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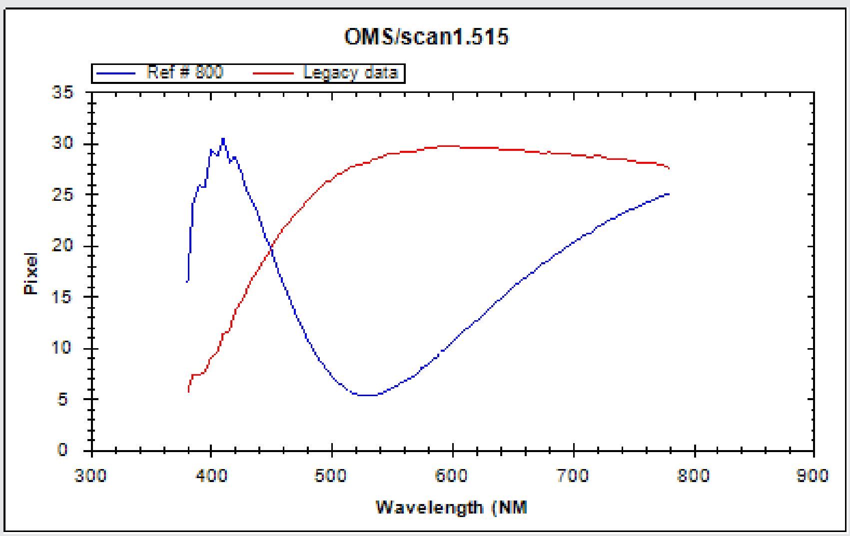
Application Note: Spectral Match Cut Points

The historical method of calling an end of a layer in optical coating was to monitor a wavelength and when a condition was met calling the end of the layer. As discussed in a previous application note the NVision optical monitor supports this method with good success. There is one problem with this technology; the measurement of only one wavelength limits the potential precision as we are typically waiting until a condition has been exceeded such as a quarter wave minima or maxima. In most cases the end point is called at some time after the actual meeting of the end point criteria condition. This requires the process engineer to design the algorithm to compensate for the delay in the decision.

Much has been discussed over the past years as to the use of a spectral fit from a broadband optical monitor and the advantage provided by a spectral match of a target spectrum. Accuracy is enhanced because a real product spectrum is used in the decision of the actual layer end.



The blue trace is the reference spectrum to be matched. The red spectrum is the current spectrum from the acquisition of the NVision Optical Monitor. This device acquires the data using a spectrometer making measurements about every 100 milliseconds. More is discussed in other application notes on how to setup the system for highest repeatability. The acquisition time is basically a function of the measurement period (integration time of the detector array) and the number of samples averaged in each measurement. The reference scan is then compared to the current scan and a goodness of fit algorithm processes the two scans to find the scan that best meets the match to the reference spectrum. The question is what is a good fit?

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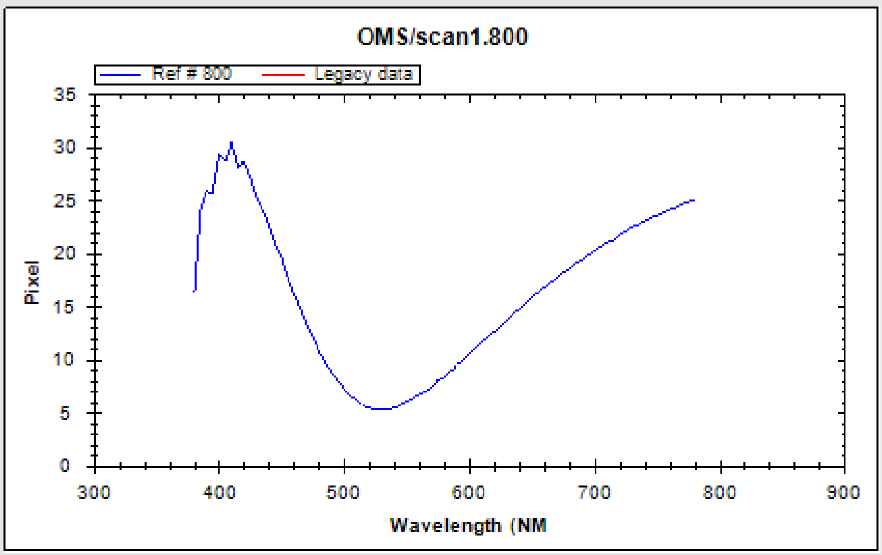
Some have suggested that a good fit is when each pixel is within a certain percentage of the required amplitude of the reference. This hard coding of goodness number then limits the robust nature of the potential algorithm. If only one pixel is just outside the limit then the algorithm fails and the system continues to deposit without stopping while looking for a match which will never occur.



