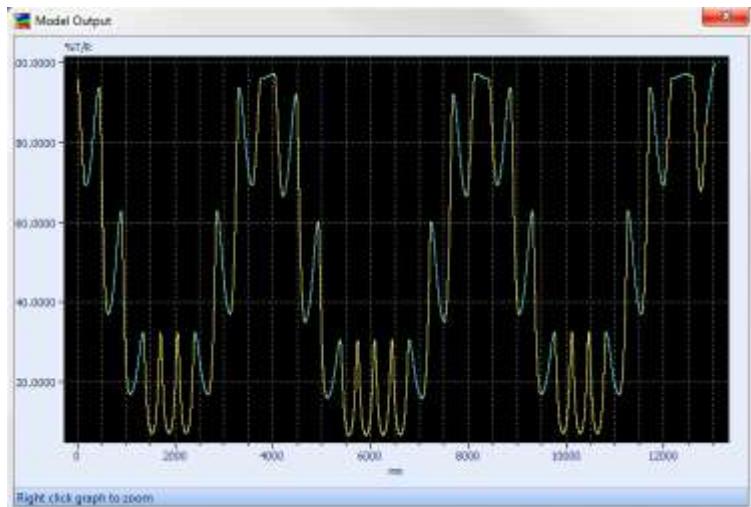
# FilmModeller

- Automatically reads a FilmBuilder<sup>©</sup> 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<sup>©</sup>

**Non QW stack**



**QW stack**



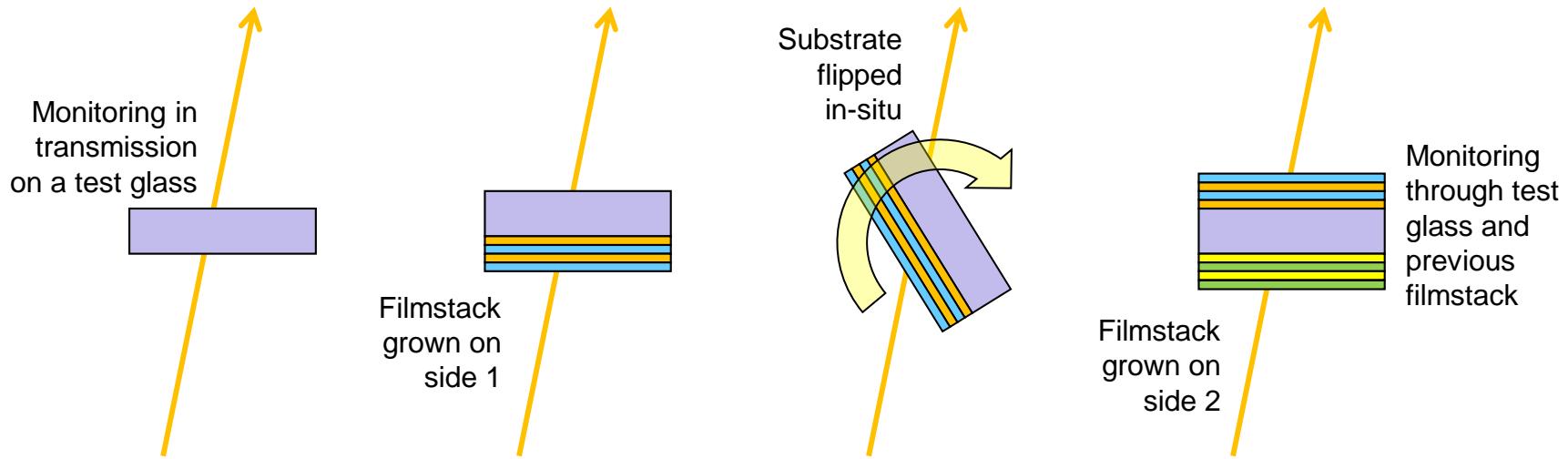
# FilmEditor

- 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

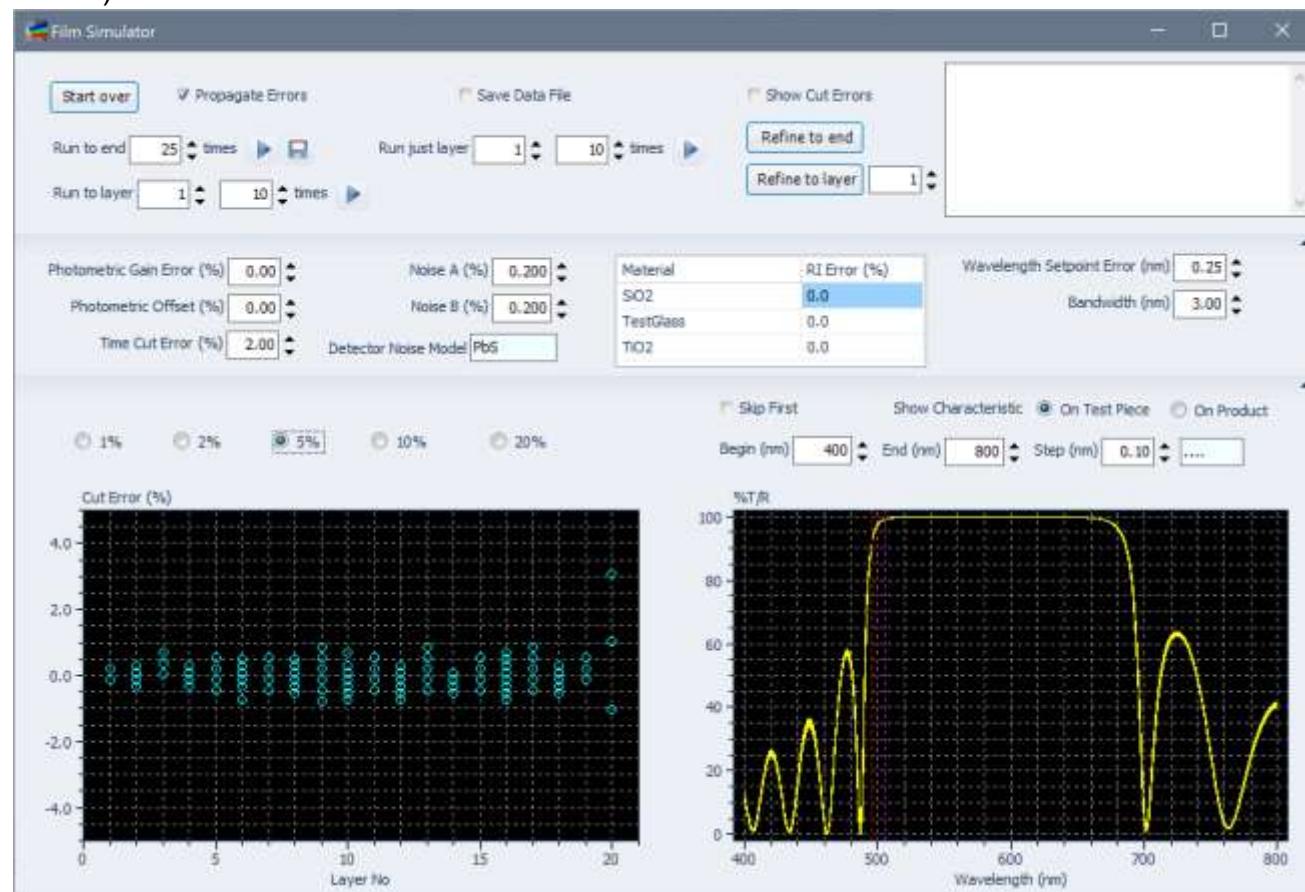


FilmMaker correctly models filmstacks on two sides of a test glass.

