Understanding the Limitations of Optical Coatings

Most optical coatings are thin transparent dielectric materials. The performance they achieve is due to the conditions of destructive and constructive interference of light as it attempts to pass through the optical element. These devices are exceptionally efficient with virtually no light lost, but the light that does not pass through the coating will be reflected to its origin.

A related aspect is that the effective path length through the coating is dependent on the incident angle. A deviation in incident angle of a few degrees can result in a shift in effective performance such that a constructive condition becomes destructive. An example of this occurs when a narrow transmission band is desired in a fast optical system (f<=8).

Often overlooked is that the thin film coating can be very efficient, but the residual surface scatter of the substrate (although insignificant regarding signal intensity) can be dramatic. Typical scatter of approximately one part in a million exists in most coatings. This energy, when scattered at the peripheral of the filter is redirected and not subjected to the interference effects intended. In addition to this scatter effect is the scatter that occurs at the edge of the coated element. These two sources of uncontrolled light can be the limiting aspect to a system's signal-to-noise ("S/N") level. This latter source of scatter is often the primary S/N limitation, especially with small parts, or when the active aperture fills the entire active surface. The edge scattered photons in comparison to those spectrally reflected that are totally random.

Rapid Spectral Solutions offers an assembly process that index matches the light that might otherwise be uncontrolled and absorbs it into the mounting hardware. Although scatter can be attenuated from the mounting edge, the specular reflection from the optical coating is likely to become very random as it hits surfaces at an angle to the optical axis. After several reflections (Keep in mind that the typical optical baffles and stops are reflecting 10 to 30% of the light falling on them) the light impinging on the coated surface can be far from the intended optical path.

An often-overlooked consideration is the operating temperature. Although typical spectral testing is done at room temperature to 30°C, the operating conditions may be significantly different. Typical protected coatings have a temperature coefficient of 0.03+- 0.01 nm/ °C, and surface coatings have a coefficient nominally a factor of 10 less. This aspect can be used as a fine-tuning approach in some applications but should be considered when seeking the ideal values.