APPLICATION NOTE

SHINING A NEW LIGHT ON OPTICAL COATING MEASUREMENT

MKS Newport Breadboard Sold Separately

The MKS Newport™ QUANTX-300 Quantum Efficiency Measurement System offers a simple and flexible alternative to traditional spectrophotometers for coating and filter characterization.

Spectrophotometers are a useful tool used to measure the transmittance, reflectance or absorptance of optical components like filters, crystals, optical coatings, dichroic mirrors, and even biological fluids as a function of wavelength. Today's dual-beam spectrophotometers deliver excellent performance but are often very expensive, scan slowly, are sensitive to alignment, and need frequent recalibration.

MKS Newport QUANTX-300 Quantum Efficiency Measurement System offers a simple and flexible alternative. By employing unique architecture, it can deliver fast, high-accuracy spectral measurements, and provide a level of operational flexibility that is not common with traditional spectrophotometer designs. These include the ability to simultaneously measure transmission and reflectance from 325 nm -1800 nm without interruption, and the capacity to test virtually any size optic.

Here we will compare the design and construction of the QUANTX-300 with traditional spectrophotometers, then examine the capabilities and advantages it offers for production-line coating metrology.

Spectrophotometer Design and Operation

Conventional spectrophotometers have long been the primary tool for measuring the optical performance of filters, glasses and coatings. These instruments typically employ a broadband light source and a diffraction grating-based monochromator to isolate a narrow wavelength band that is scanned across the spectrum of interest, measuring the transmission of the sample at each wavelength.

Inside the spectrophotometer, the monochromatic beam is divided into two optical paths. One passes through the sample and the other is directed to a reference detector. This normalizes any variations in lamp intensity or detector response during the scan. This dual-beam architecture helps ensure stability and accuracy over long-term measurement periods.

In practical operation, the process begins with a baseline or “100% transmittance” scan performed with no sample in place before a calibrated detector. The operator then mounts the optic under test, ensuring alignment and beam centering through the sample onto the detector, and repeats the scan.

The instrument then measures the intensity of light transmitted by the sample at each wavelength across the desired spectral range and calculates transmittance normalized to the baseline scan. Specular reflectance from the sample usually requires a second, calibrated detector placed into the reflected optical path. Results are typically displayed both graphically and numerically and can include derived absorbance or optical density data for coatings designed to block specific wavelength ranges.

Achieving accurate data across wide spectral ranges often requires switching between multiple detectors, depending on the wavelength region being measured. This increases measurement time and introduces uncertainty in stitching together the detector response in the wavelength overlap regions. Mechanically switching between the different detectors during wavelength tuning is both inconvenient and slows scanning speed. While such instruments provide excellent precision, their reliance on frequent calibration, controlled alignment, and long scan times can impact their utility in production-line testing.

Understanding the QUANTX-300

The QUANTX-300 was originally designed to deliver precise measurements of solar cell quantum efficiency for photovoltaic research. This requires accurate control of wavelength and optical power, as well as accurate detector calibration. Several innovative design features were specifically developed to enable these capabilities.

However, the underlying architecture of the QUANTX-300 makes it equally well suited to performing the optical filter and coating measurements normally handled by a spectrophotometer. In fact, the design form of the QUANTX-300 offers a level of flexibility beyond what spectrophotometers typically provide. To understand how this is possible, it’s worthwhile reviewing some key aspects of the construction and operation of the QUANTX-300.

Optics in the QUANTX-300 direct the output of a 100-watt xenon arc lamp through a chopper then through a filter wheel (to eliminate harmonics), and next into a 1/8 m monochromator. This chopped and spectrally selected output passes through a beamsplitter. The transmitted beam goes to a monitor detector, and the reflected beam goes through the component under test and on to a calibrated detector.

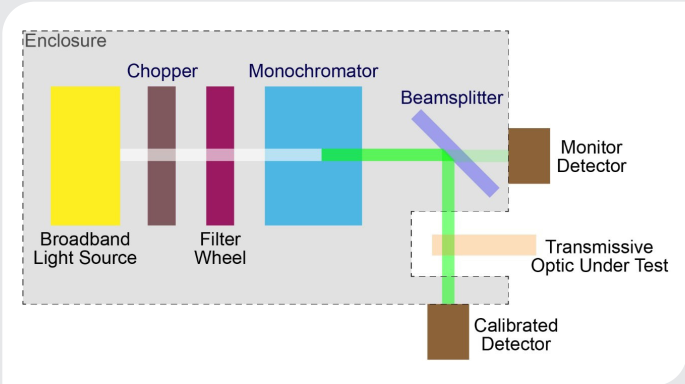

Figure 1. Block diagram of the QUANTX-300 optical system. The optic under test and the detectors are external to the main instrument enclosure.