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

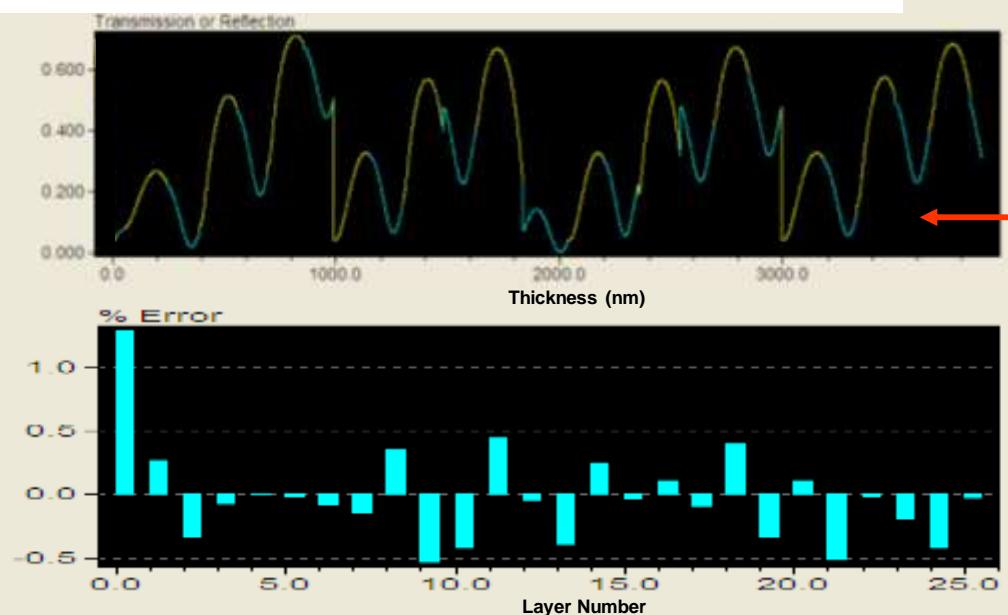
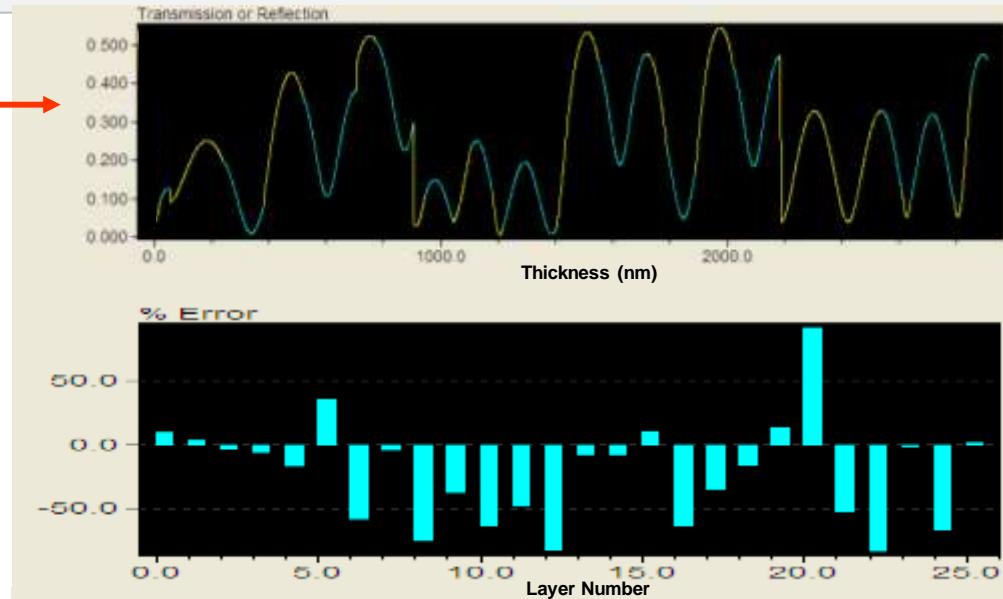
- Off-Line simulation runs including
  - Optical Model
    - Physical effects of Optical Monitoring hardware (bandwidth, wavelength, noise)
    - Physical effects of Customer's Coating Tool
      - E-gun noise (material dependent)
      - Gun dep rate control
      - Test glass changes
- Calculates 'cut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

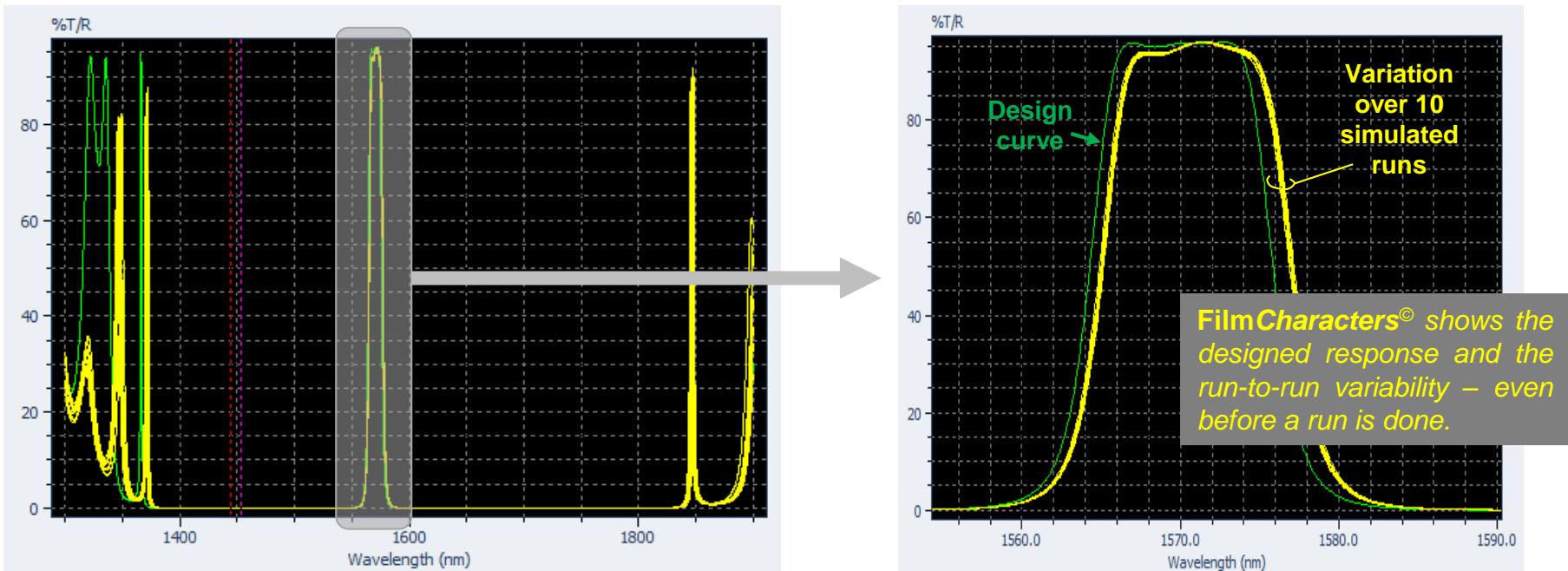
- Change monitor wavelengths
- Change Test Glass scheme
- Change filter settings

