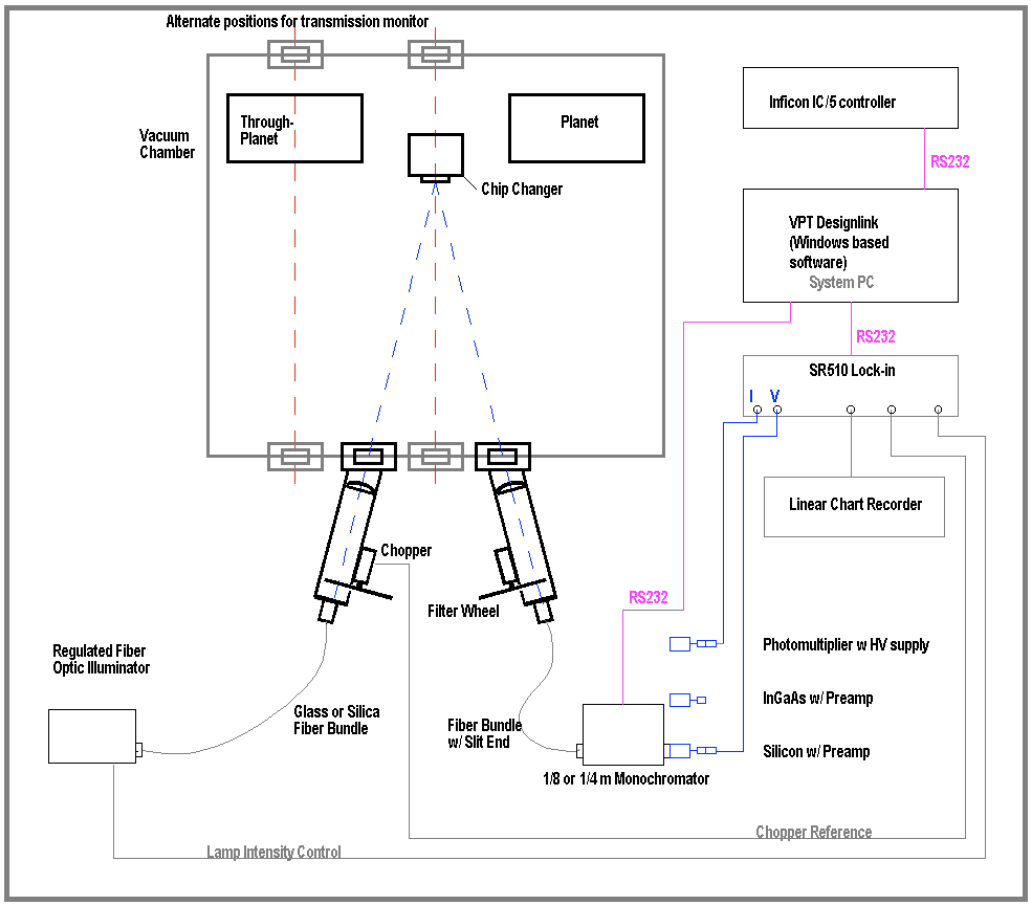
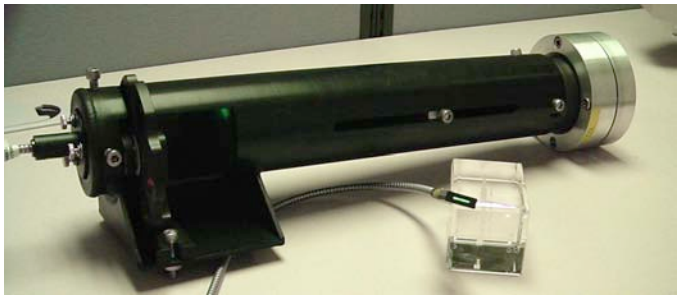
Vacuum Process Technology LLC

VPT VLOM1 White Light Optical Monitor

The VPT optical monitor uses fiber-coupled optics for better imaging and stability with standard off-the-shelf components for easy maintenance. A powerful software package, VPT Designlink, integrates the crystal controller, optical monitor, and data logging. A schematic of the monitor is shown in the figure below.





