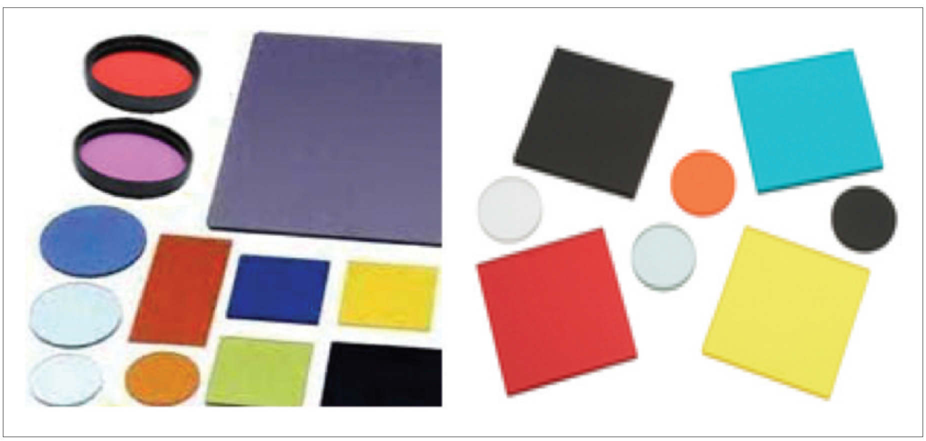
APPLICATION NOTE

UV/VIS/NIR SPECTROSCOPY

# Gaining high resolution measurements of optical filters in the NIR range with the LAMBDA 1050 UV/Vis/NIR

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The most common measurement for optical filter quality testing is done in transmission mode with the results typically displayed in %T. The measurement may be performed at any angle of incidence required by the filter design. The angle of incidence light used can range from normal to greater than 60˚ with 45˚ being one of the most common requirements. When measurements are to be performed at angles other than normal, typically considered to be between 5˚- 8˚, polarization affects need to be considered.

All modern high performance spectrophotometers use reflective gratings to disperse the source energy into specific wavelengths. This process will create strongly polarized light which will be used for sample analysis. For this reason, to achieve the truest results a depolarizer should be used at angles higher than 8˚ to measure a sample under random polarization conditions. If specific angles of polarization are required by the analysis, a polarizer should be added to allow the specific angle of polarization to be measured. This could range from S to P polarization or any angle between.

Optical filter types and design requirements vary widely from simple neutral density filters to the most complex multi layer bandpass designs. All have specific design requirements and all require spectroscopic analysis to validate designs and for quality control in manufacturing. Typical design requirements of several common types of filters are shown in Figures 1 and 2

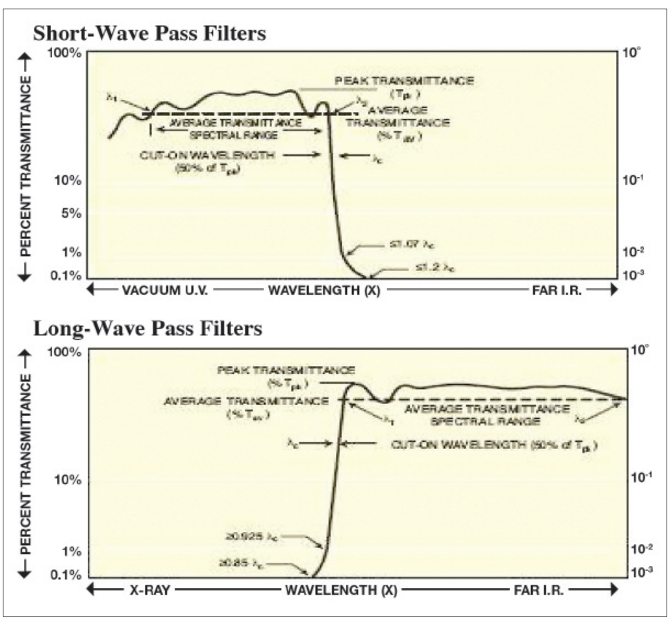


*Figure 1.* Typical filter design requirements.

