Absolute Specular Reflectance Measurements at Fixed Angles

With the widespread use of anti-reflective optical coatings, multilayer dielectric coatings, solar controlling thin films, and laser mirrors, specular reflectance measurements have become even more important for research and QC applications. Specular reflectance measurements are used to characterize the film thickness, refractive index, and other optical properties of these materials. Labsphere has designed a series of specular reflectance accessories that allows specular reflectance measurements to be performed at five key beam incidence angles: 8°, 15°, 30°, 45°, and 60°. Called the PELA-6000 “VN” Series Accessories, this series of reflectance accessories is designed exclusively for the Perkin Elmer Lambda 900 Spectrophotometer.

The term “VN” describes the beam path shapes in the reference (V) and sample (N) configurations. (See Figure 1) The only difference between the reference (baseline) and sample scans is due to the introduction of the sample into the beam path. As long as the optical path length, mirror surfaces, and reflection angles do not change from baseline to sample scan, the measurement is absolute. Each VN reflectance accessory measures absolute specular reflectance at a well-defined, repeatable angle by a single strike method. The VN accessory design provides tremendous advantages over other available specular reflectance methods.

Traditional methods for the analysis of specular samples at variable angles have several limitations which Labsphere's new VN reflectance accessory was designed to overcome. For instance, standard specular reflectance devices with angles ranging from near-normal at 7.5° to grazing angle at 80° are available for the measurement of relative specular reflectance. With these accessories, the user compares the sample's reflectance to that of a calibrated specular reflectance standard, such as a first surface aluminum mirror. While highly accurate measurements can be performed with these relative specular accessories, the measurement accuracy is dependent upon the calibration standard used. Any surface contamination, mirror damage, or degradation of the reflectance standard will introduce erroneous results. In addition, it is often not possible to find a suitable specular standard standard...
The PELA-6000 VN Series accessories are designed to measure the reflectance of highly specular, non-scattering, first-surface reflectors. The VN accessory utilizes the Perkin Elmer Lambda 900’s photomultiplier tube and lead sulfide detector for measurements in the 190–2600 nm wavelength range. The measurements are performed in an absolute fashion, without the need for a calibrated reflectance standard, and with only one reflection off the sample surface. The VN accessory design is easy to use and is well-suited for the QC lab environment and the measurement of one inch diameter test samples.

The PELA 6000 VN Series of reflectance accessories consists of a main adapter baseplate, the PELA 6001, and five separate fixed measurement angle “Daughter Plates,” the PELA 6008, 6015, 6030, 6045, and 6060. These interchangeable plates allow absolute specular reflectance scans to be performed at the key measurement angles of 8°, 15°, 30°, 45°, and 60°, respectively. PELA 6000 Series baseplates are precision machined using wire EDM technology for repeatable mirror and sample positioning. Each VN accessory fits into the standard Perkin Elmer Lambda 900 sample compartment and uses the instrument's own detectors and electronics. The baseplate mounts kinematically onto the main PELA 6001 adapter baseplate for easy installation and removal of the accessory. The optical alignment of the VN unit can be set and locked on each daughter plate so that changing between measurement angles does not require a complete optical realignment. Easily removable mirrors can be changed to convert between the V and N optical configurations.

**VN Accessory Design**

The PELA-6000 VN Series accessories are designed to measure the reflectance of highly specular, non-scattering, first-surface reflectors. The VN accessory utilizes the Perkin Elmer Lambda 900’s photomultiplier tube and lead sulfide detector for measurements in the 190–2600 nm wavelength range. The measurements are performed in an absolute fashion, without the need for a calibrated reflectance standard, and with only one reflection off the sample surface. The VN accessory design is easy to use and is well-suited for the QC lab environment and the measurement of one inch diameter test samples.
A clip-style sample holder is provided permanently mounted to each VN accessory daughter plate. Samples which are from 1–3 inches in diameter and up to 3/8 inches thick can be measured with the standard sample holder. Sample sizes are limited by the amount of physical clearance between the edges of the sample and other accessory mirrors, especially at high beam angles. Custom sample holders may be designed if space permits. Samples must be flat, specular, first surface reflectors only.

Because light polarization can strongly influence specular reflectance measurements, especially above a 30° incidence angle, it is recommended that a common beam depolarizer be used on the Lambda 900 in conjunction with the VN reflectance accessory. To perform sample studies at known polarization, the 30°, 45°, and 60° VN accessories are fully compatible with Perkin-Elmer’s motorized polarizer cassette assembly. Due to space constraints, the 8° and 15° daughter plates are not compatible with Perkin Elmer’s polarizer cassette assembly. However, a manual polarizer mount is available as a custom component for the 15° VN accessory.

Optical Design

The VN optical design uses the difference between the direct path to the detector and the matching path with a single reflection off the sample to determine a specular sample’s reflectance. The path lengths of the baseline and reflectance scans are identical. Therefore, the measurement is absolute. This VN design is depicted below.

In the reference (V) configuration, mirrors M1, M2 and M3 are used. M1 is fixed. M2 and M3 are movable to allow for changing configurations. In the 8°, 15°, and 30° daughter plates, a lens assembly is also used to match the sample beam size to the Lambda 900 detector optics.

![Reference “V” Configuration](image)

In the sample (N) configuration, the same mirrors M1, M2 and M3 are used, but now M2 and M3 have been moved to create the “N” optical path. The specular sample is also in the sample beam path, completing it, and M3 is rotated so its reflective surface faces the sample. Because the sample “N” beam path must be the same length as the reference “V” configuration, M2 is placed closer to M1 in the sample measurement configuration.
Since the path length, mirror surfaces, and reflection angles remain the same during both the reference (baseline) and sample scans (except for the introduction of the sample), the measurement is absolute.

**Additional Reading**

