spec METRIX

SpecMetrix® Mobile Cart System

SENSORY ANALYTICS™

The Sensory Building
405 Pomona Drive
Greensboro, NC 27407 USA
E-mail: support@specmetrix.com
Website: http://www.specmetrix.com

Table of Contents

Introduction

The *SpecMetrix®* Mobile Cart 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®* Mobile Cart 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 spreadsheet report 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 surface, a portion of the light is reflected from the top surface, while part of the light is transmitted. This transmitted beam will then reach the next interface (either another layer of coating for multi-layer systems, or the substrate for a single-layer coating) at which point reflection will take place again. The resultant beam of light that reaches the fiber optic probe is comprised of a waveform from each reflection point. These superimposed waveforms produce a pattern of constructive and destructive interference fringes, with a frequency that directly corresponds to the absolute thickness of the film or coating.
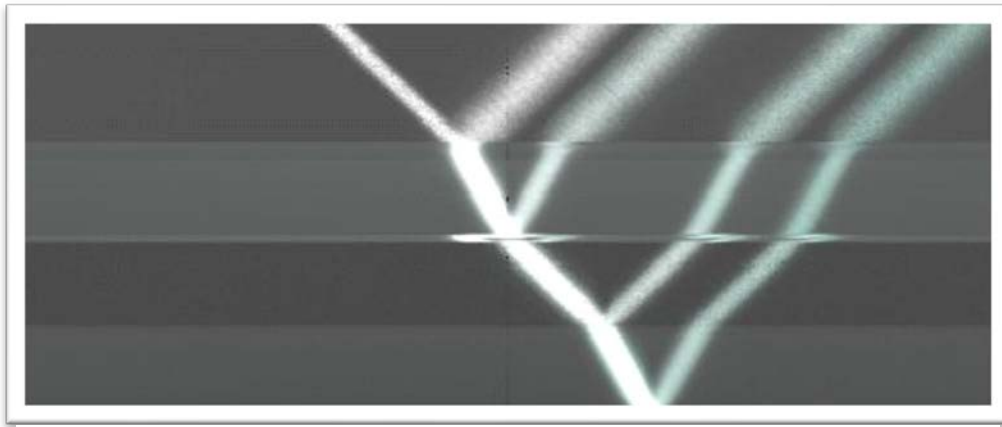

Figure 1 – *Light Rays Passing Through Different Layers of the Material*

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 absolute thickness of film or coating applied to the substrate.
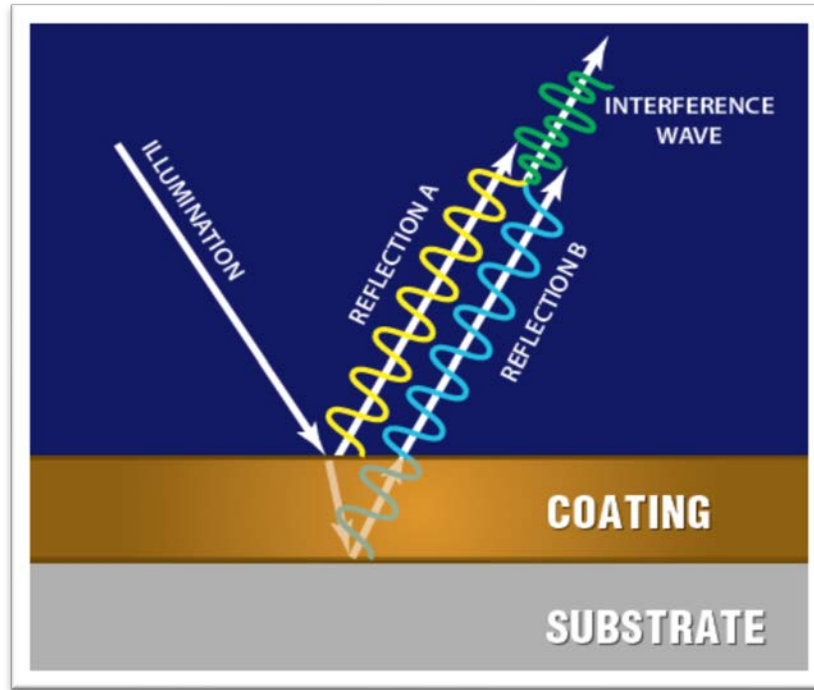
*Figure 2 – **Interference Model***

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® Mobile Cart System

SpecMetrix®: Out of the Box

The *SpecMetrix*® Mobile Cart system includes all the components of a regular lab system along with the necessary hardware components needed for measurement such as an 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 7 platform. Another Windows Software can run from this box just like a standard PC computer.

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

a) *SpecMetrix*® **Unit:**

Figure 3 – SpecMetrix Mark II unit

b) **Keyboard and Mouse**

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.

c) *SpecMetrix*® **Mobile Cart**

d) **Printer** (Optional)

Figure 4 – Self-Referencing Probe

     The Self-Referencing fiber optic probe has three legs with SMA-905 ferrules. The Read Fiber connects to optical detector (labeled Vis or NIR), and the other two legs connect to *Light Source 1* and *Light Source 2* respectively.

Figure 5 – Mark II Probe Side

     Illustrates all connections available for the SpecMetrix® unit. Depending on the specified unit configuration not all these connections may be present.

Quick Start Guide

1. Connect the probe 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 be connected to the optical source that is best suited for the application (refer to section entitled *Selecting the Proper Optical Package* for more on optical source selection). The *SpecMetrix*® software should also be set to receive data from the appropriate optical package. This selection is made in the *System Configurations* tab in the box labeled *Optical Source Options*.
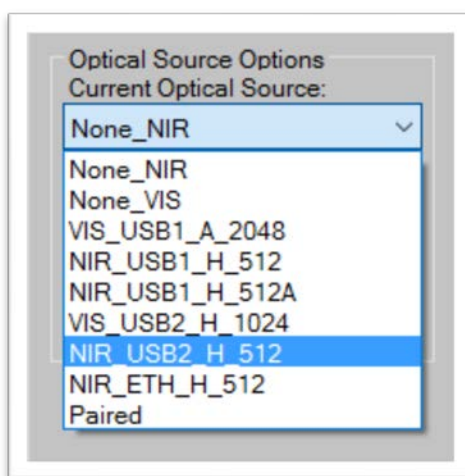

Figure 6 – Optical Source Options

2. Adjust the probe to be approximately 5mm above the sample. The probe separation distance is optimized when the beam of incident tightly focused into a crisp beam. For highly reflective surfaces this may saturate the detector, in which case a message will be displayed in the software advising that reflectance is too high.

3. Select the *Part Info* tab.

4. Select a pre-defined measurement recipe from the drop-down list entitled *Part #* in the upper-left corner of the screen. If a recipe has not yet been established for the coating of interest then choose a generalized recipe and adjust the thickness min and max values, along with the upper and lower specification control limits accordingly. Rename the recipe to avoid overwriting the original, and save it by clicking on the *Update Part* button. (Note: Transferring developing a coating recipe from generic

parameters will generally work well when measuring in units of absolute thickness. If surface density units to measure coat-weight are required then coating data will need to be entered to calculate an accurate conversion factor)

5. Select the tools menu and ensure that *Peak Analysis* is selected (further explanation of this feature is provided in the subsection entitled *Peak Analysis*).

6. Select the *System Configuration* tab and check that *Auto Integration Time* option is selected. *Integration time* is the amount of time that the sensor is exposed to the light signal, like exposure time for cameras. With Auto Integration Time enabled, the system will automatically compensate for the reflectivity of various samples. With this feature enabled it is not necessary to adjust the probe height for optimal reflectance unless the system warns that the reflectance is out of range.
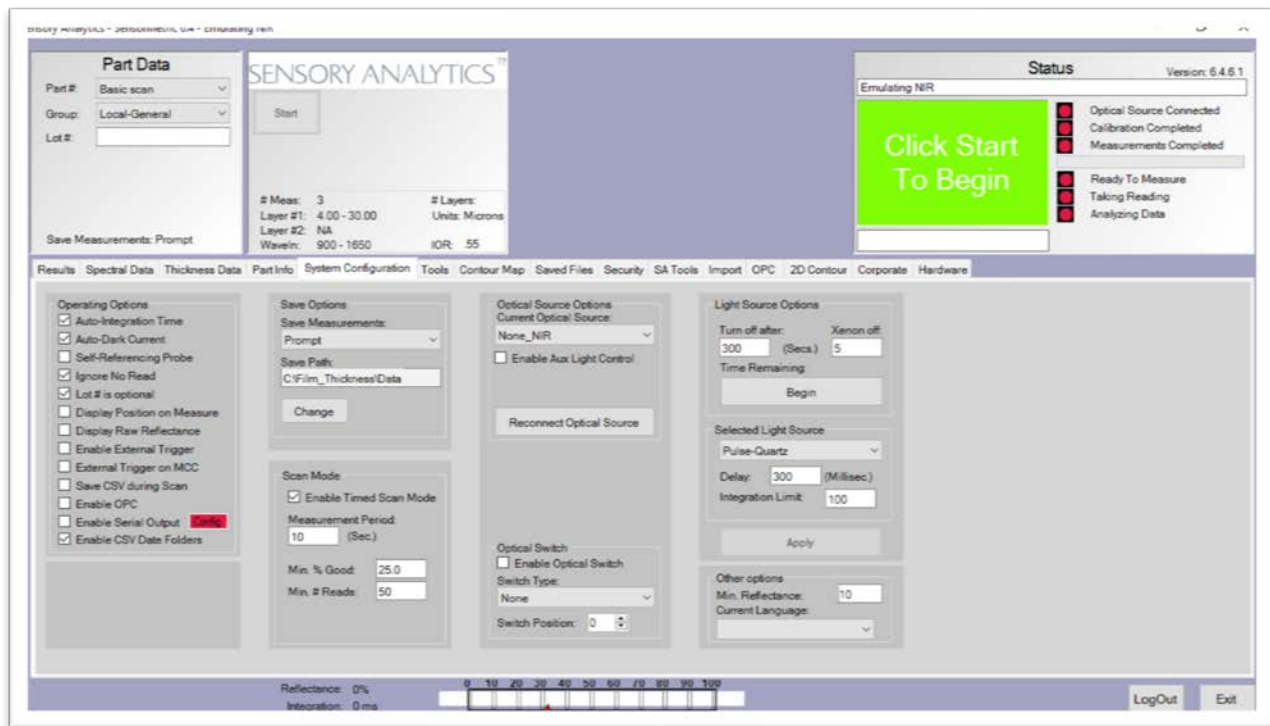
Figure 7 – System Configuration Options

Operating Options in the System Configuration menu.