A regulated fiber optic illuminator is coupled to a 3.1 mm fiber bundle, made of glass (for VIS-IR applications) or silica (for UV-Vis applications). The illuminator is equipped with an interface to allow external power control of the lamp power. The transmission and receiver tubes (left) are gimbal-mounted for coarse alignment and provide x-y motion in the image plane for fine alignment. The tubes may be mounted in a reflection or transmission mode on a coating

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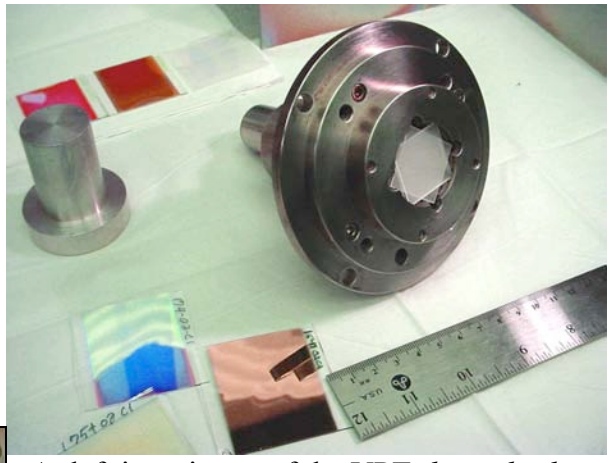
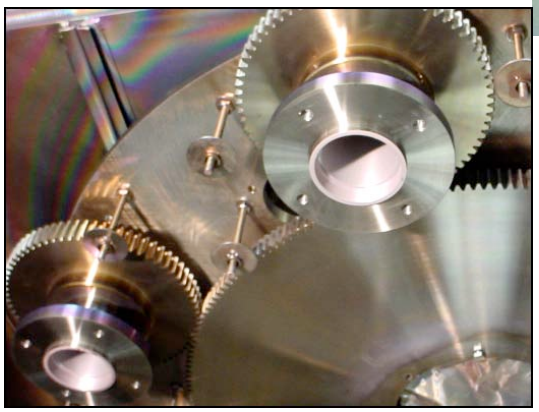
chamber and in custom applications as an intermittent monitor directly through the planet.

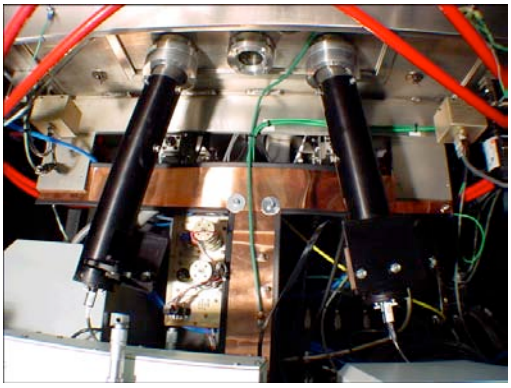
The monitor operates in the reflection mode with the VPT 1" chip changer. This changer is loaded with fifty 25 mm x 25 mm glass slides ground on the backside. The chip changer has been designed for reliable operation in a production environment. Monitoring hardware may be optionally provided in transmission mode for straight-through monitoring through a fixed or rotating transparent substrate.





At left is a picture of the VPT *through-planet* hardware. The planet hardware provides a 50 mm clear aperture port for intermittent monitoring of a flat substrate mounted in the middle of the planet. This optional hardware may be used either with a triggered VLOM (for single-wavelength results) or with a triggered spectral detector array. Software for signal gathering and analysis of the second option is under development at VPT.

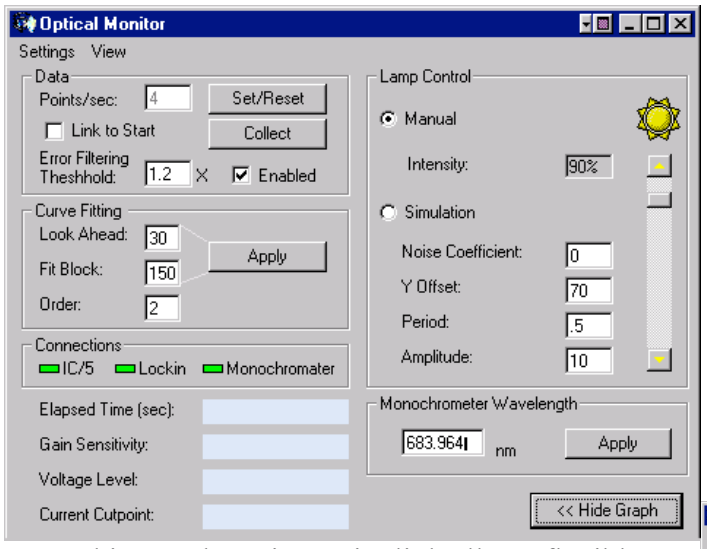
A fiber optics bundle from the quartz-halogen light source is mounted with a chopper on an x-y mount to provide precision pointing onto the chip changer or substrate mount. The chopper has an adjustable speed from 25Hz to 1 kHz. The input and output lenses are focusable and are mounted in an exterior tube below the chamber. The output lens focuses the image onto a 11 mm fiber bundle. The beam passes through a 6-position 1" rotary filter holder for manual selection of order-sorting filters. The output fiber terminates in a slit shape and is coupled to a 1/8-meter Oriel cornerstone series monochromator (which may easily be upgraded to a ¼ meter monochromator). The monochromator has two gratings for the full Visible-IR range. The wavelength can be set or scanned with either the controller hand controller or PC-based software. The micrometer slits are adjustable manually.



