

SensorMetric[®] Lab System Manual

SENSORY ANALYTICS[™]

The Sensory Building
405 Pomona Drive
Greensboro, NC 27407 USA
+1 (336) 315-6090
E-mail: support@specmetrix.com
<http://www.specmetrix.com>

Table of Contents

.....	1
Introduction:.....	3
Description.....	3
Background Theory	3
Installation.....	6
Setting up the SpecMetrix® Lab System.....	6
Connecting the Hardware:	6
Quick Start Guide	8
Setting up Part Parameters	12
Selecting the Proper Optical Package	12
Part Info Tab	13
Updating Part Info.....	14
Importing Part Info	14
Layer Settings	15
Identifying Interference Evaluation range	20
System Configuration	23
Operating Options:.....	23
Save Options:.....	25
Setup Mode	25
Scan Mode	29
Light Sources Options.....	32
Tools	34
Manage Measurement Plans:	34
Manage Peak Analysis:.....	35
Conversion Calculator	38
Taking a Measurement (Walkthrough).....	38
Role of the Restart Button.....	42
Role of the Retake Button.....	44
Warning Messages and Resolution.....	47
Security	51
Loading Saved Measurement Data	52
Contour Map	52
Backing Up Data.....	53
SpecMetrix® On-Line Support.....	54

Introduction:

The *SpecMetrix*® lab system is an innovative real-time measurement platform for coating thickness and film weights, as well as selected other non-contact measurements.

SpecMetrix® is the film thickness measurement software used by the *SpecMetrix*® lab system for transparent and semi-transparent layers or coatings.

Description

The *SpecMetrix*® lab system is a unique process information technology platform providing a non-contact, non-destructive real-time thickness measurement solution. This is a significant advancement over the current QA techniques which are tedious, invasive or can require destructive analysis.

The measurement system has been developed using state of the art optical, electronic and computer subsystems, combined with proprietary *SpecMetrix*® software. The system collects optical signals from the part's surface to yield a precise coating thickness measurement. For lab operation, the system uses a fiber optic holder that is hand-adjusted over the specimen to obtain the measurement. The system also has a provision for high-level automation where automatic operation via a gantry, fixed arm or robotic instrumentation is possible to help minimize labor and simplify measurement tasks.

The *SpecMetrix*® operator interface is extremely user friendly and effectively masks the enormous amount of complex spectral and mathematical analysis from the operator. Once the part parameters are set up for a specific type of part, any individual without a background in optics can operate the instrument as the measurement procedure is very straightforward.

SpecMetrix® software also includes quality reporting features. The results of the measurement - including operator information, part information, thickness results etc. - are populated into the report sheet and a spreadsheet is used as a report file for simplicity and flexibility.

Background Theory

Thickness measurement using the optical sensor within the *SpecMetrix*® portable measurement system works on the principle of optical interference, and has been exclusively ruggedized by Sensory using proprietary software and algorithms. By projecting a beam of light onto a coated specimen, part of the light is reflected from the top surface, part of the light is refracted (coating surface and substrate will have different refractive indices) and this refracted beam of light is again reflected from the surface of the substrate. The resultant beam of light emits constructive and destructive interference with varying amounts of phase change from the light rays.

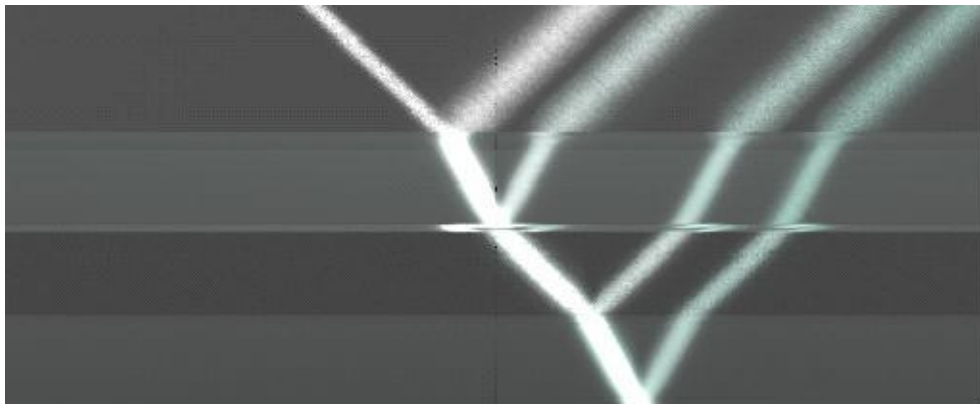


Figure 1 - Light rays passing through different layers of the material

The resulting interference spectrum varies depending on the thickness of the specimen and optical properties of the coating material. Embedded in the *SpecMetrix*® software is a highly sophisticated and exclusive thickness calculation algorithm which evaluates the interference spectrum over a suitable interference range. This computation technique returns the specific thickness of film or coating applied to the substrate.

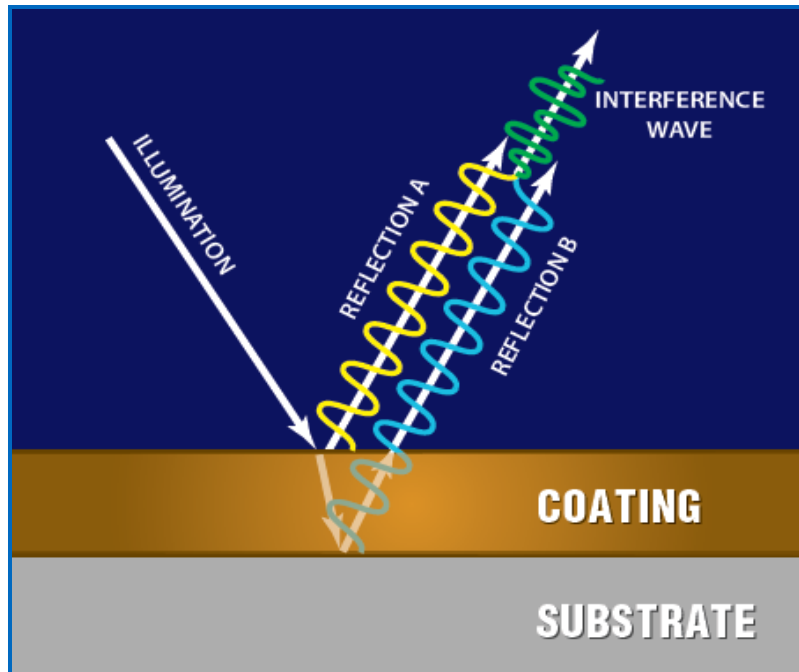


Figure 2 - Interference Model

The model above illustrates the interference model used in thickness evaluation. Part of the light incident on the surface of the layer (coating) is reflected and part of the light is transmitted. The transmitted light is in turn reflected from the surface of the substrate and these two reflected rays interfere constructively and destructively to generate an interference spectrum of periodic modulation. Surface roughness and the optical properties of the coating will limit the bandwidth where the analysis can occur.

Installation

Setting up the SpecMetrix® Lab System

The *SpecMetrix*® lab system includes all the components of a regular laptop along with the necessary hardware components needed for measurement such as optical package, light source and data acquisition hardware embedded inside the box. It has four external USB ports through which other external hardware can be connected to the *SpecMetrix*® unit. The operating system is a standard Windows XP platform and other Windows Software can run from this box just like a standard PC computer.

After the *SpecMetrix*® lab system has been delivered to help meet your real-time measurement needs, please check and make sure the following items are included:

1. *SpecMetrix*® Display Unit
2. Keyboard and Mouse with mousepad
3. Film ring and puck
4. *SpecMetrix*® Lab Stand
 - a. Base Plate
 - b. Stand
 - c. Adjustable arm
5. Lab Probe (not shown)

The figure to the right illustrates a base plate for holding the test sample (4). The base plate provides a flat surface that is perpendicular to the incident beam of light.

6. Optional Items
 - a. White Tile
 - b. Collimating Lens

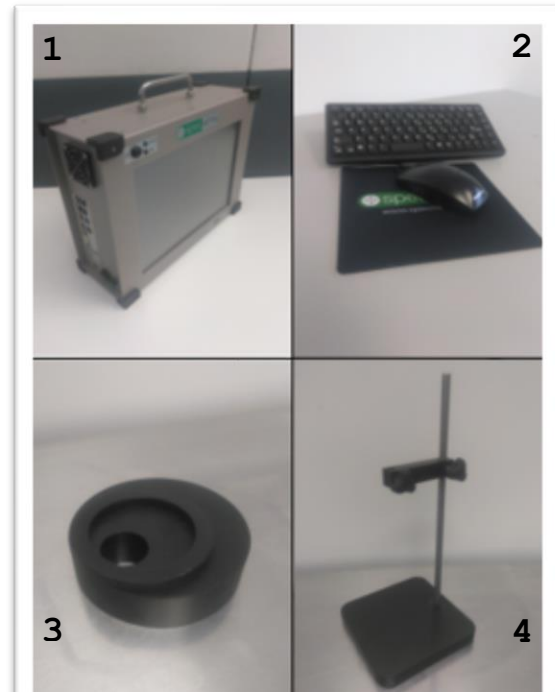


Figure 3 - Enhanced Lab Out of the Box

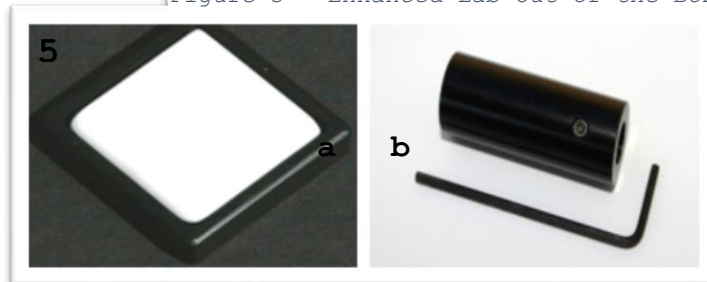


Figure 4 - Optional Items

Connecting the Hardware:

a) Fiber Optic Connections:

***Note:** Depending on the chosen configuration, either a standard probe with two legs or a Self-Referencing probe with three legs will be supplied with the system and these are shown in figures below.*



Figure 6 - Standard two-leg probe



Figure 5 - Self-Referencing probe

- **Standard probe:** Two-legged probe; the Read Fiber connects to the Optical Source (VIS or NIR spectrometer) and the Light Source connects to the lamp of the Display Unit.
- **Self-Referencing probe:** Three-legged probe; one Read Fiber connects to the Optical Source (VIS or NIR spectrometer), the two Light Source fibers connect to Lamp 1 and Lamp 2 of the Display Unit.
- The other end of either probe should be connected to the optical stand as in Figure 3, box 4.
- Attach the collimating lens to the fiber optic probe end if necessary and if supplied with the system. See Figure 7.



Figure 7 - Collimating Lens attached to probe tip

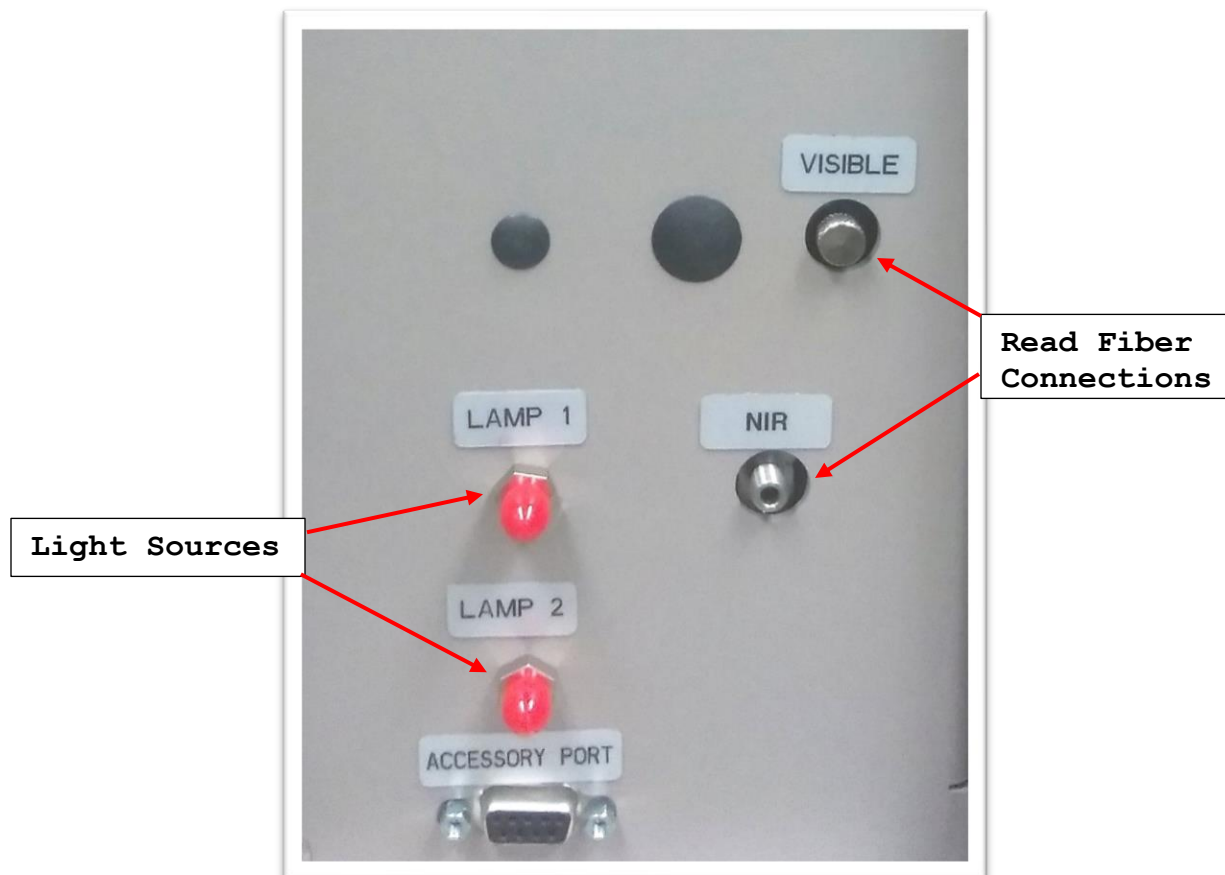


Figure 8 - Display Unit connections

The figure above illustrates all connections available for the SpecMetrix® unit. Depending on the specified unit configuration not these connections may be present. As described earlier, one end of the fiber optic cable has either two connectors for standard probe (*Light Source and Read Fiber*) or three connectors for Self-Referencing probe (*Light Source 1, Light Source 2, and Read Fiber*) which are connected to the appropriate ports in Figure 8.

b) SpecMetrix® Keyboard and Mouse Connections:

The SpecMetrix® measurement system comes with an integral touch screen display and has USB ports on the unit to attach standard keyboard and mouse devices.

Quick Start Guide

1. Connect the probe to the display unit as described in the previous section. Some units will be equipped with two optical packages labeled VIS (visible) and NIR (near-infrared), while other applications only require a single optical package. If both connections are present then the *Read Fiber* should connect to the optical source that is best suited for the application. The *SpecMetrix*® software should also be set to receive data from the appropriate optical package. This selection can be made under the *System Configurations* tab in the box labeled *Optical Source Options*.

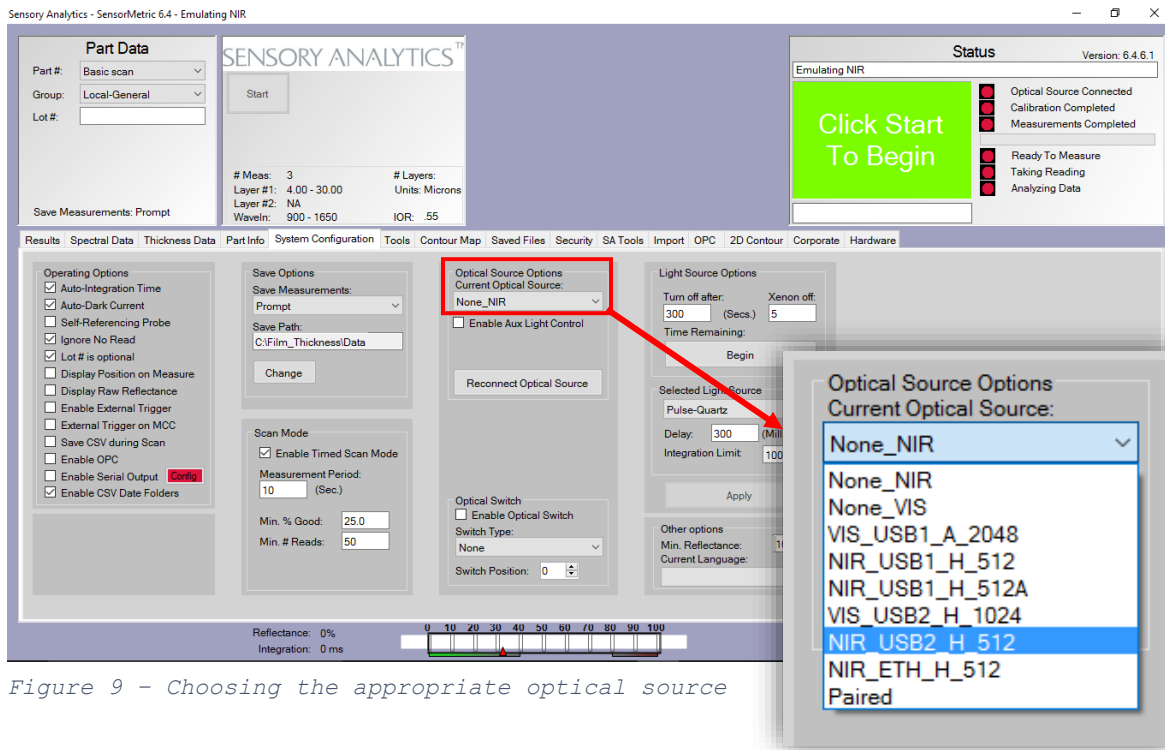


Figure 9 - Choosing the appropriate optical source

Figure 9 shows the drop-down menu options for choosing an appropriate optical source. These options are determined by check boxes in the Hardware Tab but more on this later.

