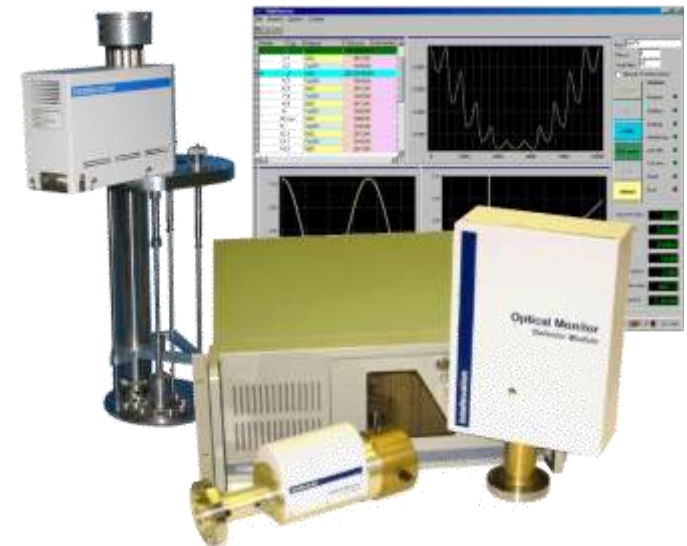
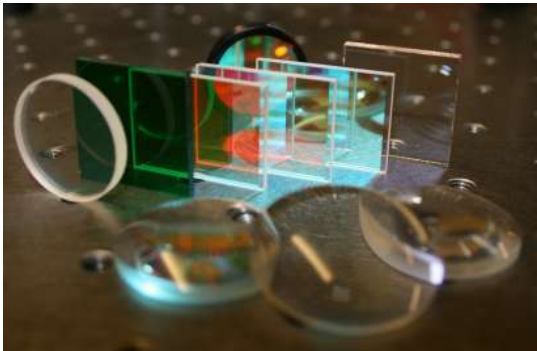


# Optical Monitoring: Delivering High Precision & Yield to the Manufacture of Optical Coatings

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

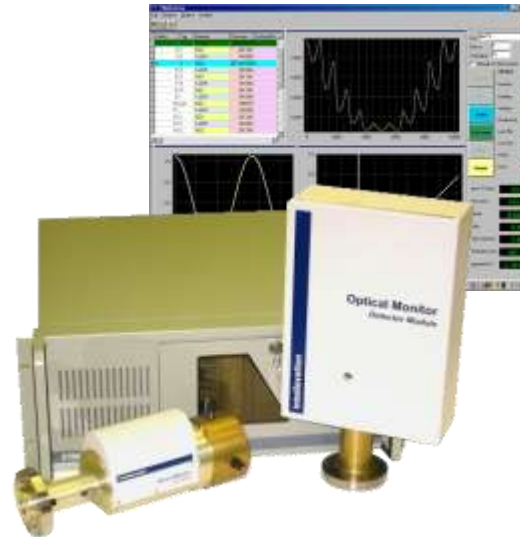


# Product Range

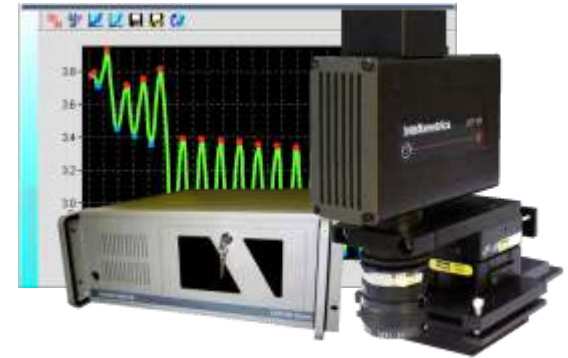
In-situ, real time measurement systems  
for thin film coating and etching applications



Crystal Monitor / Control Systems (**Xtal**) for monitoring and controlling material growth rates, typically in simple vacuum deposition systems.



Optical Monitor / Control Systems (**OMS**) for monitoring and controlling material growth rates, typically in complex vacuum deposition systems.



Laser End Point Detection Systems (**LEPD**) for monitoring and controlling material etch rates, typically in reactive ion etching systems.

# Manufacturing & Quality

**Quality is important to us.**

**Our manufacturing is performed using:**

- Formal Quality Systems
  - ISO 9001 / 14001 Certifications
- State-of-the-Art equipment / processes
  - Supply Chain Management
  - Assembly
  - Testing
  - Qualification
  - Direct Fulfilment
  - Aftersales Logistics & Repair



