Optics Characterization Using a Universal Measurement Spectrophotometer

Precise, well-defined characterization of optical components such as mirrors, lenses, and filters is fundamental to advancing product development and manufacturing in industries such as display technologies, solar energy, and advanced photonics. Confirming that each optical component performs its intended function helps to support product quality and to meet required measurement standards demanded across industries. For example, knowing the angle-dependent reflection spectrum of glass in LCDs and OLEDs helps engineers understand how ambient light interacts with the display surface to avoid glare, contrast loss, and color shifting. Additionally, anti-reflective coatings on the optics in VR headsets must perform well across a wide range of angles to reduce the amount of ghosting and glare, which has a direct effect on the user's immersive experience and eye strain. Having complete control over optical characterization parameters enables accurate, reproducible measurements that verify products like these meet their intended performance specifications.

Ebatco's Agilent Cary 7000 Ultraviolet-Visible-Near Infrared (UV-Vis-NIR) spectrophotometer comes with a Universal Measurement Accessory (UMA) that is capable of measuring diffuse scatter, reflectance, transmittance, and absorptance through independent 360° sample rotation and 10-350° detector positioning. It can measure absolute specular reflectance with an angle of incidence (AOI) ranging from 5-85°. The UMA also comes with an automatic polarizer capable of controlling the input polarization at any angle from 0-90°. It leverages these independent degrees of freedom without a need to manually reposition the sample or adjust the input beam optics, ensuring robust measurements. To highlight the UMA's diverse optical characterization capabilities, two measurements were made on different optics samples using different UMA modalities.

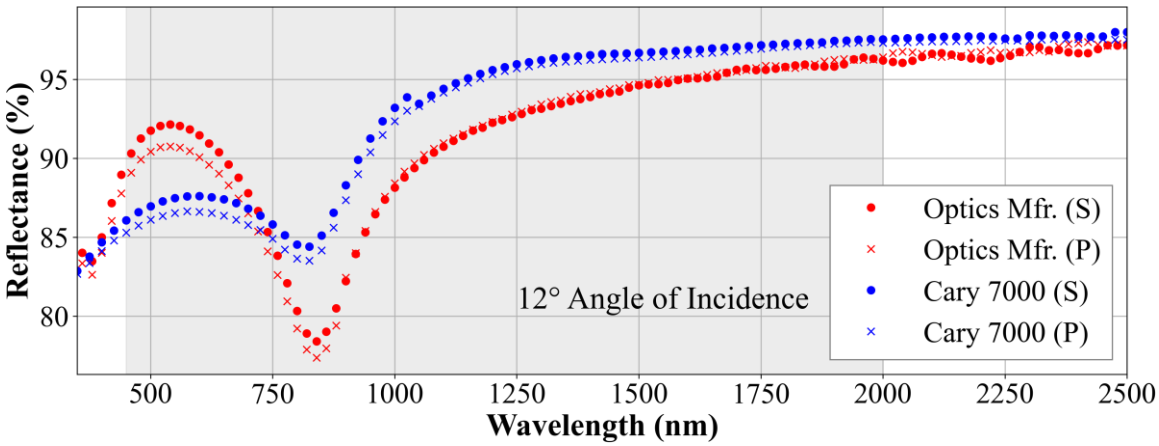

Figure 1. Reflectance spectra of aluminum mirrors at a 12° AOI using S (dots) and P (crosses) polarizations, comparing Cary 7000 (blue) to Optics Manufacturer (red). The gray shaded regions highlight the spectral region over which the performance characteristics are guaranteed by the manufacturer.

First, the reflectance spectra of an aluminum mirror using both vertical (S) and horizontal (P) polarized light were measured, as shown in Figure 1. For this measurement, the sample angle relative to the input beam was 12° and the detector angle was 24°. The blue traces are data taken by the Cary 7000, and the red traces are data reported by the optics manufacturer (note that the optics manufacturer data was taken on a mirror from a representative lot, so the Cary 7000 and optics manufacturer datasets were taken on different aluminum mirrors). The Cary 7000 data for both polarizations shows a flat reflectance from 1200 – 2500 nm, with a minimum in reflectance around 840 nm, a recovery towards 500 nm, and another decrease in reflectance in the UV region. This response is consistent with the optics manufacturer dataset. Ultimately, the manufacturer guarantees an average reflectance, R_{avg}, of greater than 90% from 450 nm – 2 µm. The Cary 7000 measures R_{avg} in that wavelength range of 92.6% for P polarization and 93.2% for S polarization, passing performance specifications.

Second, the reflectance and transmittance spectra of a dielectric filter were co-measured at a 45° sample angle—the manufacturer-specified AOI—which is shown in Figure 2. The purpose of the filter is to separate the shorter, blue wavelengths from the longer, red wavelengths. The detector angle was set to 90° for the reflection measurement and set to 180° for the transmission measurement. The optics manufacturer guarantees the average transmission, T_{avg}, from 600 to 1200 nm should be greater than 85%, and R_{avg} from 325 to 475 nm should be greater than 90%. With a measured T_{avg} of 95% the transmission specification is met. However, the R_{avg} was measured at 77%, indicating the filter does not reflect wavelengths in the UV-Vis range as well as advertised.

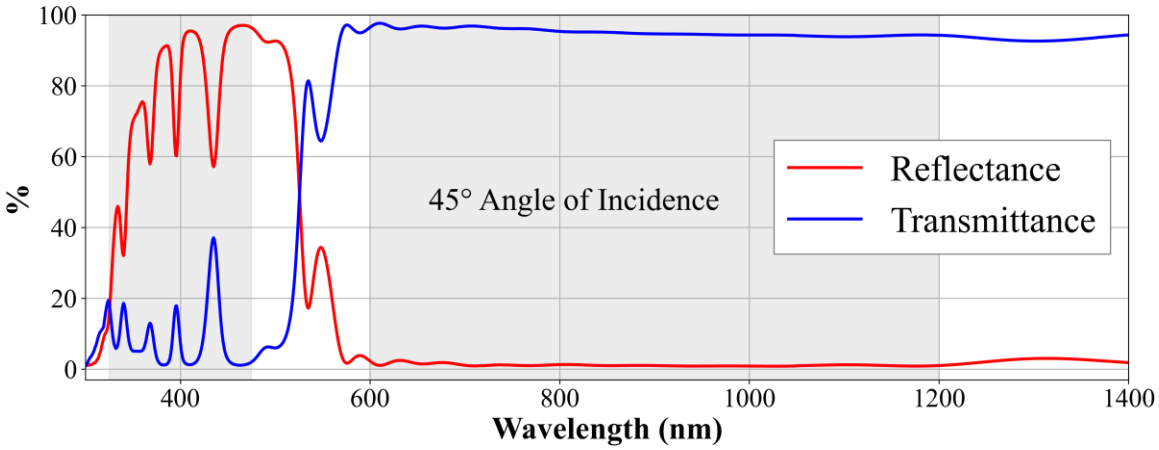

Figure 2. Reflectance and transmittance of a dielectric filter at a 45° AOI. The gray shaded regions highlight the spectral regions over which the performance characteristics are guaranteed.

As demonstrated above, the Cary 7000 equipped with a UMA offers comprehensive control for the optical characterization of various materials. With its independent control of wavelength, polarization, sample angle, and detector angle, the instrument enables precise, reproducible measurements that meet the rigorous demands of modern optical component development.