7. 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.

8. 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.

9. 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.

10. 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.

11. 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.

12. The section entitled *Identifying Interference Evaluation Range* explains how to select the correct wavelength range such that the interference pattern is can be evaluated with minimal extraneous signal noise. The part info for your measurement recipe should be set accordingly and saved.

13. 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 to isolate the layer of interest. This will be discussed in further detail in the following sections.

Setting up Measurement Recipe Parameters

***Selecting the Proper Optical Package*:**
While some *SpecMetrix®* systems will not require two optical sensors, others may be equipped with both NIR (near-infrared) and Vis (visible). The user 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:

Vis (Visible): The Visible optical package analyzes interference data from in the 400-1000 nm wavelength 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 base layer. 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.

NIR (Near-Infrared): The NIR optical package analyzes interference data from the 900-1700nm wavelength 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 earlier.

Setting up Part Parameters (measurement recipes)

To update/add part parameter information, additional fields are provided in the tab labeled "Part Info" (refer to figure below). All the part parameters can be updated in these fields and upon clicking "Update Part Info", the new parameters will be updated. Following is an explanation of each field under "Part Info" tab.
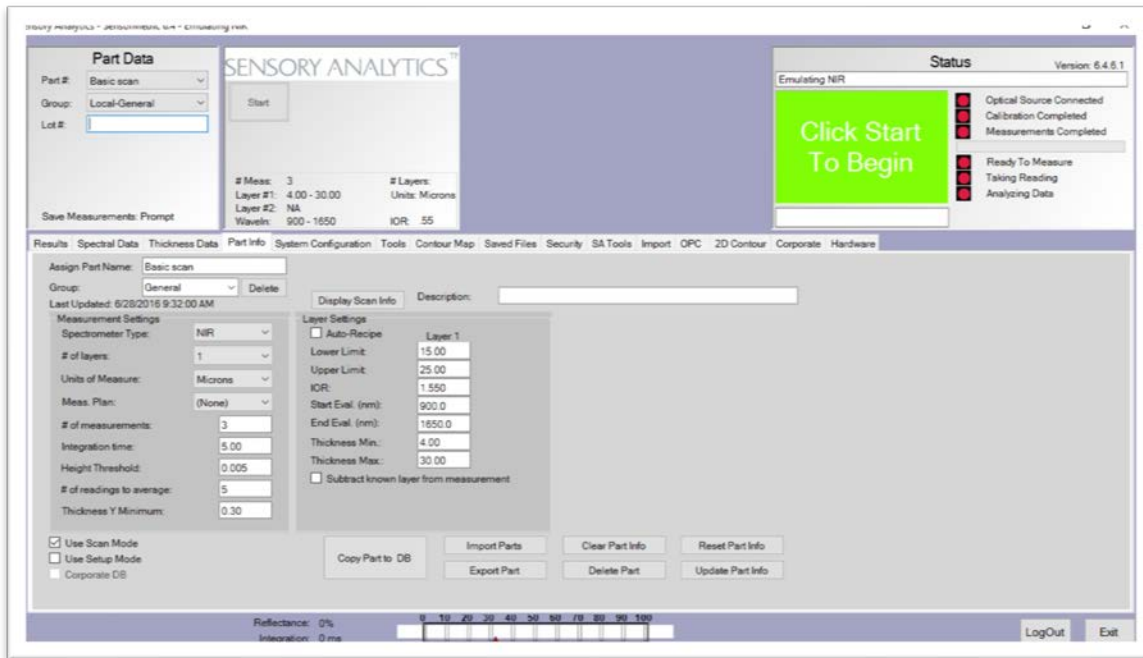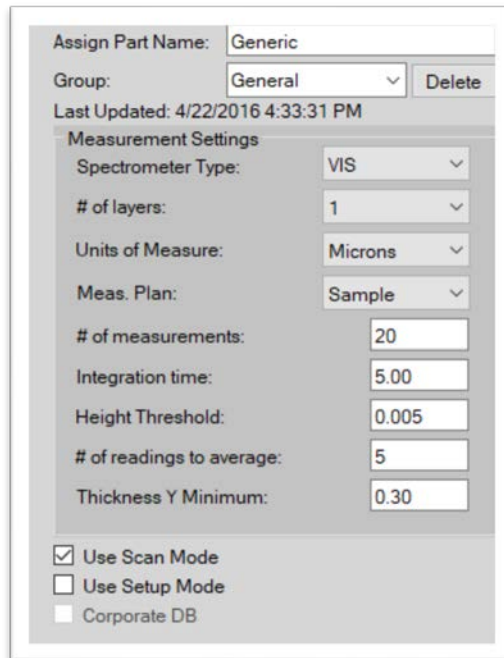

Figure 8 – Part Info

Use Setup Mode: *"Setup Mode" is used while experimenting with parameter adjustments 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, for instance, 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:

Figure 9 – 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. (<u>Note</u>: If the name of the part is altered, then upon saving a new part file will be generated rather than replacing the previous settings)
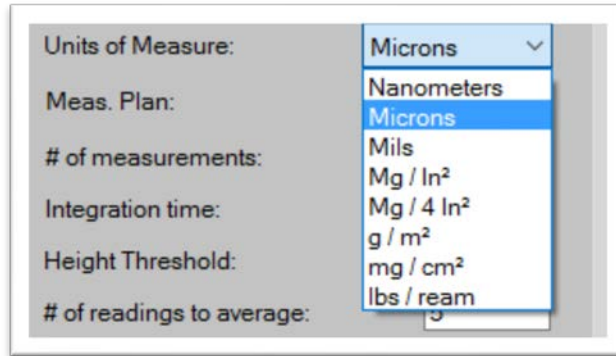
Assign Group Name: This field is mainly useful for Part organization. If the number of part recipes becomes excessive then the drop-down menu for Part Name becomes overpopulated making it difficult to find the right part. To alleviate this problem a set of parts with some similar characteristics can be organized into one ***Group***. A ***Group*** for Part Names is like a folder for files.

# of Layers:

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:

Figure 10 – Measurement Units drop-down

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, g/cm²,* and *lbs/ream*. 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-Density Conversion Data:

Figure 11 – Thickness-to-Density Conversion Data

The "*Thickness-To-Density Conversion*" panel will be enabled **only** if surface density units are selected (*mg/in², mg/4in², g/m², g/cm²,* and *lbs/ream).* 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/4in²).*

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:

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. A report file cannot be generated until this number of measurements is satisfied.

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: 2
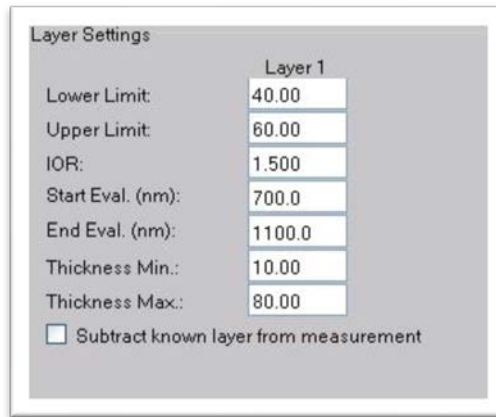
Integration Time is the time in milliseconds used to sample the optical package detector array once. Sensitivity of the instrument is directly proportional to the integration time. For a highly reflective sample, integration time should usually be low to avoid saturating the detector, whereas for a sample 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. When Automatic Integration Time is enabled then this value will be adjusted.

Height Threshold: Height Threshold: 0.01

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.

Layer Settings:

Figure 12 – 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   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 (more on this topic later).

End Evaluation

| End Eval. at: | 1050.0 |

This is the ending wavelength for the interference evaluation range. Again, this should be chosen as close to the end of interference modulation range as possible (more explanation is given in the following section).

