Near-Infrared Spectroscopy

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Near-infrared spectroscopy is a common analytical technique for chemistry and process control, where typical applications include identification of species and determination of water and fat content. New detector and optical bench options make it possible to configure miniature fibre optic near-infrared spectrometer setups for high-resolution applications such as laser and optical fibre characterisation.

Laser Analysis using NIR spectroscopy

Characterisation of laser lines – examples include solid state lasers at 1064 nm and at wavelengths from 1020-1050 nm, as well as semiconductor lasers with response in the 900-1800 nm range – often require a high optical resolution. Ocean Optics has tested the optical resolution performance of the NIRQuest512-2.2 spectrometer. The NIRQuest512-2.2 spectrometer has a Hamamatsu G9206-512W InGaAs-array detector and is responsive from 900-2200 nm. For the test a xenon source used for spectrometer wavelength calibration was measured. The low-pressure gas-discharge source has a number of closely aligned emission lines in the region from ~820-2000 nm.

The NIRQuest512-2.2 was configured with a 100 lines/mm grating set to 900-2050 nm, with a 25 µm slit and gold-coated collimating and focusing mirrors for enhanced reflectivity. A 50 µm VIS-NIR optical fibre was used to collect signal from the xenon source. The integration time was set to 350 ms and spectral averaging set to 5.

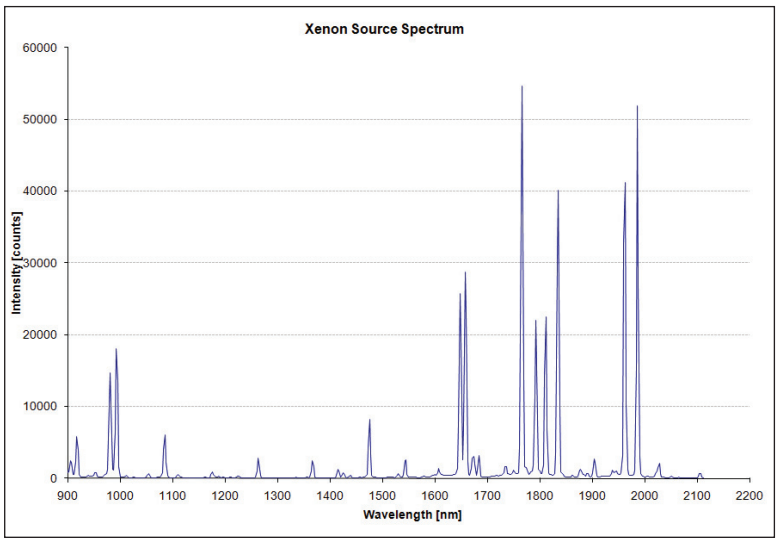

Figure 1. Spectrum of a xenon calibration source measured with the NIRQuest512-2.2

The spectrum from the xenon calibration source *(Figure 1)* illustrates that optical resolution of ~4.6 nm (FWHM) is possible with the NIRQuest512-2.2 in its standard configuration *(Figure 1)*.

What's more, even better optical resolution is possible in a NIRQuest512-2.2 configured with a grating that has a narrower spectral bandwidth. For example, a NIRQuest512-2.2 with a 600 l/mm grating set over a 100-nanometer bandwidth and configured with a 25 µm slit would yield optical resolution of <0.5 nm (FWHM). Resolution would improve even more with a 10 µm slit, but at the expense of throughput. For most laser applications, that's likely to be an acceptable trade-off.

Analysing photovoltaic materials using NIR spectroscopy

Miniature fibre optic spectrometers are attractive analytical tools for photovoltaic materials research and quality control.

Typical applications include analysis of the optical properties of solar cell materials, spectroradiometric measurement of solar simulators used in panel testing and quality control in panel production. NIR spectroscopy can be used amongst other to measure the reflection properties of potential photovoltaic panel materials.

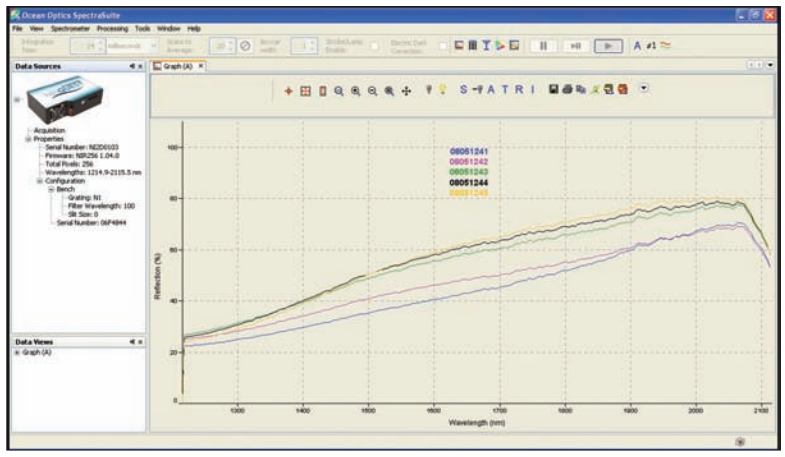

Figure 2. Screenshot of the SpectraSuite software that shows the results of reflectivity analysis of several coated glass samples measured with the NIRQuest 256-2.1