2. Adjust the probe to be approximately 5mm above the sample as in Figure 10.

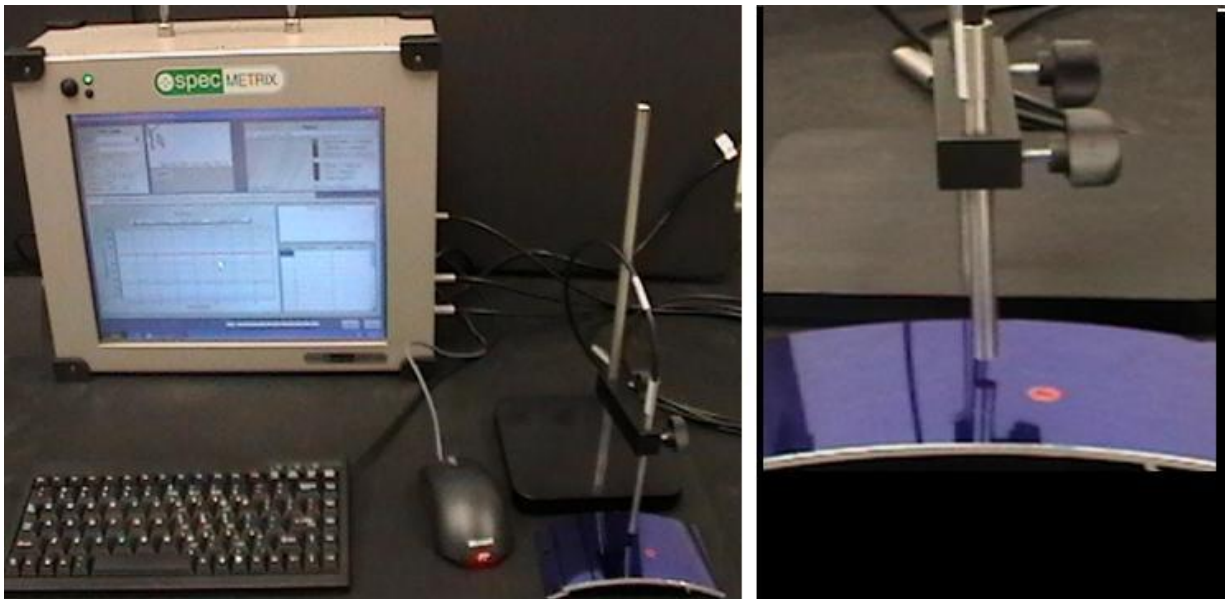


Figure 10 - SpecMetrix® Display Unit connections

3. Select the *Part Info* tab.
4. Select the “*sample part*” from the drop-down list entitled *Part #* in the upper-left corner of the screen. The thickness min and max should be edited for your sample along with the upper and lower specification control limits. *Sample Part* contains generic part parameters.
5. Rename the part and save it by clicking on the *Update Part* button.
6. Select the tools menu and ensure that *Peak Analysis* is selected (see section 9 for more explanation of this feature).
7. Select the *System Configuration* tab and check that *Auto Integration Time* option is selected. This causes the system to automatically select the correct integration time for the current probe height. With this feature enabled it is not necessary to adjust the probe height for optimal reflectance unless the system warns that the integration time is out of range.

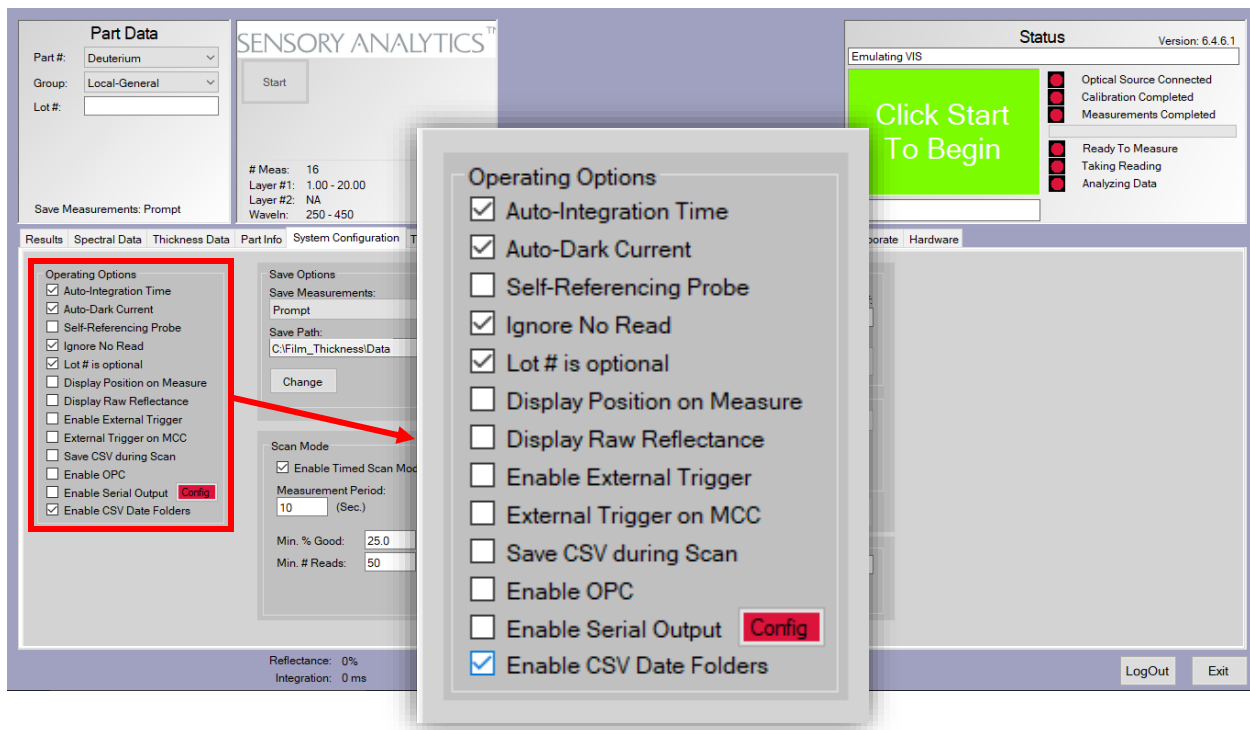


Figure 11 - Operating Options in the System Configuration menu

8. A *SpecMetrix*[®] system can be supplied with either a *Self-Referencing Probe* (which has 3 optical connections) or a standard probe (which has only 2 optical connections). While using a *Self-Referencing Probe*, please check to make sure that the *Self-Referencing Probe* option has a check mark under the *System Configuration* tab.
9. Check if *Auto Dark Current* is selected. This feature is optional, however when enabled it tends to yield more accurate measurements by compensating for the any extraneous signal that results from reverse-bias leakage in the photosensitive detector.
10. Check if *Lot number optional* is checked. If this feature is not checked then the user will be required to enter a “Lot #” before beginning a measurement series.
11. Press the green *Start* button located near the top of the screen. At this point users with a *Self-Referencing Probe* can begin taking measurements, while those without will be prompted to take a single reference measurement. Reference measurements are ideally taken on bare substrate but can also be taken directly on the coating of interest. After taking this reference measurement, it is necessary to shift the sample slightly so that the beam is focused on a slightly different point.

12. Select the *Spectral Data* tab and click *Measurement #1*. The system will automatically perform an analysis of the sample measurement and display the interference pattern.
13. Section 5.3 explains how to select the correct interference range. The part info for your sample should be set accordingly and saved.
14. Press measure again and the thickness measurement should be displayed. You can select the thickness data tab to see how the system evaluates your sample thickness. The thickness range parameters in the “Part Info” tab may need to be adjusted.

Setting up Part Parameters

Selecting the Proper Optical Package

While some *SpecMetrix*® users will not require two optical sensors, others may be provided both and will therefore need to use discretion in determining which light source and corresponding detector is appropriate for each measurement. Below is a brief overview of the two optical package configurations along with the advantages and limitations of each:

1. **VIS (Visible):** The Visible optical package analyzes interference data from in the 400-1000 nm range (if a Xenon source is included then the range extends down to 200nm). These shorter wavelengths yield higher resolution and precision when measuring extremely thin samples (0.2-5µm). Because these wavelengths are discernible to the human eye it is generally more difficult to get good interference data from opaque or heavily pigmented samples as one can observe that visible light does not penetrate these samples very well. This limitation is often exploited to the user’s advantage in instances such as isolating a clear varnish coating that is applied over a dark-colored paint. Since the visible light easily penetrates the clear varnish, and mostly reflects off the painted surface it makes a useful tool in measuring those layers independently.
2. **NIR (Near-Infrared):** The NIR optical package analyzes interference data from the 900-1700nm range. While this spectrum doesn’t provide quite as much resolution for the extremely thin layers as does the visible, it is much more versatile in measuring a

variety of materials. Near-Infrared light is considered long-wave radiation, and like radio and microwaves it has a greater ability to penetrate materials that are slightly opaque or heavily pigmented.

Once the user has selected an optical package it is critical that the *Read Fiber* is physically connected with the optical source of choice, and that the *Optical Source Options* box in the *System Configuration* menu matches this selection as described in section 4.

Part Info Tab

Part parameters for a new part can be populated by first entering the name of the part in the “Assign Part Name” field (which is under the “Part Info” tab) and populating the parameter fields under it with appropriate values, as in the figure below. The parameters for the new part along with the part name will automatically be saved upon clicking “Update Part” button. Measurement Plan for a part is optional and is only used when the user desires to generate a contour map for a specific part.

The screenshot shows the 'New Part Info' dialog box. Red annotations highlight key areas: 1 points to the 'Assign Part Name' field containing 'Thin NIR'; 2 points to the 'Measurement Settings' and 'Layer Settings' sections; 3 points to the 'Update Part Info' button. The 'Measurement Settings' section includes fields for Spectrometer Type (NIR), # of layers (1), Units of Measure (Microns), Meas. Plan (None), # of measurements (20), Integration time (5.00), Height Threshold (0.005), # of readings to average (5), and Thickness Y Minimum (0.30). The 'Layer Settings' section includes an 'Auto-Recipe' checkbox, a table for Layer 1 with fields for Lower Limit (2.00), Upper Limit (5.00), IOR (1.550), Start Eval. (nm) (900.0), End Eval. (nm) (1650.0), Thickness Min. (1.20), and Thickness Max. (8.00), and a 'Subtract known layer from measurement' checkbox. At the bottom, there are checkboxes for 'Use Scan Mode' (checked), 'Use Setup Mode', and 'Corporate DB', along with buttons for 'Copy Part to DB', 'Import Parts', 'Export Part', 'Clear Part Info', 'Delete Part', and 'Reset Part Info'.

Figure 12 - New Part Info

Steps:

1. Use the Assign Part Name field to create a new recipe.

2. Enter Part Info under Measurement Settings and Layer Settings.
3. Click the Update Part Info button to save the Part Info.

Updating Part Info

To update/add part parameter information, additional fields are provided on the user interface screen under the tab “Part Info” tab (refer figure below). All the part parameters can be updated in these fields and upon clicking “Update Part Info”, the new parameters will be updated. The following is an explanation of each field under “Part Info” tab.

The screenshot shows the 'Part Info' tab in a software application. The interface includes a top navigation bar with tabs like Results, Spectral Data, Thickness Data, Part Info, System Configuration, Tools, Contour Map, Saved Files, Security, SA Tools, Import, OPC, 2D Contour, Corporate, and Hardware. The 'Part Info' tab is selected, displaying various configuration fields. On the left, 'Measurement Settings' include Spectrometer Type (NIR), number of layers (1), units of measure (Microns), measurement plan (None), number of measurements (3), integration time (5.00), height threshold (0.005), number of readings to average (5), and thickness Y minimum (0.30). On the right, 'Layer Settings' include an unchecked 'Auto-Recipe' checkbox, and a table for Layer 1 with values for Lower Limit (15.00), Upper Limit (25.00), IOR (1.550), Start Eval. (nm) (900.0), End Eval. (nm) (1650.0), Thickness Min. (4.00), and Thickness Max. (30.00). Below these are checkboxes for 'Subtract known layer from measurement' (unchecked). At the bottom, there are checkboxes for 'Use Scan Mode' (checked), 'Use Setup Mode' (unchecked), and 'Corporate DB' (unchecked). Action buttons at the bottom right include 'Copy Part to DB', 'Import Parts', 'Export Part', 'Clear Part Info', 'Delete Part', 'Reset Part Info', and 'Update Part Info'.

Figure 13 – Part Info Tab

Importing Part Info

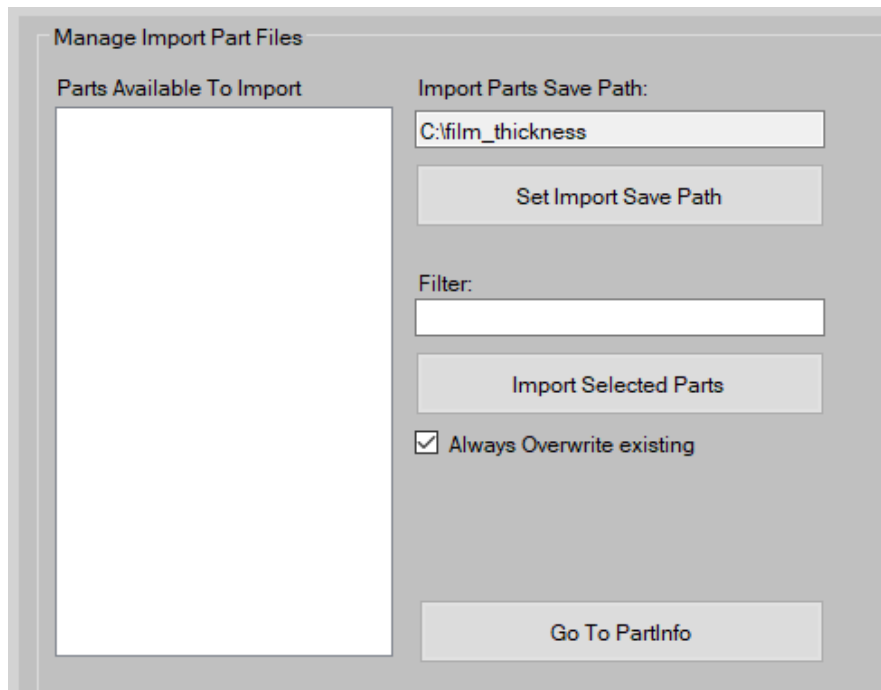


Figure 14 - Import Tab

The recipe for a new part can be imported from a file with a “.prt” extension. To import a part recipe file from a specific directory, set the *Import Part Save Path* to the directory in which the part file resides by clicking on the “*Set Import Save Path*” button.

All available part files in the specified directory will be populated on the *Parts Available to Import* panel on the left.

The part file that needs to be imported can be chosen from the available list and upon clicking the *Import Selected* button, the chosen part file will be imported into the part recipe list.

Layer Settings

Layer Settings

☐ Auto-Recipe

Lower Limit: 15.00

Upper Limit: 25.00

IOR: 1.550

Start Eval. (nm): 900.0

End Eval. (nm): 1650.0

Thickness Min.: 4.00

Thickness Max.: 30.00

☐ Subtract known layer from measurement

Figure 15 - Layer Settings

Low limit:

Lower Limit: 7.00

This is a quality control limit. Any measurement value below this limit will be regarded as an invalid measurement.

