Miniature Spectrometers for Narrowband Laser Characterization

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Keywords

- High resolution
- Laser power
- Spectral shape

Techniques

- Emission spectroscopy
- Absolute power measurement

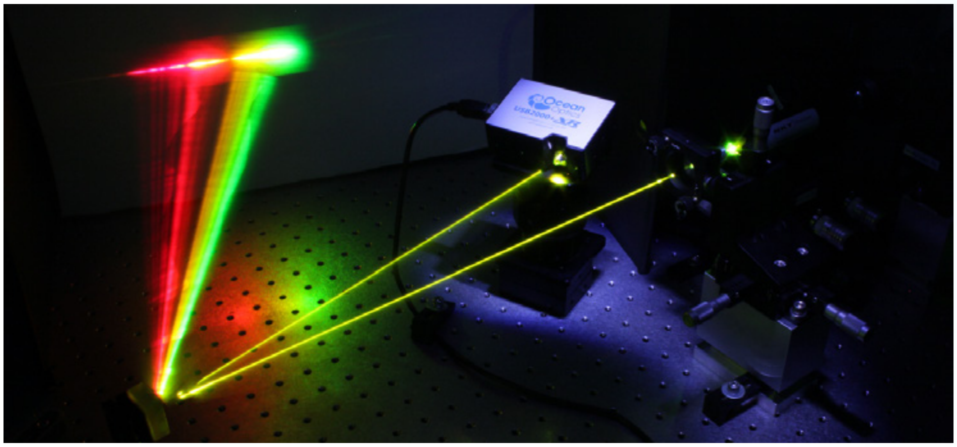
Applications

- Laser characterization
- Laser power output
- Quality control

In less than 60 years, lasers have transformed from the imagined "ray gun" of science fiction into everyday reality. Used everywhere from bar code scanners to sophisticated single-molecule microscopes, lasers are powerful and cost-effective light sources for applications spanning basic research to consumer entertainment. Characterization of wavelength and power is an important part of working with these sources, and compact, plug-and-play spectrometers are an excellent tool to do so.

Background

Miniature spectrometers can be used to characterize laser output, either as part of an internal laser feedback loop or externally. Ocean Optics modular spectrometers can be configured for sub-nanometer optical resolution (FWHM) performance in the UV-VIS (200-1100 nm) and high resolution in the NIR (800-2500 nm), with fast response times and triggering functions for synchronizing laser events to spectral acquisition. Our spectrometers also can be calibrated to measure the absolute power of low-power laser sources.



Combined Wavelength and Power Monitoring

Laser diodes are prone to wavelength and power output fluctuations due to temperature variations, often requiring feedback loops and stabilization. At just over 40 mm square and less than 25 mm tall, our STS microspectrometer offers a compact and powerful solution to laser monitoring that fits easily into a laser system or sub-assembly. When equipped with a 10 µm slit, the STS is capable of resolving laser output with resolution close to 1.0 nm (FWHM), and can accommodate both fiber and free-space coupling.

As shown in Figure 1, a collimated 532 nm laser diode was characterized using a radiometrically calibrated STS-VIS (~1.5 nm FWHM resolution). The laser beam was transmitted through a beamsplitter and the reflected beam (approximately 30%) was collected by an integrating sphere; the STS-VIS measured the laser's absolute spectral radiant flux and integrated power.

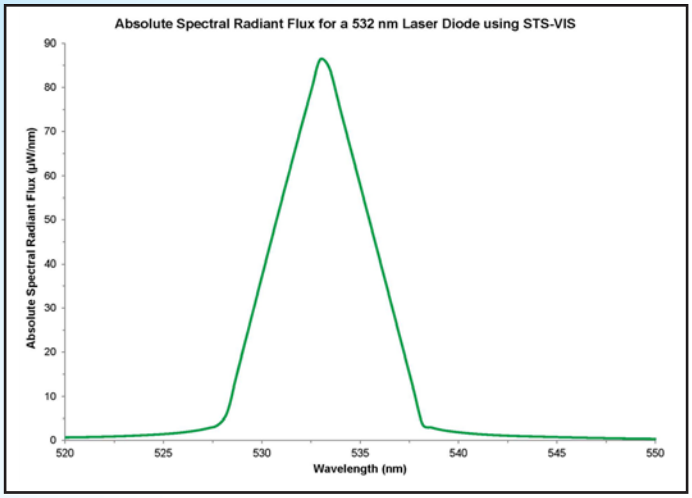


Figure 1. The small-footprint, high performance STS microspectrometer is an excellent option for integration into a laser source sub-assembly.

By integrating the spectral radiant flux over the region from 500-560 nm, and by using the ***Energy, Power and Photons*** feature in OceanView spectroscopy software, we calculated a total integrated laser power of 521 µW.