This is not a problem with a match as seen above. The sample and reference coincide as a perfect match. Unfortunately in the real deposition world nothing is ever perfect as seen in the sample below. More often than not the deposition of optical thin films is fraught with issues that cause the deposition to be slightly different than the design. Notice that the spectra in the sample below no longer coincide. The adaptive algorithm still finds the “best” match allowing for the differences and the real world variation. When two samples match identically it is easy to call an end but when they are never an exact match then the algorithm must find the best of the choices. This takes some thinking on the computers part. An algorithm that does not have the ability to adjust on its own will be subject to failure.

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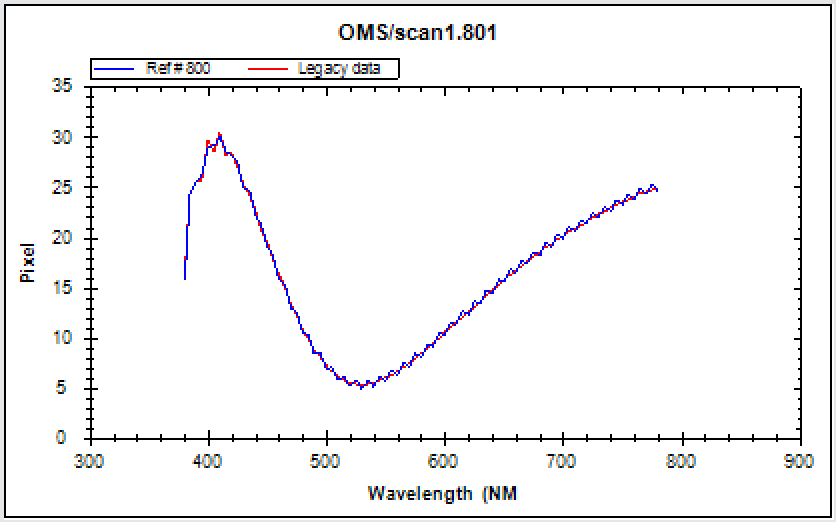
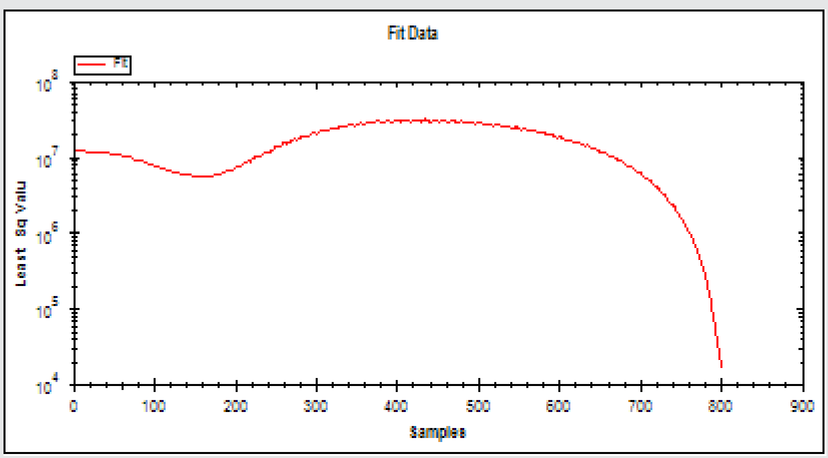


A spectral match can be determined by an evaluation of the lowest or best possible match. The following graphic describes the fit for the above match.



This graphic as mentioned describes the plunging goodness value as it draws close to the best fit. In every case the probability of the actual being perfect is so low that the fit threshold must be somewhere above zero.

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Therefore two fit algorithms monitor the goodness of fit. The first method monitors the fit for a basic goodness threshold. At this point the system will start looking for the best case condition that occurs after the threshold is met. This algorithm then looks for the lowest perceived difference between the reference and the measurement spectra. This will always be one measurement late because it will be looking for the slope to change to the positive. One measurement should be about 100ms plus some time for the coating system to shut down the deposition process.

The second algorithm will simultaneously be looking for a more refined threshold event to occur based on the input from the recipe. After the basic goodness threshold has been met the system also looks for the refined threshold. If this is met the coating fit is considered to be met and the coating system is commanded to stop deposition.
Given two different match criteria the worst case fit would be one scan past the best fit and the best case would be the best fit or an exact match. The system can also provide a best fit qualifying number to be tested for validity.

This validation value can be tested and then a decision can be made to evaluate the coating recipe for change. At the present time an interface has been designed to Essential Macleod for the creation of the reference spectra and for the export of the finished layer for optimization of the recipe.

The potential for more accurate and complex using the spectral match method has been discussed in many publications but is now finally available in a production instrument.

Please contact Telemark at sales@telemark.com to find out how Telemark/NVision Optical Monitoring systems can improve your yields and profitability.

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