Ocean Optics has run some tests for a manufacturer of thin film photovoltaics panels who requested near infrared (NIR) reflectivity analysis of several coated glass samples. Measurements were conducted in the NIR range from 1200-2100 nm under ambient lab lighting conditions. Because the absorbance of photovoltaic panels is so critical, determining the reflectivity at panel edges and elsewhere is a good indicator of the light loss at those areas. The use of anti-reflective coatings and glass dopants are among the approaches manufacturers may evaluate in improving panel efficiency.

For this test, the NIRQuest256-2.1 was used. This 256-element spectrometer is especially well suited for applications involving higher wavelengths (peak responsivity is ~1900 nm). Five coated glass samples were analysed using this spectrometer, configured with a 100 um slit and optimised for the range from 1200-2100 nm. The sampling setup comprised a high-powered tungsten halogen light source, a 400 µm reflection probe and a reflection/transmission optical stage (fixture).

The measurements showed good stability with no averaging and boxcar smoothing.

The reflection spectra for the supplied samples *(Figure 2)* demonstrated that reflection values increased as a function of wavelength comparably across all five samples, peaking at about 2000 nm (2 µm). Also, the gap between the least reflective and most reflective samples was relatively narrow at the lower and upper ranges of the spectrometer setup, with the greatest variation observed at approximately 1700 nm.

As developers of photovoltaic materials continue to seek improvement in cell efficiency, the need for analytical tools that are convenient for evaluating glass coatings, dopants and other materials is great.

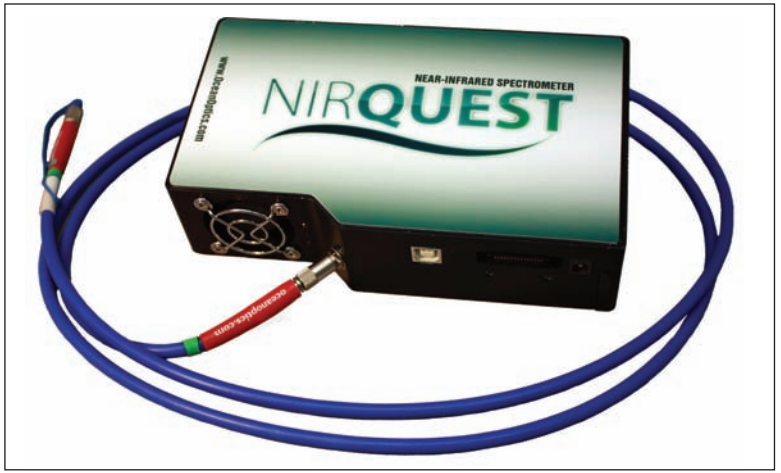

Figure 3. The NIRQuest miniature fibre optic spectrometer for measurements in the NIR range from 900 – 2500 nm

Optical sensing systems such as NIR spectrometers, thin film measurement systems and solar simulator testing units are easily configured for both research lab and process line applications. In this case study, we demonstrated how NIR spectroscopy can be used to determine the reflectivity of coated glass samples relative to each other and to known reflectance standards.

As a result, the solar light capturing efficiency of the five sample coatings now can be inferred with the utiliSed Ocean Optics spectrometer and accessories.

NIRQuest spectrometers

NIRQuest miniature fibre optic NIR spectrometers *(Figure 3)* use a high-performance Indium Gallium Arsenide (InGaAs)-array detector in a compact optical bench with thermoelectric cooler and low-noise electronics.

A high gain mode option improves system sensitivity for low light-level and low-concentration measurements. The spectrometer's rapid integration times – spectral acquisition of 1 millisecond is possible – makes it viable for high volume production environments. A high gain mode option improves system sensitivity for low light-level and low-concentration measurements.

NIRQuest also has external hardware triggering functions, which allow users to capture data when an external event occurs, or to trigger an event after data acquisition. This capability can be especially useful for capturing data from automated processes or from devices such as solar simulators that flash synchronously.

The NIRQuest uses SpectraSuite Spectrometer Operating Software – a modular, Java-based spectroscopy platform that operates in Windows, Mac OS and Linux operating systems. Plus, NIRQuest can be bundled with the Remora Network Adapter from Ocean Optics to turn the system into a multi-user spectral data server over Ethernet or your existing Wi-Fi connection.