Thickness minimum

| Thickness Min.: | 3.00 |

This parameter determines the thinnest layer 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.
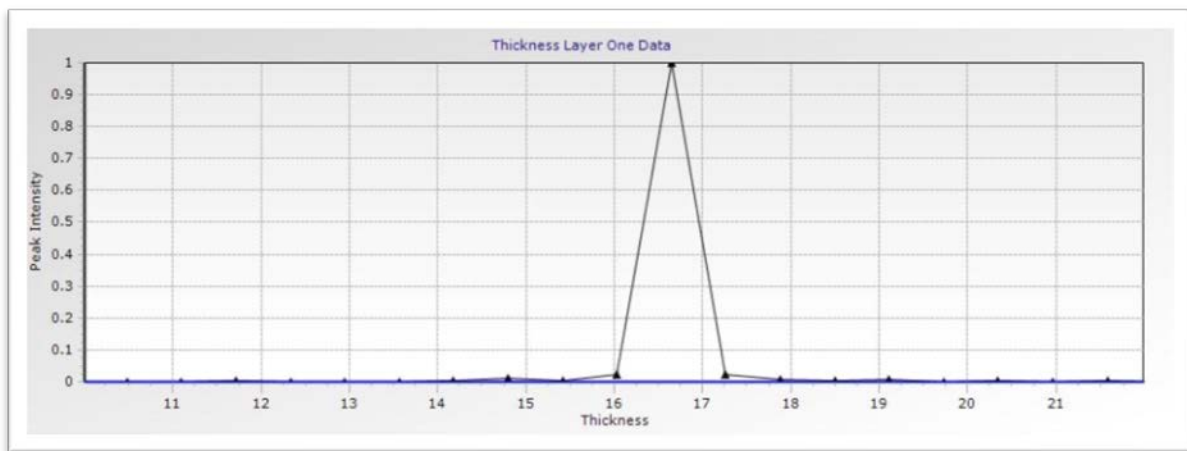
Easily Recognizable Thickness Peak Example:

Figure 13 – Thickness Peak (Easy)

The Thickness peak in the above figure 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*:*
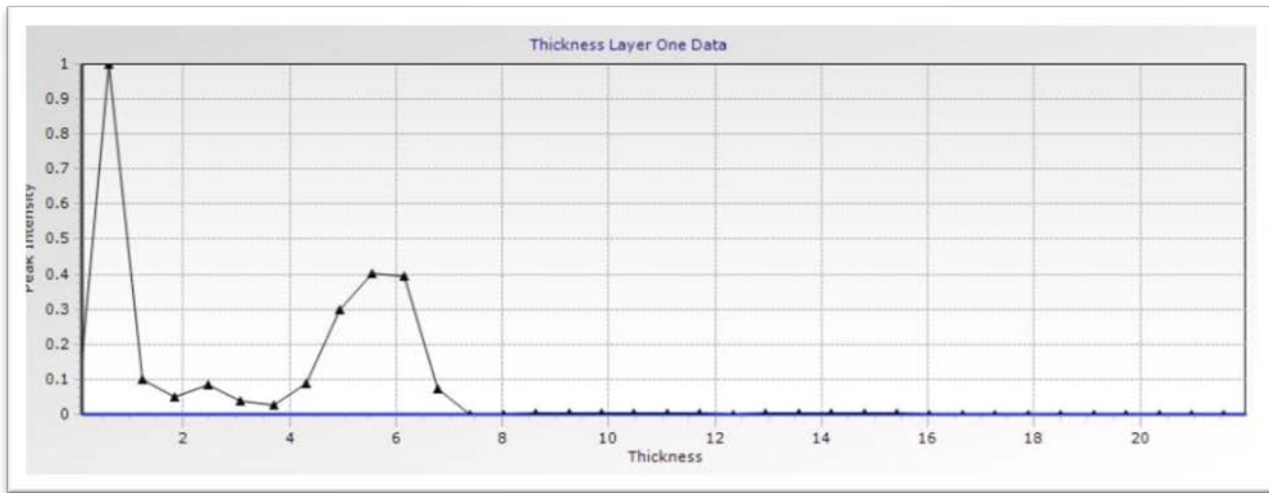
Figure 14 - False Thickness

The above *Thickness Data* graph is for a 5.63µm coating sample. The lower thickness limit or thickness minimum was chosen as 0.3µm 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 do not have an expected layer thickness in the nanometric range.*

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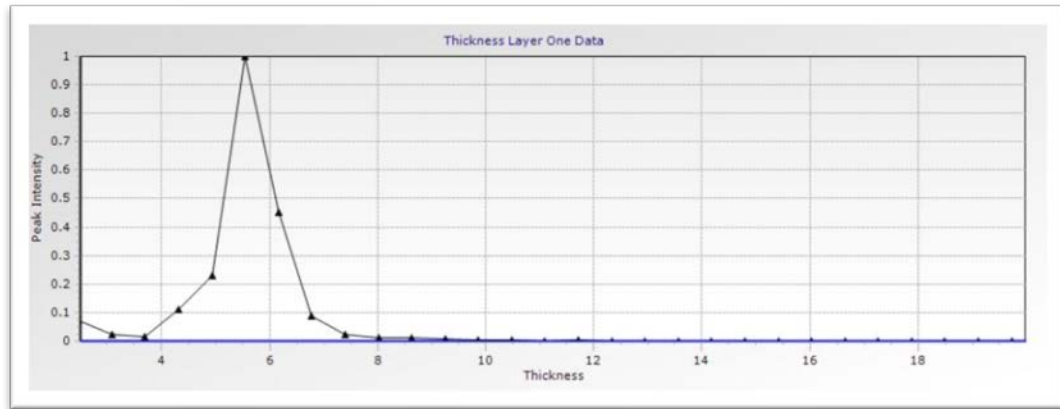

Figure 15 – Thickness Peak(Adjusted)

Thickness maximum   Thickness Max.:   25.00

This parameter determines the thickest layer 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.

Export Part: 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: Import Parts

This can be used to import a 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 900nm to 1650nm)*. For optimal results, the interference evaluation range should 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 900nm and 1650 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
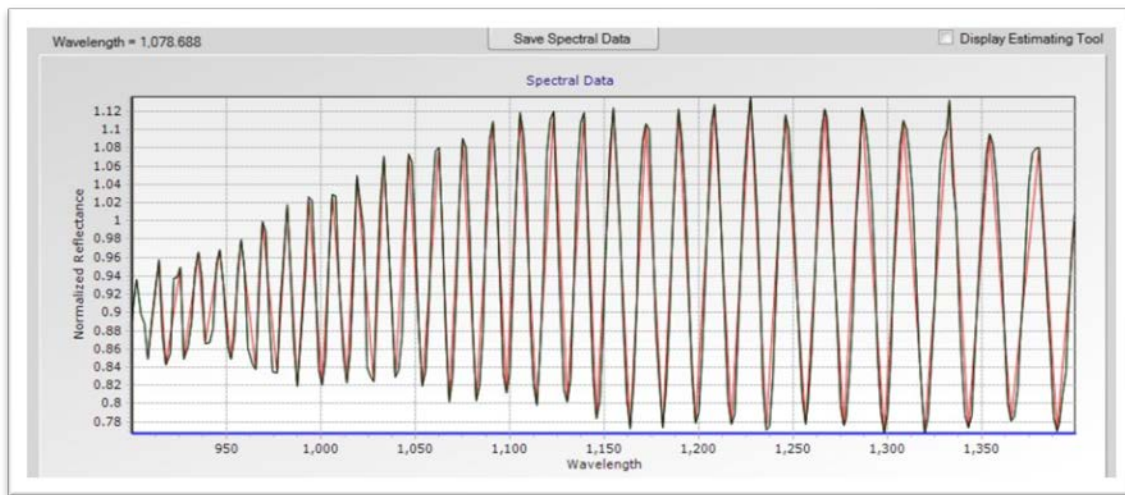
Figure 16 – Interference Pattern (Recognizable)

Interference is good over the entire range of NIR (900nm and 1650 nm).

Slightly Complex Interference Spectrum
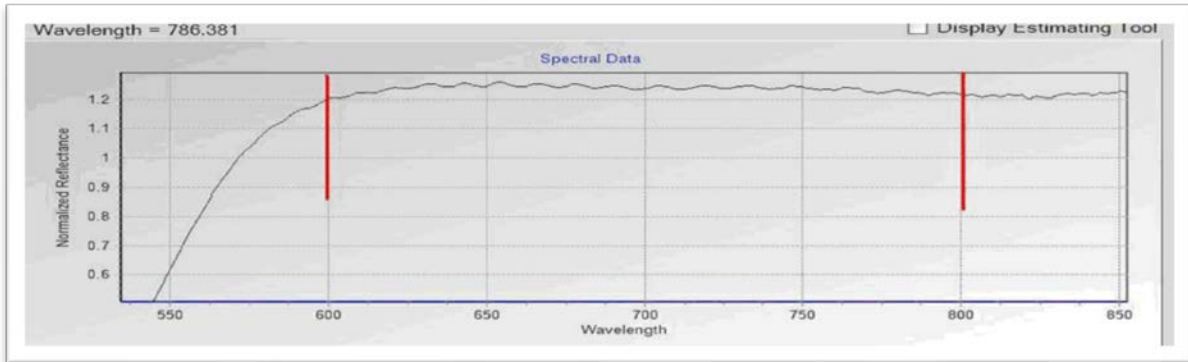
Figure 17 - Interference Pattern (Slightly Complex)

Interference is between 600nm and 800 nm.

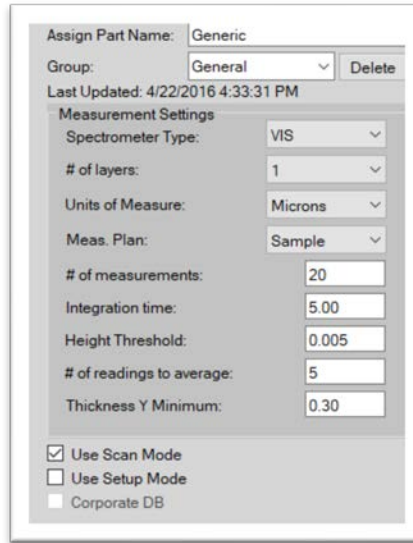### *More Complex Interference Spectrum*
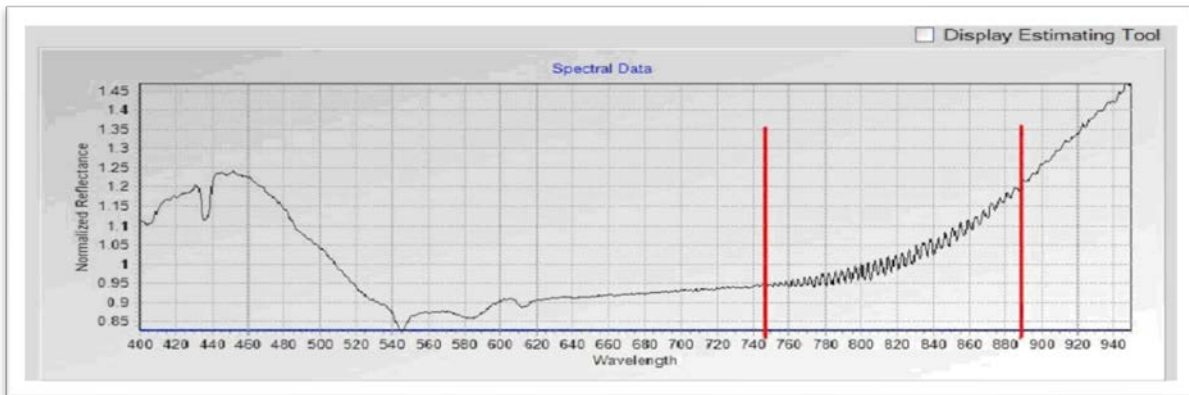
Figure 18 - Interference Pattern (More complex)

Interference is between 745nm and 875nm approximately.

