APPLICATION NOTE

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Light Sources and Photo-detectors for OBS® Sensors

CAMPBELL SCIENTIFIC, INC.®
WHEN MEASUREMENTS MATTER

Light Sources and Photodetectors for OBS® Sensors

Sensors that use the OBS® method have narrow- or intermediate-band illumination systems, depending on whether a laser diode (LD) or infrared-emitting diode (IRED) is used in their construction. This application note describes infrared-emitting diodes and laser diodes, as well as photodiodes, daylight filters, and operating spectra.

Laser Diodes

Laser diodes have narrow, multimode emission spectra resembling the one shown in Figure 1. The LD bandwidth is about 2 nm at half power (FWHM). They have built-in photodiodes to monitor the light output of the laser chip so that photocurrent can be used to control the illumination of the sample. In this way, fluctuations in light power caused by sensor temperature and laser aging are virtually eliminated. The drift of our OBS-4 LD-based sensor, for example, is less than 2% per year of continuous operation. The two disadvantages of lasers are that they emit coherent light, which because of interferences can fluctuate in intensity in a sample volume by as much as 50%, and they are less efficient in converting electrical current to light than IREDs.

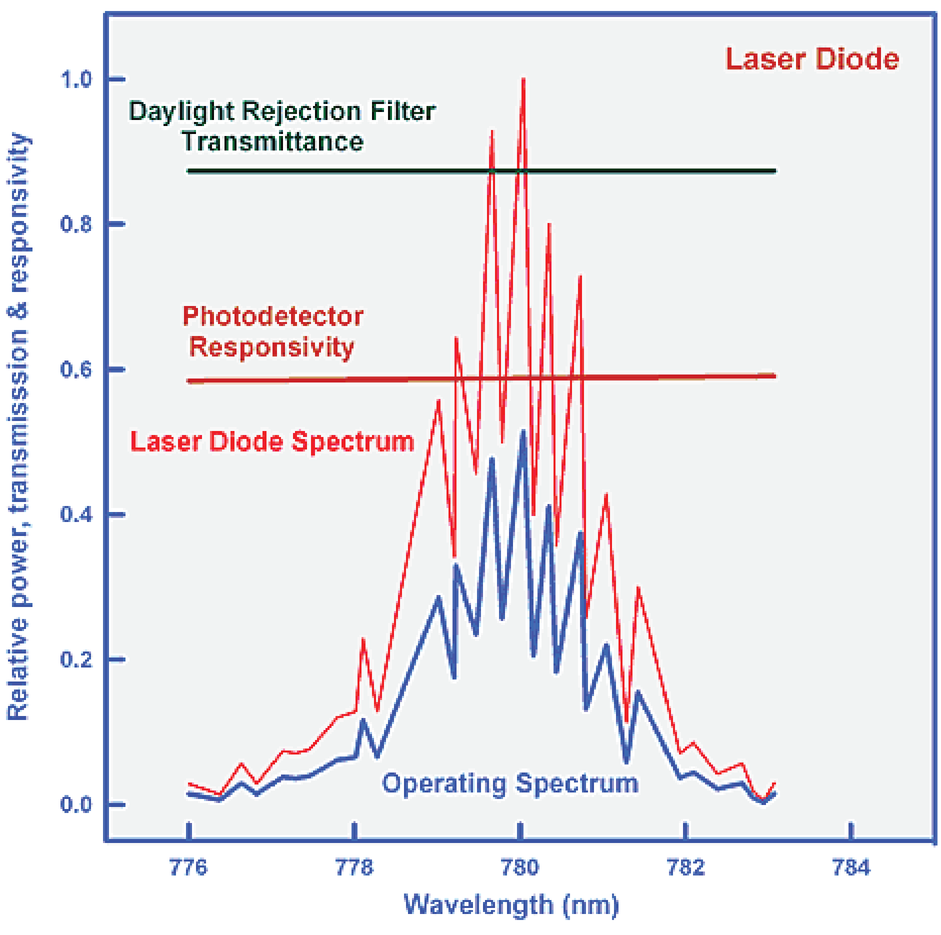

Figure 1. Graph shows the relative power, transmission and responsivity of a laser diode. Laser diodes have narrow, multimode emission spectra.