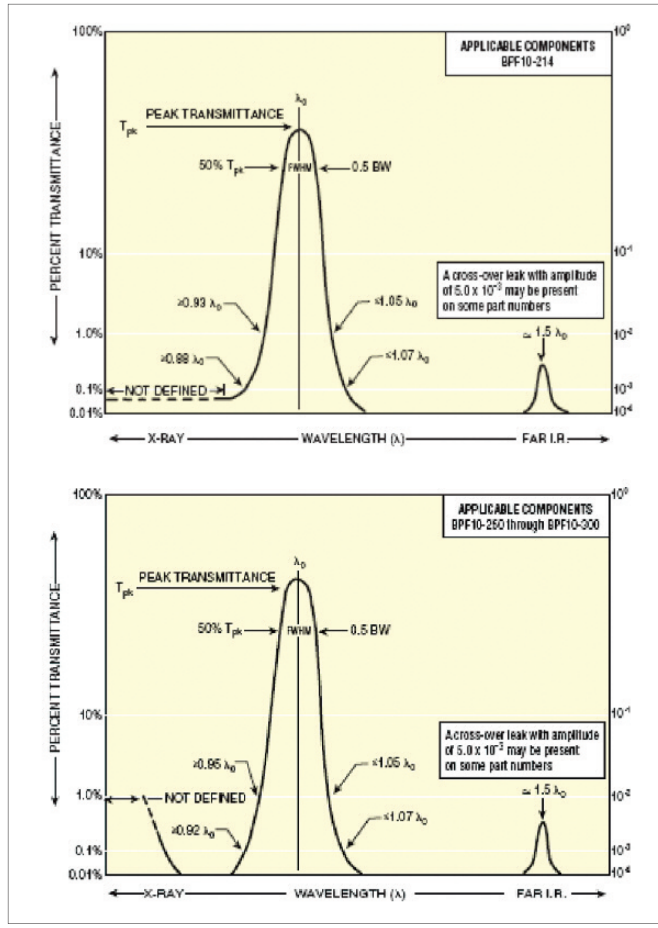


*Figure 2.* Typical bandpass filter response characteristics.

Optical filters have many functions, including color correction, used to improve color balance in many optical systems, to neutral density filters that produce specific reduction in the level of transmitted light. Thin film filters used in laser based systems have more demanding requirements typically requiring very narrow bandpass and very high out-of-band blocking. The characterization of these diverse optical filter types is critical from design through manufacturing, providing validation of a specific design and the necessary means to perform QC/QA of finished products.

The LAMBDA™ 1050 utilizes three detectors for optimum energy detection across the entire wavelength range of the instrument, 175-3300 nm: A gridless PMT for detection in the UV/Vis, a high sensitivity Peltier cooled InGaAs detector for use in the 800-2600 nm region and a Peltier cooled PbS detector for the range from 2500-3300 nm. This offers the best combination of scanning speed and photodynamic range that can be achieved on a given sample type.

In determining the best method for the analysis of a specific filter several factors need to be considered. The design specification will provide the majority of the information necessary for a spectroscopic analysis. Wavelength range, bandpass, transmission and out of band blocking will all be defined and need to be taken into consideration.

Key to a successful analysis is translating the specification requirements into the method setup parameter used by the spectrophotometer. Choosing high resolution and a very small data interval for a filter type which has no spectral features will simply waste valuable time. In general the resolution needs to be 4-10 times smaller than the bandpass of a given component to provide sufficient data to validate a component.

Photodynamic range is another important consideration. The level of absorbance of a given material will impact how a method is developed and how fast a sample can be scanned. A notch filter with very high absorbing requirements may require reference beam attenuation to be used to achieve accurate data on the true performance of a filter. Simply knowing the design goal of the component will determine the method details for a successful analysis to be performed.

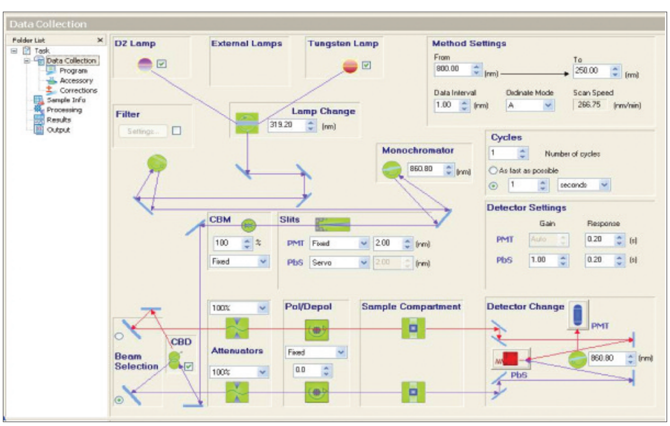


*Figure 3.* LAMBDA 1050 3-detector data collection display.