Upper limit:

Upper Limit: 10.00

This is a quality control limit. Any measurement value above this limit will be regarded as an invalid measurement.

Note: The measured value is color coded such that any measurement below the Lower Limit or above the Upper Limit is displayed in red, and any measurement that is between the Lower and Upper Limits (within specification) will be displayed in green.

Index of Refraction (IOR):

IOR: 1.520

Index of refraction of the coating depends on the nature of the coating. The engineer setting up part parameters MUST know the index of refraction of the coating to obtain accurate thickness results. Index of refraction of most common materials is readily available as most of that information is published. If the material used in the coating has an unknown index of refraction then it can be calculated if there is a sample of known thickness, or the IOR can be measured using a refractometer.

Start Evaluation layer 1 ("Start Eval. at"):

Start Eval. at: 600.0

The “Start Eval.” value is the starting wavelength (measured in nm) for the interference evaluation range for Layer 1. This value should be chosen as close to the beginning of the interference modulation as possible.

End Evaluation layer1 (“End Eval. At):

End Eval. at: 1050.0

This is the ending wavelength for the interference evaluation range for layer1. Again, this should be chosen as close to the end of interference modulation range as possible.

Layer 1 Thickness minimum:

Thickness Min.: 3.00

This parameter determines the thinnest layer (layer1) that can be considered for analysis. This is not a quality control limit. It is recommended to have a reasonably close value to the expected thickness value of the coating. (for example: if the expected thickness of the coating is 12 microns, its recommended to have a Thickness Minimum value of 6 microns, or on an average at least 50% of the expected value). This reduces the possibility of having a noisy Thickness peak being reported as the thickness of the sample and increases the probability of identifying the right peak.

Easily Recognizable Thickness Peak Example:

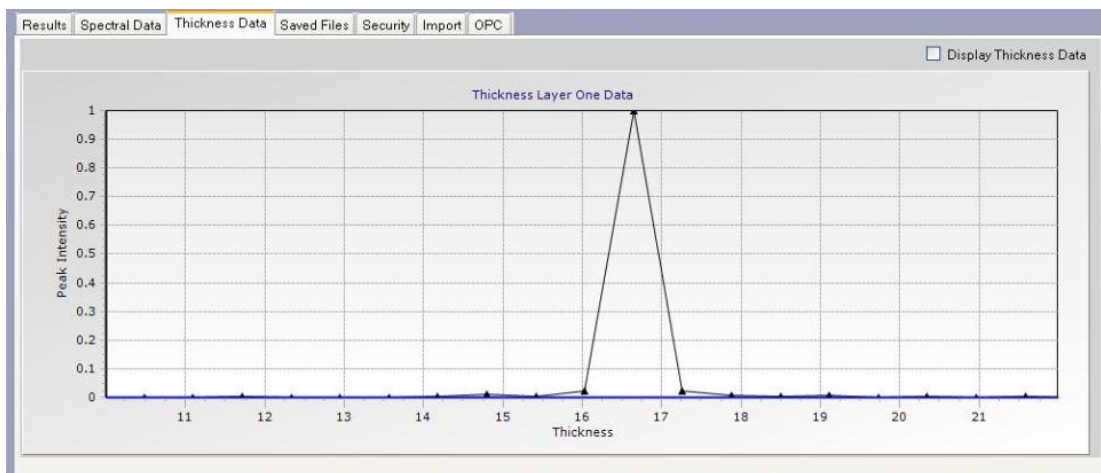


Figure 16 - Thickness Peak (Easy)

The Thickness peak in Figure 16 is easily identifiable as it is the only peak in the entire Thickness spectrum, and no other noisy peaks are present. This type of Thickness

spectrum usually results for films that are non-dispersive and have good reflectance in the selected interference evaluation range; in short, films for which there is well-defined periodic interference modulation. For coatings or films which cannot produce well-defined interference the Thickness peak will not be as pronounced as it is shown in the above figure.

Following is an example of such a Thickness spectrum.

False thickness values because of poor choice of thickness limits:

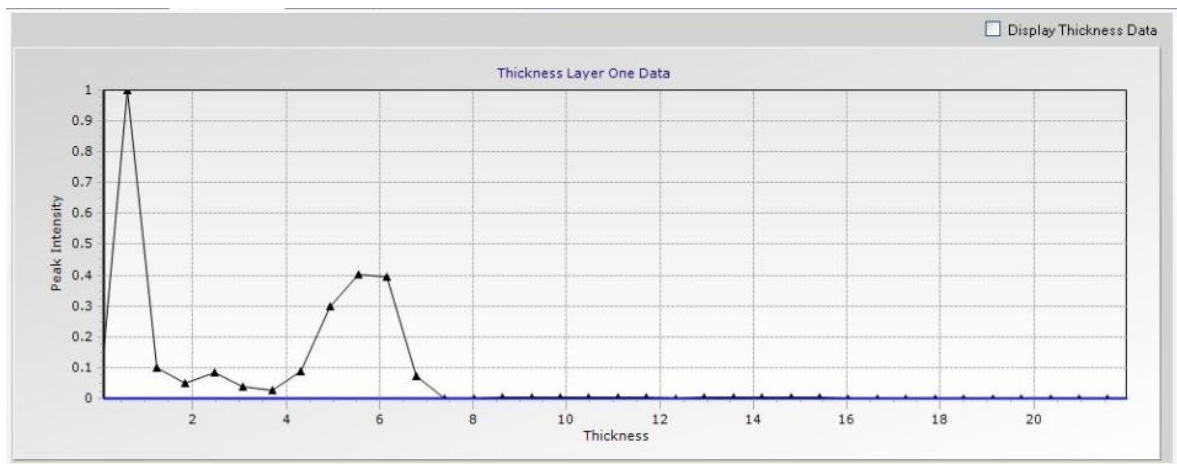


Figure 17 - False Thickness values

The above *Thickness Data* graph is for a 5.63 μ m coating sample. The lower thickness limit or thickness minimum was chosen as 0.3 μ m and, due to some low frequency noise the software will identify the *false thickness peak* labeled in the figure (false peak is because of noise associated with taking measurements in not so ideal environment), and report the thickness value as 0.52 microns instead of 5.63 microns (*true peak* corresponds to 5.63 microns).

The above sample produces an ambiguous *Thickness Data* spectrum. Fortunately, *SpecMetrix*[®] can overcome this scenario with the help of parametric setup. Proper identification of thickness minimum will enable the software to identify the real peak.

To refine the selected thickness range “Display Estimating Tool” under “Spectral Data” Tab can be used to estimate approximate thickness based on interference spectrum. Changing the thickness minimum from 0.3μm to 2μm resulted in a clean unambiguous Thickness spectrum for the same exact sample as shown below.

Note: *It is recommended to have a thickness minimum of at least 1 micron for samples that*

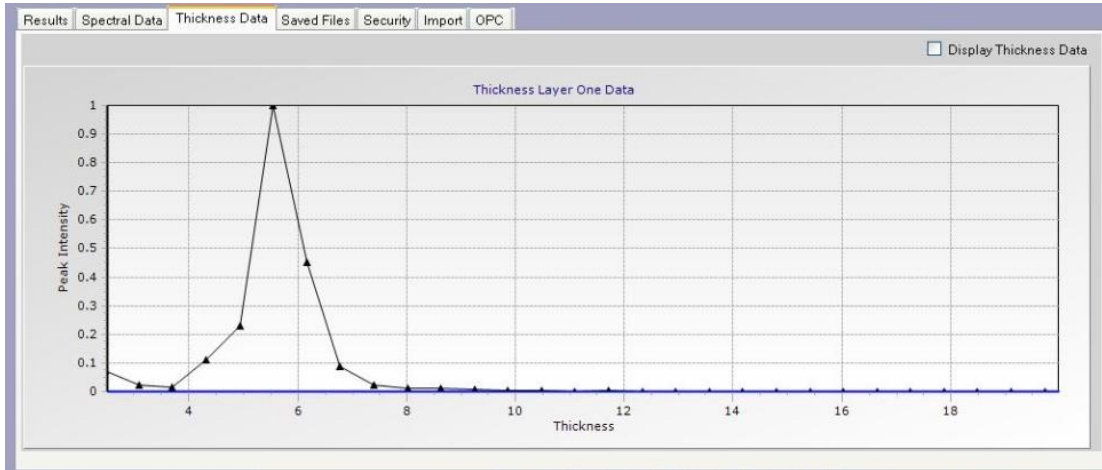


Figure 18 - Unambiguous Thickness Spectrum

do not have an expected layer thickness in the nanometric range.

Noisy frequencies usually appear in the very left end of the Thickness spectrum, so choosing the appropriate value for thickness minimum is more important than thickness maximum.

Layer 1 Thickness maximum (in microns):

Thickness Max.: 25.00

This parameter determines the thickest layer (layer 1) that can be considered for analysis. This is not a quality control limit. It is usually advisable to set this value around 1.5 times the upper control limit.

Start Evaluation layer 2 λ_1 (in nm): Starting wavelength for the interference evaluation range for layer 2. *To be used only with double layer coatings.*

End Evaluation layer 2 λ_2 (in nm): Ending wavelength for the interference evaluation range for layer 2. *To be used only with double layer coatings.*

Layer 2 Index of Refraction: Index of refraction of layer 2.

Layer 2 Thickness minimum (in microns): *SpecMetrix®* has the capability to measure two layered samples provided each of those layers have different refractive indexes with the thickness of each layer being reasonably different from the other. It is recommended to choose a layer 2 thickness minimum such that it does not fall in the range of layer 1 thickness minimum to layer 1 thickness maximum.

Layer 2 Thickness maximum (in microns): This parameter determines the thickest layer (layer 2) that can be considered for analysis. This is not a quality control limit. There is no recommendation as to what value should be chosen for this field. It is recommended to choose a layer 2 thickness maximum such that it does not fall in the range of layer 1 thickness minimum to layer 1 thickness maximum.

Export Part:



Clicking on this button will export the current part recipe to the directory specified in the *System Configuration* path under the Save Path field.

Import Part:



This can be used to import a specific part recipe. Clicking on this tab will take the user to “Import” tab where a part recipe can be imported (See section **Import** for more information).

Identifying Interference Evaluation range

The selected optical module inside the thickness measurement system can collect reflectance information over a wide range of wavelengths from 300nm to 1200nm. (**Note:** *The wavelength range while using an NIR optical package is 878nm to 1680nm*).

For optimal results, the interference evaluation range must be selected as precisely as possible. Given below are a few examples of identifying interference evaluation range. Interference modulation wave usually appears in the form of a damped sine wave. Please

note that these examples are for visible optical package but the wavelength region will be different for an NIR optical package (between 880nm and 1680 nm).

Note: Although identifying interference evaluation range is not a complex procedure, Sensory Analytics recommends that these part parameters should be set by trained personnel.

Easily Recognizable Interference Spectrum

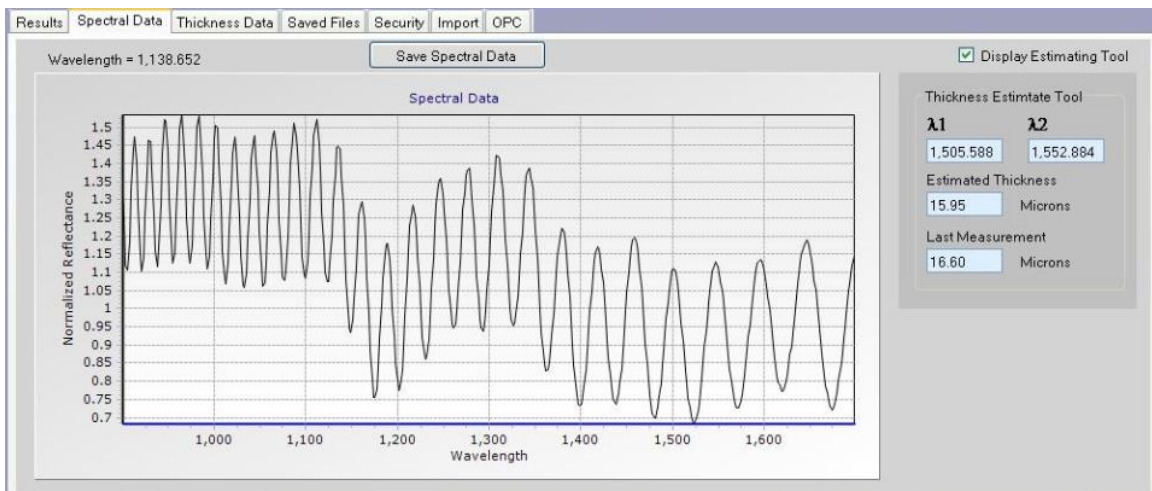


Figure 19 - Easily recognizable interference spectrum

In the example above, interference is good over the entire range of NIR (900nm and 1700 nm).

Slightly Complex Interference Spectrum

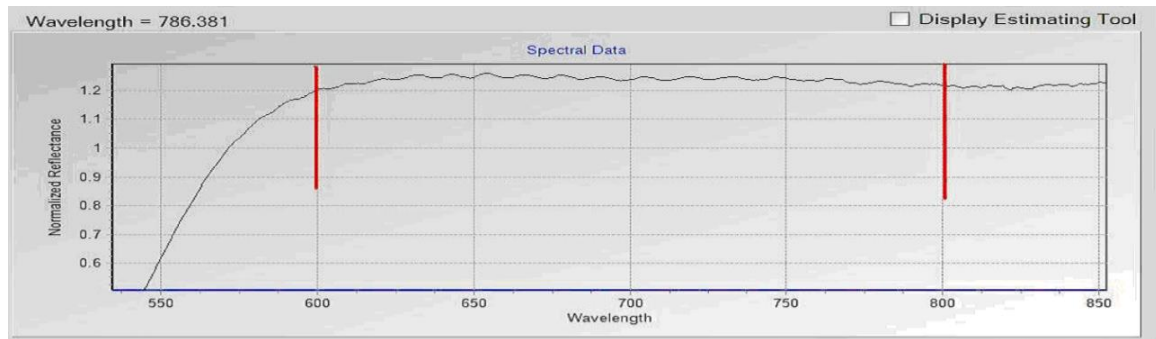


Figure 20 -Slightly Complex Interference Spectrum

Interference is between 600nm and 800 nm.

More Complex Interference Spectrum

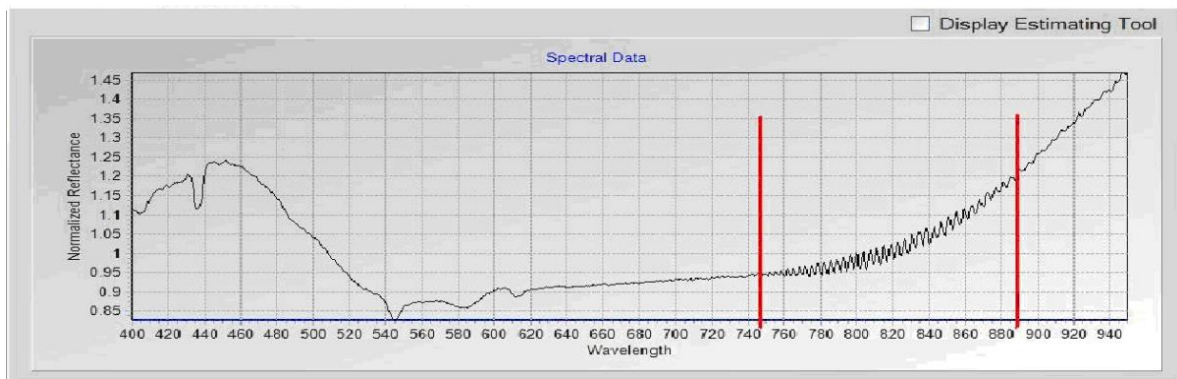


Figure 21 - More Complex Interference Spectrum

Interference is between 745nm and 875nm approximately.

