Technical Note

Thinking inside the box- Interference filters in Reflection

Everyone has used interference filters in a transmissive configuration where the light passes through the filter to cause some effect (band-pass, long-pass, short-pass, etc.) but these filters can also be used in a reflective configuration where the desired light is reflected off of the filter and the transmitted light is rejected or absorbed. Interference filters, by nature, do not generally absorb any light- all light is reflected or transmitted (Figure 1). Of course there are exceptions, especially in the UV and IR, where the intrinsic properties of the materials cause them to absorb certain wavelengths. Scatter also occurs at a low level in most thin films. The ability to reflect some wavelengths and transmit others is exploited in applications like beam combining, where laser beams of different wavelengths are directed onto a single optical axis and fluorescence applications where dichroic mirrors are used to reflect excitation wavelengths and transmit fluorescence signals. When no absorption is occurring, the sum of the reflected and transmitted light is 100%.

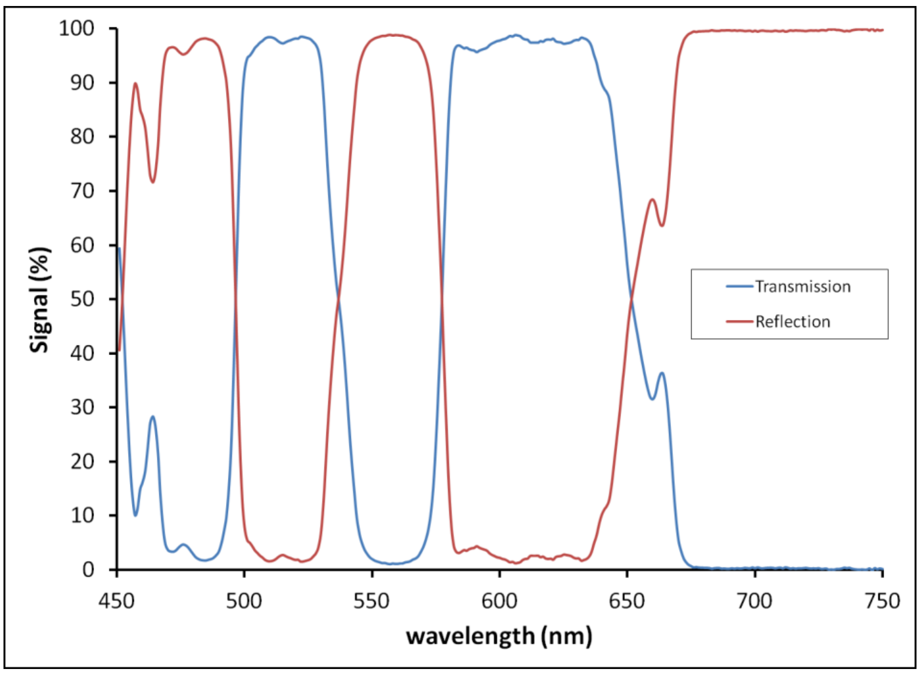

Figure 1- %T and %R of a filter at 45° angle of incidence. These add up to 100% for most interference filters in the visible wavelength regime.

Baffle Filters- Omega calls a reflective filter assembly a “baffle filter” in which a number of reflecting filters are positioned to produce the desired effect. A variety of configurations can be designed to maintain the optical axis or to steer the beam in a particular direction (Figure 2). Alternatively, the individual filters can be used as steering or folding mirrors in the customer’s optical system design. One factor to keep in mind is that the filter will have optimal performance (steepest edges and highest transmission or reflection) in a collimated beam at a single angle of incidence (AOI). Typically, splitting of s and p polarization occurs at higher AOIs, but some of this can be controlled at the filter design phase.

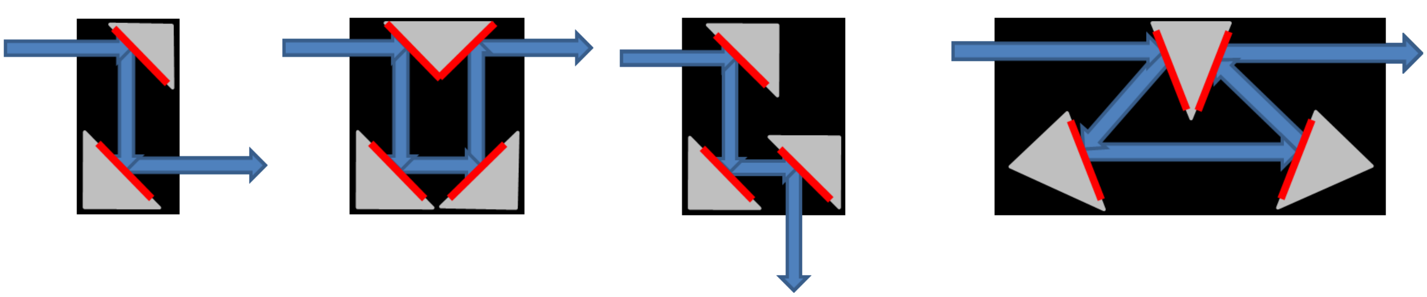

Figure 2. Some Baffle Filter designs at 45° and 22.5° AOI. These design concepts can be incorporated into nearly any optical system.

Applications and Performance:

UV bandpass filters with visible light blocking- Most materials used for thin-film coating start absorbing light in the UV (<350 nm or so). This makes it very difficult to produce a highly transmitting UV filter while simultaneously blocking the full visible spectrum. The traditional approach is to use induced transparency in metals (MDM design) to achieve good visible blocking and some degree of transmission in the UV (Figure 3). The transmission of these types of filters is typically low (<50%), but the blocking is high. Higher transmission and steeper edges can be achieved with purely dielectric stacks (Figure 3) of UV-compatible materials, but the blocking range is limited unless very large stacks are used. Switching to a reflecting (baffle box) configuration with a 22.5° AOI allows for high %T in the bandpass and good blocking in the visible due to the use of absorbing epoxies in the assembly.