**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.**

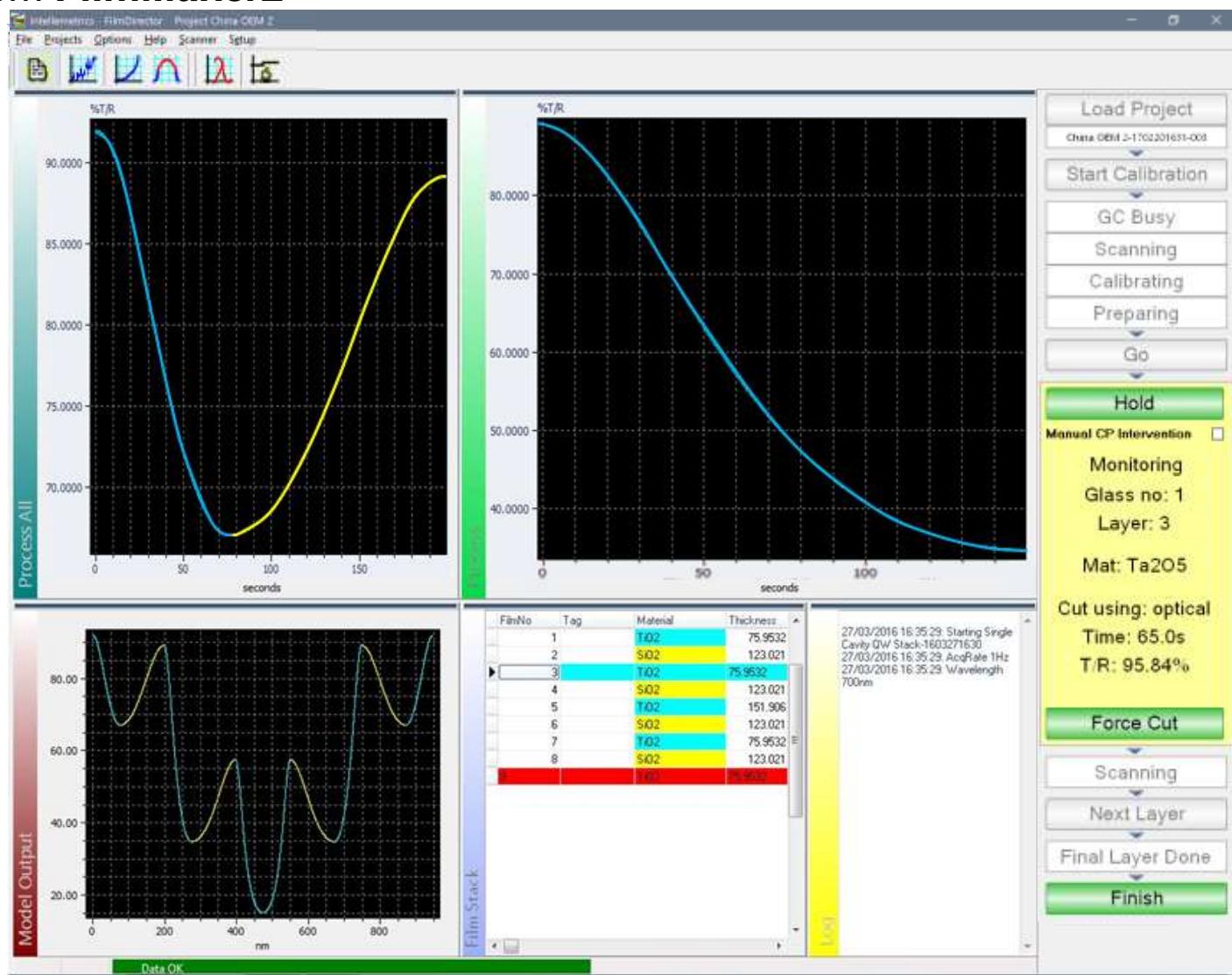
# FilmCharacters - Pre Coating Run

- Determine the Spectral Characteristics of the final film stack
- Compare the THEORETICAL DESIGN spectra with the 'REAL-LIFE' spectra from **Film Simulator** ©
- 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

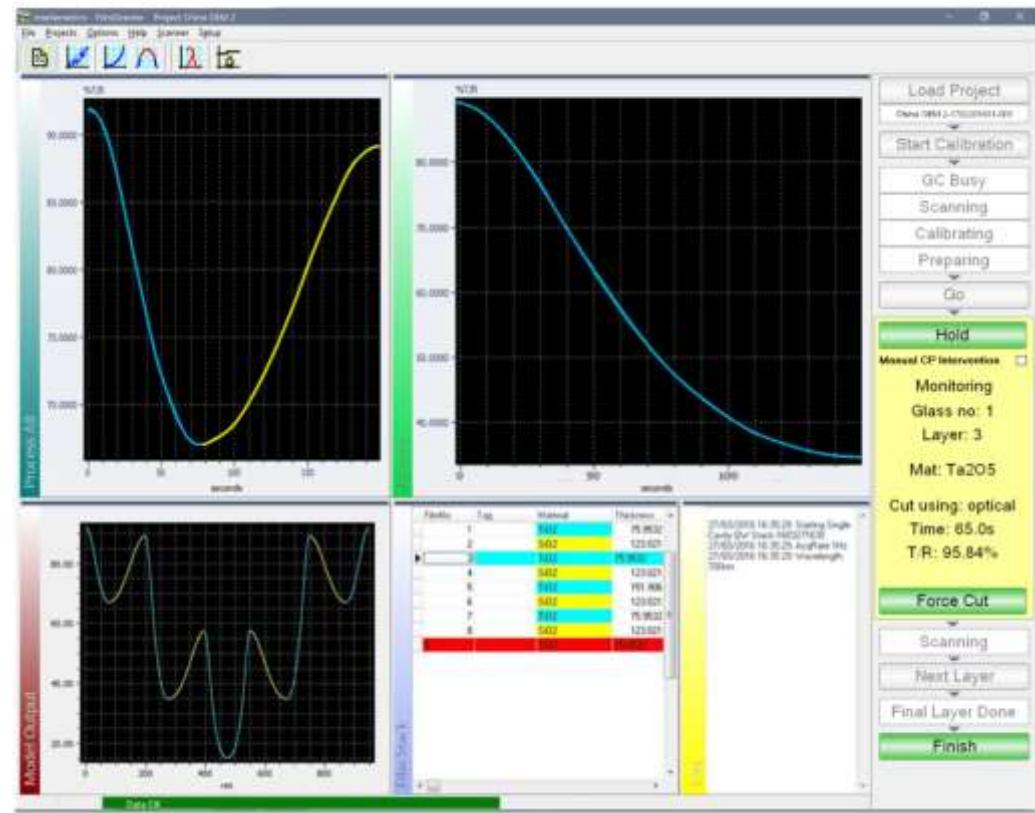
- Loads a project from **FilmMaker2**
- Performs the run under automatic or manual control as required
- Autocalibrates on start up
- Automatically changes the wavelength and the test glass
- Detects each cut and controls the deposition through an advanced I/O capability.