High Resolution Spectral Measurement

When more than just a center wavelength is needed, a high resolution spectrometer may be appropriate. Our HR series of spectrometers are offered with a variety of gratings and with two high-density CCD array detectors, allowing you to custom-configure a system for your specific wavelength range with high resolution. This allows a single spectrometer to measure multiple characteristics of the laser including peak location, FWHM, integrated area under the peak and other parameters.

Using an HR4000 spectrometer, we characterized a 532 nm laser diode over a narrow wavelength range. The spectrometer was configured with a narrow (5 µm) slit and a 2400 line/mm grating to achieve <0.05 nm resolution (FWHM). With the ***Peak Metrics*** feature in OceanView software, we identified the center wavelength at 531.4 nm and determined the laser had a FWHM of 0.14 nm (Figure 2). In combination with a power meter, a high-resolution spectrometer can provide complete characterization of even a very narrow laser source.

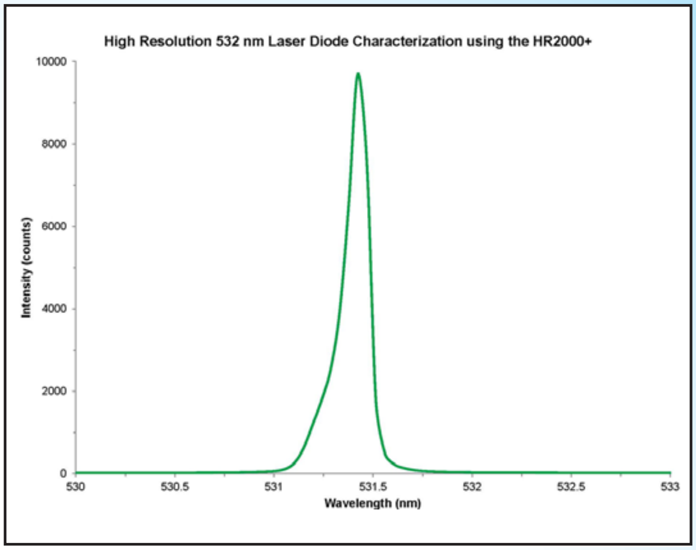


Figure 2. HR series spectrometers work well for laser applications with sub-nanometer optical resolution (FWHM) requirements.

Monitoring Near-IR Lasers

Laser applications are moving increasingly into the NIR, including pharmaceutical development, stand-off explosives detection, and other defense and security applications.

To demonstrate the capability of Ocean Optics spectrometers for the characterization of NIR lasers, we measured the output of a wavelength-stabilized 1064 nm laser using a NIRQuest spectrometer. Configured with a 10 µm slit and a 600 line/mm grating, this custom configuration delivered 0.25-0.46 nm resolution (FWHM) over the range of 975-1125 nm.

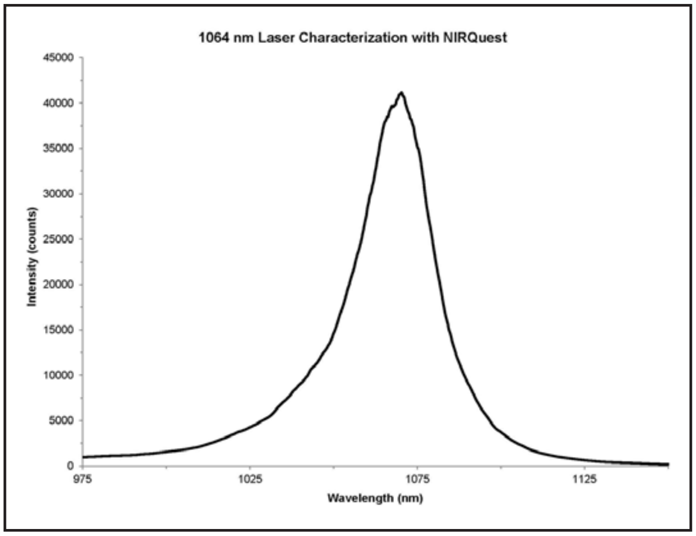


Figure 3. With the optimum combination of gratings and slits, NIRQuest spectrometers can be configured to characterize NIR lasers.

The peak characteristics measured for the 1064 nm laser are shown in Figure 3. We used the ***Peak Metrics*** feature in OceanView software to determine the center wavelength of 1068.3 nm. Additional peak characteristics that can be determined include centroid, FWHM and 90% bandwidth.

Broadband Tunable Lasers: The New Frontier

In addition to the traditional narrowband lasers described above, a host of versatile broadband and tunable laser sources has taken the industry by storm in the last 10-20 years, including Ti:sapphire lasers, OPOs and supercontinuum lasers. Though not as new, even dye lasers have their place in this world. These tunable sources by their very nature require ongoing spectral characterization, which is easily achieved using a compact STS microspectrometer.

Summary

Whether measuring center wavelength, spectral shape or power, compact spectrometers are a convenient, low-cost tool for the characterization and monitoring of many types of laser sources. Contact an Application Sales Engineer today to customize the system that is right for your application.

Contact us today for more information on setting up your spectroscopy system from Ocean Optics.

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