Several detectors can be supplied with the monitor and must be manually changed when switching wavelength regions. The detector packages include a transimpedance preamplifier with a 5-position gain switch. Close-coupling of the preamplifier to the

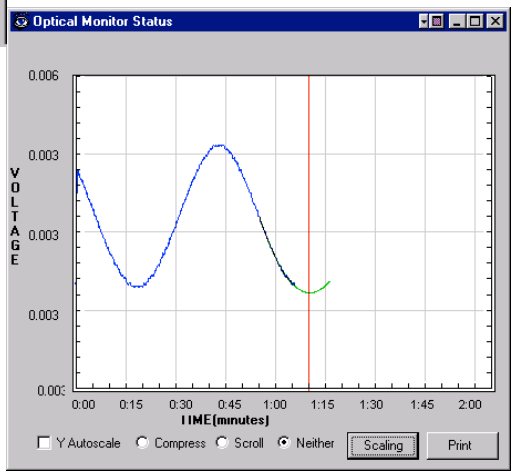
detector provide for superior noise characteristics in the coating environment. These detectors may include a side-on Photomultipier tube, Silicon, or InGaAs. The PMT includes a high-voltage power supply with a Hammamatsu R928 photomultiplier housed in a *mu* metal tube (to isolate the tube from changes in the surrounding magnetic field). Voltage control (gain) is made through software. The input goes directly into the lock-in current input.

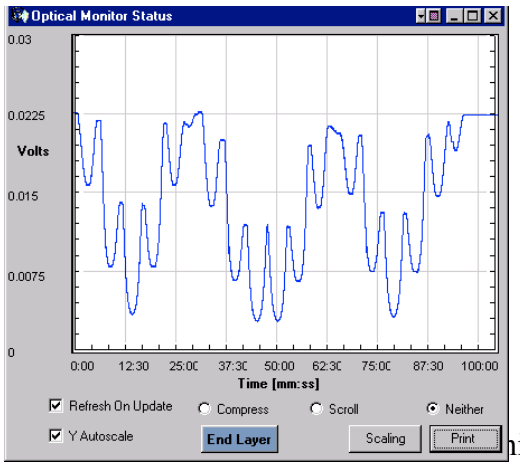
A Stanford Research Scientific SRS510 (www.srsys.com) lock-in amplifier conditions the signal. This amplifier is a full-featured analog lock-in with a broad gain region and DC offset for zero suppression. The amplifier has an additional number of A/D inputs for providing a ratio output. A Linear 200mm chart recorder plots the signal for use by the operator. The signal to noise for the system is a function of wavelength and exceeds 8000 for a 4 nm bandwidth slit setting.



The VLOM software is built into VPT Designlink control packages that controls the Inficon IC/5 thickness controller, the monochromator, and the lock-in amplifier. The control box for the optical monitor is seen at left.

A graphing package in Designlink allows flexible scaling of the data and also shows the current fitting results in real-time The green line is the extension of a polynomial fit and the red line is the predicted cutpoint. Also indicated on this screen are cutpoints based on physical thickness and a weighted average of the level method and the physical thickness measurement. All parameters for a layer including the number of quarter-waves, wavelength, cut-method weighting and data fitting parameters are stored in a Microsoft Excel® spreadsheet.