The measurement path above the calibrated detector is in the open and easily accessible, allowing nearly any sized component to be tested. The chopped optical beam both eliminates ambient light effects to the sample and supports lock-in detection for a high dynamic range. The monitor detector is user-calibrated to predict the optical power at the sample for each wavelength corrected for any lamp fluctuation, measured simultaneously during the calibrated detector scan.

The QUANTX-300 employs a patented, summed Si/Ge reference detector to permit continuous measurement from 325 nm to 1800 nm in a single scan, without switching detectors or optics. To accomplish this, it combines a silicon detector (for the visible wavelengths) and a germanium detector (for the near infrared) in a monolithic housing. These are arranged so that light reflects from one to the other and sums up their signals. The housing itself captures and eliminates stray light from reflecting back into the optical path.

Besides simplifying extended wavelength scans, the NIST traceable Si/Ge reference detector also reduces measurement uncertainty. Its design eliminates breaks in the measurement process and ensures that every data point is collected under identical optical and electronic conditions. The result is a single, seamless measurement with excellent sensitivity, high repeatability, and none of the downtime or complexity associated with switching detectors in a multi-detector system.

Using the QUANTX-300

In addition to the monitor detector is a second persistent detector in the QUANTX-300, which is a reflectance detector, utilized for measuring reflected light at normal incidence to the sample under test, perpendicular to the scanning beam. Both the monitor and reflectance detector are modules integrated into the main QUANTX-300 enclosure. The calibrated reference detector can be readily aligned under the sample. As a result, it’s easy to configure the system to capture light transmitted through the sample, light reflected from its surface, or both simultaneously. An optional, off-axis detector is available to measure the angular reflection off the sample surface, such as common dichroic or hot/cold mirror applications. Thus, the QUANTX-300 provides much improved operational flexibility over a traditional spectrophotometer.

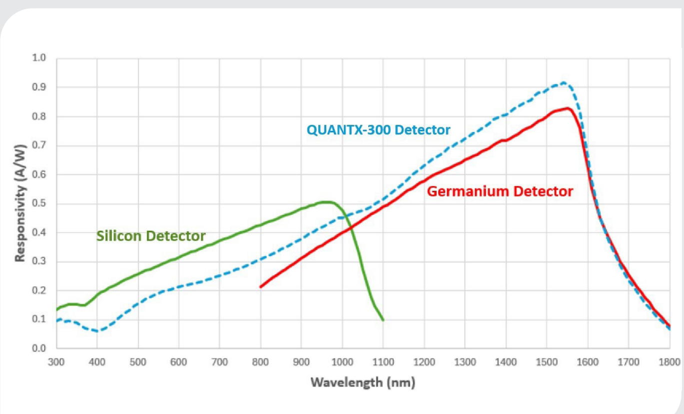

Figure 2. The patented QUANTX-300 detector extends from 325 – 1800 nm without a transition by switching from a Silicon to a Germanium detector during a wavelength scan.

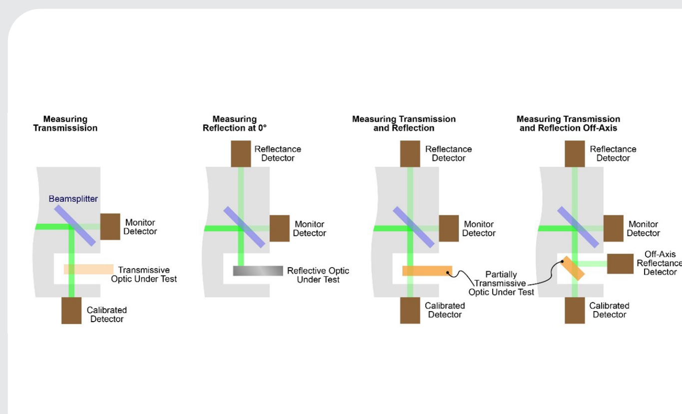

Figure 3. The calibrated Si/Ge reference detector and optional off-axis reflectance detector can easily be repositioned to support measurements of transmission, reflection, or both.

The QUANTX-300 employs achromatic optics, meaning the output maintains its 1mm x 1mm beam size over the entire wavelength range. The small, focused beam allows the user to measure small samples down to a few mm or measure multiple points on large samples. The inherent stability of the QUANTX-300 simplifies setup, minimizes alignment errors, and ensures consistent illumination throughout the measurement.

To initiate a measurement with the QUANTX-300, the user first calibrates the monitor detector to the calibrated reference detector aligned in the output beam without a sample in place. This maps the optical power at the sample location onto the response of the monitor detector. Next the user calibrates the reflectance detector using two known reflectance standards: one high reflectance mirror and one low reflectance glass.

The user is guided through the easy calibration process using the QUANTX software.

After saving the calibration files, the system is ready to measure the sample as often as desired. The optical layout places the sample directly in the open beam path (between the beam splitter and the detector) allowing nearly any size or geometry of optic to be tested. The component is typically tilted slightly to prevent back-reflections from re-entering the optical path.