# FilmDirector2

## Key Features

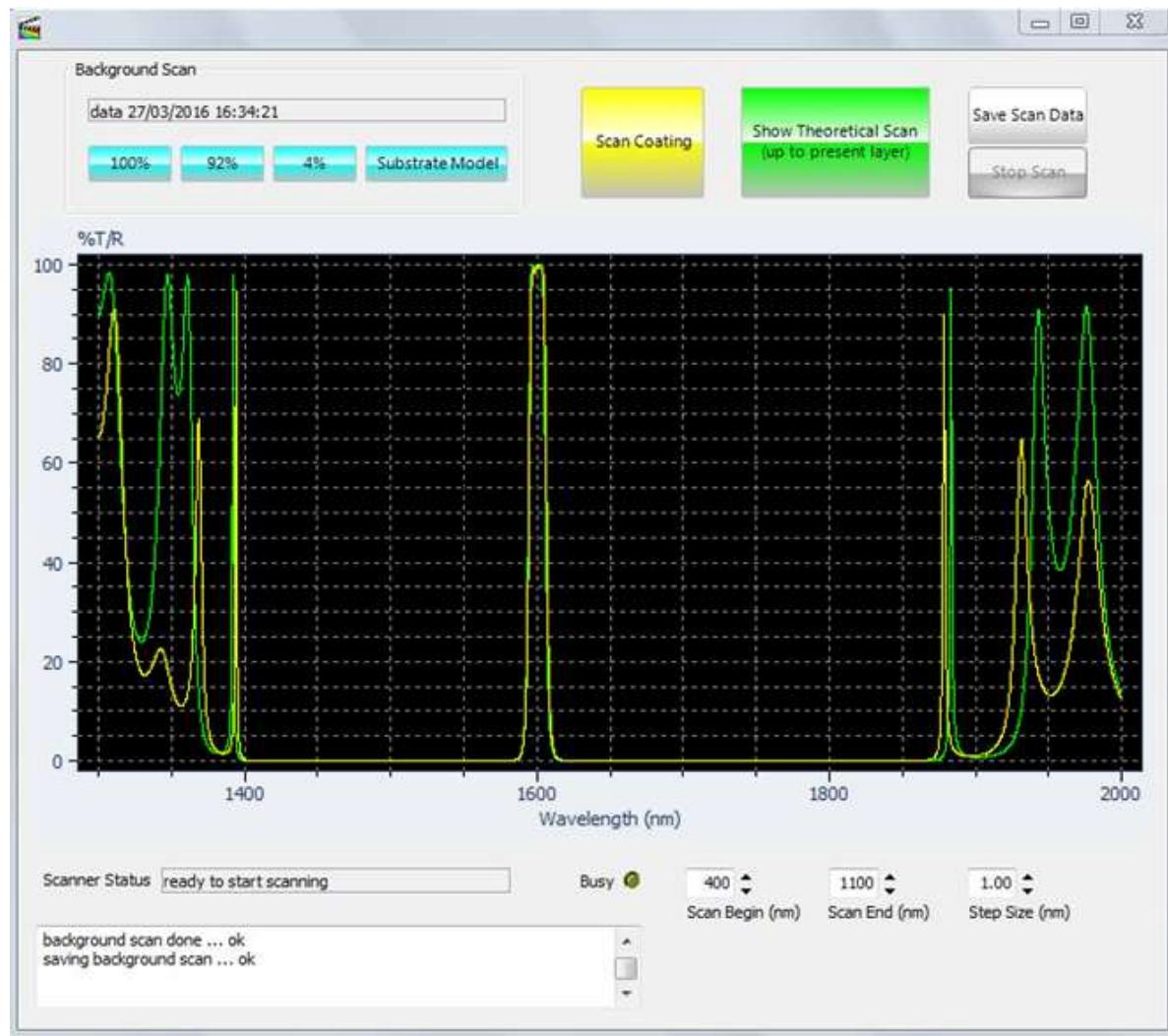
- Incorporates advanced model fitting algorithms for cutpoint determination
- State machine based controller can recover/continue a process context even after a shutdown.
- Integrates seamlessly with **FilmMaker2<sup>®</sup>** design front-end.
- Freely configurable, panelled user-interface.
- Fully 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

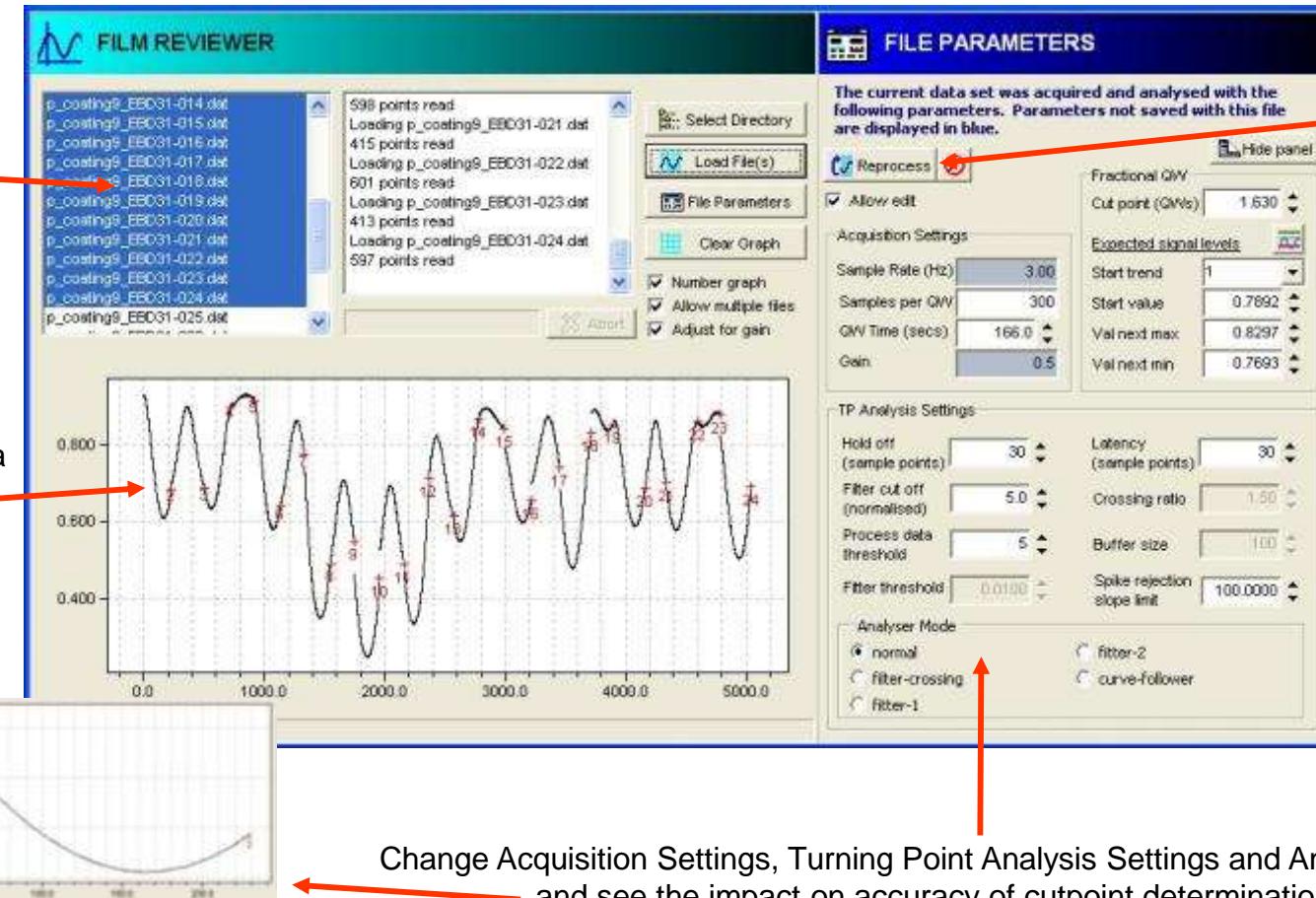
- Perform wavelength scan on bare substrate before coating.
- Perform wavelength scan after each layer, or at the end of the coating run.
- Automatic scanning can be preselected in FilmMaker2, or scans be done ‘on the fly’ as required.
- Displays theoretical scan as well as experimental scan for easy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