Adding new part information:

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 on the next page. 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.

Figure 19 – Part Info

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.

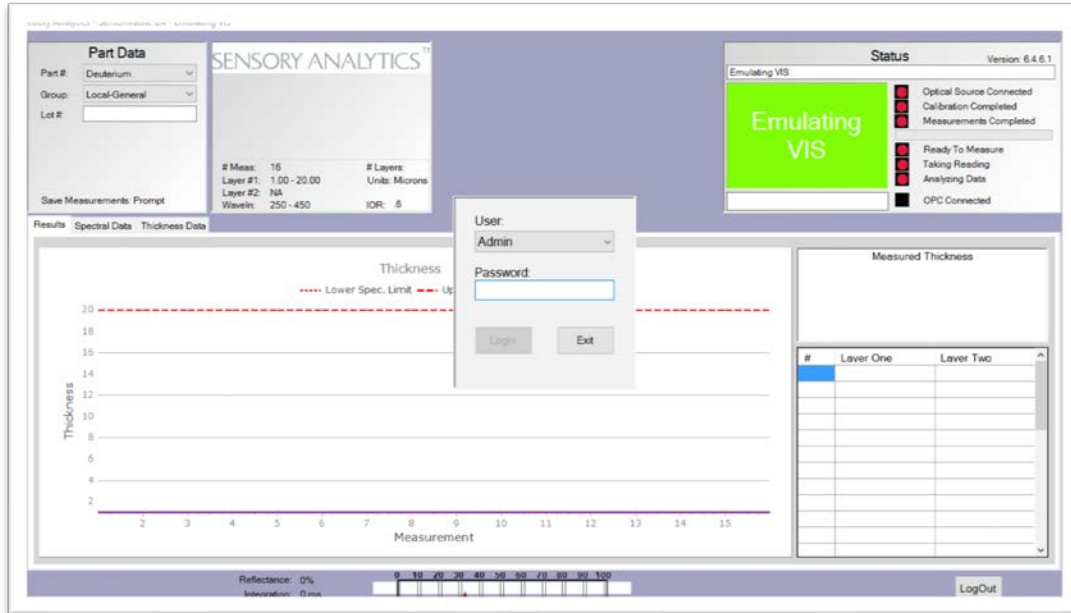The operator name will be part of the file name used to store the report file.

Figure 20 – User Login

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).

   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.

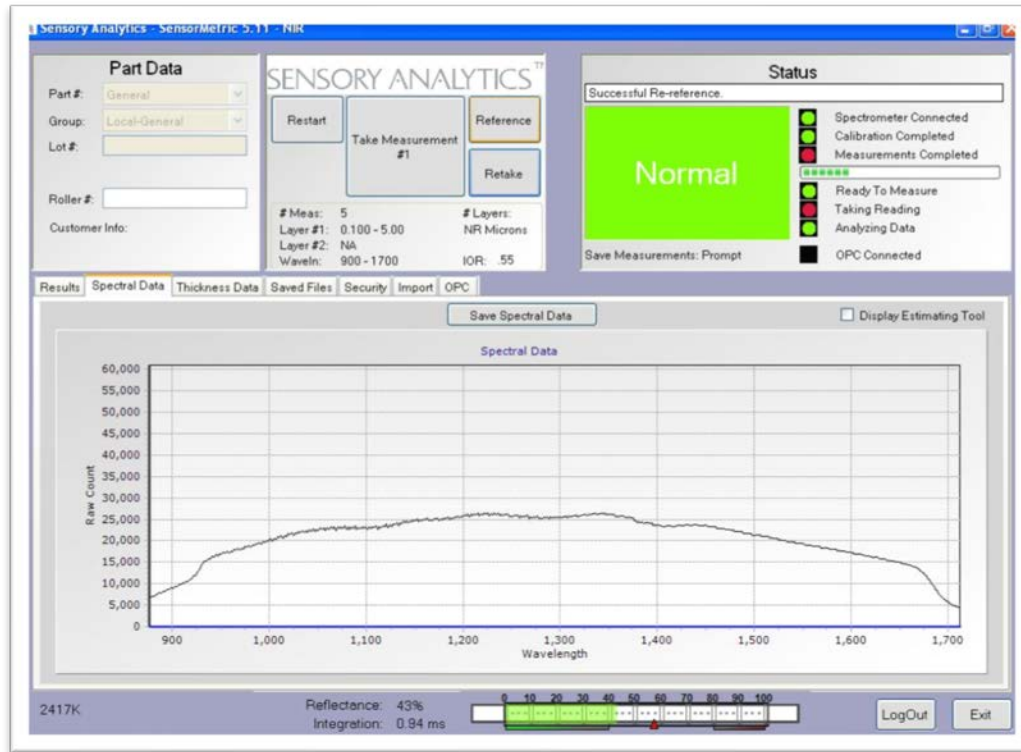The figure below shows how a reference measurement typically looks on the *Spectral Data* tab:

Figure 21 – Spectral Data

Replace the reference sample with the actual sample that must 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.

f) Continue taking measurements until the all of measurements for that specific part have been completed.

g) Spectral data (interference data) can be seen by clicking on the *Spectral Data* tab. Similarly, Thickness graph can be observed under *Thickness Data* tab.

h) 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.
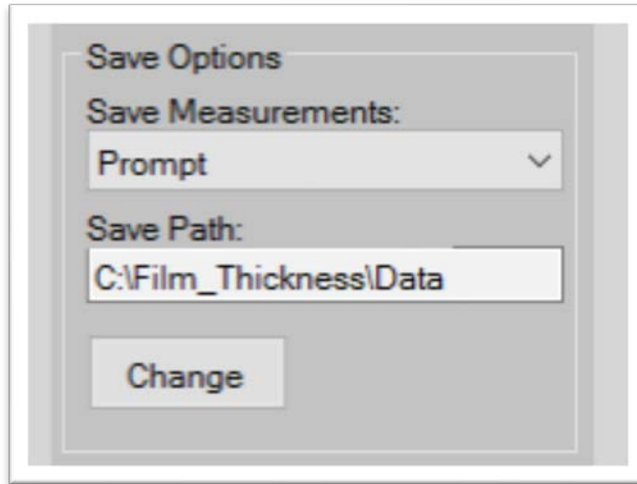
Figure 22 – Save Options

Note: *For default settings, the report file will be stored in C:\film_thickness\Data 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 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.
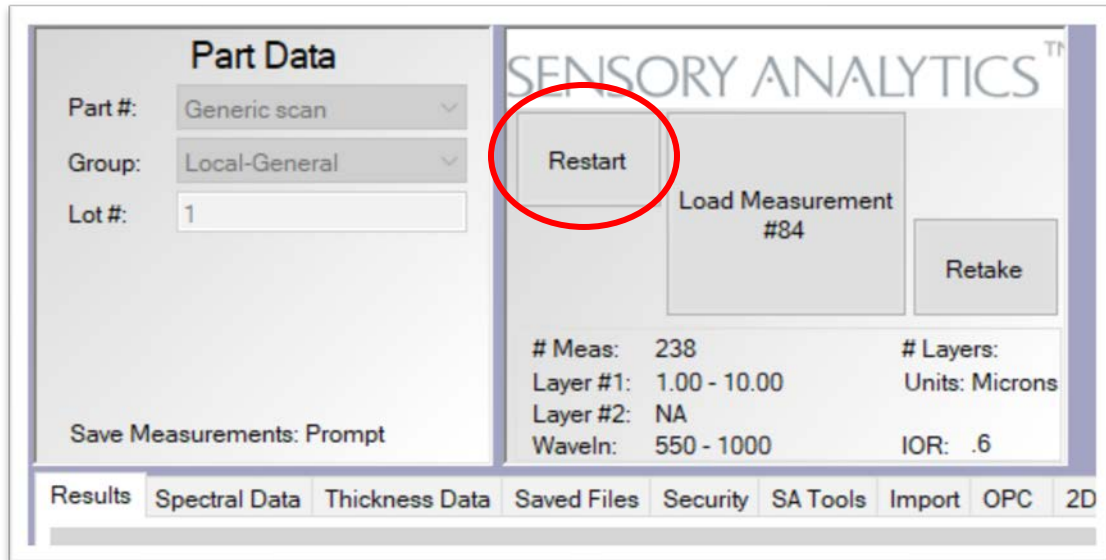
Figure 23 – Restart Button

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

a) 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).

b) 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 Retake Button
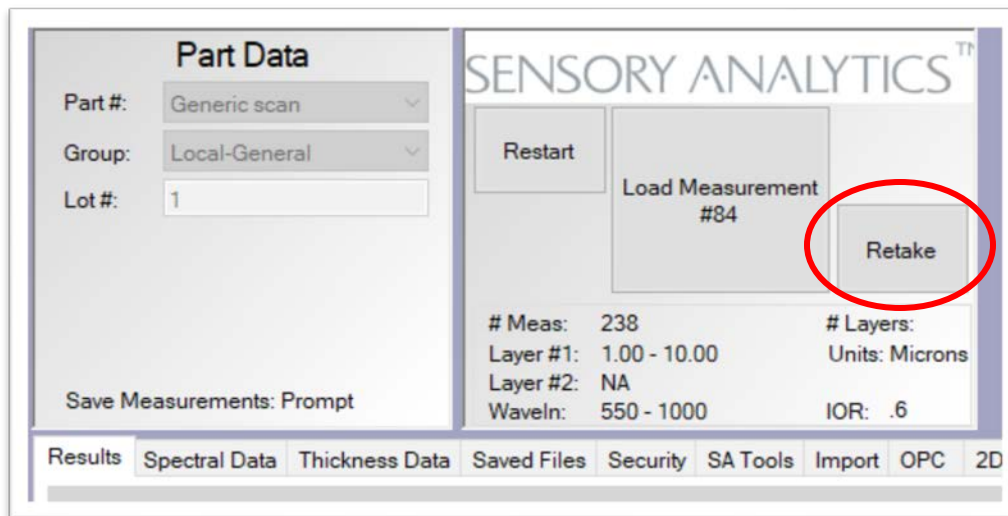
Figure 24 – Retake Button

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.