System Configuration

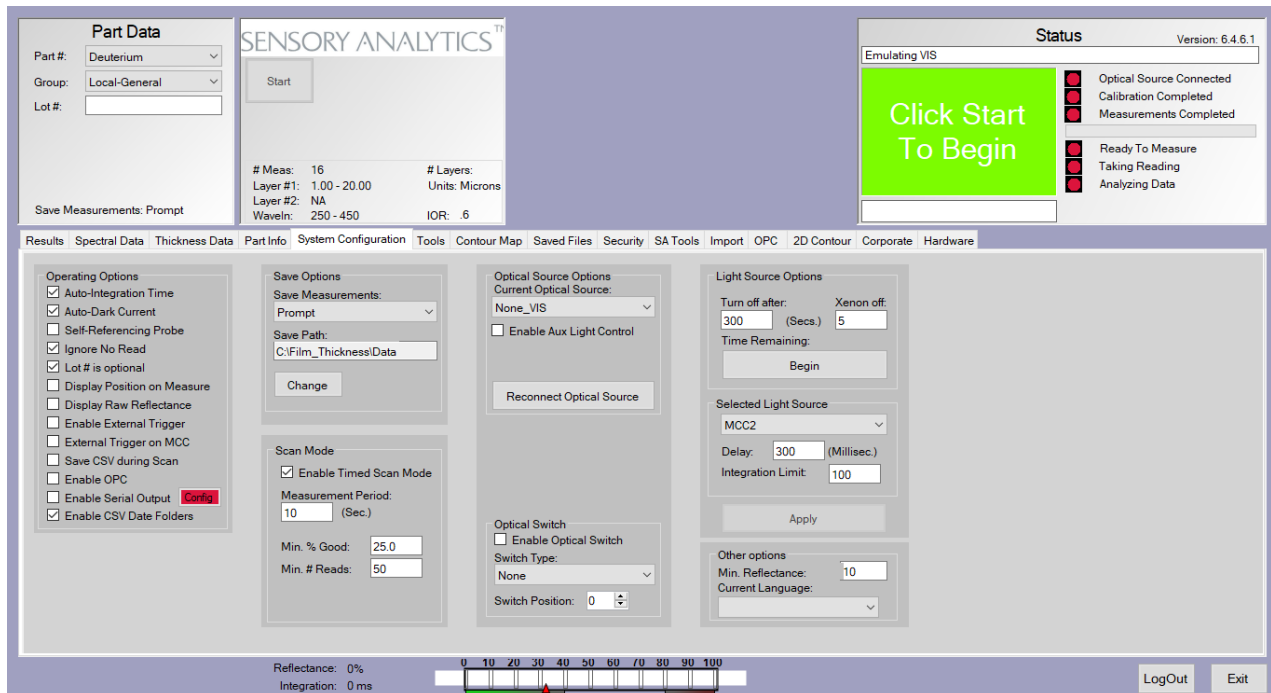


Figure 22 - System Configuration Tab

Operating Options:

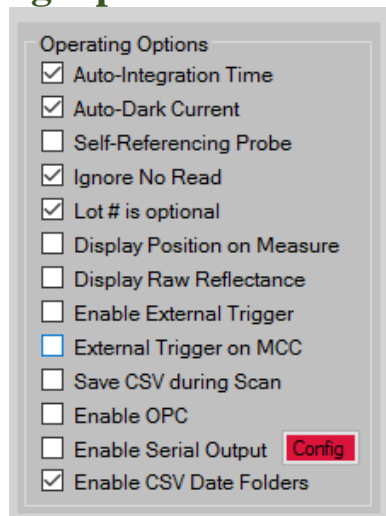


Figure 23 - Operating Options

Auto Integration Time: If there is a sample with different amounts of reflectivity in different areas (If the underlying substrate varies in color then it has a different reflectivity) then the user can check this box and the system will automatically calculate the integration

time and adjust the light intensity without the user having to move the probe. It is recommended to enable auto integration time while using the *Self-Referencing probe*.

Auto Dark Current: If this option is selected then the system will automatically take a dark current each time a reference measurement is taken. If this is not selected then the dark current is only taken at the beginning when the software is launched and the system retains that dark current spectrum until “calibrate” button is clicked. It is recommended to choose *Auto Dark Current* in conjunction with *Auto Integration Time*.

Self-Referencing Probe: This option needs to be selected when the *Self-Referencing probe* is being used. A self-referencing probe has three fiber legs instead of the regular two fibers. By using this type of probe, the “*reference measurement*” step can be eliminated as this probe has auto referencing capabilities.

Ignore No Read: If this option is chosen then the software will automatically ignore any *No Read (NR)* measurement *No Reads* occur usually because of noisy interference spectrum (measurement on a bad spot on the sample for example). The *No Read* measurement will not be populated in the generated report file at the end of the measurement run. Upon selecting this option, the software will automatically erase the most recent NR measurement and the user can retake the measurement in a different spot on the sample.

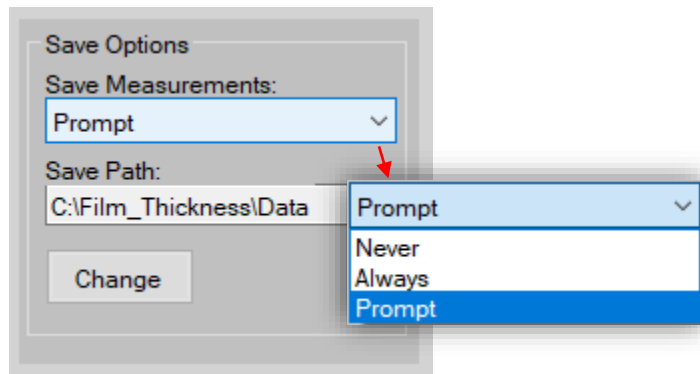
Lot # is optional: If this option is chosen then the measurement series can be initiated by the software even without entering a lot number (lot #). Otherwise the software will not allow the user to take measurements without entering the lot #.

Display Position on Measure: If this option is selected, software will provide a status of the current measurement for a given measurement plan.

Enable External Trigger: This option is chosen when there is an external trigger mechanism to trigger the measurement; such as a foot-switch. When this option is selected, upon pressing the foot-switch, the measurement will be taken by the system without the

user clicking on the measurement button on the screen. The foot-switch will act as an external trigger for prompting the system to take a measurement. This option should not be chosen unless an external trigger mechanism exists.

Save Options:



*Figure 24 - Save Options
drop-down menu*

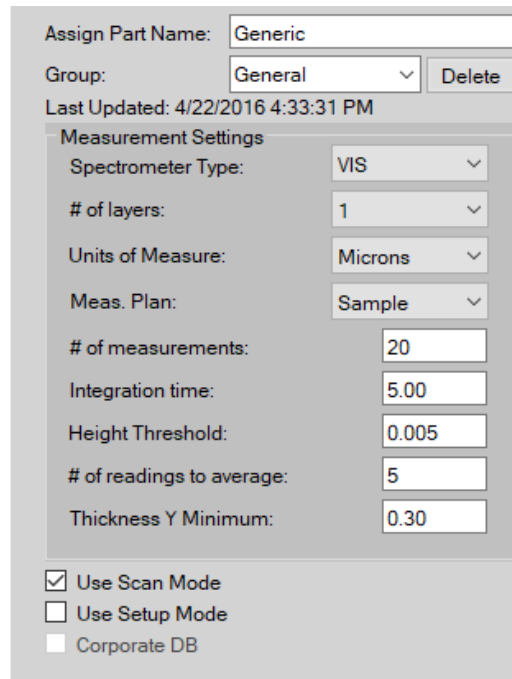
The user also has an option to automatically save the measurements at the end of the measurement run, skip saving the measurements, or have the software prompt the user to save the measurements. It is also possible to select the directory path where the user wants the report file to be stored. The directory path can be changed by clicking on the “Change” button under “Save Path” field and selecting the desired directory.

Setup Mode

“Setup Mode” is an experimental mode. If this option is selected then the user will have the ability to change the part parameters in the middle of a measurement series. This way, the user can experiment with various evaluation ranges without having to restart the

measurement series every time. *Measurement results are not saved in this mode.* This mode is mainly used to fine-tune part parameters.

Measurement Settings:



Assign Part Name:

Group:

Last Updated: 4/22/2016 4:33:31 PM

Measurement Settings

Spectrometer Type:

of layers:

Units of Measure:

Meas. Plan:

of measurements:

Integration time:

Height Threshold:

of readings to average:

Thickness Y Minimum:

☒ Use Scan Mode

☐ Use Setup Mode

☐ Corporate DB

Figure 25 - Measurement Settings

Assign Part Name: This is a unique ID given to the part that is being measured. All established measurement settings specific to that part are saved along with the Part Name; therefore, once a measurement recipe has been properly established it can be referenced at any time by calling upon that Part Name in the drop-down menu.

Assign Group Name: This field is mainly useful for Part organization. If the number of part recipes becomes excessive then the drop-down menu for Part Name becomes overpopulated making it difficult to find the right part. To alleviate this problem a set of parts with some similar characteristics can be organized into one ***Group***. A ***Group*** for Part Names is like a folder for files.

of Layers:

of layers: 1

This is the field in which the user can select the number of layers that need to be measured from the drop-down menu. A maximum of 2 layers can be measured simultaneously provided the refractive index of both the layers is different.

Units of Measure:

Units of Measure: Microns
Meas. Plan: Nanometers
of measurements: Microns
Integration time: Mils
Height Threshold: Mg / In²
of readings to average: Mg / 4 In²
g / m²
mg / cm²
lbs / ream

Figure 26 - Units of Measure drop-down menu

The user has an option to select the measurement units. The measurements can be reported in *mils*, *microns*, *nanometers*, *mg/in²*, *mg/4in²*, *g/m²*, and *g/cm²*. The conversion factors between different units are given below.

1 mil = 25.4 microns = 25400 nanometers

1 micron = 1000 nanometers = 0.0393 mils

1 nanometer = .001 microns = 0.000393 mils

Thickness to Weight Conversion:

Measurement Settings	Layer Settings	Thickness-To-Density Conversion Data
Spectrometer Type: VIS	Layer 1	Conversion Rate: 1.000
# of layers: 1	Lower Limit: 0.500	<input checked="" type="checkbox"/> Invert Conversions
Units of Measure: Mg / In²	Upper Limit: 3.00	Calculated Conversion? <input checked="" type="checkbox"/> Calc
Meas. Plan: Sample	IOR: 1.800	Calculated Conversion: 0.005
# of measurements: 20	Start Eval. (nm): 450.0	Wet Density Units: g/l
Integration time: 5.00	End Eval. (nm): 900.0	Wet Density (g/L): 11.000
Height Threshold: 0.005	Thickness Min.: 0.500	% Solid Weight: 64.00
# of readings to average: 5	Thickness Max.: 3.00	% Solid Volume: 12.00
Thickness Y Minimum: 0.30	<input type="checkbox"/> Subtract known layer from measurement	Conversion Type
<input checked="" type="checkbox"/> Use Scan Mode		Layer 1
<input type="checkbox"/> Use Setup Mode		<input type="radio"/> Dry - To - Dry
<input type="checkbox"/> Corporate DB		<input checked="" type="radio"/> Wet - To - Dry
	Copy Part to DB	Clear Part Info
	Import Parts	Reset Part Info
	Export Part	Delete Part
		Update Part Info

Figure 27 - Thickness-to-Density Conversion Data Panel

The “Thickness-To-Density Conversion Data” panel will be enabled *ONLY* if the chosen units are mg/in^2 , $mg/4in^2$, g/m^2 , g/cm^2 . This is the panel which will help the user calculate the conversion factor to convert a thickness in microns into the desired units of coat weight. The user needs to have knowledge about the wet density, percentage of solids by weight and volume used in the coating formulation. After these values are provided, the software automatically computes the conversion factor for a given part and displays the measurement in the chosen units. There will be different conversion factors for wet thickness conversion and dry thickness conversion. The operator can choose either a “Dry-to-Dry” or “Wet-to-Dry” option. In the case of “Dry-to-Dry” conversion, dry thickness (e.g.: microns) can be converted to dry coat weight (e.g.: $mg/4in^2$).

If the user chooses to determine an empirical value for conversion factor by correlating the wet thickness in microns and dry film weight in msi, or similarly for a *dry-to-dry* conversion, then a default conversion factor can be entered under the “System Configuration” tab.

Measurement Plan:

Meas. Plan: (None) ▼

This should be populated only if the user desires to see a contour graph at the end of the measurement run. This is mainly used to generate a topographical contour map and the parameters for a Measurement Plan can be changed under “Tools” tab.

Number of Measurements:

of measurements: 6

This field has the information about number of measurements to be taken by the operator for the specified part number. There is no specified upper limit for choosing the number of measurements.

Note: *If the user is interested in viewing a contour map then its desirable to have the total number of measurements in the part info be equal to the number of rows multiplied by number of columns under the chosen measurement plan.*

Integration Time:

Integration time:

Integration Time is the time in milliseconds used to sample the optical package detector array once. Sensitivity of the instrument is directly proportional to the integration time. For a highly reflective sample, integration time should usually be low to avoid saturating the detector, whereas for a sample which is not as reflective the integration time must be higher. A typical range for integration time would be between 2ms and 10ms for the visible optical package and 1ms to 100ms for the NIR optical package; although in some cases involving samples with exceptionally low reflectivity, the integration time needs to be set higher than the typical ranges mentioned above.

Note: *Signal intensity also depends on factors like intensity of the light source and the distance of the optical probe from the sample; not just from the selected integration time alone.*

Height Threshold:

Height Threshold:

This is the minimum amount of height (distance from the bottom point to the top point for a given interference wave) required not to consider the interference wave as noisy.

Scan Mode

Scan Mode is designed to do a quick scan across a given sample and get an average thickness throughout the length of the scan. Since the effective area of measurement of the

sensor is close to a millimeter, while measuring samples with a large surface area it is more convenient to scan quickly across the sample and get an average measurement over a given area instead of multiple single measurement points.

Scan Mode:

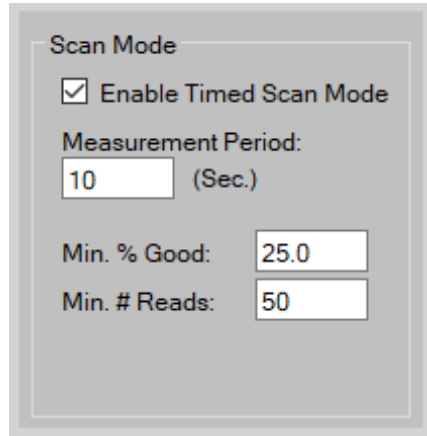
A screenshot of a software window titled "Scan Mode". Inside the window, there is a checkbox labeled "Enable Timed Scan Mode" which is checked. Below this, there is a label "Measurement Period:" followed by a text input field containing the number "10" and the text "(Sec.)". Further down, there are two more settings: "Min. % Good:" with a text input field containing "25.0", and "Min. # Reads:" with a text input field containing "50".

Figure 28 - Scan Mode

This feature can be used to scan and take continuous measurements over a large area on the sample. Measurement period indicates the desired period over which measurements are taken. Min % Good indicates the number of valid measurements within that period and Min # Reads indicates the minimum number of measurements needed for the scan to be valid.

Below is the procedure to run measurement sequence in *Scan Mode*.

- a) Click on the Scan Mode option under *Part Info* tab as shown and then click on “Update Part Info” to save the settings.

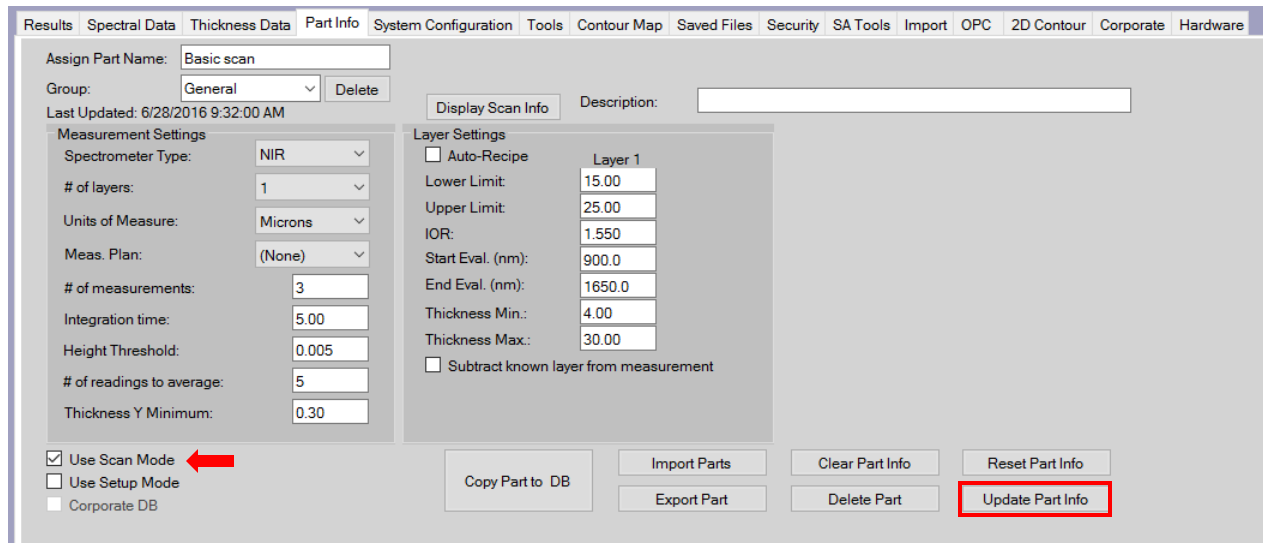


Figure 29 - Using Scan Mode

- b) Wait until the software displays “Begin Scan” screen and press the “Take Measurement 1” button while scanning across the sample at the same time.