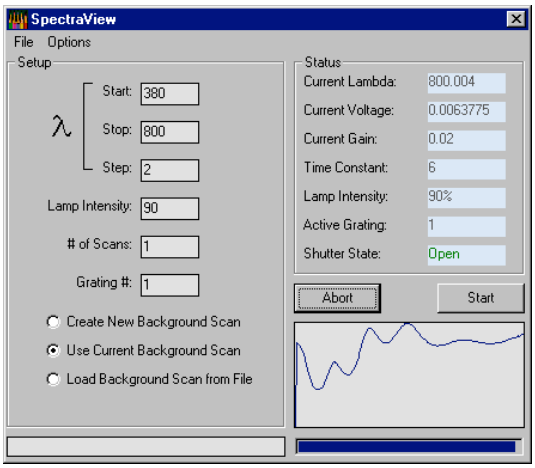


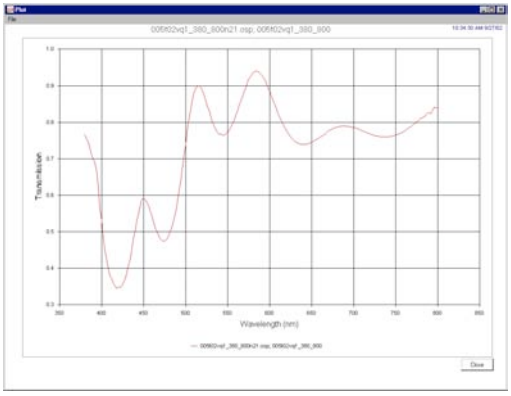


The graphics screen may be rescaled at any point during the coating to view all or just a portion of the optical monitor data. At left is a plot of a 3-period interference filter monitored in transmission and made automatically by the VLOM1 software. The optical monitor data may also be logged and stored for later analysis.

A settings screen allows a default configuration of the lock-in amplifier that can be downloaded into a file for recall later. Calibration values for both gratings are also maintained in these settings.

The Spectraview software controls the monochromator and the lock-in amplifier to provide normalization scans and sample scans over the spectral range of a given detector. All data is written to simple file easily read into MS Excel® or other thin film characterization programs for analysis.





One command provides spectral plots and overlays from other files that are suitable for printing.

All parameters for coating are entered into Microsoft Excel® spreadsheets such as the one at right. The placement of data is very flexible. The column heading must be provided and correctly spelled for Designlink to locate essential data. All of your coating designs may be stored in an Excel worksheet and accessed at any other time.

IC/5 Process Load Sheet — *VPT inc* 15-Oct-03 — **Chrma1**

Format ID(do not chang	SDZ81181p
Process#	6
Layer Cour	48
Design	CHROMA2A2 TI/SI 48L 4.48M*
run	
Customer	10 cav wideband
Date	12/9/2003
Materials	Ti3O5 SiO2
Temp	No heat

	Ti	SiO2	units
Ib	250	250	ma
Vb	500	600	volts
Va	450	400	volts
O2	38	3	sccm
Ar	0	21	sccm
Ar n	5	5.5	sccm
E/B	115	115	%
O2	3	float	10^{-4} torr
Rate	3	8	%

Op Mon Parameters

Start Avg	20
Reset Avg	30
Max Samples	5
Cut Window	20
Cut Suppress	70
Min Rate	20
Look Ahead	300
Fit Block All	100
Max Thick	115

NOTE: THICKNESS COLUMN IS IN KILOANGSTROMS

Hcal	0.729	H/L ratio	Mean cal	H	-5	Single Rot. Geometry
Lcal	1.018	0.72	0.874	L	-12	
Overall cal	1.000					

L> Transition up
L< Transition down
Spacer

Layer#	type	Phys Thick.	Thickness	Rate	Material	Crucible	QWOTs	Lambda	New Chip	WT 1	WT 2	WT 3	Fit Block
1	6H	301.1	2.191	3	9	4	6	478	n		1	0	50
2	L>	81.4	0.817	8	2	1	1	478	n	0.5	1	0	150
3	H	50.2	0.361	3	9	4	1	478	n		1	0	100
4	LLLL	325.5	3.303	8	2	1	4	478	n		1	0	100
5	H	50.2	0.361	3	9	4	1	478	n		1	0	50
6	L<	81.4	0.817	8	2	1	1	478	n	0.5	1	0	150
7	H	50.2	0.361	3	9	4	1	478	n		1	0	100
8	L	81.4	0.817	8	2	1	1	478	n		1	0	100
9	HH	100.4	0.727	3	9	4	2	478	n		1	0	40
10	L	81.4	0.817	8	2	1	1	478	n		1	0	150
11	H	50.2	0.361	3	9	4	1	478	n		1	0	50
12	L>	81.4	0.817	8	2	1	1	478	n	0.5	1	0	150
13	H	50.2	0.361	3	9	4	1	478	n		1	0	100
14	L	81.4	0.817	8	2	1	1	478	n		1	0	100
15	HH	100.4	0.727	3	9	4	2	478	n		1	0	40
16	L	81.4	0.817	8	2	1	1	478	n		1	0	150
17	H	50.2	0.361	3	9	4	1	478	n		1	0	50
18	L<	81.4	0.817	8	2	1	1	478	n	0.5	1	0	150
19	H	50.2	0.361	3	9	4	1	478	n		1	0	100
20	L	81.4	0.817	8	2	1	1	478	n		1	0	100
21	HH	100.4	0.727	3	9	4	2	478	n		1	0	40
22	L	81.4	0.817	8	2	1	1	478	n		1	0	150
23	H	50.2	0.361	3	9	4	1	478	n		1	0	50
24	L>	81.4	0.817	8	2	1	1	478	n	0.5	1	0	150
25	H	50.2	0.361	3	9	4	1	478	n		1	0	100