# Why Use Optical Monitoring?



## The Challenges:

Complexity ↑

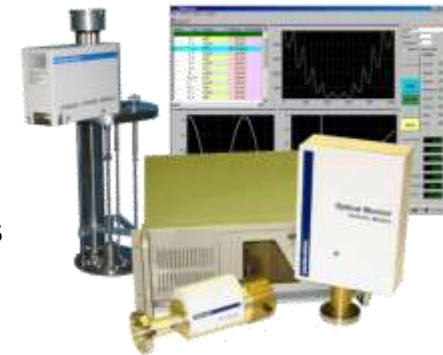
Precision ↑

Volume ↑

Cost ↓

## The Solution:

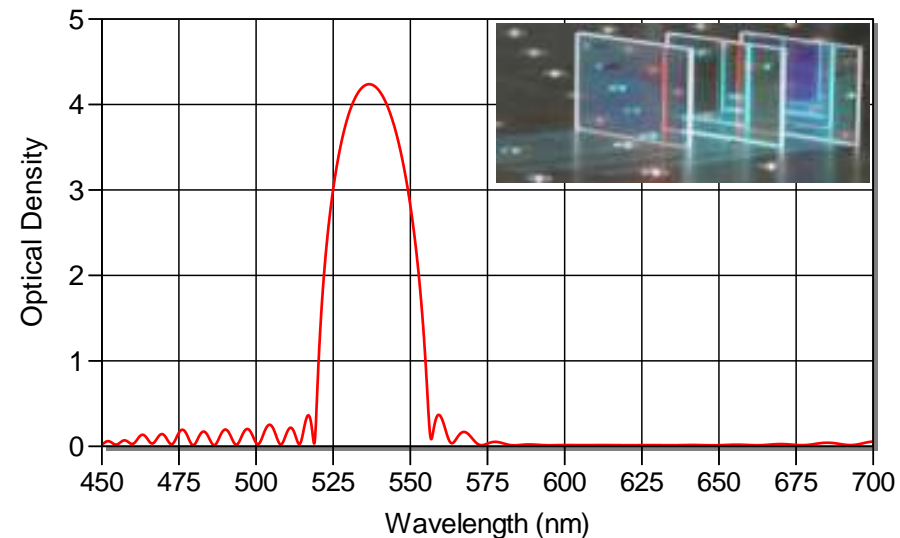
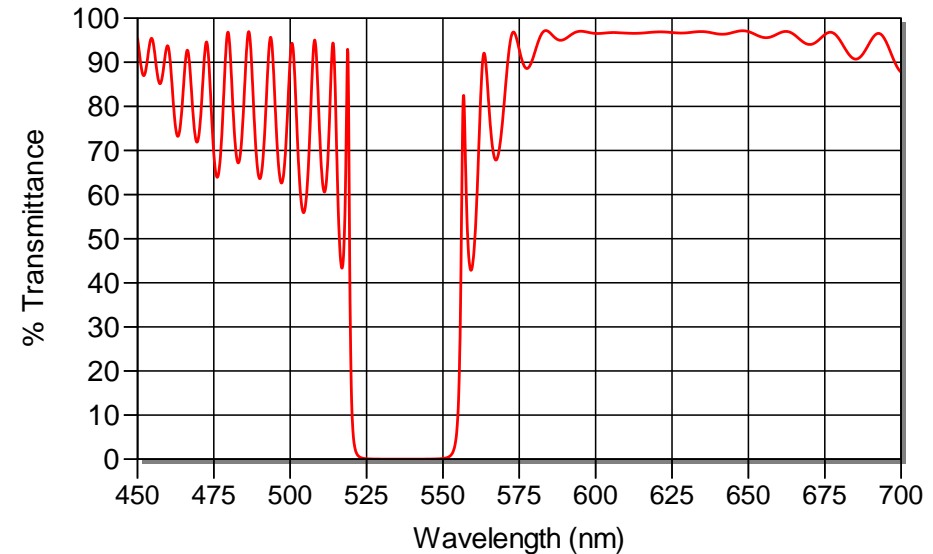
- Quartz crystal measures the **Deposited Mass**
- Optical Monitoring measures the true **Optical Thickness**
- Inherent error compensation in optical monitoring
  - Film stack errors can **decrease** as layer thickness and complexity increases



# Optical Monitoring Vs Quartz Crystal Example

## Target Specification

- **Product:**  
High Performance Steep Edge  
Notch Filter
- **Materials:**  
 $\text{TiO}_2 / \text{SiO}_2$   
Ebeam deposition and IAD
- **Film Stack Design:**  
Demanding 34 layer film stack  
with non-QW termination
- **Band Edge Position Spec:  $\pm 0.3\text{nm}$**

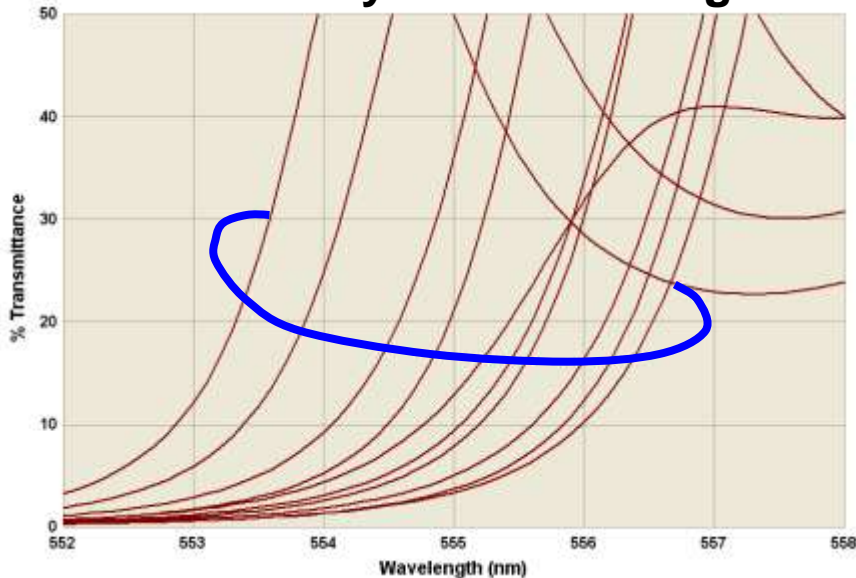


# Optical Monitoring Vs Quartz Crystal Example

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.