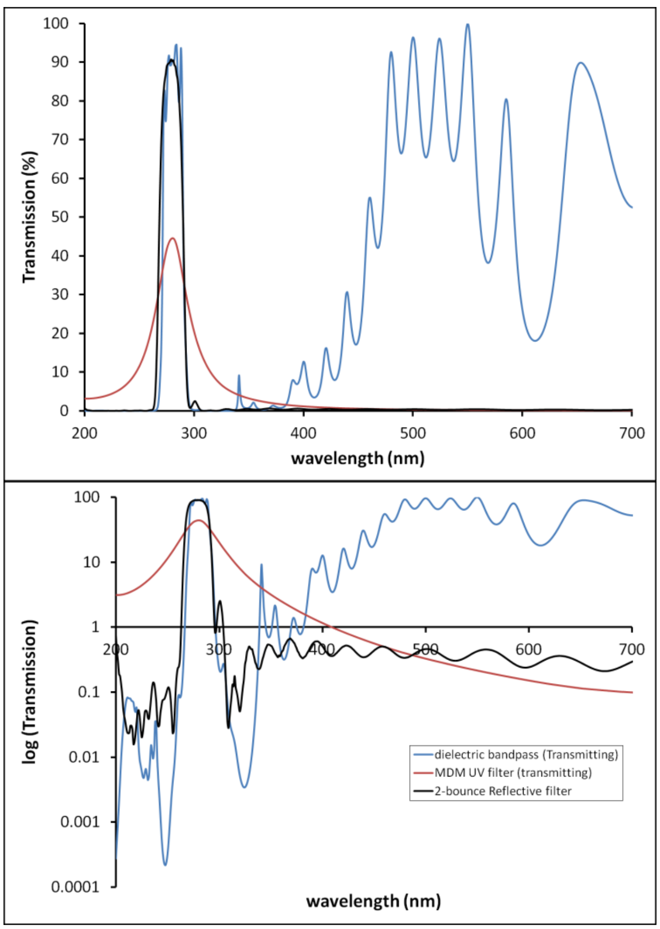

Figure 3. Comparison of MDM and transmissive UV filters with a 2-bounce reflective filter. **Top**- linear scale, **Bottom**- log scale to emphasize blocking. The reflective filter maintains narrow bandwidth, high throughput and blocking over a wide wavelength range.

Narrow notch rejection filters- The nature of thin-film interference filters makes transmissive notch filter designs very difficult, especially when a high OD is required over a very narrow wavelength range. However, Omega is quite adept at producing extremely high transmitting narrow bandpass filters which, when used in reflection can create very narrow notches.

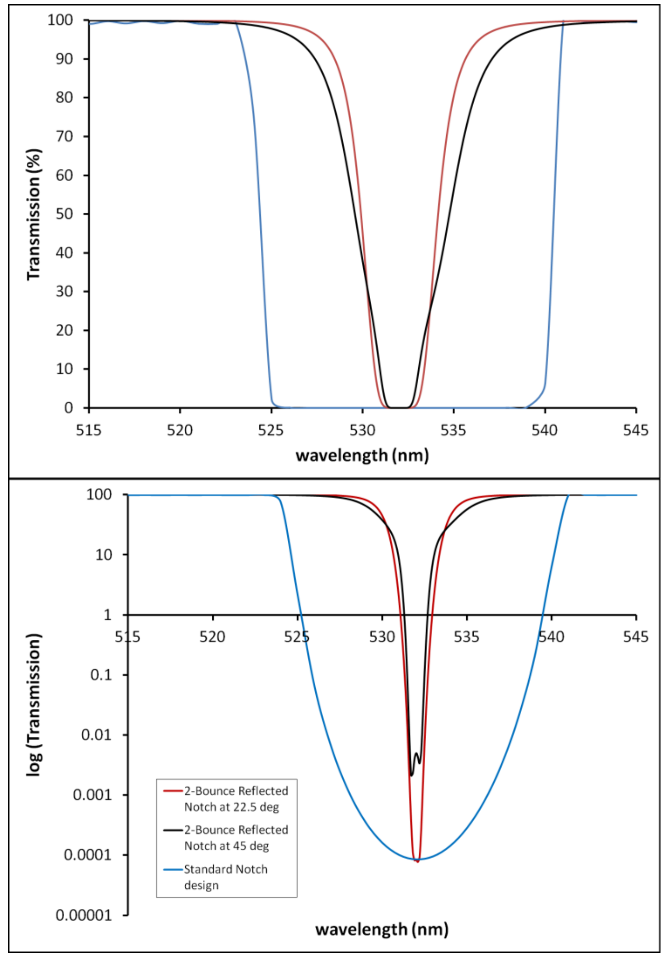

Figure 4. Top- A standard transmissive notch design with 2-bounce reflective notches designed at 2 AOIs. **Bottom**- The same data presented in log scale to show blocking (OD 6 in red and blue curves).

Using this design technique, the notch width at 50% T can be reduced from about 16.5 nm (in the standard transmissive filter) to 6.2 nm wide at 45° and 4.3 wide at 22.5° AOI. Increasing the AOI widens the notch because of splitting of the two polarization states (s and p) at angle. This is seen in the bottom of Figure 4 as a double-dip in the black trace.

Omega wants to help you “think inside the box” with your next optical design project. Please contact us to discuss how you can incorporate baffle filters and these design principles into your system.