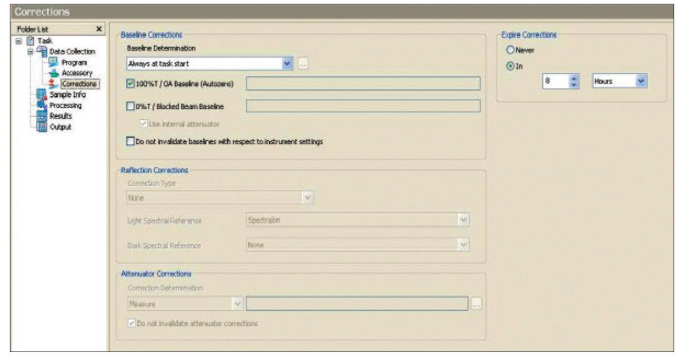


*Figure 4.* UV WinLab correction display.

Measuring a laser bandpass filter with a center wavelength of 1064 nm and a bandpass of 1 nm is a common requirement. A filter of this type will require slit resolution of 0.25 nm to achieve sufficient resolution to determine its characteristics. The LAMBDA 1050 using an InGaAs detector in the NIR region allows both high resolution and wider photodynamic range improving both signal-to-noise and speed of analysis over a conventional PbS detector. A typical setup display is shown in Figure 3.

Along with the basic system setup parameters, UV WinLab™ allows the selection of baseline corrections for optimization of the required photodynamic range. The correction display in Figure 4 shows the user selections to perform this optimization.

With the proper selection of operating parameters completed and baseline data acquired, sample measurement can now be performed. Figure 5 shows the typical response of a laser line filter. Excellent signal-to-noise is seen in the spectra even at very high resolution.

Figure 6 shows the same filter measured on a typical spectrophotometer using a PbS (Lead Sulfide) detector in the NIR region. Poor signal-to-noise is due to low sensitivity of the detector at very high resolution.

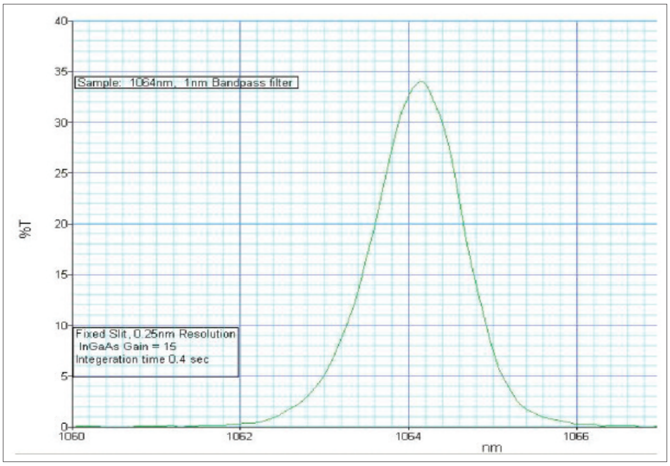


*Figure 5.* 1 nm Laser line filter measured with 0.25 nm resolution on a LAMBDA 1050 using an InGaAs detector

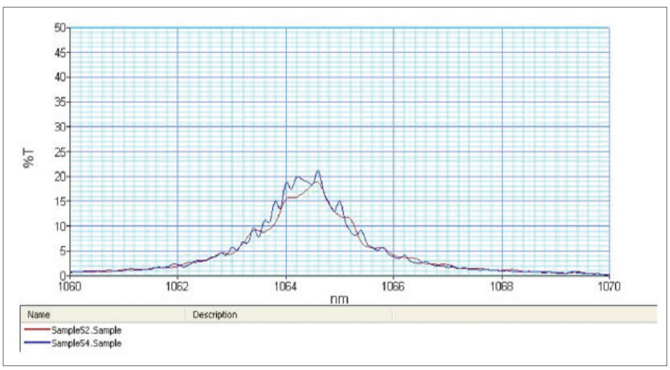


*Figure 6.* 1 nm Laser line filter measured with 0.25 nm resolution on a LAMBDA 950 using a PbS detector.

## Conclusion

The addition of an InGaAs NIR detector allows measurements at high resolution in the NIR region with excellent signal-to-noise performance. In addition measurements in the sub nanometer range are now possible using fixed resolution due to the increase in sensitivity at fast scanning speeds.

For full details of the LAMBDA 1050 UV/Vis/NIR spectrophotometer, see the Technical Specifications sheet.

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