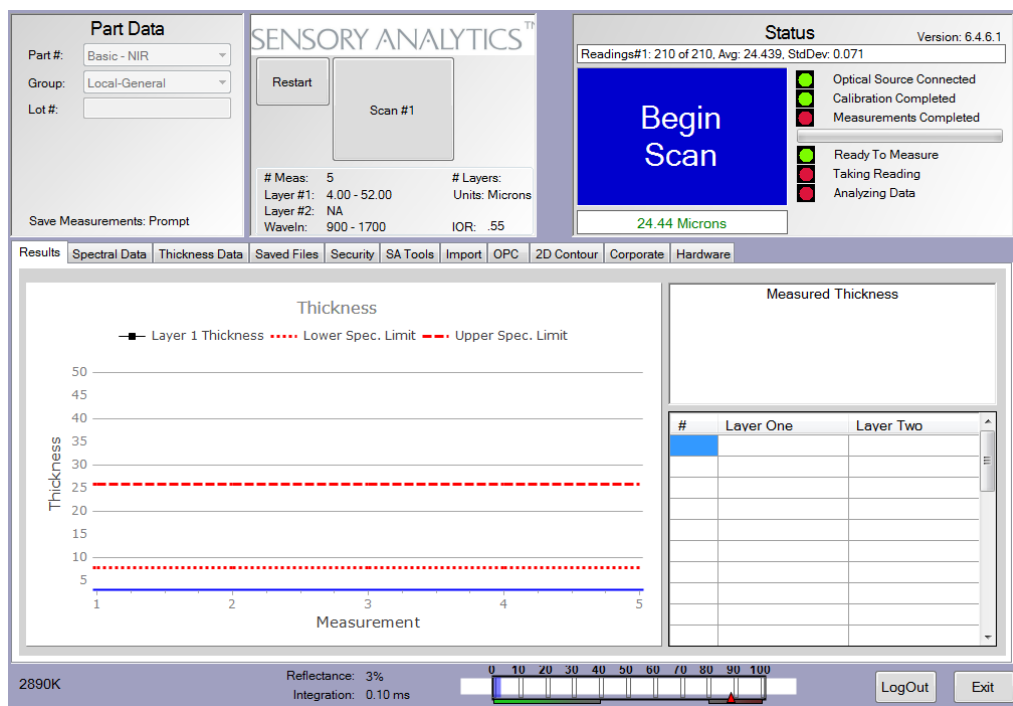


Figure 30 - Beginning a scan

- c) The duration of the scan, along with a few other parameters of the scan mode, can be set in the *Systems Configuration* tab.

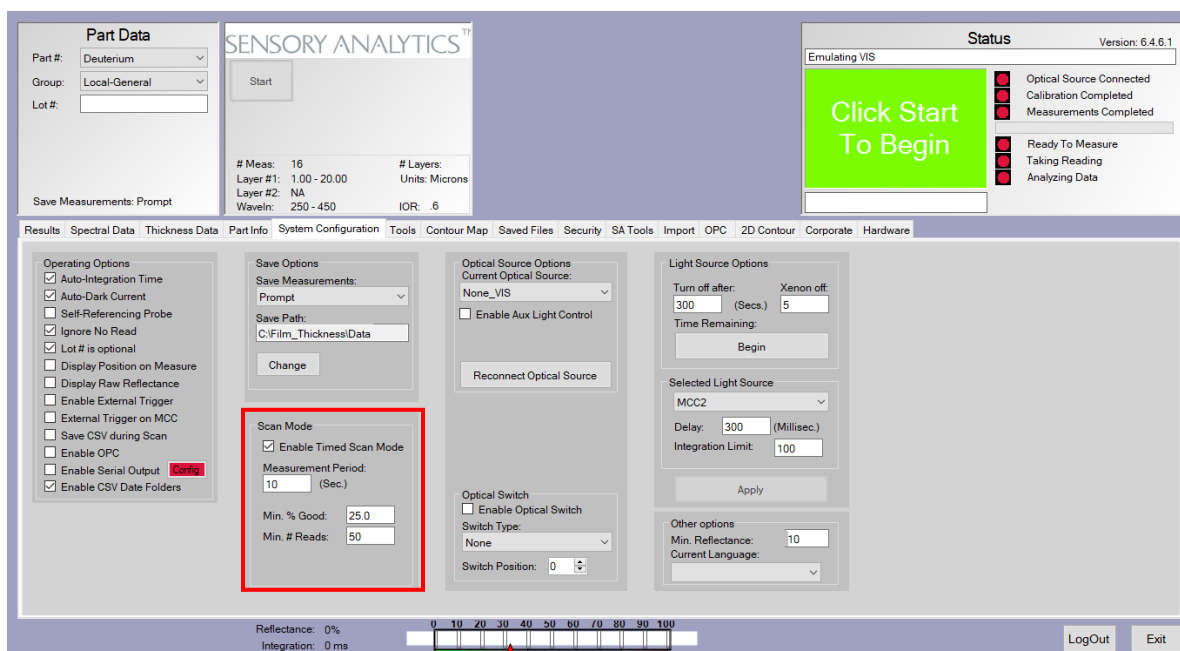


Figure 31 - Scan Mode parameters

- d) Repeat Steps (a) to (c) until the required number of measurements is complete and click on “End Measurement Run” to save the measurements.

Light Sources Options

Depending on the technologies incorporated into your *SpecMetrix*® lab system, the unit can have multiple light sources. (Tungsten-Halogen light source and Pulsed Xenon light source for example). Since the available light sources are installed before the unit is shipped, these settings are pre-configured.

Selected Light Source:

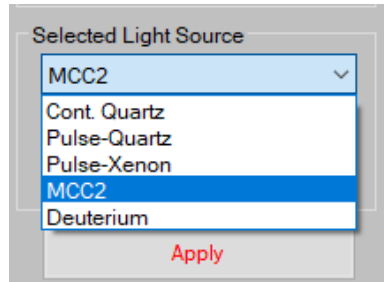


Figure 32 - Selected Light Source drop-down menu

If there are multiple light sources in the system, then the user can choose one of the appropriate light sources for a given application. Measuring a thin film (or coating) that is less than 300nm requires a Xenon light source, if the thickness is more than 300 nm then “Cont. Quartz” (Tungsten-Halogen) can be used. (While using a Self-Referencing Probe there will be an additional Multiplexor-2 light source.

Note: *If Pulse-Xenon option is chosen the minimum integration time should be 10 milliseconds.*

Delay:

The *Delay* box located in the *Light Source Options* portion of the System Configuration tab is used to set the amount of time (in milliseconds) in which the light bulb will be powered prior to the measurement being initiated. Because incandescent light bulbs require a brief period to reach an equilibrium output this feature must be properly set above the minimum threshold to produce stable measurements, but there is no critical maximum value. It becomes evident that this parameter is not properly set when the spectral data of a measurement shows discontinuities, or isn’t present across the full spectral range. As a rule, 300 milliseconds seems to be a suitable value, however with microscopic variations in the bulbs’ filaments there is a possibility that this number will need to be increased.

Tools

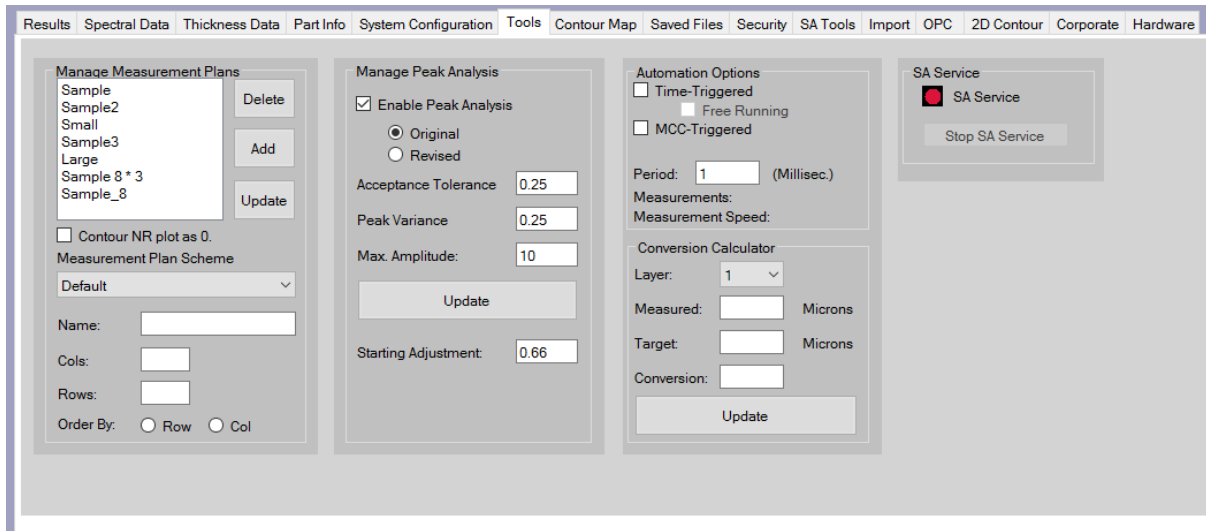


Figure 33 - Tools Tab

Manage Measurement Plans:

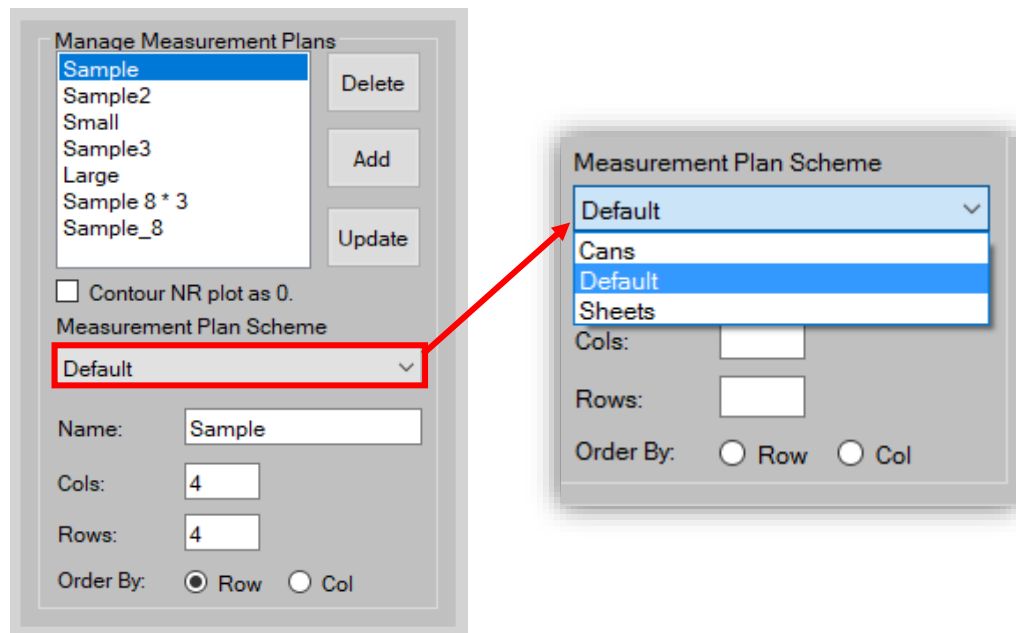


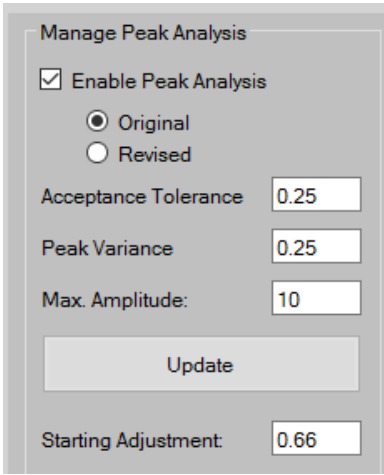
Figure 34 - Manage Measurement Plans

The “Manage Measurement Plans” is the panel in which the parameters can be set up for topographical contour map. This panel has a list of measurement plans and each measurement plan is basically a matrix of rows and columns. (e.g. If the user desires to have a map of 16 locations on a beverage can, 4 around and 4 down, then the measurement

plan can be setup with a 4X4 matrix as shown in the Figure 34). The user must have knowledge of the actual physical measurement locations as the software does not have knowledge of the measurement locations. The software reports a contour map as a grid (rows by columns) with each square in the grid corresponding to a specific measurement in the measurement series and is color coded according to the lower and upper control limits. If a measurement is below the lower control limit then the contour map displays the corresponding square in blue and if a measurement is above the high control limit then the contour map displays the corresponding square in red.

If the **Measurement Plan Scheme** is chosen as “Cans” then the contour map is labeled as *Around* and *Down*. If the scheme is “Sheets” then it is *Across* and *Down* and a “Default” scheme is designated by *Rows* and *Columns*.

Manage Peak Analysis:



The screenshot shows a 'Manage Peak Analysis' dialog box. It has a title bar 'Manage Peak Analysis'. Inside, there is a checked checkbox labeled 'Enable Peak Analysis'. Below it are two radio buttons: 'Original' (which is selected) and 'Revised'. There are three input fields: 'Acceptance Tolerance' with the value '0.25', 'Peak Variance' with the value '0.25', and 'Max. Amplitude' with the value '10'. Below these fields is a button labeled 'Update'. At the bottom, there is another input field labeled 'Starting Adjustment' with the value '0.66'.

Figure 35 – Peak Analysis

Enable Peak Analysis: The peak analysis algorithm in the software can be activated by choosing this option. Peak Analysis algorithm is designed to validate the true *Thickness peak* by automatically eliminating the false and noisy low frequency *Thickness peaks*. In absence of peak analysis algorithm, the software will not report a thickness if there are multiple *Thickness peaks* and the onus is on the user to eliminate the false peaks by optimizing the part parameters using the thickness estimate tool. When the Peak Analysis feature is enabled however, the software tries to automatically identify the true *Thickness peak* even with the presence of other false peaks. Please note that the parameter *Maximum*

Thickness (value set under the *Part Info* tab) is used by the software to automatically filter and reduce noise in the interference spectrum, so it is recommended to use a value which is twice the expected thickness.

Spectral and Thickness Data “without” peak analysis algorithm:

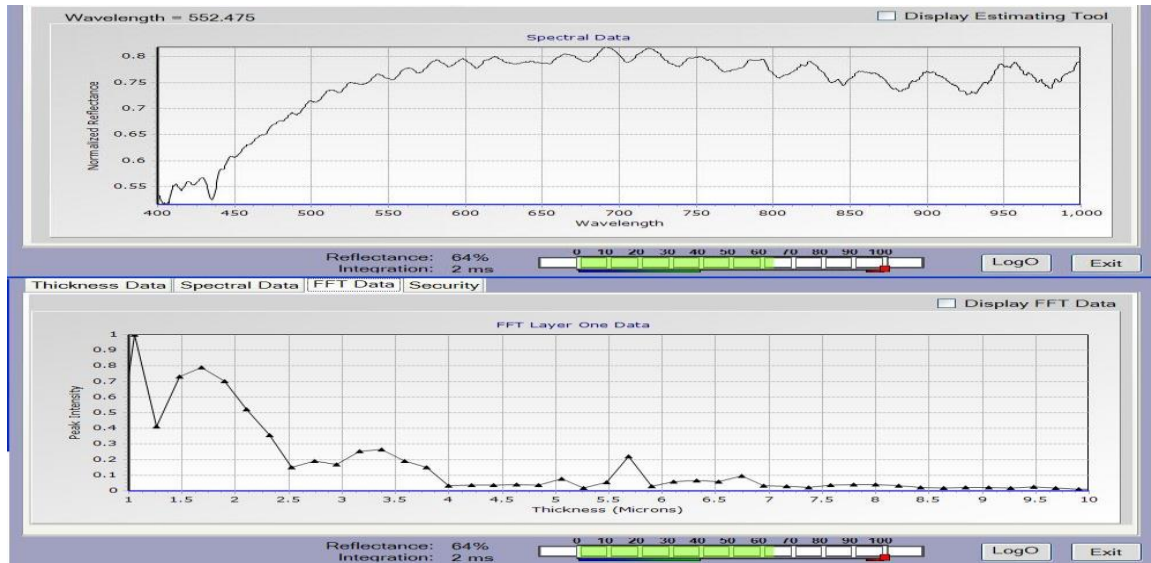


Figure 36 - Without PA algorithm

No thickness is reported in this case because of presence of several false peaks. The software will report a *No Read* due to the absence of quality thickness spectrum.