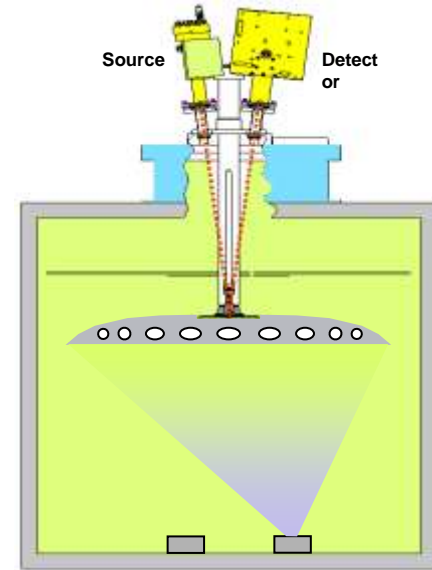
# Advanced Measurement System

## Optical & Electrical Noise

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

## Solution

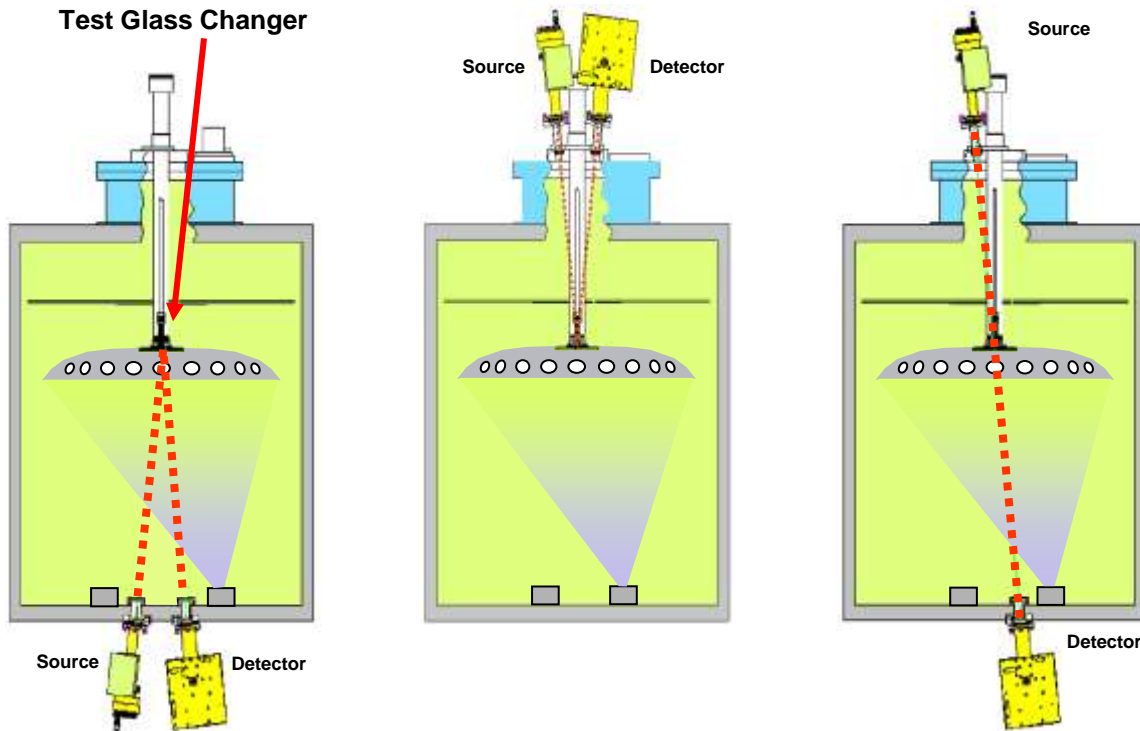
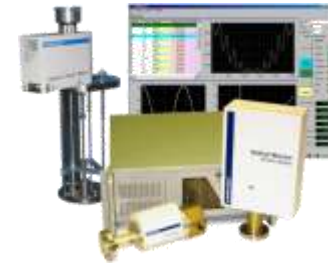
- Dual beam system
- Four phase chopper (light / dark / reference / dark)
- Time demultiplexed common optical path
- High speed digitisation and DSP within detector head
- High off axis rejection optics
- Rugged optical mounts
- High EMF / EMC immunity



**Result – High Quality, High Precision Data**

# In-Direct Optical Monitoring – Test Glass

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



**Example: Symphony Series  
High Precision Electron  
Beam Deposition with IAD**

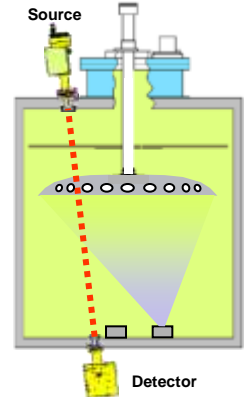
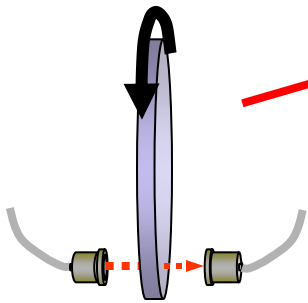
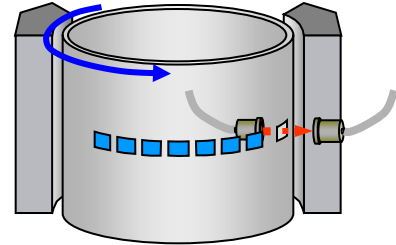


**TECPORT OPTICS, INC.™**

# 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 (2ms)

**Example: OptoFab 3000**   
**High Precision Ion Beam Deposition**  
**High quality AR and HR facet coating**

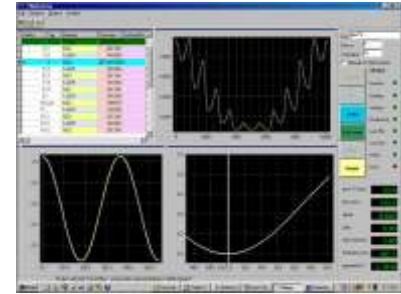


# Wavelength Ranges

**Source Module:** Quartz halogen 300 – 2400nm  
Extension down to 250nm achieved with deuterium source

## Detectors

- PMT 250 - 800nm
- Silicon 400 - 1100nm
- Peltier Cooled Si plus InGaAs 500 - 1650nm
- Peltier Cooled PbS 800 - 2400nm



## Standard Products

- Free Space Systems
  - IL551 300 – 800nm
  - IL552 400 – 1100nm
  - IL553 500 – 1650nm
  - IL555 1000 – 2200nm
- Fibre Based Systems
  - IL561/UV 250 – 800nm
  - IL562 400 – 1100nm
  - IL563 500 – 1650nm



