NIR Analysis of Photovoltaic Panels

Near Infrared Spectroscopy is Useful Tool in Photovoltaics Panel Development

With their modest cost, compact size and great flexibility, miniature fiber 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. In this case study, we evaluated NIR spectroscopy as a tool to measure the reflection properties of potential photovoltaic panel materials.

Background

A manufacturer of thin film photovoltaics panels 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.

Experimental Procedure

Five coated glass samples were analyzed using an Ocean Optics NIRQuest Spectrometer (Figure 1), configured with a 100 um slit and optimized for the range from 1200-2100 nm. The sampling setup comprised a high-powered tungsten halogen light source, 400 µm reflection probe and a reflection/transmission optical stage (fixture). A specular reflection standard with ~85-98% reflectivity from 800-2500 nm was used as a reference. SpectraSuite spectrometer operating software, a Java-based spectroscopy platform that operates in Windows, Mac OS and Linux operating systems, completed the setup.

The glass samples were placed on the sample holder uncoated side down, to ensure that the probe was measuring the reflection from the coating through the glass. The optical stage helped to position the probe at 90º to measure specular reflectance. In specular reflection, the angle of incidence is equal to the angle of reflection. Specular reflection increases with the amount of gloss on a surface.

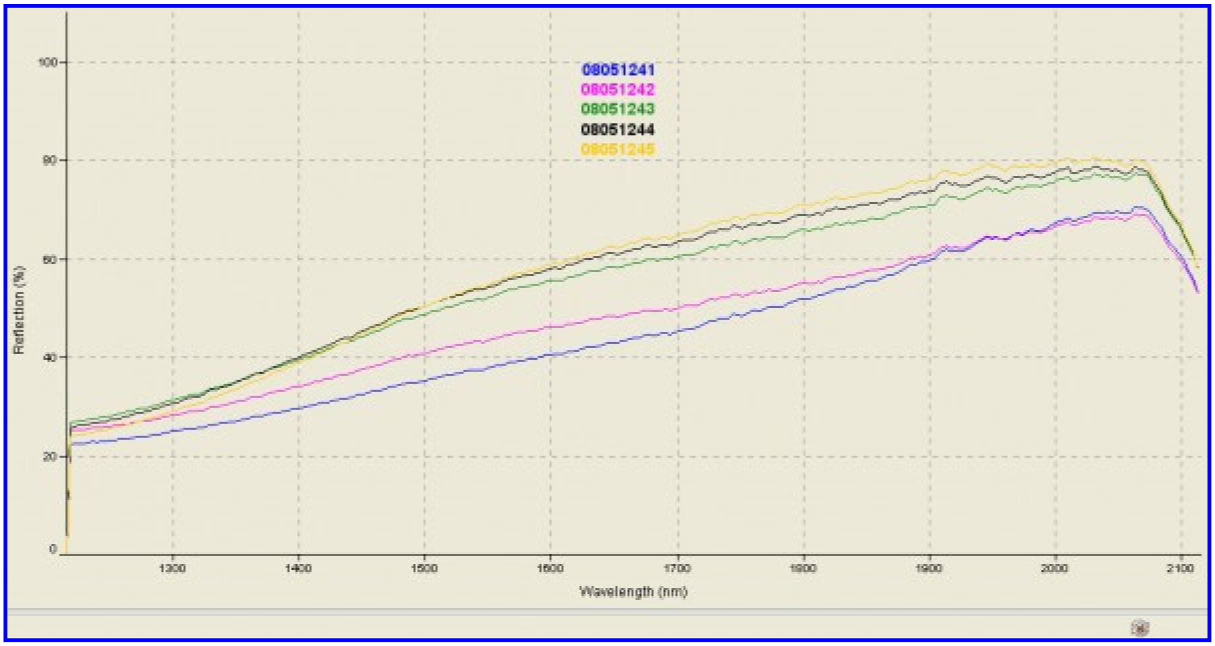
Measurements were taken under overhead lighting conditions, without use of a dark room or box. The high-powered (20 W) tungsten halogen light source provided continuous illumination from 360-2000 nm. The distance from the tip of the reflection probe to the surface of the sample was measured at ~7 cm for each sample, to simulate production conditions.

Ocean Optics NIR Spectrometers use a high-performance Indium Gallium Arsenide (InGaAs)-array detector in a compact optical bench with thermoelectric cooler and low-noise electronics. The particular model used for this setup – the NIRQuest256-2.1 — is a 256-element spectrometer suited to applications involving higher wavelengths (peak responsivity is ~1900 nm). 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.

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.

Results

The measurements showed good stability with no averaging and boxcar smoothing; therefore, only one set of spectra was collected. 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.



Reflectance intensity of the coated samples ranged from approximately 25% at the lower wavelengths to as much as 80% at the higher wavelengths. These values are relative to the response of the specular reflectance standard, which has nearly "flat" reflectivity across all NIR wavelengths.

Conclusions

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. 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 our 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 utilized Ocean Optics spectrometer and accessories.

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