# FilmReviewer - Post Coating Run

- FilmReviewer<sup>©</sup> 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

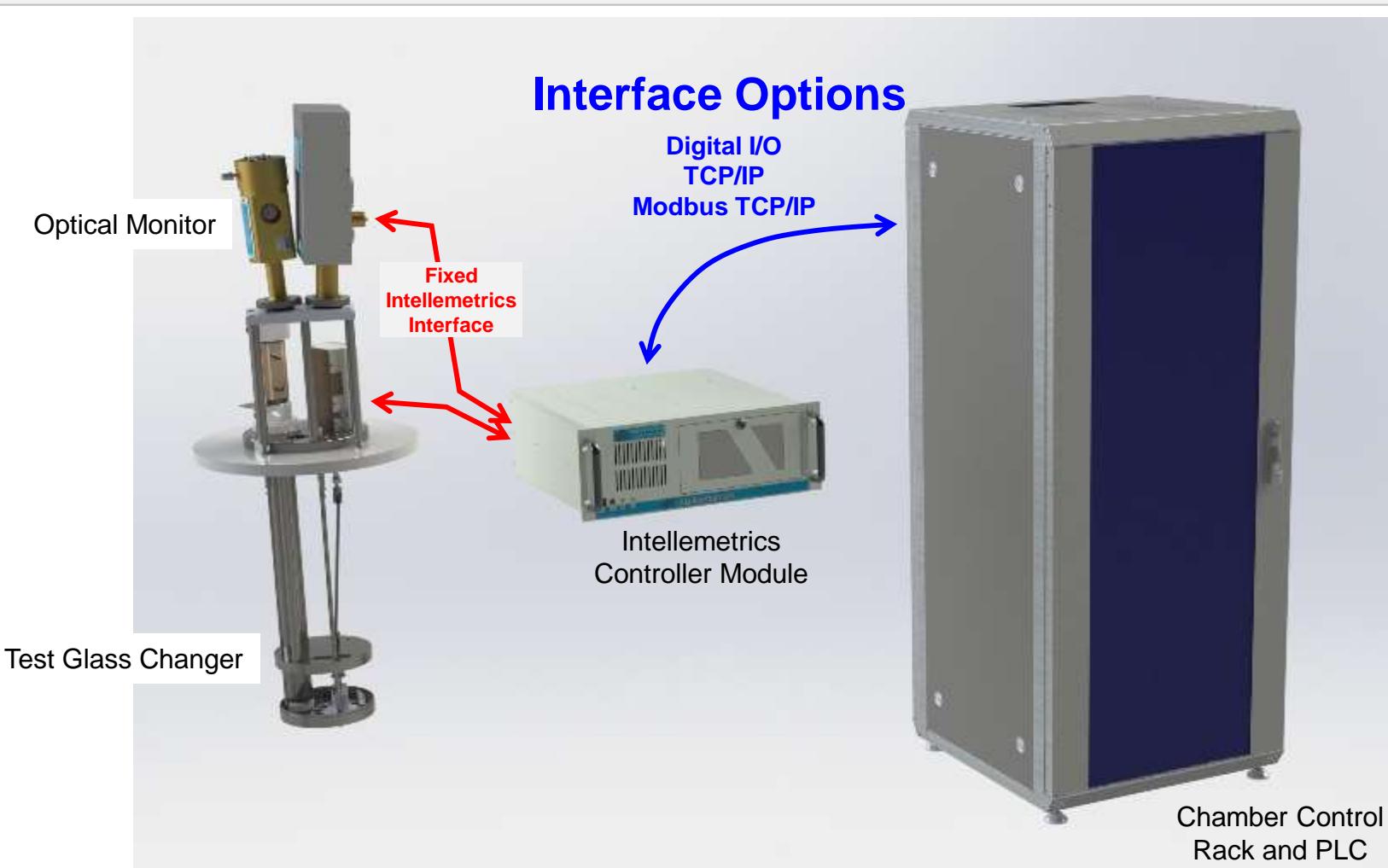


View the raw data  
for the whole  
stack or analyse  
a layer at a time

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

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

# Integration into Your Coating System

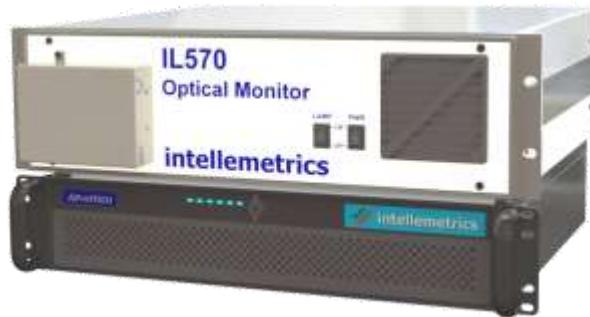
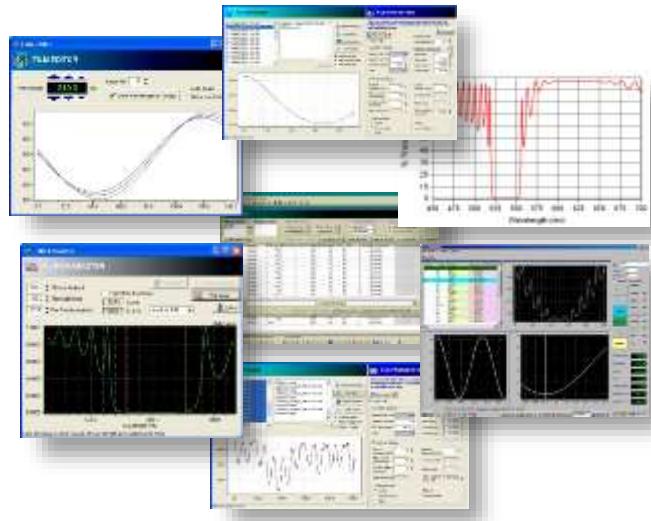


Complete seamless integration for fully automated operation.