System Configuration
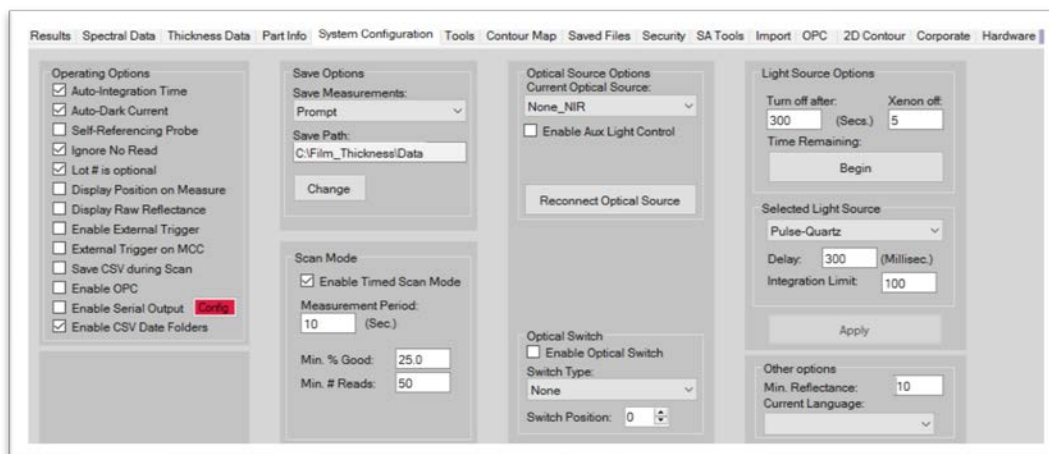
Figure 25 – System Configuration Tab

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.*
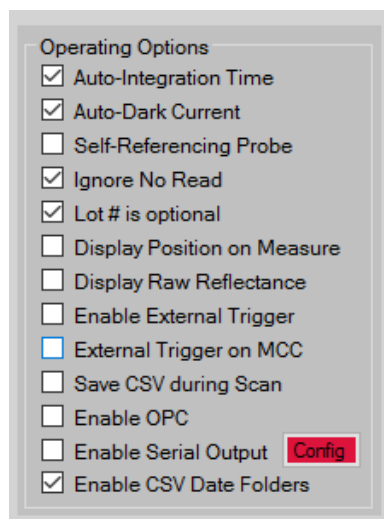
Figure 26 – Operating Options

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 the one on the mobile cart system. When this option is selected, upon pressing the switch, the measurement will be taken by the system without the user clicking on the measurement button on the screen. The 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. See picture below that indicates the switch on the mobile cart.

Figure 27 – External Trigger

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.
 (See Figure 21)

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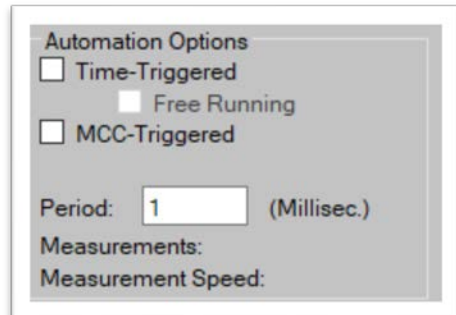
This feature under the *Tools* Tab, can be used to scan and take continuous measurements over a large area on the sample. Measurement period indicates the desired time over which measurements are taken. Min % Good indicates the number of valid measurements within that period and Min # Reads indicates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

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 generally installed before the unit is shipped, these settings are generally pre-configured.

Figure 29 – Light Source Options

Selected Light Source:

     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 "Pulse-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 *Selected Light Source* 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. Generally, of thumb 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.

Thickness Estimate Tool

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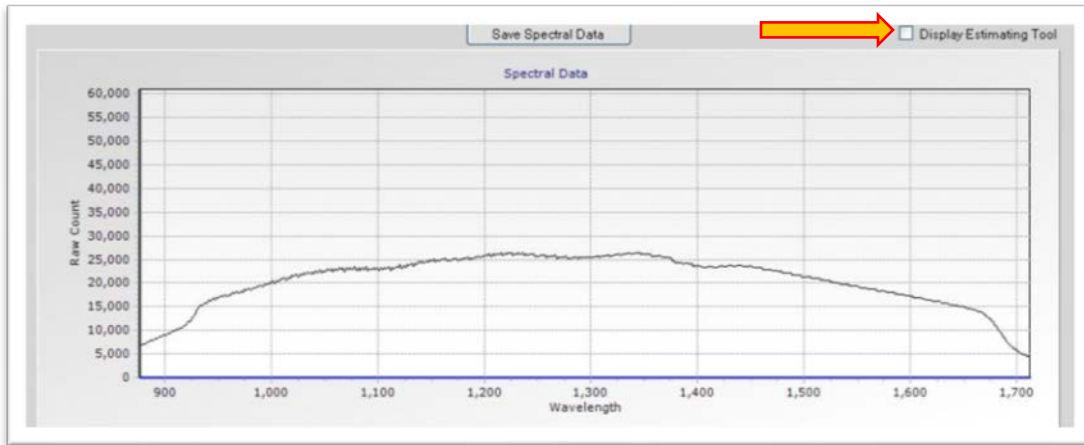

Figure 30 – Thickness Estimate Tool

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.
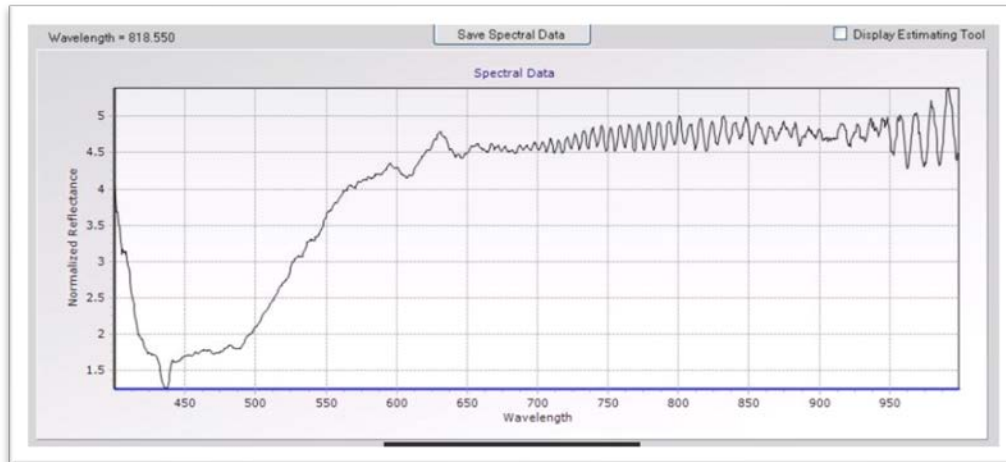
Figure 31 – Thickness Estimate Tool 2

Below is the Thickness graph that is obtained after evaluating the interference spectrum.
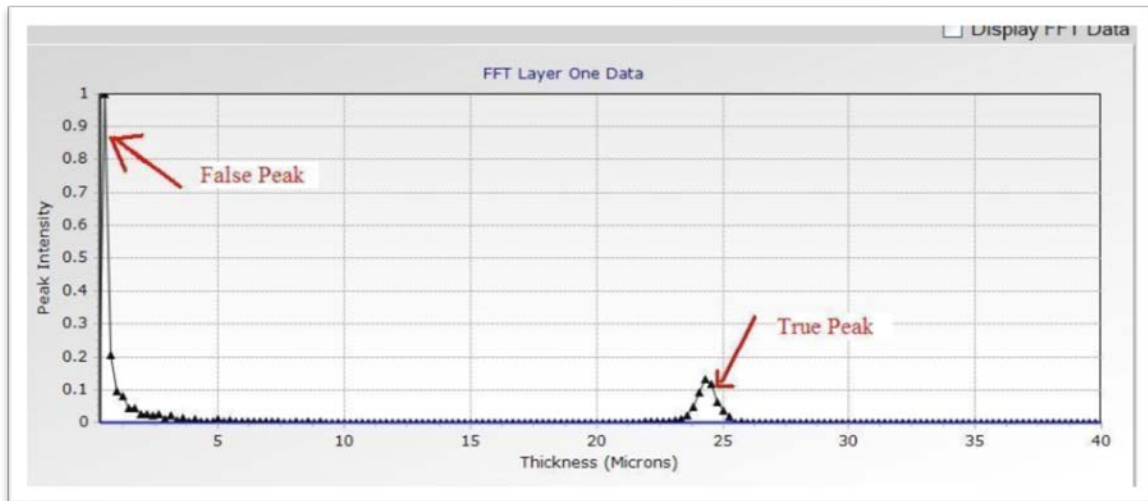
Figure 32 – Interference Spectrum evaluated