Specifications for the VPT VLOM1 White Light Optical Monitor

Description	An advanced white-light instrument for general-purpose optical monitoring of optical thin films
Software	Runs on system computer, Microsoft Windows operating system Designlink software communicates with Inficon IC/5 controller, lock-in amplifier, and spectrometer. Other controllers will be added later. Determine layer end point using a weighted average of physical thickness and several optical cut-point algorithms including, polynomial fit, min-max, steepest descent, set R or T, and Airy equation fit. Logs optical, quartz-crystal and source power data in a summary or detailed formats. Coating design, monitor wavelengths, algorithm weighting, and chip eject points, are pasted into a Microsoft Excel® spreadsheet that is read by Designlink software. MS Excel® can now serve as a database for all your coating run parameters. Simple rules allow for flexible spreadsheet design by the user. Displays vital data of all parameters on screen in real-time. Wavelength scans (motor-driven) can be made at anytime during coating of witness. Any number of normalization scans may be stored at anytime. Software activates shutter to measure dark noise. Controls chip changer - can re-normalize after any chip or any layer. Controls and stores essential lock-in parameters. Read rate to 50 reads per second, data smoothing occur by filtering at Lock-in amplifier and averaging of multiple readings. Scope mode aids alignment of optics.
Optics	Rugged fiber-coupled optics provide a solid optical bench for high-stability measurements. Fused silica optics are available as an option to extend the range into the UV (>340 nm).
Mode	The VLOM1 is custom built. Any typical Transmission or Reflection geometry can be used.
Range	450 mm aperture beam focal length: Infinity to 30 cm from baseplate.
Magnification	~ 2.5 in a 1150mm (45") chamber. Spot-size of fiber bundle is 18 mm at the witness.
Source	Quartz-halogen tungsten bulb powered by a software-controlled regulated power supply. Option1 – High energy: bulb is directly mounted on the transmitter tube (high energy).

Option2 – High stability: light is fiber-coupled to transmitter tube allowing easier maintenance and alignment.

Chopper	Phase locked-loop chopper adjustable from 25-2000 htz. Allows for synchronization from an external source. Digital display of chopper speed.
Witness holder options	1) High reliability 25mm x 25mm chip changer for reflectance. Temperature-controlled heater tied to vacuum control system is available as an option. Holds 50 witness pieces.. 2) Rotating witness holder for transmittance and better uniformity control on witness. 3) Static holder with kinematic alignment of 50mm x 50mm witness.
Receiver	Both transmitter and receiver tube have rugged gimbal mountsfor coarse alignment with fine adjustments made in the image plane (to make alignment simple). The receiver also has a filter wheel for 25 mm order-sorting filters. A fiber couples the light to a slit-shaped fiber bundle on the monochromator end.
Monochromator	Oriel motor-driven software-controlled 1/8 meter monochromator with 2 selectable gratings. Adjustable micrometer slits are standard with fixed slits available as an option. Standard gratings are 600 l/mm with blazes at 750 and 1600 nm. Many other gratings are available. Option: Oriel 1/4 meter monochromator.
Detectors	Detectors are manually interchanged Silicon (380-1100nm) with integrated selectable gain amplifier Photomultiplier (320-950 nm) with integrated HV power supply controlled by software InGaAs (900-1750 nm) with integrated selectable gain amplifier
Lock-in Amplifier	Stanford Research Systems SRS510 Lock-in Amplifier Amplifier runs in auto-gain from Designlink software. Full scale sensitivity - 10 nV to 500 mV: current - 100 fA to 0.5 mA Detector/preamp dark noise is 850 nV. The SRS 510 is a versatile, high precision scientific instrument. It has several different levels of noise filtering and provides effective isolation of the signal from extraneous signals. The expert user will take advantages of the many front panel capabilities of the 510. VPT Designlink software will fully control all settings of the 510 for the less advanced user. More specifications on the SRS 510 can be found at www.srsys.com
Chart Recorder	A Linear 200 mm chart recorder is provided for paper recording of the output signal.

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