**Other wavelength ranges available on request.**

# Accessories: Test Glass Changers

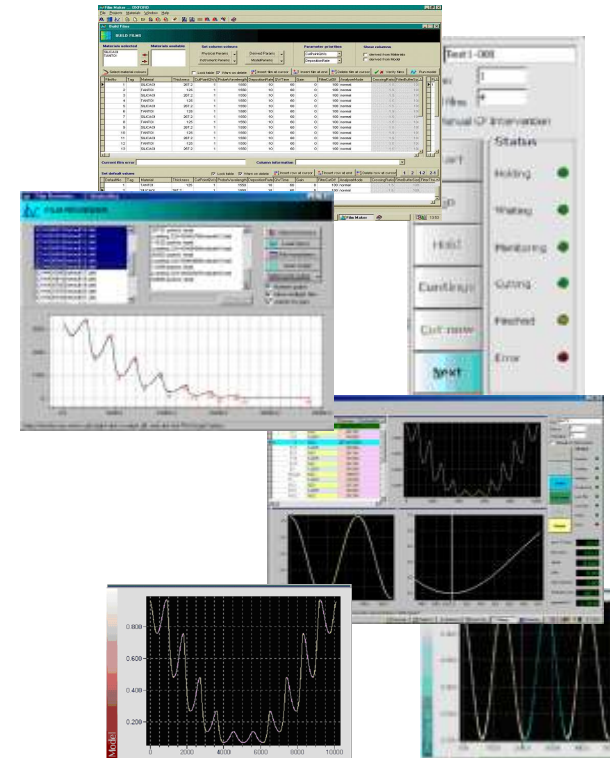


- In-house designs. Customised for your chamber geometry.
- Driven from Optical Monitor system for true integration and automation.
- Optional Integrated Multiposition Crystal Changer.
- Suitable for front or back face reflection and transmission optical monitoring modes.
- Optical alignment from outside the chamber, i.e. under vacuum.
- Up to 20 test glass carousel system or 250 glass drop glass system.
- Integrated carousel system for fibre based monitor retrofitted to your crystal changer.



# Powerful Software

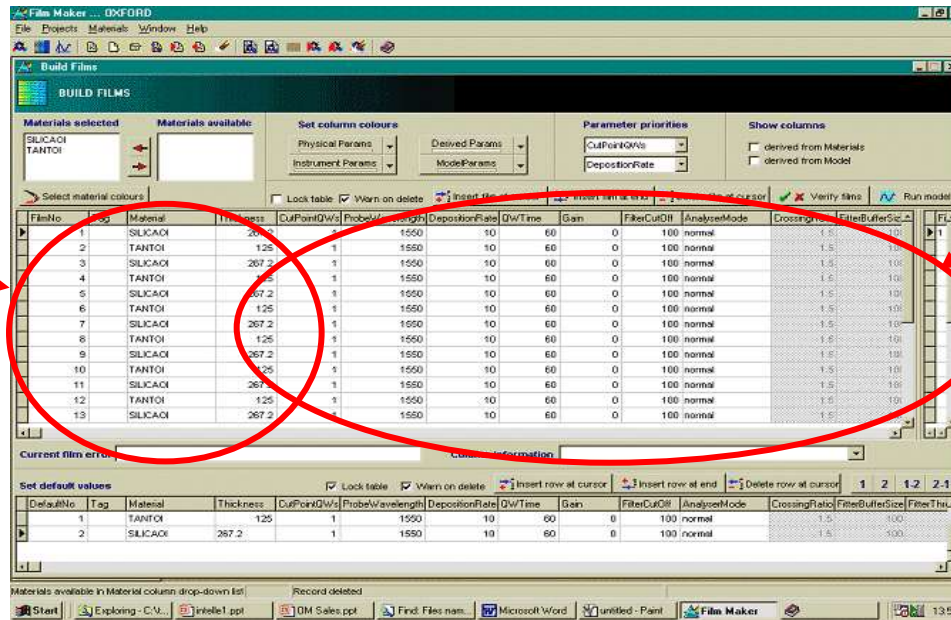
- Intellemetrics Optical Monitors give thin-film engineers the tools to decrease process development time & manufacturing costs AND increase yield & product performance.
- The system combines advanced optoelectronic hardware with a suite of powerful software packages including
  - **FilmMaker**®
    - **FilmBuilder**®
    - **FilmModeller**®
    - **FilmPhasor**®
    - **FilmSimulator**®
    - **FilmCharacters**®
    - **FilmReviewer**®
  - **FilmDirector**®
- to provide a single complete integrated solution.



# Film Stack Design → Optical Monitoring Scheme

## FilmBuilder

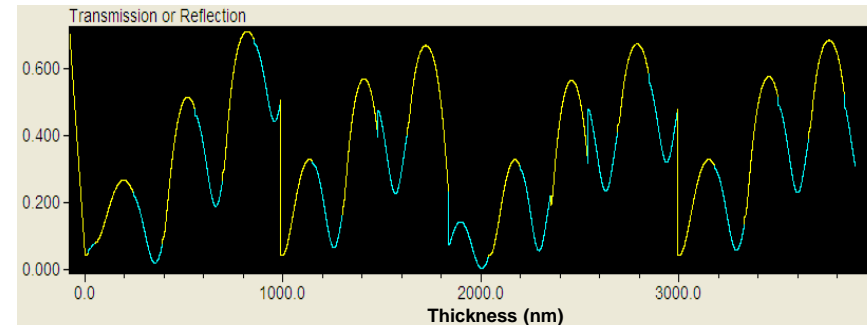
Film Stack Design  
Import from  
FilmStar, TFCalc,  
Essential MacLeod,  
Optilayer, etc.