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.
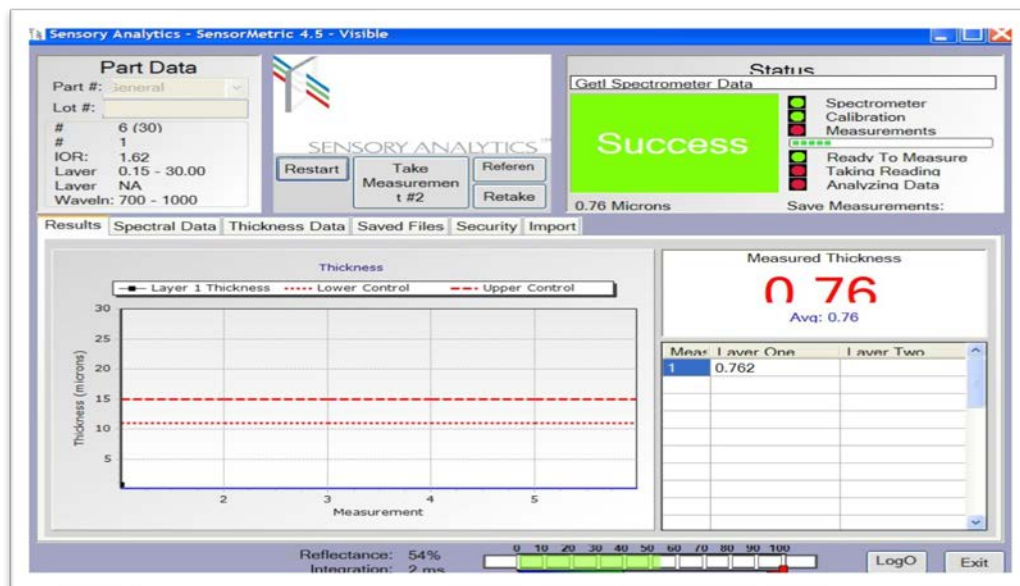

Figure 33 – Measured Thickness

In the above case, the thickness reported by the software is 0.76µm which is incorrect. To determine the correct peak easily, "Display Estimate Tool" can be used.

Procedure for finding approximate thickness:

a. Click on the peak value of a cycle. λ_1 is automatically populated by the software (860.644 nm in the example below).

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 (869.590nm in the example below).
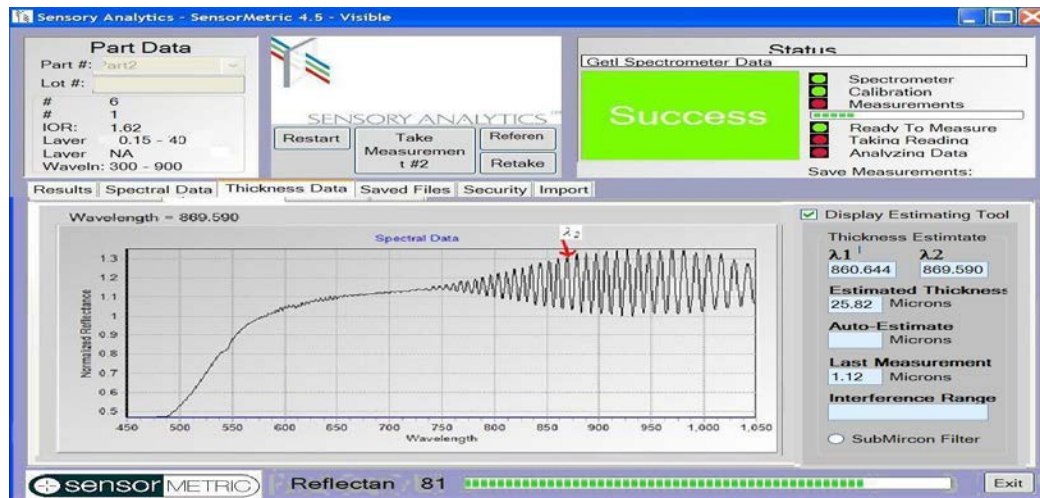
Figure 34 – Estimated Thickness

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.

c. As can be seen from the above screenshot, the Estimated Thickness (25.82µm) is well above the displayed thickness of the last measurement (0.76µm). If the minimum thickness limit "Thickness. Min" is increased from 0.15µ to about 12 µ (under the "part info" tab), the software will ignore the false low thickness and always report the thicker, correct peak. On the next page is the Thickness graph obtained after changing the thickness limits.
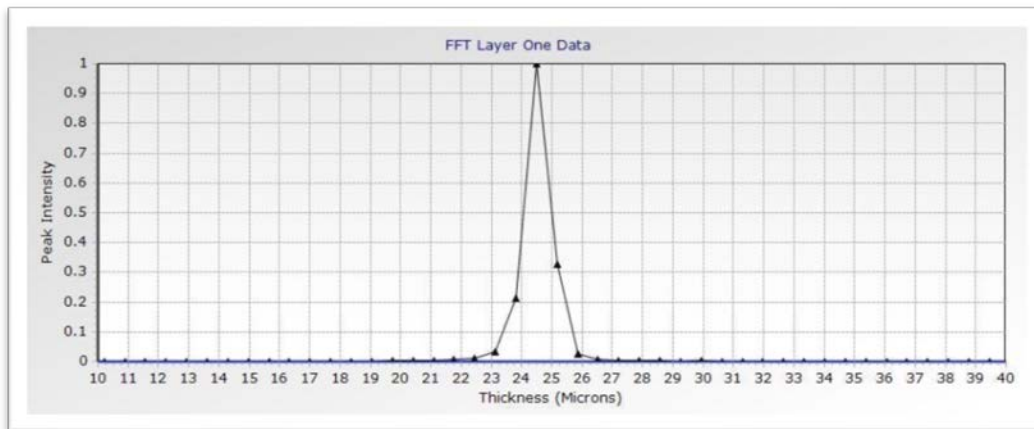
Figure 35 – FFT Layer One Data

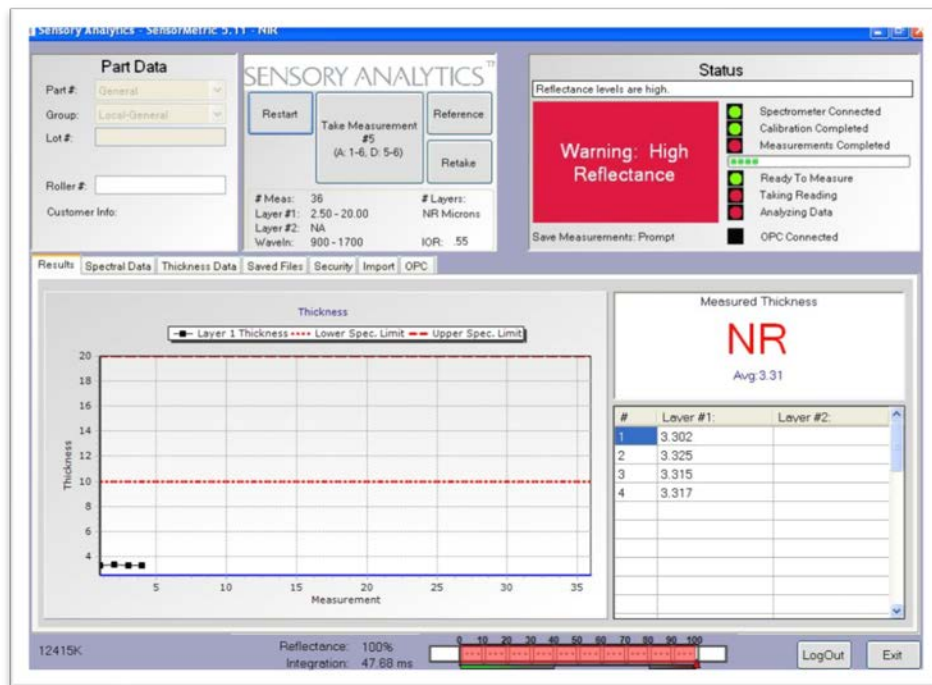# Warning Messages and Resolution:

High Reflectance Warning:

Figure 36 – 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

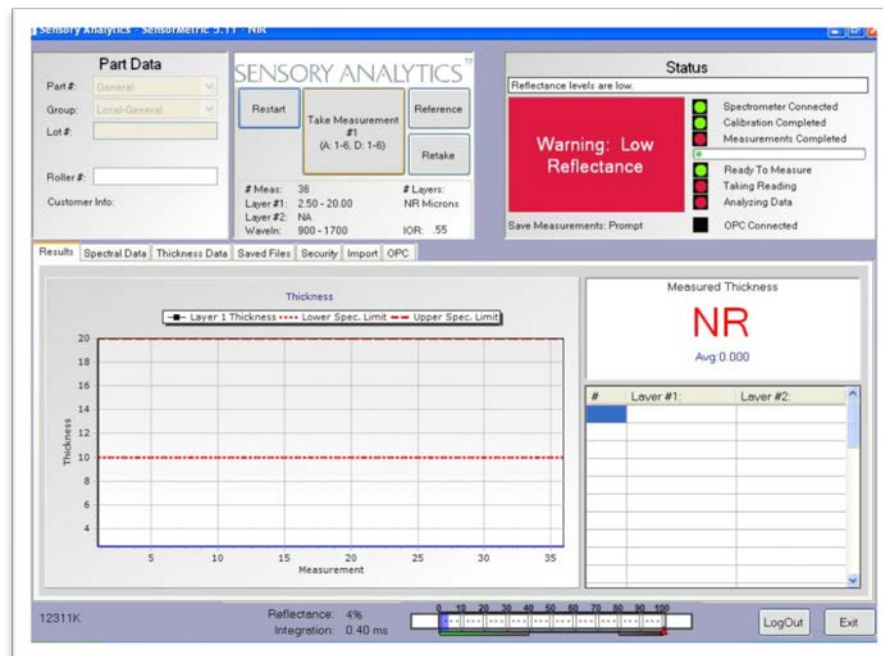this, the operator can lower the Integration Time or raise the height of the probe which will decrease the reflectance off the sample.

No Read:

Figure 15 – 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. Probable 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 38 – No Read No 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.