Spectral and Thickness Data “with” peak analysis algorithm:

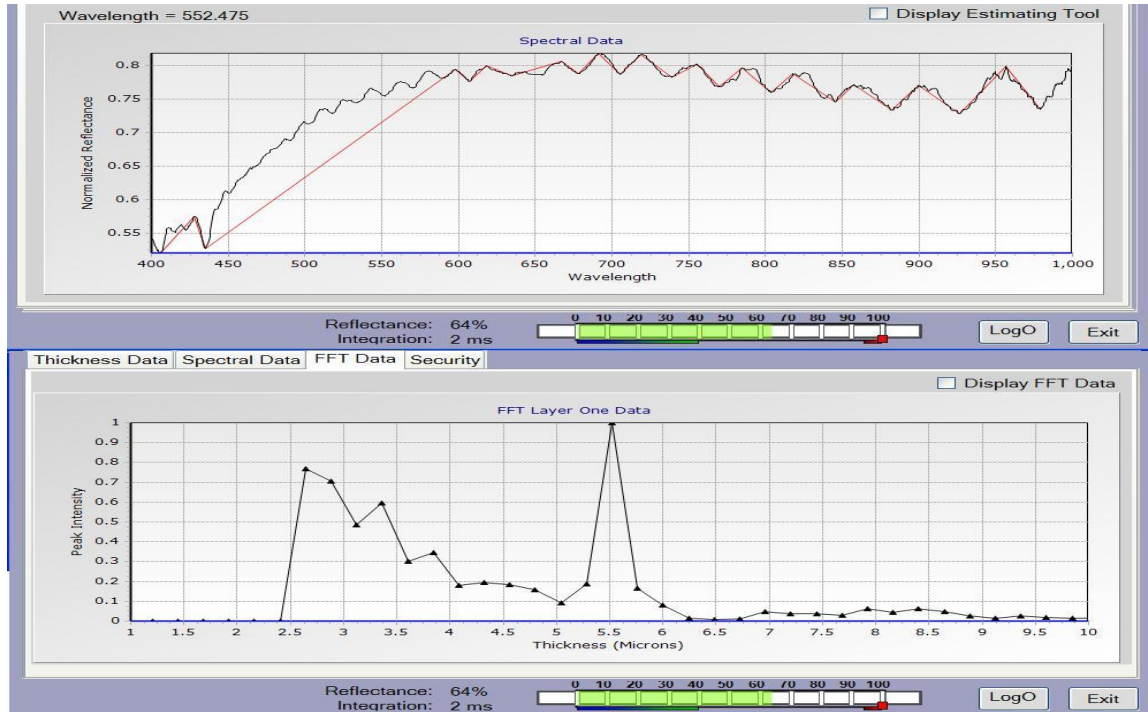


Figure 37 - With PA algorithm

Using peak analysis for the same spectral data, the software calculates the thickness as 5.4 microns. The red curve is the portion of the curve used by the peak analysis algorithm to estimate the thickness and there by identifying the true Thickness peak.

Acceptance tolerance: This is the amount of acceptable variation in percentage between the final estimated thickness by the peak analysis algorithm and the thickness displayed by the software. If a value of 0.2 is used in this field then a 20% variation is acceptable between the calculated thickness by the software and the *estimated* thickness by the peak analysis. If the variation is more than what is acceptable as defined by the acceptance tolerance value then the software will flag the measurement as a “No Read”. Typical range for this parameter is 0.1 to 0.5.

Peak Variance: is the amount of variation allowed in thickness between the calculated thickness and individual peak estimates. (See Section 9 for an example of estimating thickness using peak estimate tool. In general, as a rule of thumb, this value should be set within 10 to 15% of the expected thickness. Depending on the nature of the samples and

the quality of interference, this parameter might have to be modified. Typical range for this parameter is 0.1 to 0.5.

Max Amplitude: is the maximum allowable height between the lowest and highest points on the interference spectrum. This will allow the software to detect and eliminate interference spectrums with unusual noisy spikes.

Conversion Calculator

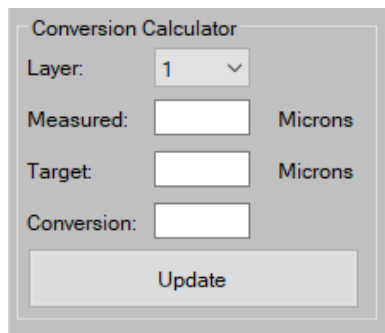
A screenshot of a software dialog box titled "Conversion Calculator". It contains four input fields: "Layer:" with a dropdown menu showing "1", "Measured:" with a text box, "Target:" with a text box, and "Conversion:" with a text box. To the right of the "Measured:" and "Target:" fields is the label "Microns". At the bottom of the dialog is a large "Update" button.

Figure 38 - Conversion Calculator

This tool is used to adjust absolute thickness values to better determine weight measurement values.

Measured: The measured thickness value that the software is reporting.

Target: The weight measurement value that the user is expecting; the Target Specification.

Conversion: The calculated conversion factor based on Target versus Measured values.

Note: Units are determined on the Part Info Tab.

Taking a Measurement (Walkthrough)

- a) Start the *SpecMetrix*® software by clicking the “SpecMetrix” icon on the desktop.
- b) Select the name of the operator taking measurements and enter the password to login.

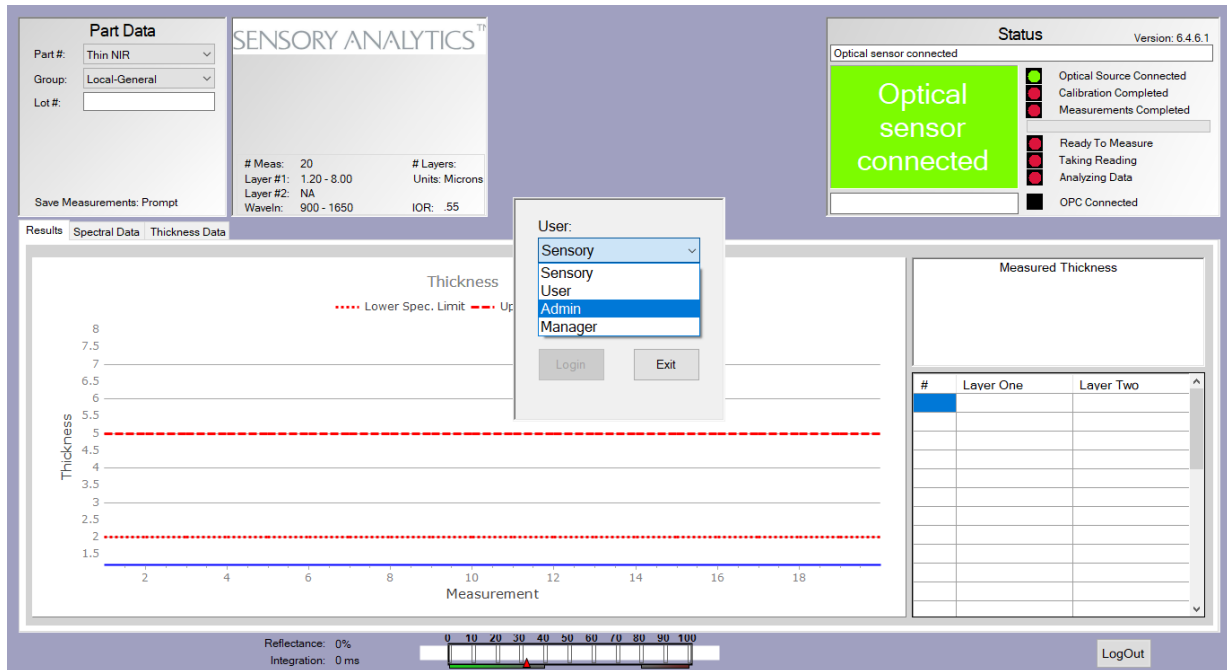


Figure 39 – Login Screen

The operator name will be part of the file name used to store the report file.

- c) Set up part parameters for the specific sample to be measured, or if this has already been accomplished then select the part number to be measured (also select the Group under which the part is classified). Please refer to Section 5 for information on setting up part parameters.

Note: The software contains some default part parameters settings.

- d) Assign a “Lot #” for the part to be measured (Lot # can be made optional). Then click on “Start” button to initiate the measurement process.

Note: Make sure that there is light coming out of the fiber optic probe now. If there is no light, then check to see if proper light source is selected in the software.

At this point it is recommended to place the reference specimen under the probe (this can be the white tile provided or a sample of uncoated substrate). (With a Self-Referencing probe, the reference measurement step does not exist).

If the *Auto Integration Time* option is selected under the *System Configuration* tab, then the system will automatically calculate the integration time for achieving optimal reflectance.

If the *Auto Integration* option is **not** selected, then there will be a continuous display of *reflectance %* at the bottom of the screen that will move from left to right showing the percentage of reflectance back from the surface of the sample. Make sure that the “Reflectance %” is not saturated (a reflectance % >94% may saturate the detectors and that will lead to erroneous results). It should also be verified that there is enough light reflecting (in general, >10% is acceptable). In a scenario where the reflectance % is too high, the first step is to lower the integration time (the minimum possible integration time is 2ms for a standard visible optical package, 1ms for NIR optical package and 10ms for the Xenon light source). The height of the probe can then be adjusted to achieve optimal reflectance. In summary, higher integration time results in higher reflectance, while a greater separation between the probe and sample produces a lower reflectance.

Either the white tile or the bare substrate can be used as a reference. Depending on the nature of the coating, a white tile, when used as a reference may not always yield good interference spectrum. In such a scenario, a bare substrate must be used as a reference, so place the appropriate reference under the probe.

- e) Click on the “Measure Reference” button.

Note: *If a self-referencing probe is used, then there is no need to take reference measurement. The reference is taken automatically while using a self-referencing probe and this step is skipped.*

The figure below shows how a reference measurement typically looks on the *Spectral Data* tab:

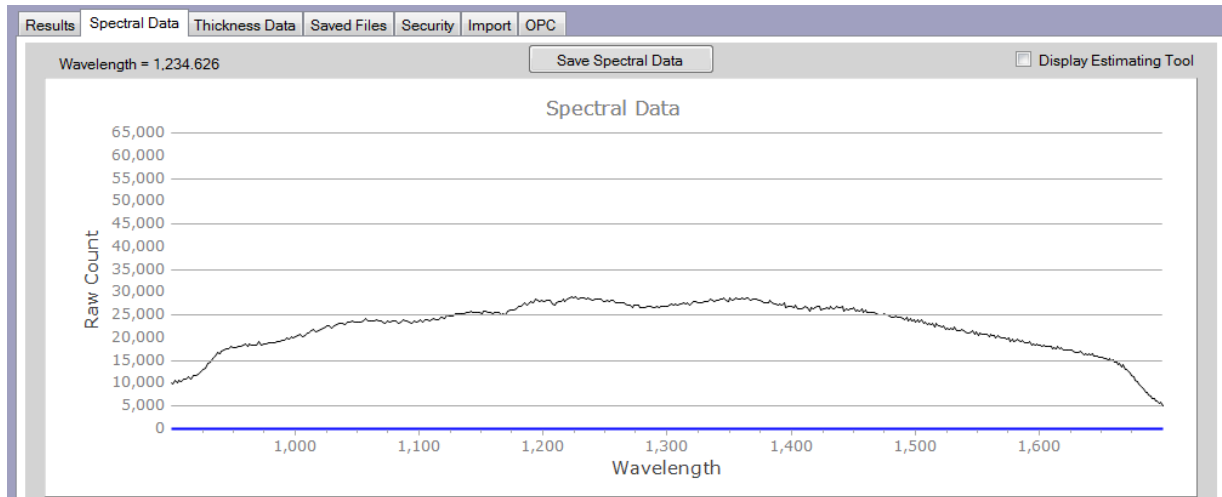


Figure 40 - Typical Reference measurement

- f) Replace the reference sample with the actual sample that is to be measured and click on “Take Measurement # 1” button. *SpecMetrix*® software computes the thickness in seconds and displays the thickness results in the *Results* tab.
- g) Continue taking measurements until the all of measurements for that specific part have been completed.
- h) Spectral data (interference data) can be seen by clicking on the *Spectral Data* tab. Similarly, Thickness graph can be observed under *Thickness Data* tab.
- i) After the measurement set has been completed, click on the “End Measurement Run” button to save the measurements. *SpecMetrix*® can be set up to save all the data to a report file automatically; otherwise the user will be prompted to save at the completion of required measurement for a specific part. This setup option is accessed in the *System Configurations* tab.

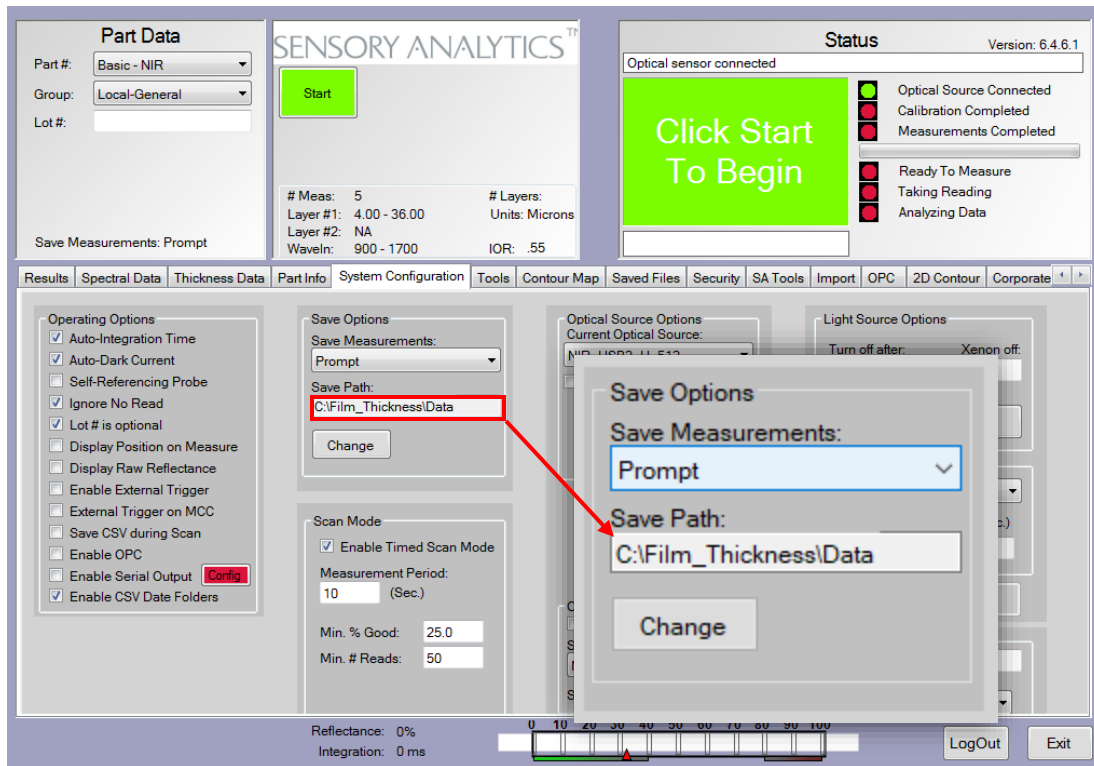


Figure 41 – Data Save Path

Note: For default settings, the report file will be stored in C:\film_thickness\ folder and the format of the file will be “part#-Lot#-operator-Time.xml”, for example the saved file for a part recipe title “OverVarnish” that is measured in the Manager log-in would be named “OverVarnish-Manager- yymmddhhmmssff.xls” where yy – year, mm-month, dd-day, hh-hour, mm-minute, ss seconds, ff-two most significant digits of seconds fraction.

Role of the Restart Button

The “Restart” button voids the measurements taken in the measurement series, and allows the user to adjust any settings and restart the measurement series.