Optical Monitoring  
Scheme Design

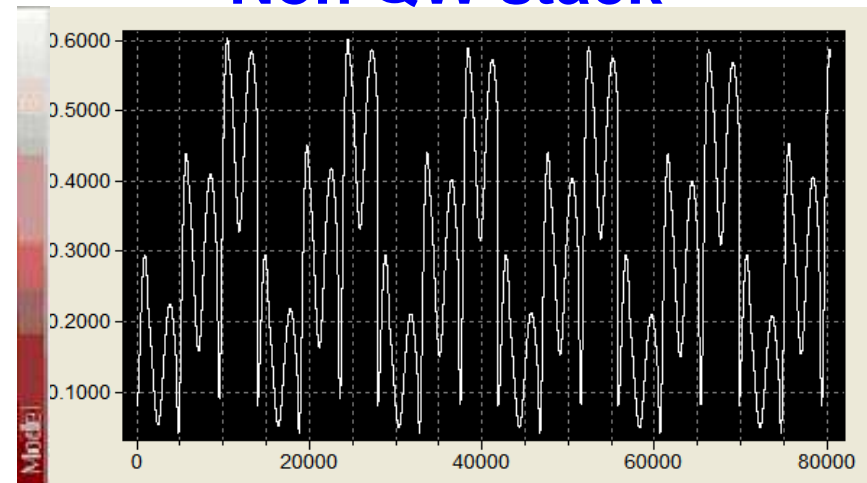
On a layer-by-layer basis, specify

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

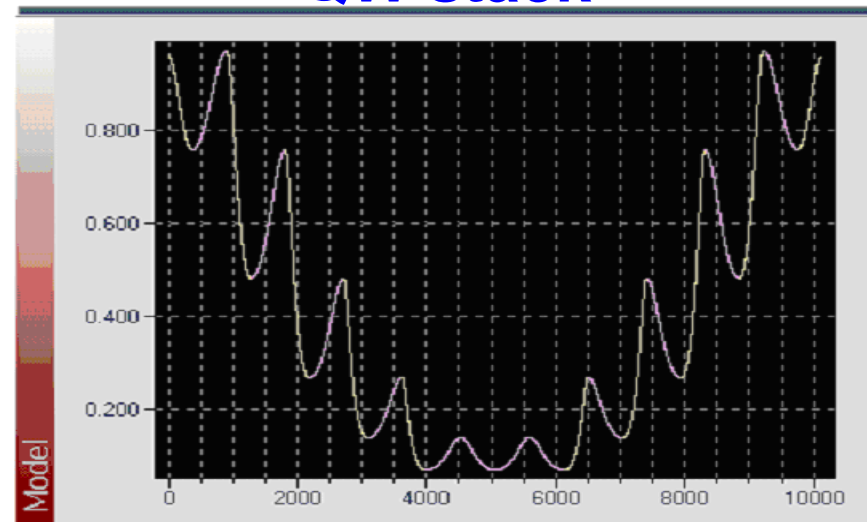


- Automatically reads a *FilmBuilder*<sup>©</sup> file
- Calculates and displays the expected Optical Signal as a function of Deposition Time
- Snapshot of whole process
- Rapidly see the effect of your model design
- Provides guide to signal compression
- Provides guide to number of films per test glass.
- Suggests optical monitoring scheme options to try in *FilmSimulator*<sup>©</sup>

## Non QW stack

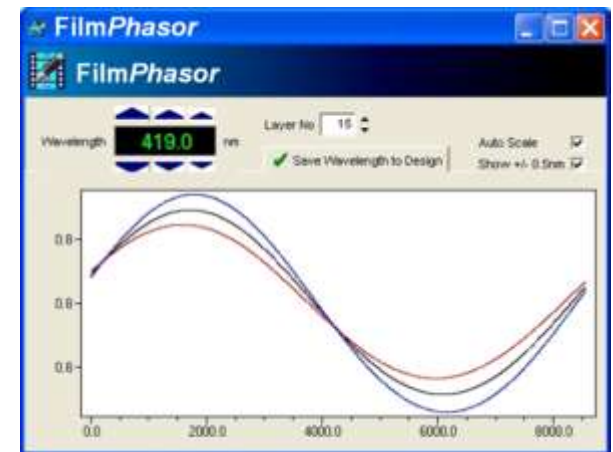
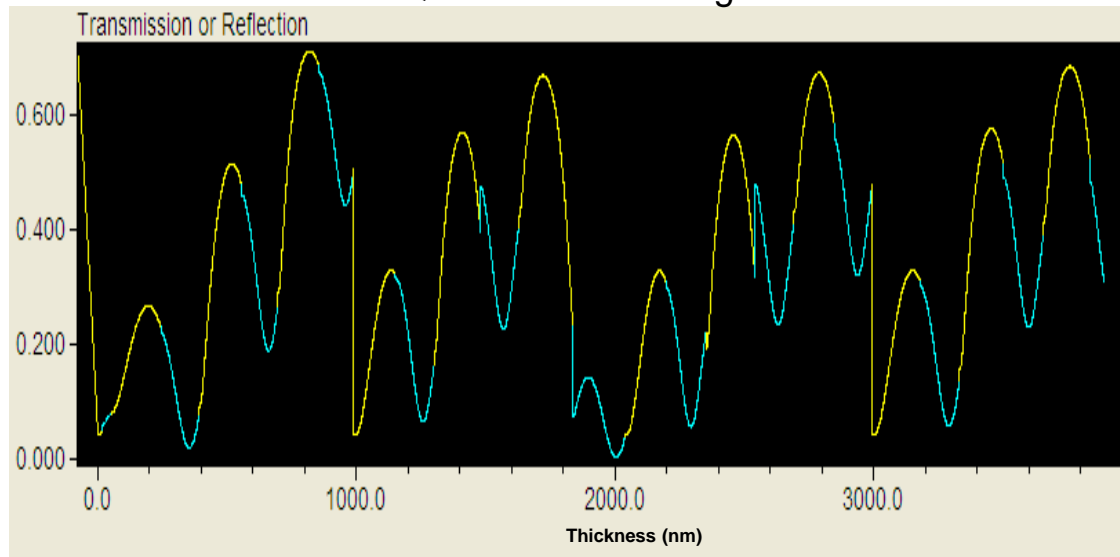


## QW stack



- Powerful process design & optimisation tool for **NON-QUARTER WAVE TERMINATION**.
- Inspect the waveform for any layer within the stack.
- Change monitoring wavelength to optimise waveform for that layer.
- Automatically shows sensitivity of that layer to small process variations – enabling design of highly robust processes.