Tools
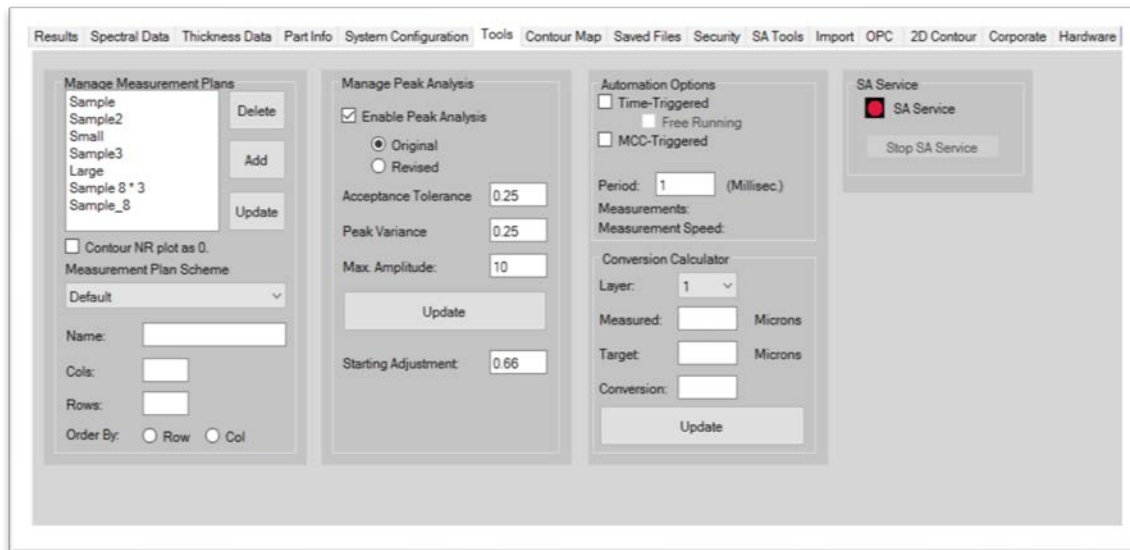
Figure 39 – Tools Tab

Measurement Plan Scheme:
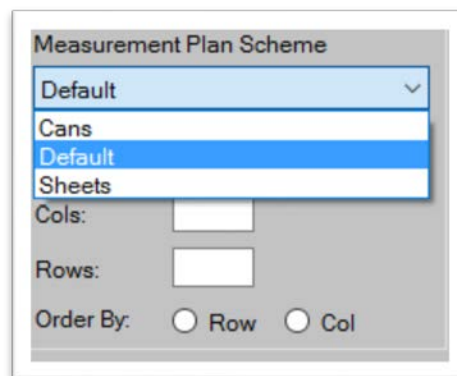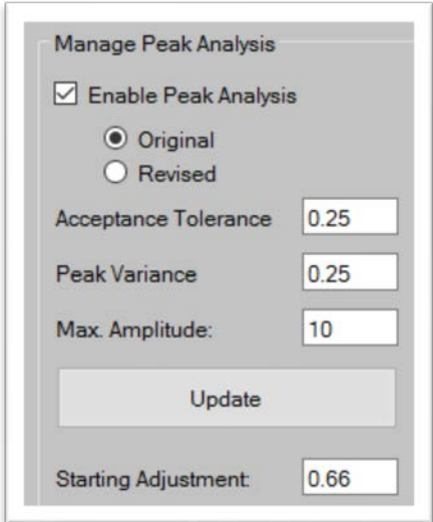
Figure 40 – Measurement Plan Scheme

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 12 locations on a beverage can, 3 around and 4 down, then the measurement plan can be setup with a 3X4 matrix as shown in the example in the screen shot above).

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 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

Figure 41 – Peak Analysis

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:
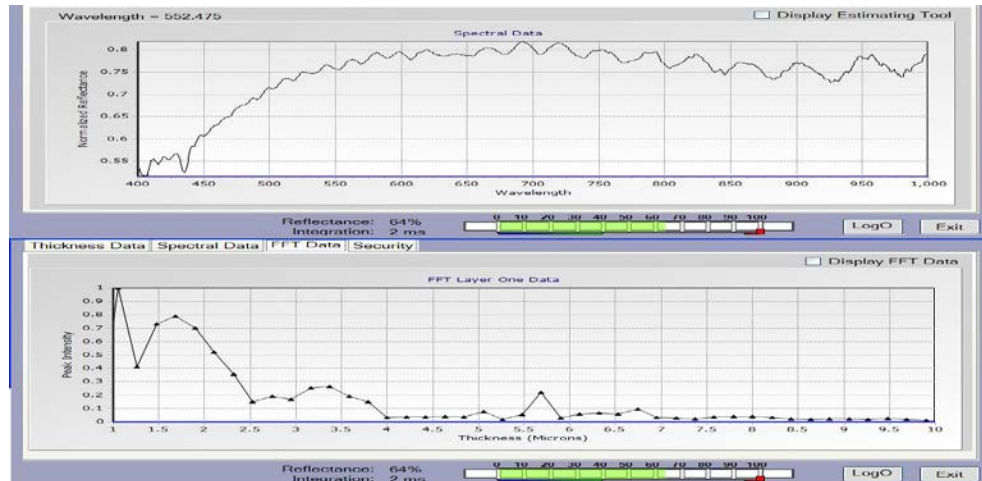

Figure 42 – Without PA

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:
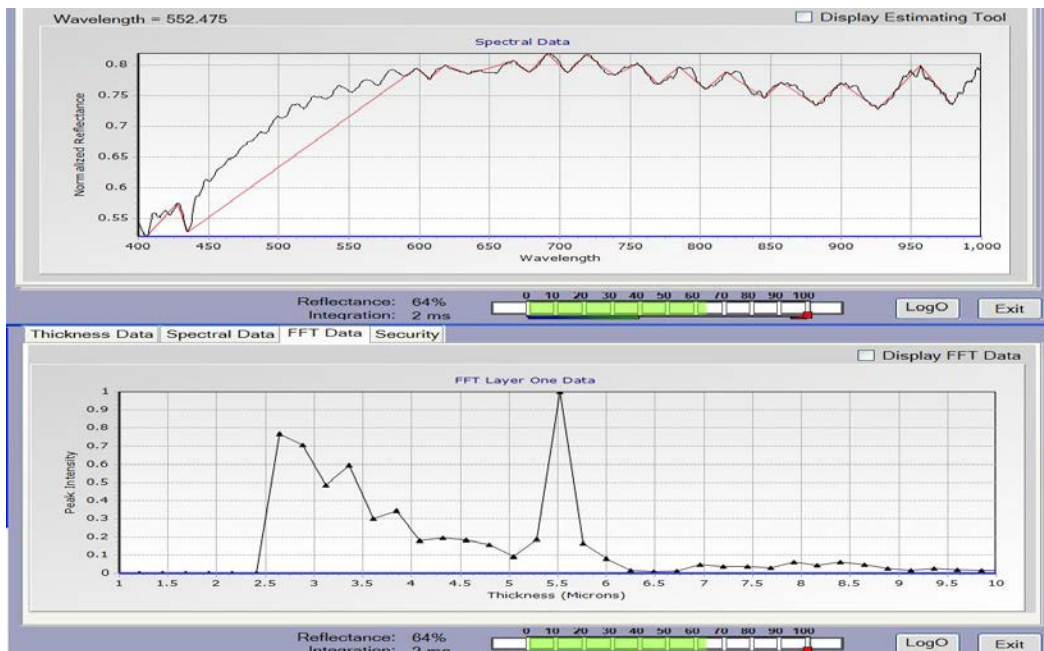
Figure 43 – With PA

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. In general, 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.
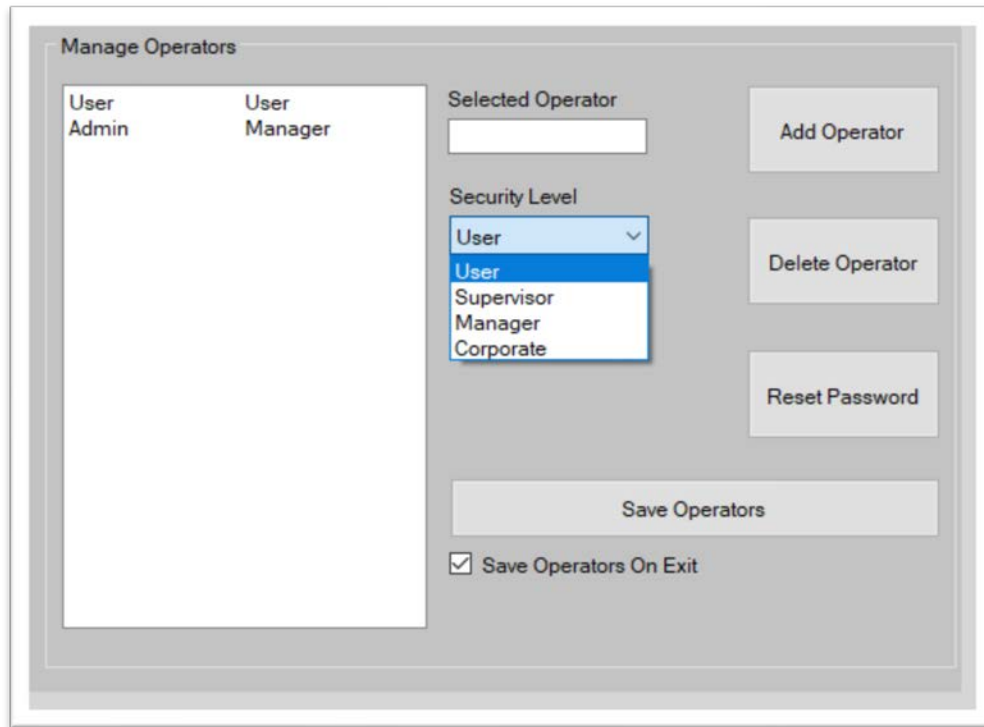
Figure 44 – Security Tab

Security

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 various levels of operators and the accessible features:

a. **Operator**: 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.

b. **Manager**: The Manager has the next highest level of access and the Manager level will have additional access to *Part Info* tab.

c. **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.