Customer can choose any one of the interfaces above, or use any combination of them.  
Interfaces are fully specified and documented.

# IL550 & IL560 Series Optical Monitors

## Customer Endorsements



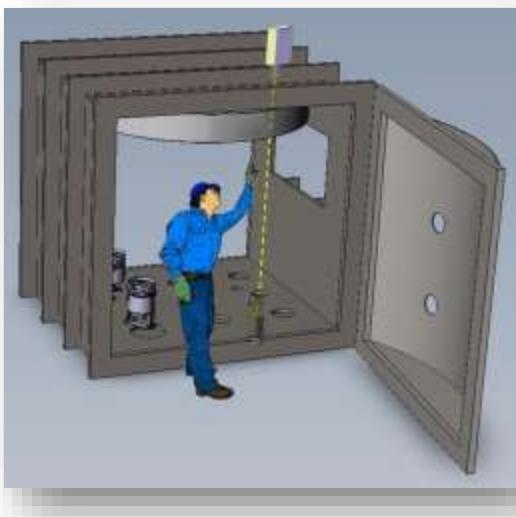
# Tecport Optics - USA



**"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.

# Tecport Optics - USA



The system was installed and commissioned at the customer's facility and met all of the customer requirements. Optical noise measurements in the field agreed with the design results and confirmed that the optical signal levels had been increased by a factor of >100. Based on the system performance, the end customer is now thinking about the possibility of even larger filmstacks.

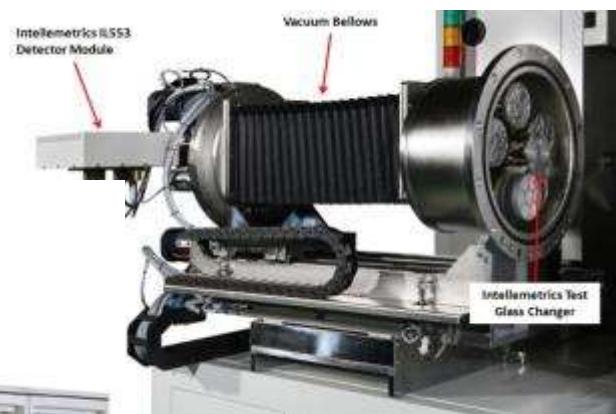
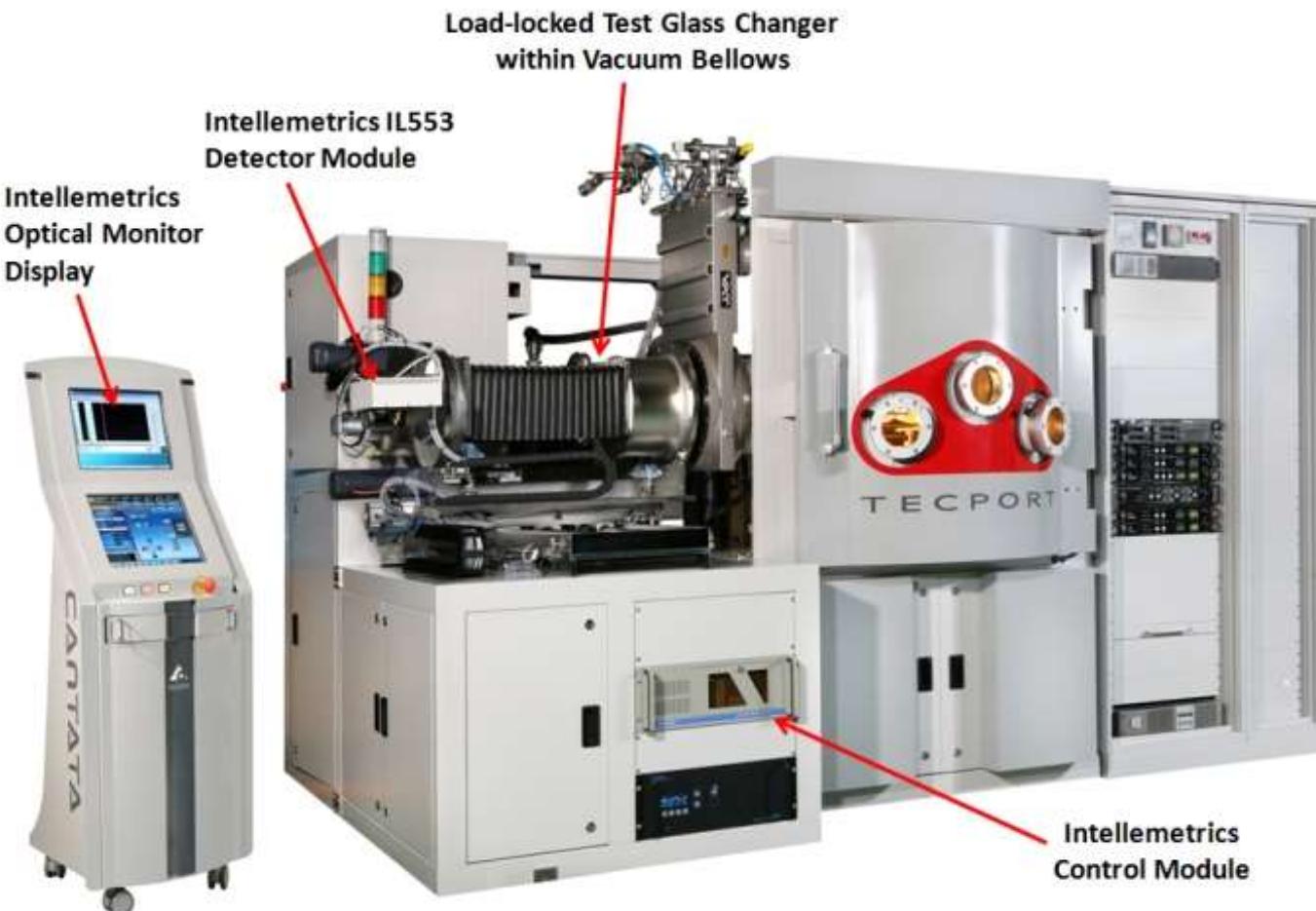
Intellemetrics recently successfully installed a new design of optical monitor onto a Tecport Optics 2m chamber used in the manufacture of high performance night vision systems. Optical designs with greater than 250 layers are being deposited in a production environment with over 500 elements being coated in each run.

