Measurement of Filters used in Night Vision Applications
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Measuring transmission filters used in night vision compatible environments demands a spectrometer system sensitive to very low light levels over a broad dynamic range, from 0.001% to 90%. A QE series spectrometer optimized for this task is a good option, offering high signal to noise, low stray light and good optical resolution from the UV through NIR.

Introduction

The human eye is designed for daylight use and is most sensitive from 380-780 nm. To extend the spectral and dynamic range of our vision, developers of night vision goggles and imaging systems use image intensifiers and optics to gather and amplify near infrared light by up to 2000x.

Night vision is an essential tool for law enforcement and the military. Night vision devices (NVDs) used within vehicles are very sensitive to NIR light emitted by lighting and displays inside the vehicle. If not properly filtered, ambient NIR light can reduce the sensitivity of an NVD to objects outside the vehicle. Night vision compatibility (NVC) filters are incorporated as a window on displays or light sources, reducing the NIR emission of these devices dramatically in the 600-930 nm range. Transmission at shorter wavelengths needs to be as high as possible to maintain visibility for users not wearing NVDs.

Experimental Conditions

Two NVC filters were measured using a QE series spectrometer configured for 350-950 nm. The setup also had a 10 µm slit for optical resolution of ~1.6 nm (FWHM) over a 200-950 nm range. Light from an HL-2000 deuterium tungsten halogen lamp was routed using a 600 µm fiber to an 84-UV-25 collimating lens mounted on an OPM-2 post mount to create a ~1.0” diameter collimated illumination beam. The filter
Since transmission curves do not adequately show blocking for filters with OD >3, both filters were also plotted on a logarithmic scale to demonstrate how blocking varies with angle and filter type. The TFF showed OD >4 blocking at 0°, but as angle was increased, blocking decreased and the blocking edge shifted to shorter wavelengths (Figure 3). The absorptive filter maintained the same shape at all angles, and the blocking increased with angle as the light traveled through more absorptive material (Figure 4). In both cases, the higher OD measurements showed more noise.

Results

Filter 1 showed very good transmission from 400-650 nm, with high blocking from 650-950 nm (Figure 1). The blocking edge shifted to the blue with increasing angle, indicative of a thin film filter (TFF). TFFs are based on interference from multiple coated layers, and are designed to reflect a range of wavelengths while passing others. As the angle changes, the effective thickness of each layer changes, causing the transmission spectrum to be shifted and distorted.

Filter 2 showed much lower transmission over a narrower range, with good blocking from 685-900 nm (Figure 2). The transmission curve did not shift with angle, but it did decrease significantly, typical of an absorptive filter (glass or plastic doped with impurities to achieve a desired spectrum). Though not as transmissive as a TFF, absorptive filters are generally much lower cost.

Figure 1: The transmission efficiency of a thin film filter sample varies by sampling angle.

Figure 2: The transmission efficiency of an absorptive filter sample decreases significantly.

Figure 3: Some thin film filters have high OD characteristics, but as the sampling angle increases, blocking efficiency decreases and the blocking edge shifts to shorter wavelengths.
Transmission filters used in NVC applications span 5 orders of magnitude and a 600 nm wavelength range, demonstrating the importance of using a broadband spectrometer such as our QE series spectrometer to deliver excellent signal to noise and low stray light for accurate measurements.

Conclusion

Figure 4: Absorptive filters typically maintain the same spectral shape at all angles, and the blocking increases with angle as light travels through the more absorptive material.

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