Following system calibration, the operator selects the detector gains, the wavelength scanning range, and wavelength step size, and initiates the automated scan without the sample. Next, the user places the sample in the beam path and runs a second scan. The system software controls all optical and electronic parameters, recording the spectral response of all detectors and computing the reflectance directly. The transmission is calculated by dividing the spectral response with the sample by the response without the sample.

$$\text{Transmission} = \frac{\text{Detector Response with sample}}{\text{Detector Response without sample}}$$

The result is a fast, broadband measurement with minimal setup, no beam-switching mechanics, and built-in correction for source drift and environmental noise.

QUANTX-300 Advantages and Limitations for Production and QA Workflows

The QUANTX-300 workflow aligns naturally with the requirements of production and high-throughput QA environments. Its open beam path and repositionable detector modules allow nearly any optic size or shape to be tested without the constraints of a fixed sample bay. Large filters, mounted components, and even partially assembled optics can be measured directly, eliminating custom fixturing and expediting sample changeover. Measurement speed is another practical benefit.

Figure 4. The compact QUANTX-300 offers a convenient alternative to traditional spectrophotometers for many applications.

A full 325 – 1800 nm scan is performed as a single continuous sweep, with no detector changes, and no baseline scans. The monitor detector continuously normalizes every data point, removing the wavelength-to-wavelength discontinuities common in multi-detector spectrophotometer designs.

Ambient light immunity and high dynamic range (provided by the chopper and lock-in amplifier) further strengthens the system’s suitability for production use. The QUANTX-300 detects only the modulated beam, ignoring constant background illumination and electrical noise. This allows measurements to be performed under ordinary room lighting rather than inside a light-tight, mechanically enclosed spectrophotometer compartment.

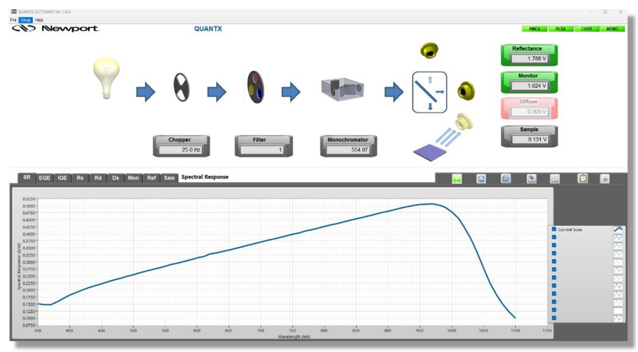

Figure 5. The QUANTX-300 system uses an intuitive, icon based graphical interface software to provide instrument controls, configuration, detector calibration, data acquisition, and signal monitoring, with easy to navigate submenus.

For certain highly demanding applications, laboratory-grade spectrophotometers may offer additional measurement capabilities. Systems using double-pass monochromators typically provide high wavelength accuracy and may support additional test laboratory certifications. They also often feature precision-engineered, fully enclosed optical benches designed to achieve very low stray-light levels, which can be important for ultra-high-OD coatings, deep-UV measurements, or applications requiring very low measurement uncertainty.

In addition, the monochromators and detectors used in these systems are typically configured to achieve narrow spectral bandwidths, allowing finer resolution of very steep coating edges. For metrology laboratories performing acceptance testing against stringent radiometric standards, these capabilities may be required.

However, these strengths are often accompanied by practical limitations. Measurements can be slower, sample positioning may be more constrained, and certain measurements may require integrating spheres or additional accessories. These systems can also involve more frequent recalibration, higher maintenance effort, and factory service requirements, which may limit their flexibility in production-oriented or application-driven environments.

Conclusion

Coating manufacturers almost universally employ spectrophotometers to measure the spectral characteristics of their products. But, in day-to-day coating verification – where testing throughput, ease of use, and flexibility matter as much as raw resolution – the MKS Newport QUANTX-300 Quantum Efficiency Measurement System can offer a more practical balance at a significantly lower price point. It delivers fast, stable, repeatable measurements with a fraction of the operational overhead, making it exceptionally well suited to modern production workflows while still delivering the accuracy required for most coating applications.

Selected QUANTX-300 System Specifications	
Monochromator	Single 130 mm optical path
Light Source	Integrated Xenon, 100 W
Spot Size	1.1 x 1.2 ±0.1 mm at working distance
Working Distance (typ.)	85 ±1 mm
Wavelength Range	325 – 1800 nm
Wavelength Accuracy	±0.5 nm
Wavelength Resolution	0.5 nm
Bandpass (FWHM)	1 – 40 nm
Signal Processing	5 – 100 Hz via Lock-In
Dynamic Signal Range	50 dB
Detectors	Patented summed Si + Ge
Scan Speed*	5.7 s per wavelength step
Full Wavelength Scan Time**	Less than 15 minutes
Maximum Sample Size	250 x 250 mm

*Total scan speed includes initial background subtraction measurement, 10 sample avg. per wavelength step, grating and filter wheel switch times
** Sample scan from 330 nm to 1800 nm, in 10 nm steps