The customer specification handed to Intellemetrics was extremely demanding with a single shot measurement once per revolution to be taken directly on a test piece mounted at a large radius on a calotte. A high calotte rotation speed, combined with a small test piece size, and a large radial distance resulted in there only being a 3ms window for each measurement. On top of this, the system was required to take measurements from 450nm out to 1080nm, work in a completely automated manner, and be capable of monitoring up to 70 layers on each test glass.



# Tecport Optics - USA

## Load Locked Ion Beam Sputtering System



Intellemetrics Test  
Glass Changer on a  
vacuum bellows  
assembly for use with  
the load-lock.

# Tecport Optics - USA

**Symphony - 1.8m Precision  
Optical Coating System**

**Intellemetrics IL551 (300 to  
800nm) Optical Monitor in Back  
Face Reflection Mode on a Test  
Glass Changer**



# 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.*

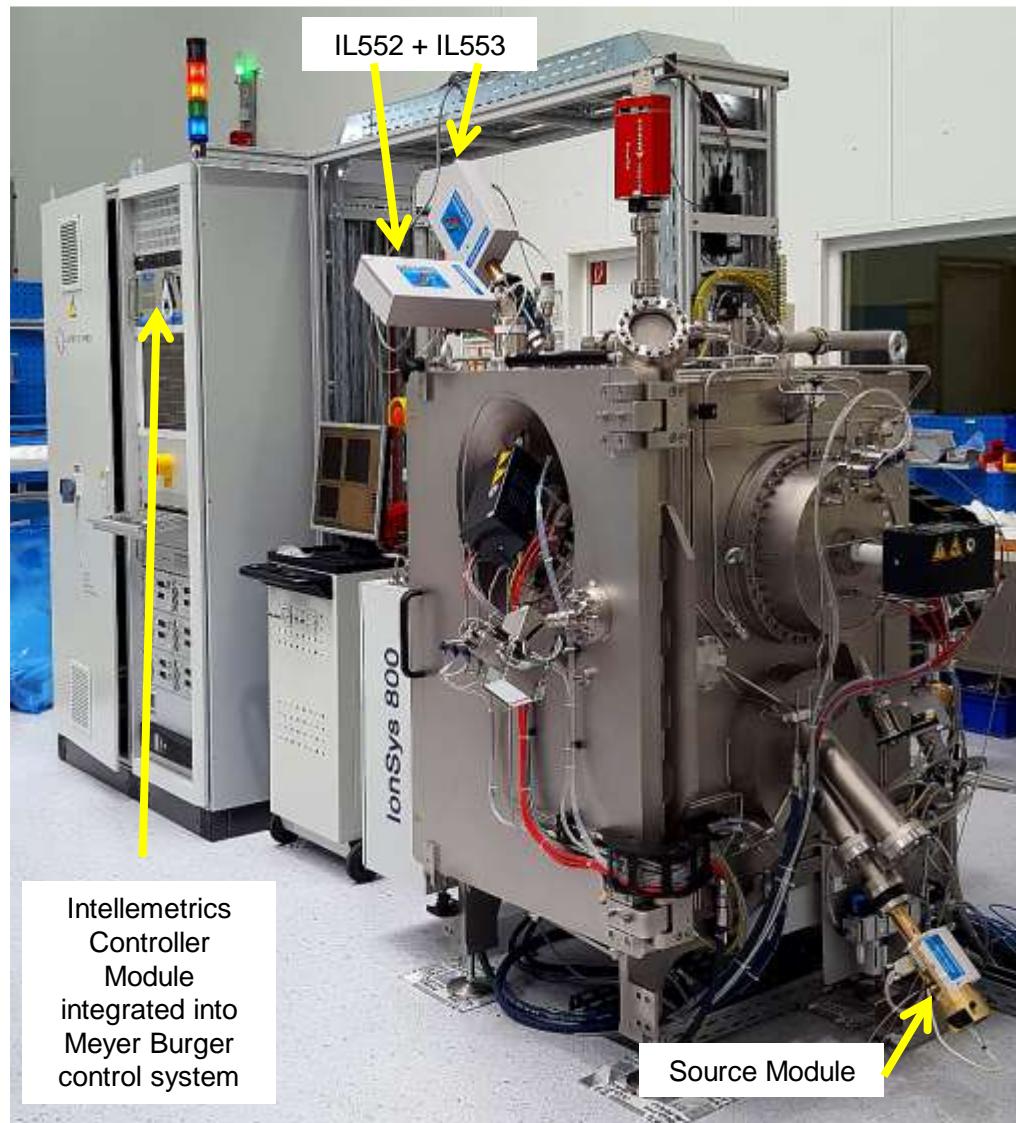
# MEYER BURGER (formerly Roth&Rau) - Germany

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.



# 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 ontop and beneath the chamber.



# Kenosistec - Italy

Production Plasma Assisted Ebeam Coater  
1m<sup>3</sup> chamber for High Precision Optical Coatings



IL553 Source & Detector  
modules mounted underneath  
chamber for front face reflection  
mode monitoring

Intellemetrics automated  
test glass changer (250  
test glasses in a stack)

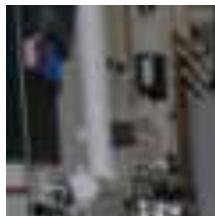
**"Kenosistec is a dynamic Italian company with more than two decades of experience in designing, developing and manufacturing High Vacuum Systems and components for Thin Film Deposition and Research Applications. Kenosistec are pleased to integrate Intellemetrics optical monitors into our coating systems."**

- Paola Santilli, Senior System Engineer, Kenosistec.

# Kenosistec - Italy

Ion Beam Sputtering System with four targets for High Precision Optical Coatings in Swiss R&D lab

IL551 for 300nm to 800nm monitoring



IL553 for 550nm to 1650nm monitoring



"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.

# Elettrorava Chamber at RRCAT - India



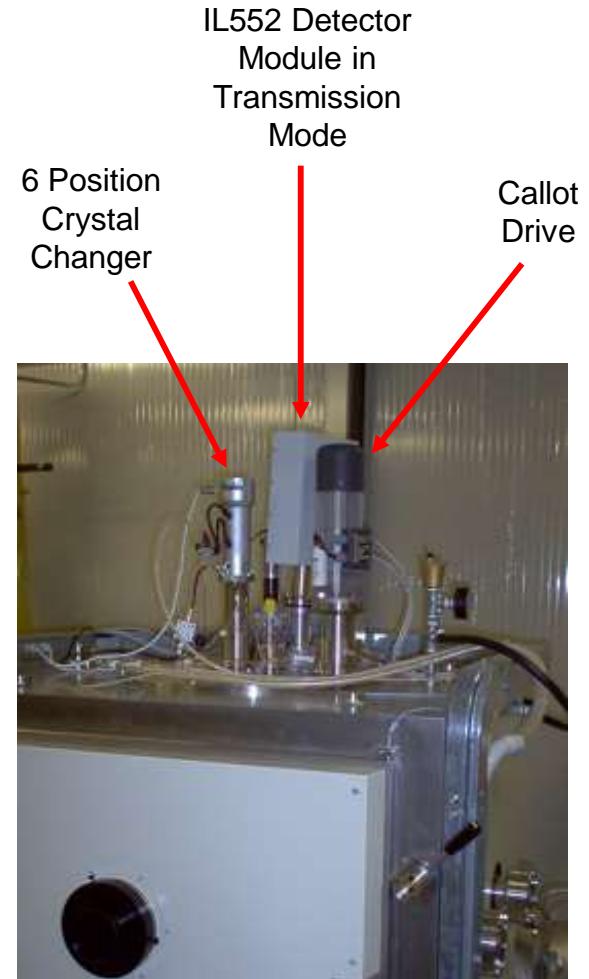
Ebeam coating chamber manufactured by Elettrorava, Italy for the Raja Ramanna Centre for Advanced Technology, Indore, India.