Non Quarter Wave Design



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

# Film Simulator<sup>©</sup> - Pre Coating Run

## ■ UNIQUE and POWERFUL feature not found in other packages

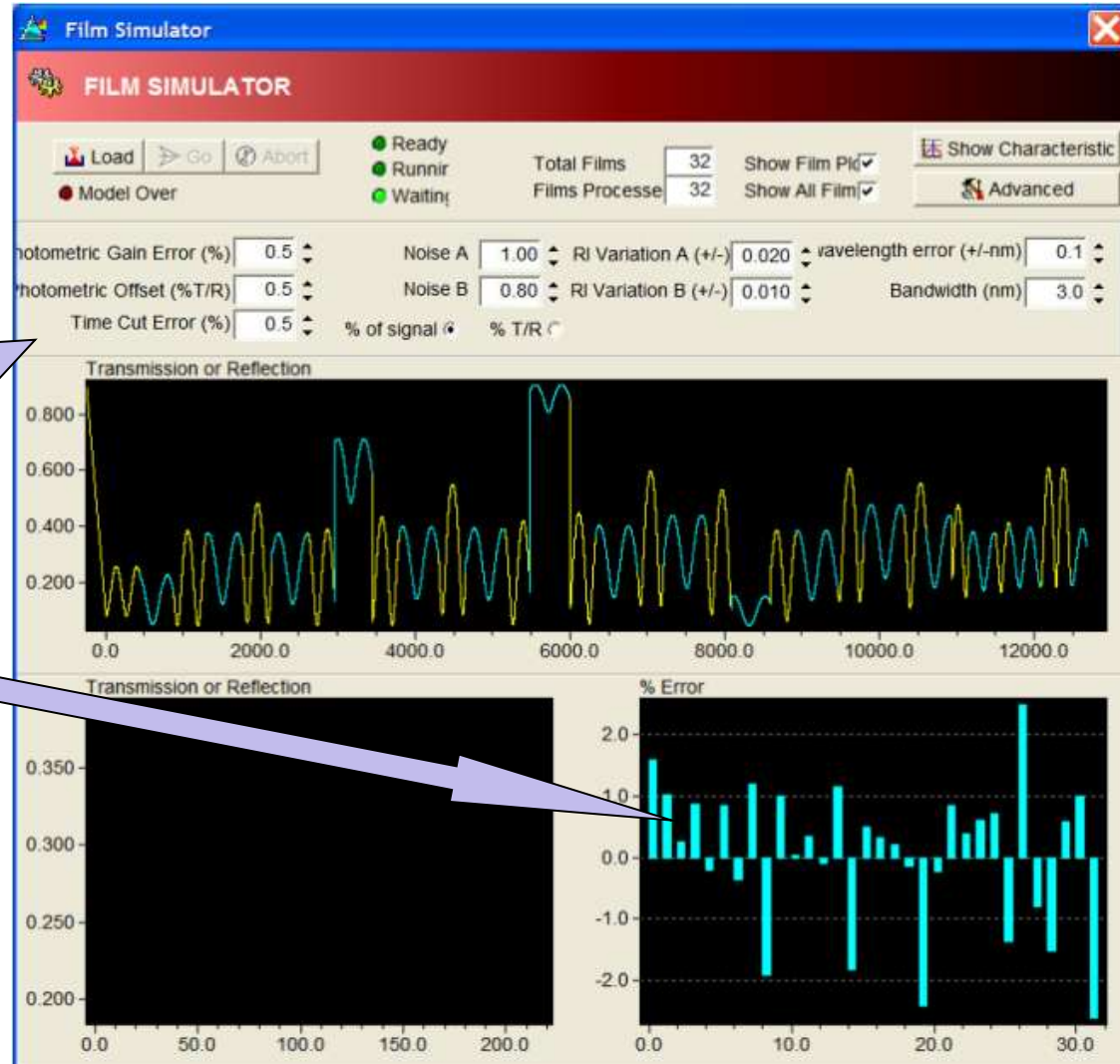
### ■ Off-Line simulation runs including

- Optical Model
- Physical effects of Optical Monitoring hardware
- Physical effects of Customer's Coating Tool
  - E-gun noise (material dependent)
  - Gun dep rate control
  - Test glass variations

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

### ■ See inside the process and Identify where errors will occur

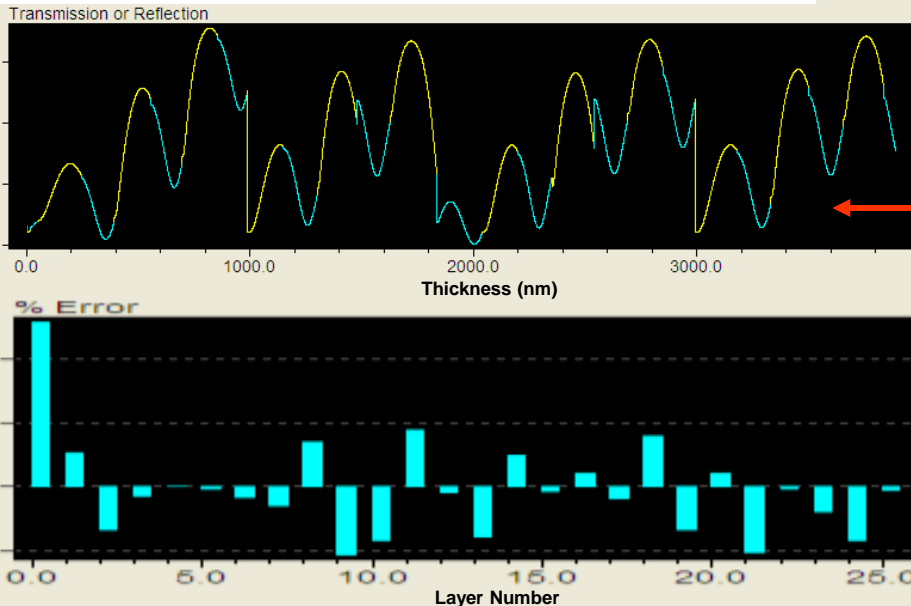
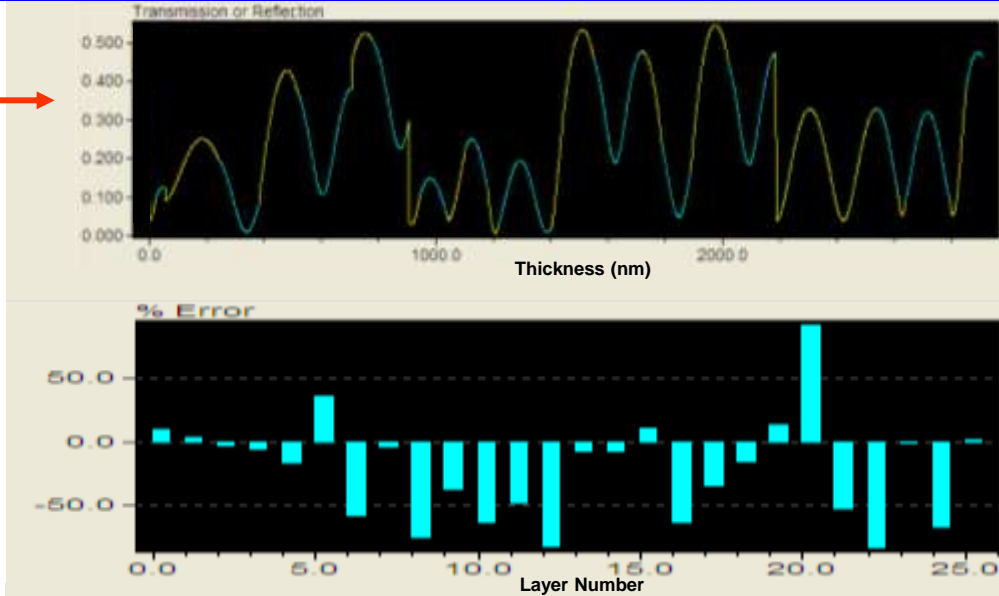
### ■ Helps the coating engineer design a ROBUST process off-line