Import
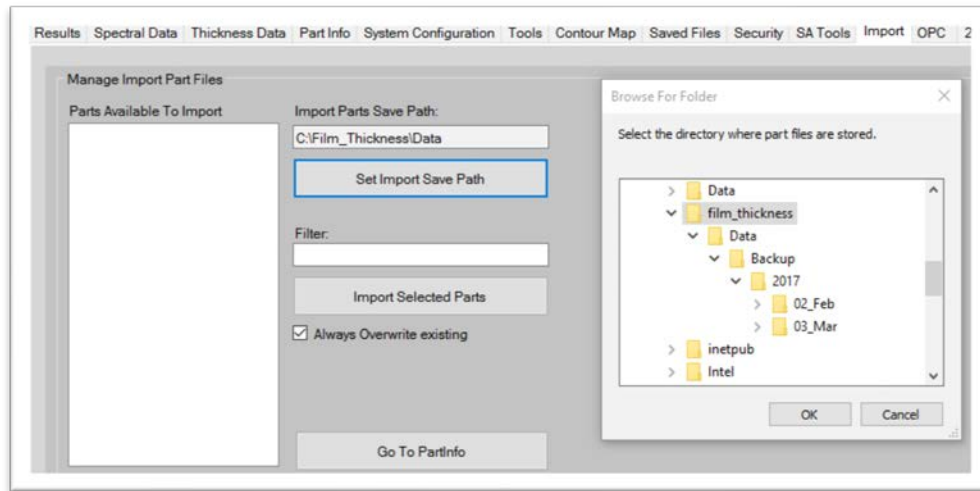
Figure 45 – Importing Part Files

The recipe for a new part can be imported from a file with a *".prt"* extension. To import a part recipe file from a 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.

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.
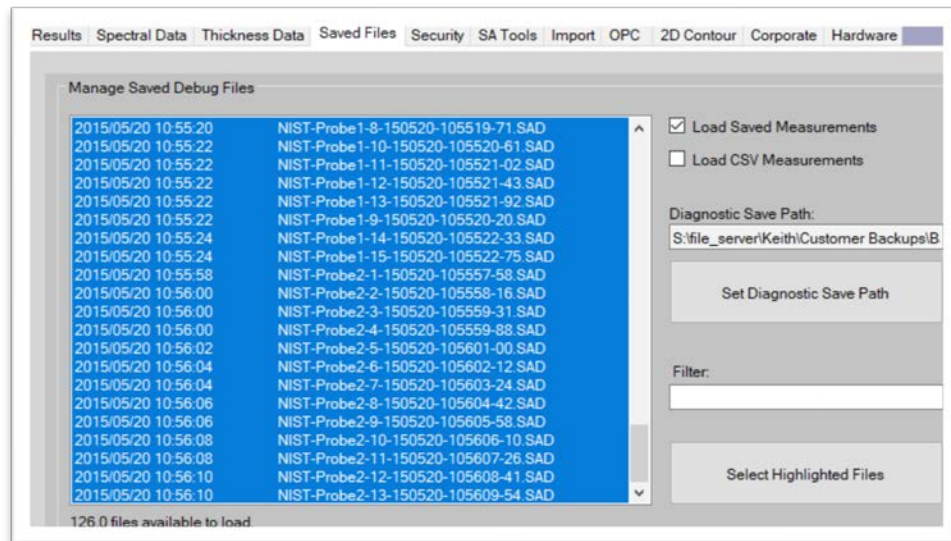
Figure 46 – Loading Debug Files

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
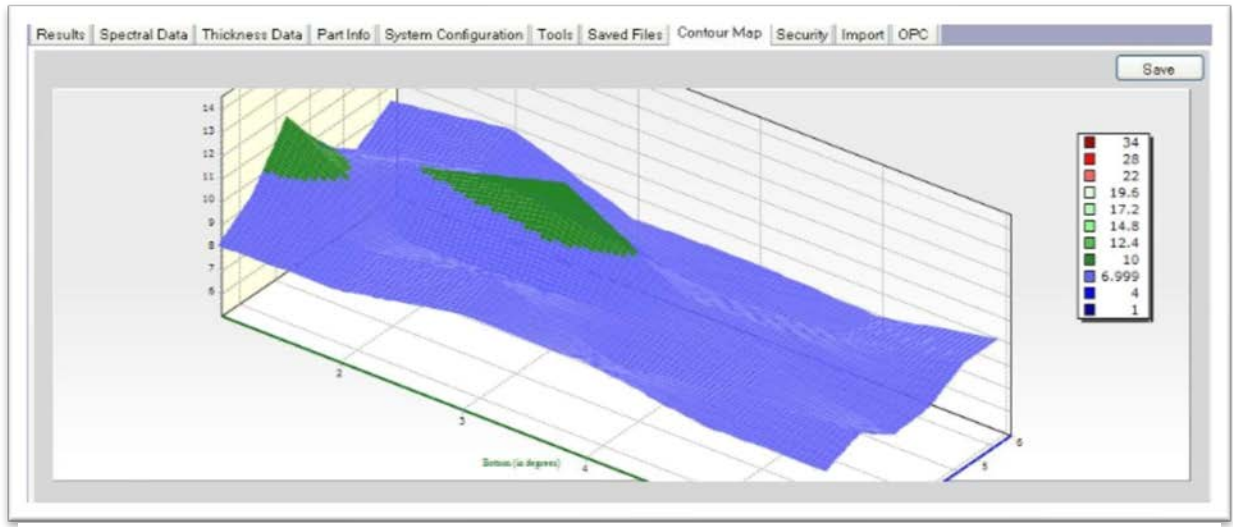
Figure 47 – Contour Map

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

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.

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 48 – 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 49 – Begin 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.
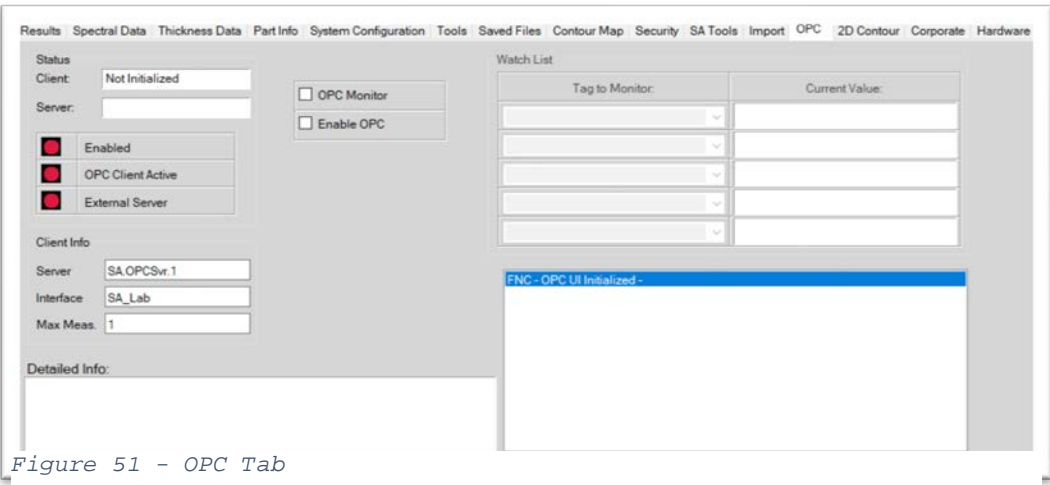
Figure 50 – Scan Mode Options

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

OPC Tab

The OPC tab offers users the ability to interface the *SpecMetrix*® system with other program controls that exist within the facility. It is recommended that customers consult with Sensory Analytics prior to adjusting the OPC configuration. For typical use of the system the OPC tab provides the ability to enable/disable OPC, as well as verify that the OPC is connected.

Figure 51 – OPC Tab

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:

a.   Click on My Computer on the desktop

b.   Click on "Local Disk C:" drive

c.   Double click on the folder named "Film_Thickness"

d.   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.

e.   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 as shown below:

Clicking this icon will result in a pop-up window opening as shown below:
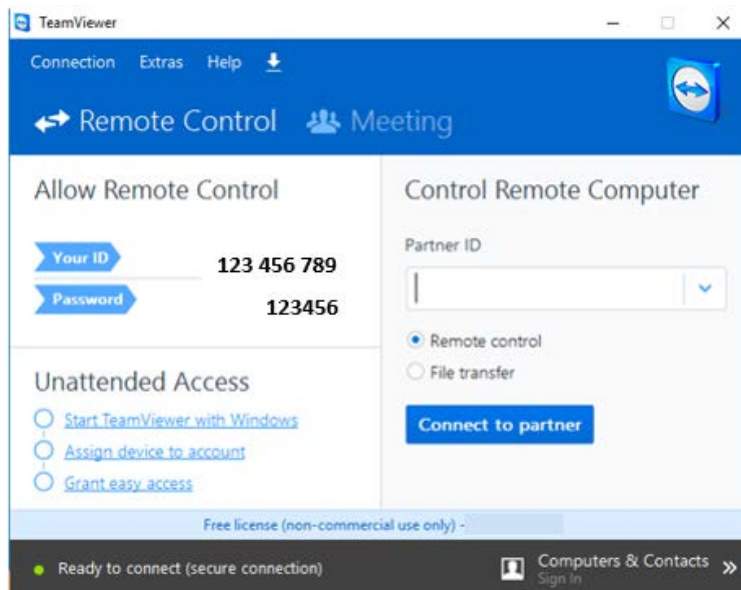
It is then necessary to contact Sensory Analytics with the 9-digit ID # as it appears in the Team Viewer Support window. This will allow the technical staff to remotely access the unit to assist with any operational needs.

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