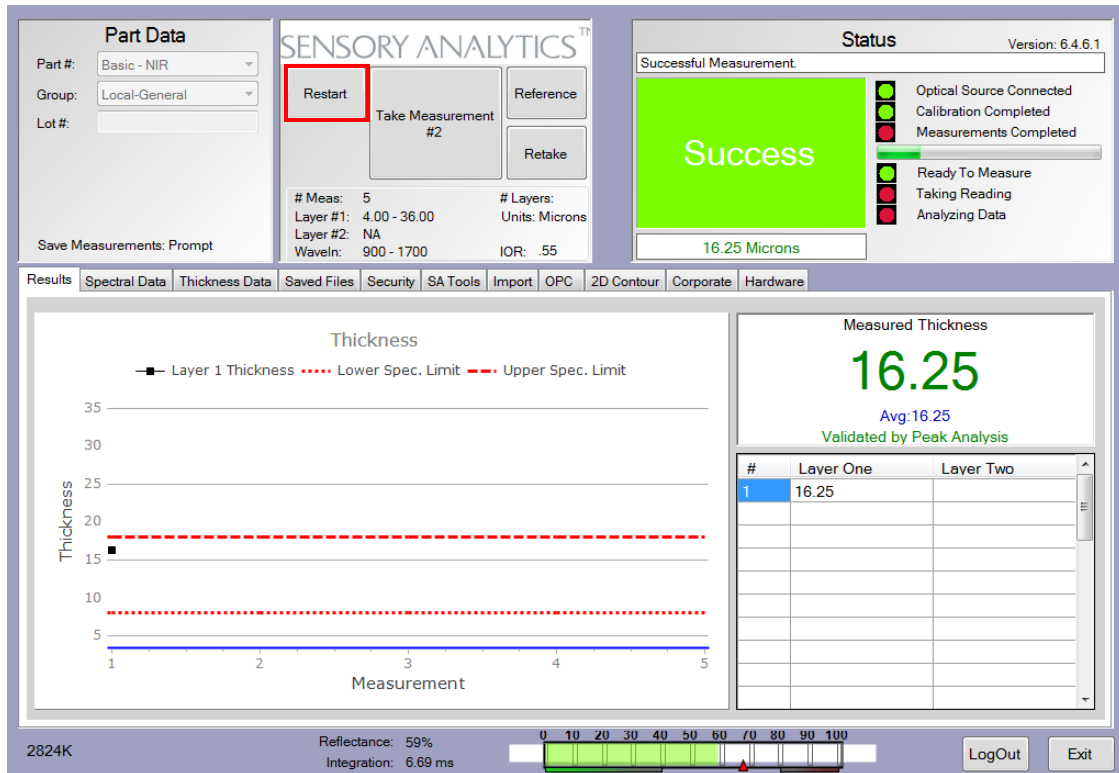


Figure 42 – Restart button

The Restart button can be used in any (but not limited to) of the following scenarios:

- If there are a series of improper measurements, then using restart will wipe out the current set of measurements and allows the user to take a fresh set of measurements (Referencing on a bad spot on the reference sample, or an out-of-focus beam are couple of examples that might trigger a series of bad measurements).
- If the selected interference evaluation range appears unsatisfactory then click “Restart”, change the part parameters under “part info” tab and start the measurement cycle again after changing the beginning and ending points for the interference evaluation range. If proper interference range cannot be identified due to lack of clearly distinguishable interference spectrum then use “Bare Sample” (uncoated sample) for reference measurement and retake the measurements to see if there is a well-defined interference.

Role of the Retake Button

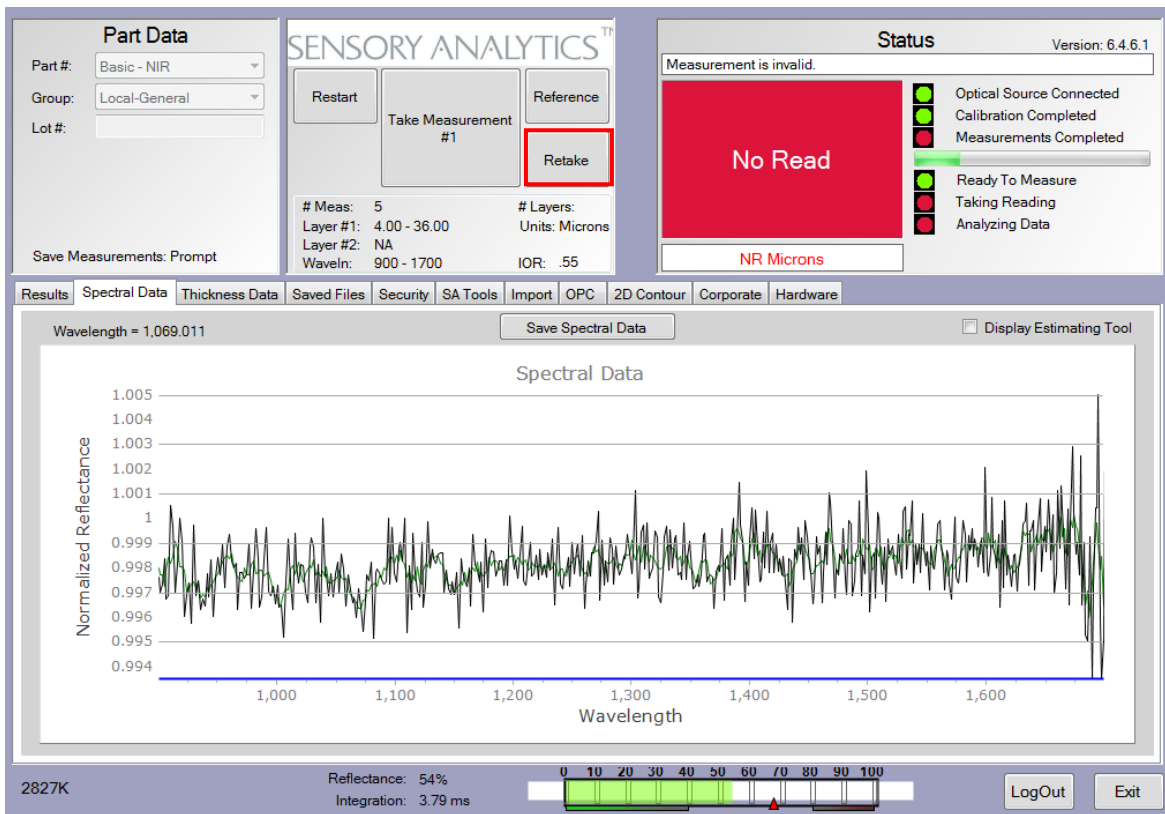


Figure 43 - Retake button

During a series of good measurements, the system may come across a bad spot on the sample (a fingerprint for example) resulting in a No Read (invalid measurement). The “Retake” button repeats the same measurement on a different spot.

Thickness Estimate Tool

To estimate the *approximate* thickness of a sample based on the interference spectrum, begin by clicking the “Display Estimating Tool” check box under “Spectral Data” tab.

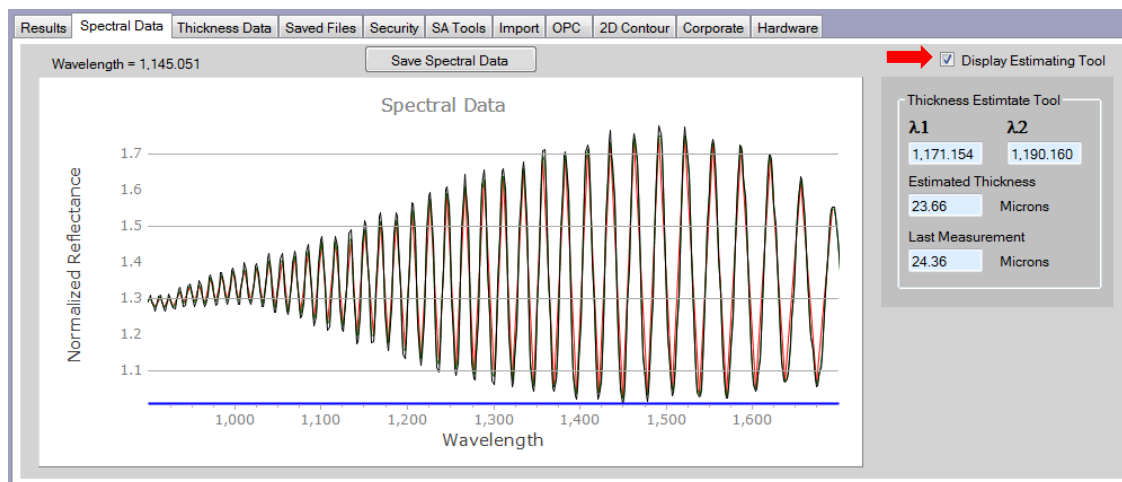


Figure 44 - Display Estimating Tool Checkbox

The thickness estimating tool is useful when setting up a new measurement recipe. This feature is used by checking the box labeled “Display Estimating Tool” in the Spectral Data tab as pictured above. Next double-click from one peak in the wave pattern to an adjacent peak. An estimated thickness value will then be displayed in the shaded region in the right side of the screen. This value is only an approximation intended as a reference point for developing a recipe given a sample of unknown thickness.

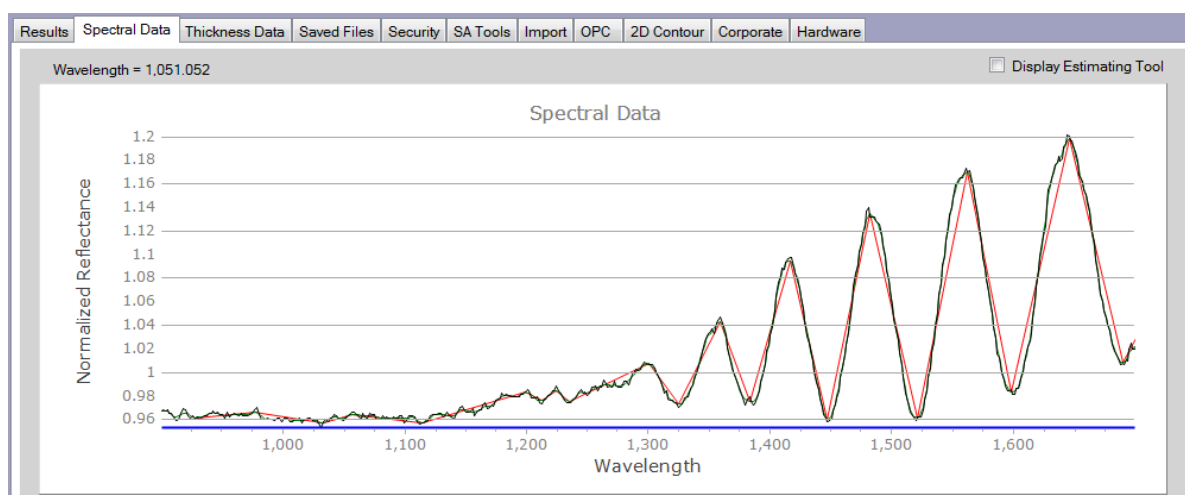


Figure 45 - Wrong Thickness reading

Below is the Thickness graph that is obtained after evaluating the interference spectrum.

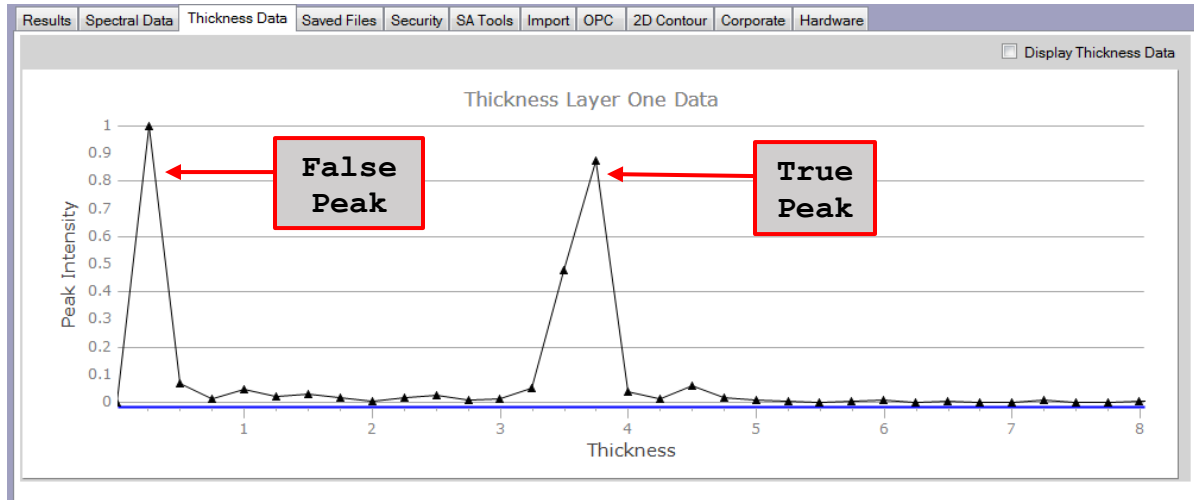


Figure 46 - True vs. False Thickness peak

As in the figure above, there are two Thickness peaks, one is a true peak and one is a false peak generated by the noise. The software automatically selects the strongest peak (peak with higher Y-axis value) as the real peak and reports thickness which is not always true, as in this case.

Procedure for finding approximate thickness and thereby the real peak:

- Click on the peak value of a cycle. λ_1 is automatically populated by the software (1,342.758 nm in Figure 46).

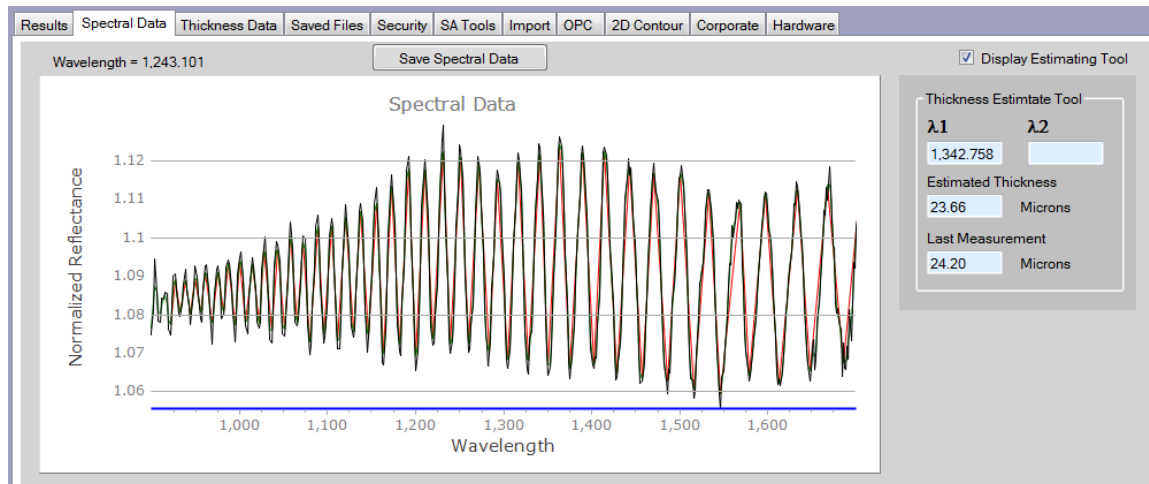


Figure 47 - Wavelength 1

- b. Click on the peak value of the cycle next to the one that was clicked on. **It's important that the second cycle is adjacent to the first cycle and to the right of the first cycle.** λ_2 is automatically populated by the software (1,363.814nm in the example below).

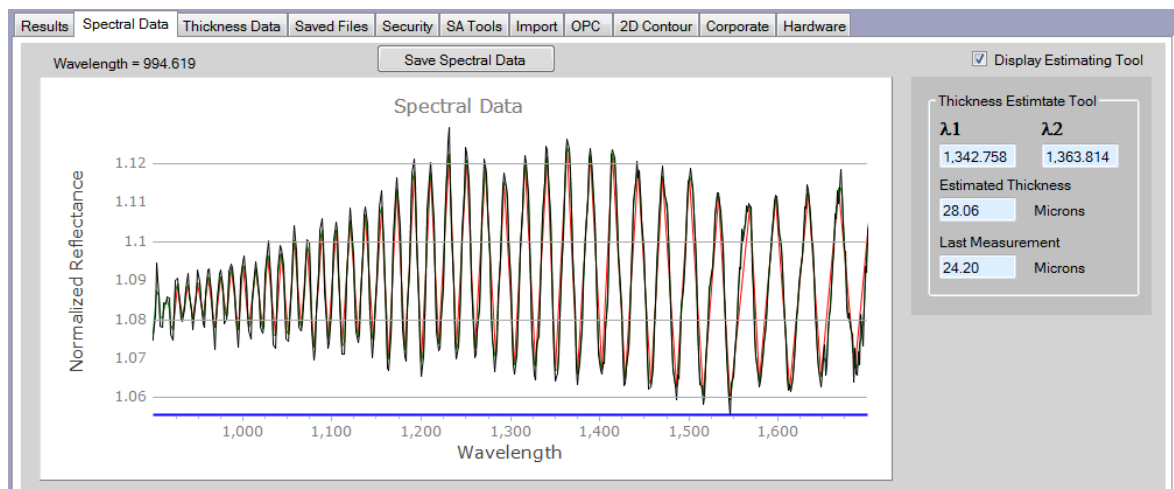


Figure 48 - Wavelength 2

The software automatically calculates the estimated thickness. This is purely an estimate and should be used only to identify the real Thickness peak which will help in fine tuning the thickness range.