System has IAD and is used for high precision optical coatings for high power laser applications.

Optical monitoring system consists of four detectors (two in reflection and two in transmission) both covering a wavelength range from 300nm to 1650nm, plus a 12 position test glass changer, all fully integrated into the chamber control system.

# Elettrorava – CSIO, India

Ion Beam Assisted Ebeam Coater for Precision Optics  
installed at CSIO, India



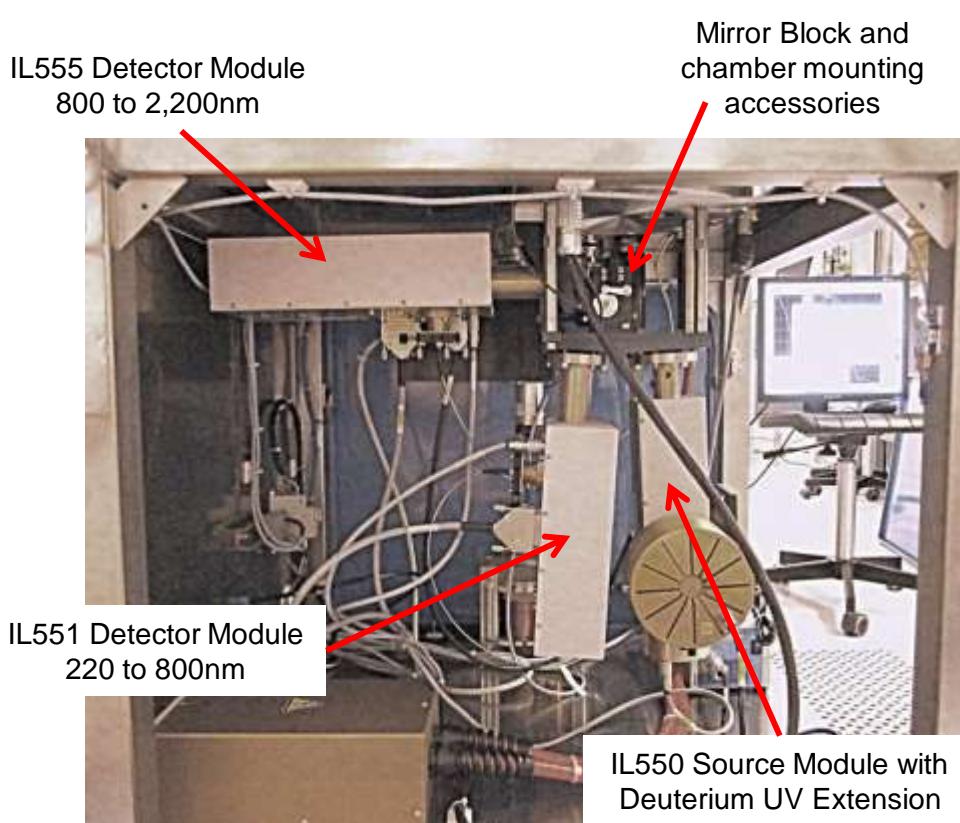


Ion beam deposition chamber with IAD installed at prestigious French research lab.

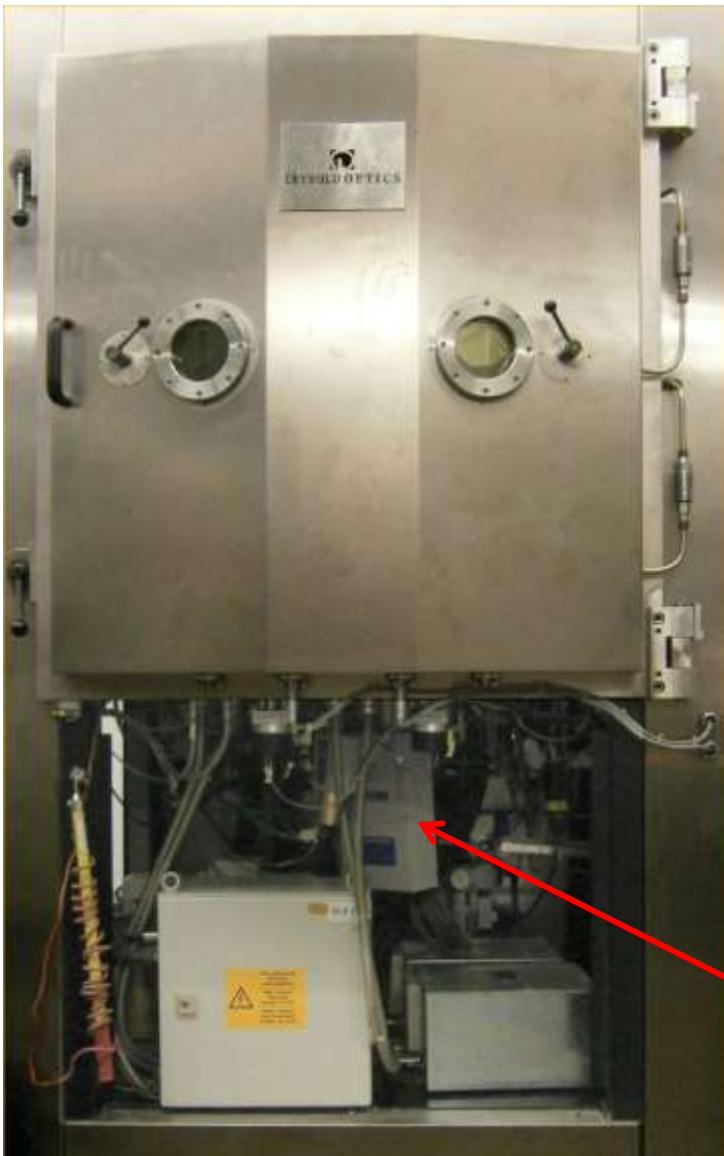
Intellemetrics optical monitor integrated for monitoring and control of a wide range of precision optical coatings.

Monitoring from 220nm to 2,200nm

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.



# 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**

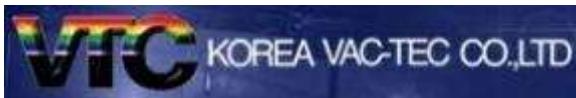
**Narrow Bandpass Filters**

**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.



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Москва, Зеленоград

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