# FilmSimulator<sup>®</sup> 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

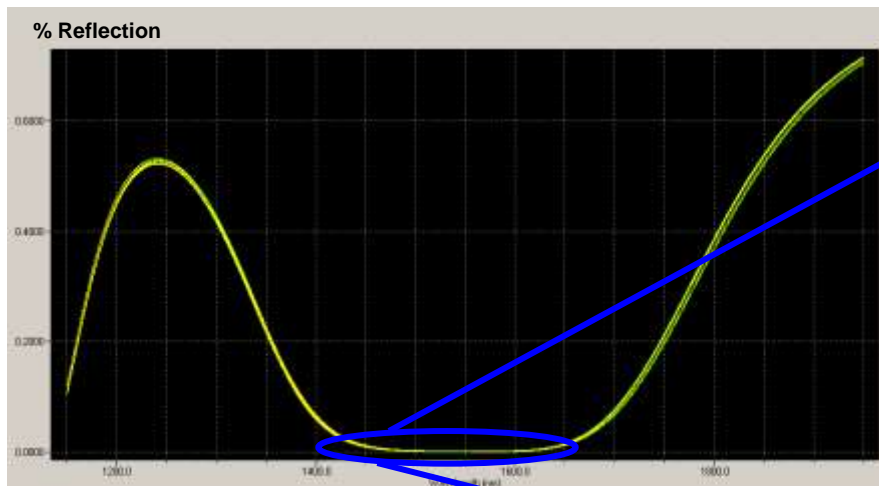
- Change monitor wavelengths
- Change Test Glass scheme
- Change filter settings
- Change QW factors
- Change number of samples per QW

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

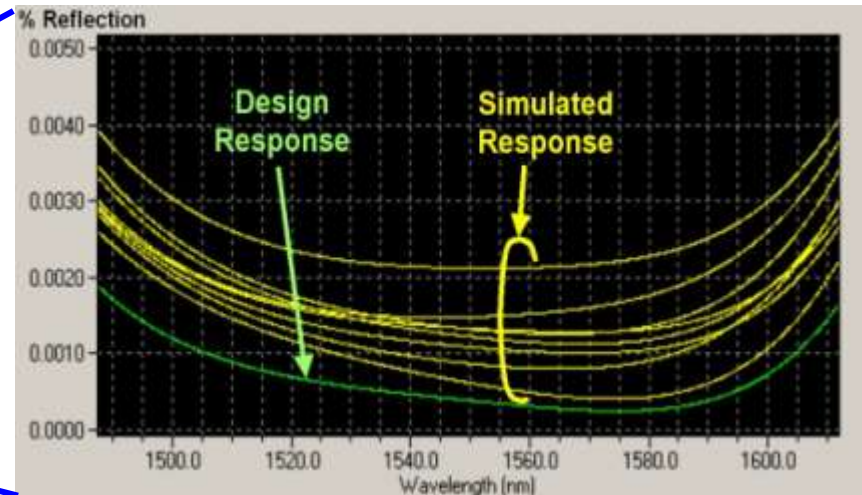
**1 hour on FilmSimulator<sup>®</sup> saves many days of process development on the production line.**

# FilmCharacters<sup>©</sup> - Pre Coating Run

- Determine the Spectral Characteristics of the final film stack
- Compare the THEORETICAL DESIGN spectra with the 'REAL-LIFE' spectra from **FilmSimulator<sup>©</sup>**
- 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 !**