Warning Messages and Resolution

High Reflectance Warning:

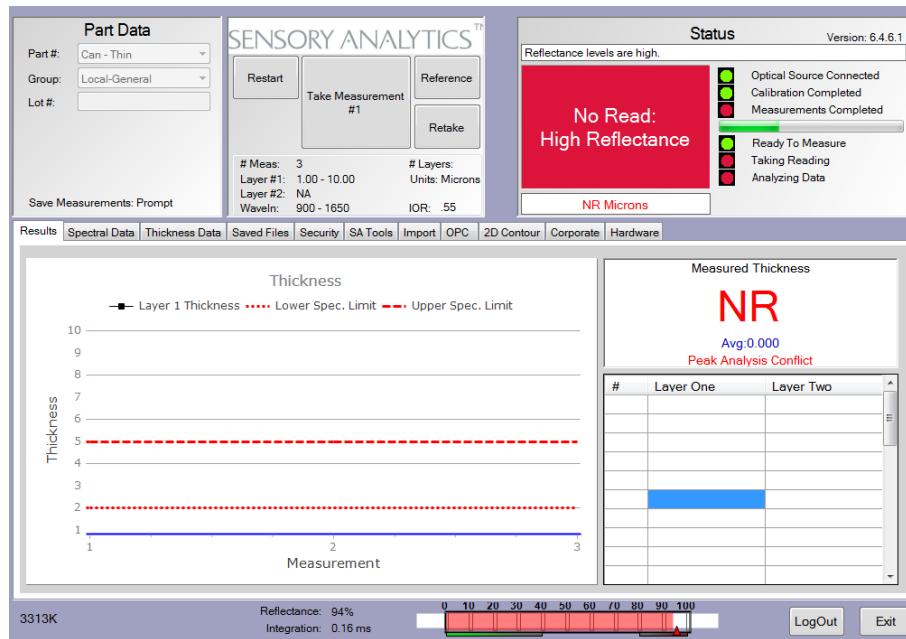


Figure 49 - No Read High Reflectance

The above warning is displayed if the reflectance coming back from the sample is greater than 94%. This will saturate the detectors and will produce erroneous results. To resolve this, the operator can lower the Integration Time or raise the height of the probe which will decrease the reflectance off the sample.

No Read:

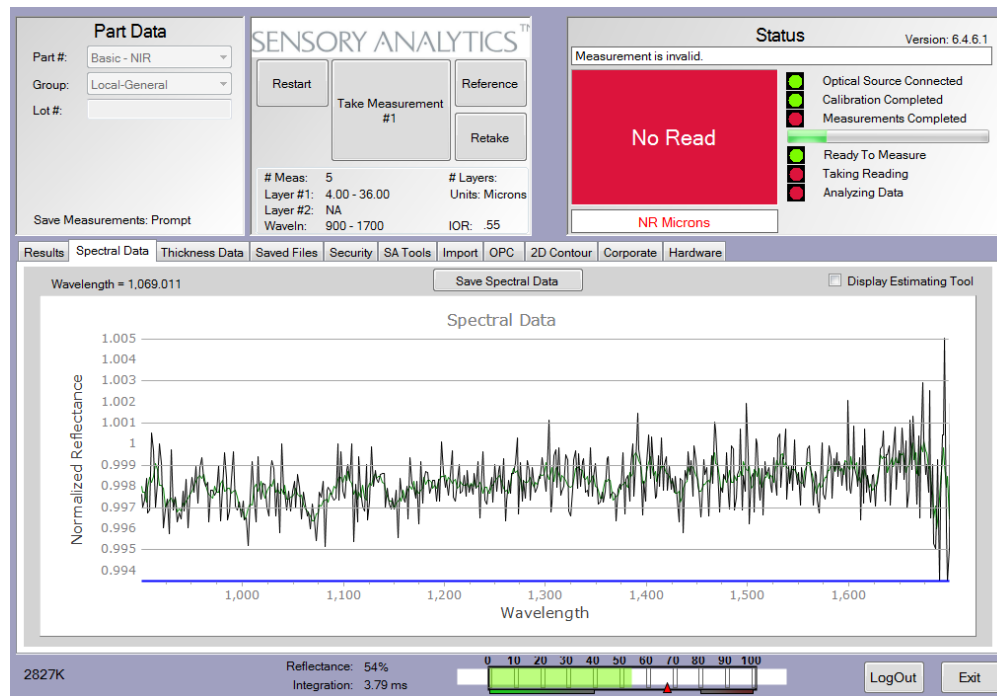


Figure 50 - No Read (NR)

The “No Read” warning is displayed when the quality of the Spectral and Thickness data is not sufficient in generating an accurate measurement. Potential causes could be improper selection of interference evaluation range, no interference on the sample (uncoated), or improper focus of the light beam. To resolve this, adjust the focus of the light beam. Restrict the interference evaluation range to an area where there is good interference and modify the thickness range if needed.

No Read Low Reflectance:

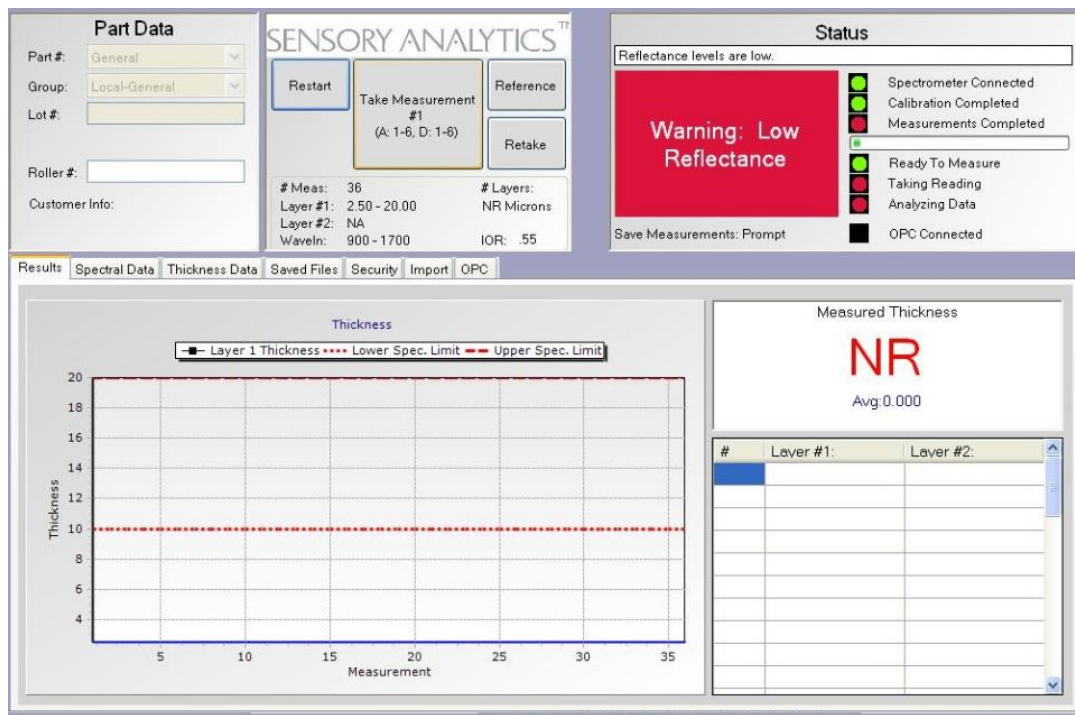


Figure 51 - No Read Low Reflectance

This warning is generated when the amount of reflectance coming back from the surface of the sample is not adequate to take the measurement. To resolve this, make sure the light source is turned on, move the probe closer to the surface of the sample or increase the integration time.

Security

User	User Manager
Admin	Manager

Selected Operator

Security Level

User

User

Supervisor

Manager

Corporate

Add Operator

Delete Operator

Reset Password

Save Operators

☒ Save Operators On Exit

Figure 52 - Security Tab

The Security tab can be used to manage operators and administrative levels of the operators. There are three levels of operators and the accessible features of the software change depending on the level of the operator. Below is a description of distinct levels of operators and the accessible features:

- User:** The Operator has the lowest level of access and will be able to access “Results”, “Spectral Data”, “Thickness Data” and “Contour Map” tabs. The operator can only observe the data but will not be able to modify part parameters or any other configuration settings.
- Manager:** The Manager has the next highest level of access and the Manager level will have additional access to *Part Info* tab.
- Administrator:** The Administrator has the highest level of access and will have access to all available tabs.

New operators can be added and existing operators can be deleted under the Security tab. The operator can choose a password at the first login.

Loading Saved Measurement Data

The reflectance data can be saved by clicking on “Save Spectral Data” under *Spectral Data* tab. The data will be saved in the current working directory. To replay the saved measurements, click on *Saved Files* tab and set diagnostic saved path to the directory where the files are saved.

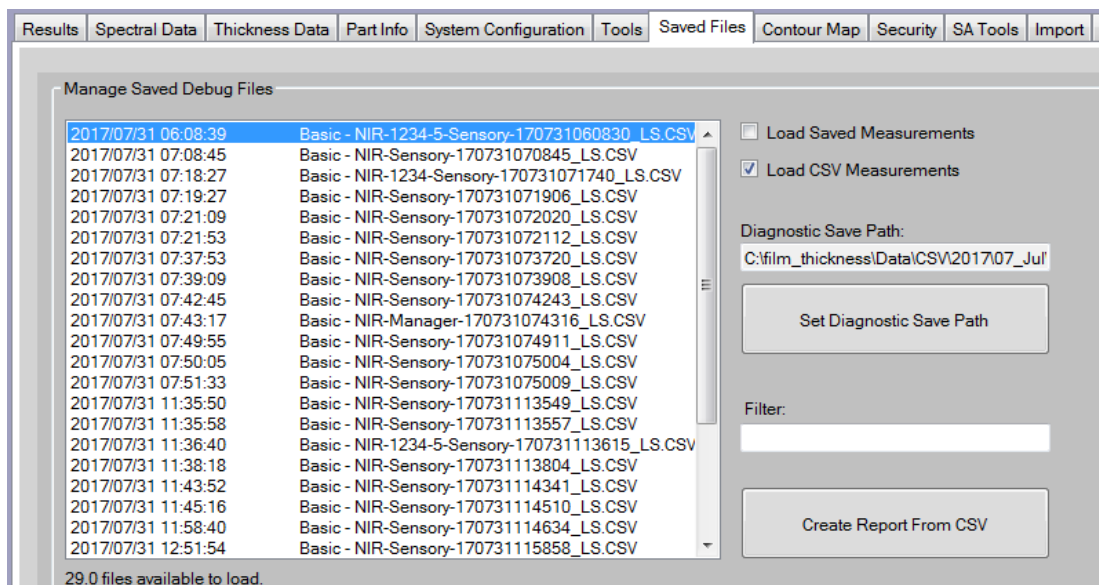


Figure 53 – Loading saved data (CSV files)

Once the directory has been selected, all the saved .SAD files will be displayed in the left side panel as shown above. Select the desired file to be displayed and click on “*Select Highlighted Files*” button.

The software will report the number of files selected and at this point the check box besides *Load Saved Measurements* should be clicked and click on the green “Load” button to start loading the saved files.

Contour Map

Contour map is a topographical map that is generated by the software. It is color coded with the legend displayed on the right.

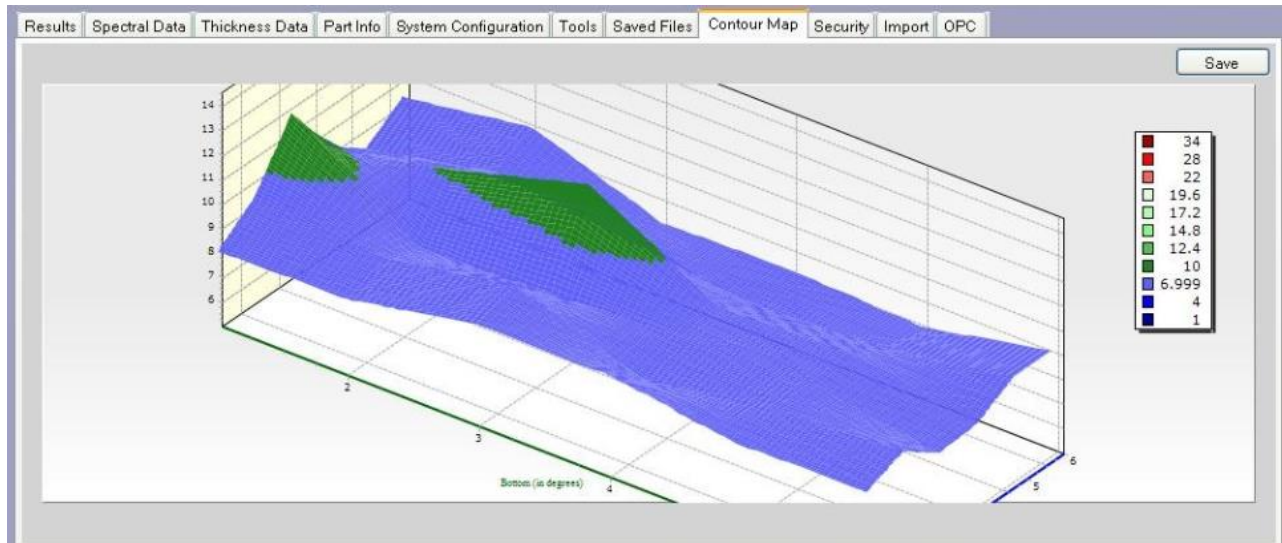


Figure 54 - 3D Contour Map

Backing Up Data

Some key software files and the measurement reports can be backed up periodically to another machine so that the user will not lose measurement data, operator information, and part parameters for various part recipes. The following procedure can be followed to back up the data periodically:

- Click on My Computer on the desktop
- Click on “Local Disk C:” drive
- Double click on the folder named “film_thickness”
- Copy all the report files. (Note that if the user has chosen a different directory to save report files copy the files from that directory instead) into a backup media of choice.
- Copy the following files “PartInfolist.xml”, “operatorlist.xml”, “MeasurementPlans.xml” and “UnitsofMeasure.xml”. These files contain the part information, operator information, measurement plans information and information about units of measurement.

SpecMetrix® On-Line Support

To facilitate with any technical support needs that may arise, the *SpecMetrix®* unit includes provisions to connect remotely with support personnel at Sensory Analytics via the “TeamViewer” program. If the unit has an internet connection, establishing a remote connection with Sensory Analytics can be achieved by double clicking on the Team Viewer Support icon located on the desktop or in the SA Menu as shown below:



Figure 55 –
Team Viewer
icon

Clicking this icon will result in a pop-up window opening as shown below:

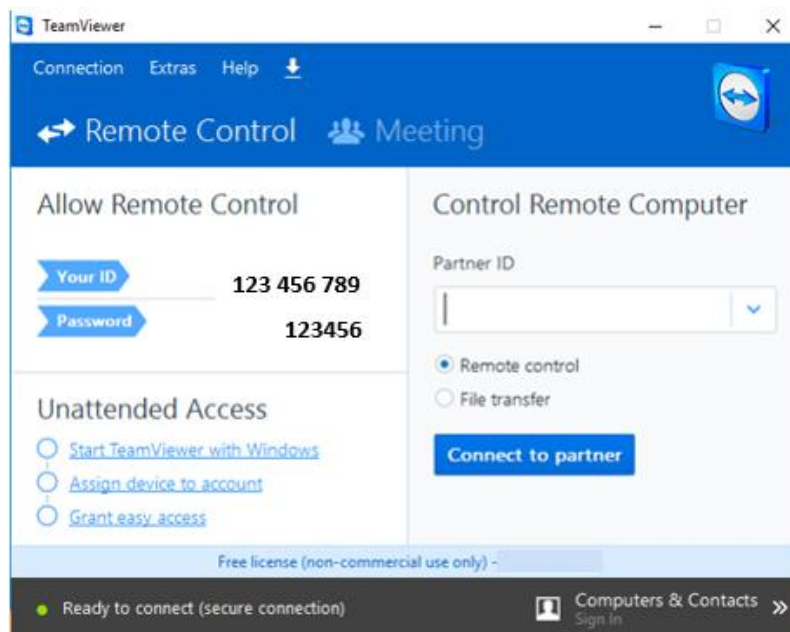


Figure 56 – Team Viewer Support Window

It is then necessary to contact Sensory Analytics with the 9-digit ID # as it appears in the Team Viewer Support window. This will allow the technical staff to remotely access the unit to assist with any operational needs.

We trust that the above information will be sufficient to meet your training and troubleshooting needs. However, in the unlikely case of any difficulties encountered in the operation of the SpecMetrix® software package, please contact your area representative for immediate service, or contact SpecMetrix® Technical Support at:

(336) 315-6090 or support@specmetrix.com