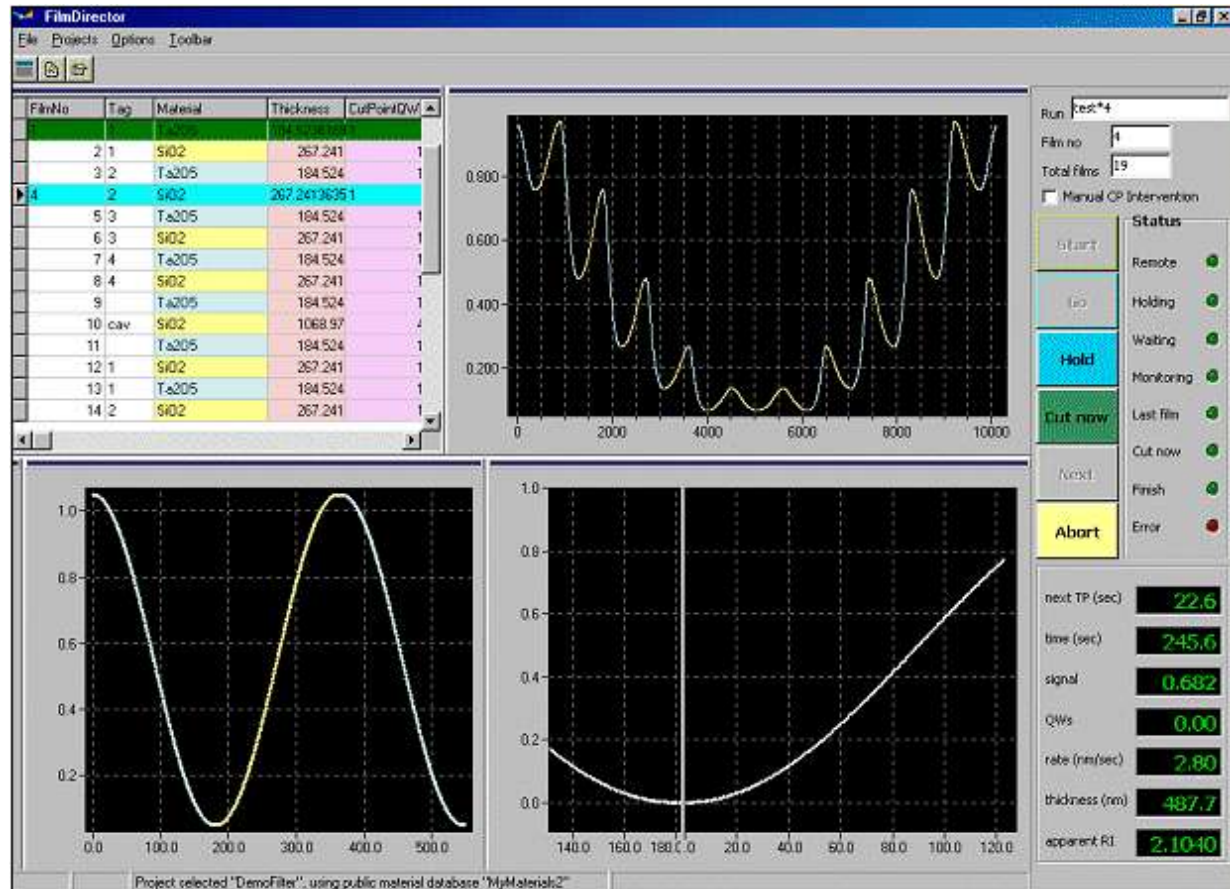


Complex non-quarter wave design. **FilmCharacters<sup>©</sup>** shows the designed response and the run-to-run variability – even before a run is done.



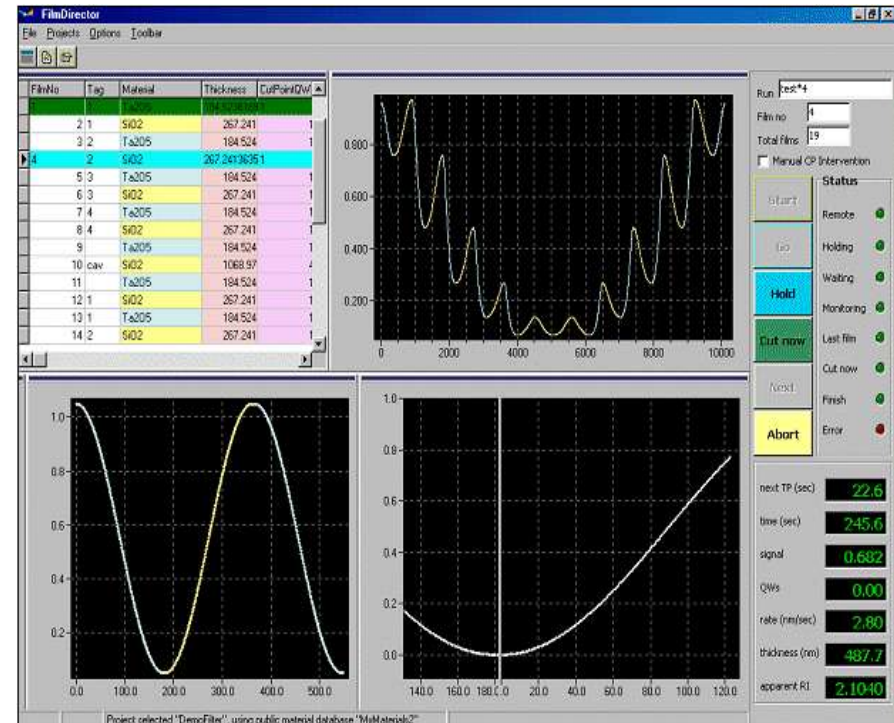
# FilmDirector<sup>©</sup>

- A fast and easy-to-use front-end that enables you to drive your process.
- Loads a process from **FilmMaker<sup>©</sup>**
- Performs the run under automatic or manual control as required
- Autocalibrates on start up
- **FilmDirector<sup>©</sup>** automatically changes the wavelength and the test glass
- Detects each cut and controls the material sources and shutters through an advanced I/O capability.



## 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 **FilmMaker**<sup>©</sup> design front-end.
- Freely configurable, panelled user-interface.
- Now includes two operating modes.
  - **ADVANCED** mode for process developers allows access to all of the parameter space.
  - **BASIC** mode enables an ADVANCED user to lock and hide many of the advanced parameters thereby providing a clear front-end for a previously optimised process, ideal for use by operators in a manufacturing environment.
- 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.



# FilmReviewer<sup>®</sup> - 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

The screenshot shows the FilmReviewer software interface. The main window is titled "FILM REVIEWER" and contains a file list on the left, a central graph showing raw data with red markers, and a "FILE PARAMETERS" panel on the right. The "FILE PARAMETERS" panel includes sections for "Acquisition Settings", "TP Analysis Settings", and "Analyser Mode". A red arrow points to the "Reprocess" button in the "FILE PARAMETERS" panel. Another red arrow points to the "Analyser Mode" section, specifically to the "filter-crossing" option. A third red arrow points to the "Reprocess" button from the text "Reprocess the data on a layer by layer basis to optimise future runs". A fourth red arrow points to the "Reprocess" button from the text "Change Acquisition Settings, Turning Point Analysis Settings and Analyser Mode and see the impact on accuracy of cutpoint determination." A fifth red arrow points to the main graph from the text "View the raw data for the whole stack or analyse a layer at a time". A sixth red arrow points to the inset graph from the text "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.

# 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 – no software required
- ✦ 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

## 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



Intellemetrics



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  
or support, please contact

## Intellemetrics Global Ltd

Tel: 0044 141 889 0700

Fax: 0044 141 889 0707

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

<http://www.intellemetrics.com>