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Infrared-emitting Diodes (IRED)

IRED sources have bandwidths of about 80 nm—40 times wider than laser diodes. They have a few handy properties. First, they create incoherent light and this makes the optical design less complicated than for sensors with lasers because interference effects are far less pronounced. Second, they produce light from electricity much more efficiently that incandescent lamps and laser diodes (8X), and finally, they can be switch on and off very rapidly enabling synchronous detection for ambient light rejection.

The spectral properties of our IRED sources are shown in Figure 2. The disadvantages are that IREDs emit light in all directions and lenses and mirrors are required to produce a collimated, pencil-like beam. There is also no convenient way to package them with a monitoring diode such as used in lasers with automatic power control.

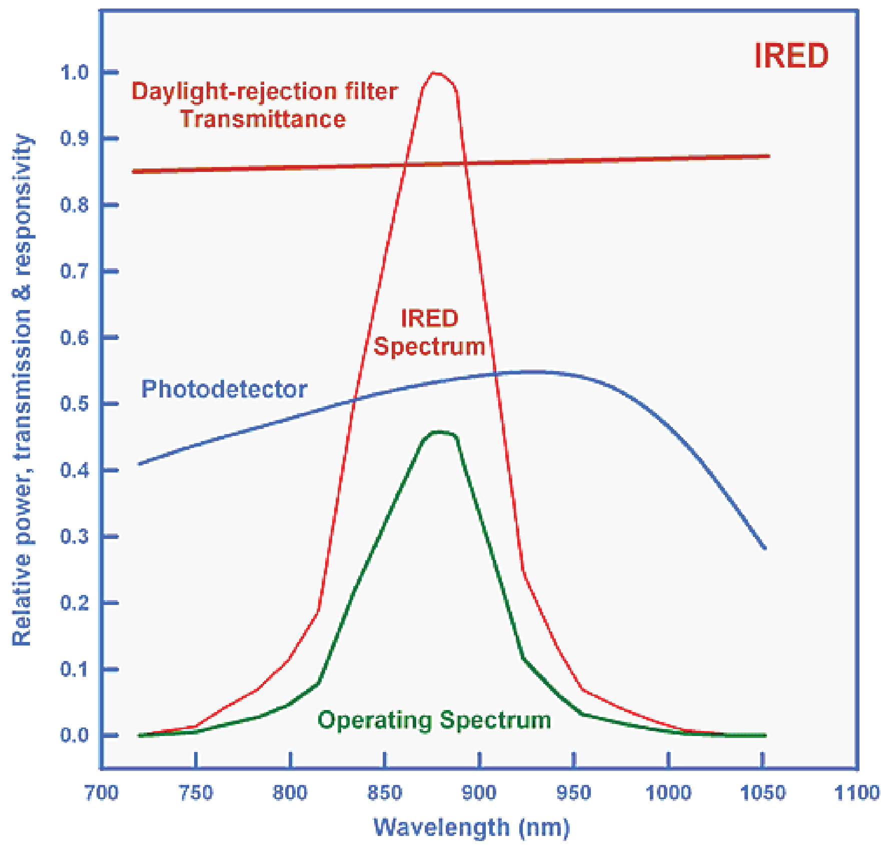

Figure 2. Graph shows the relative power, transmission, and responsivity of a IRED diode. The bandwidth of the IRED is ~40 times wider than laser diodes.

Diodes Used in OBS Sensors

OBS sensors detect light with silicon PNN+ photodiodes. The OBS sensor diodes have: 1) excellent linearity and low noise, 2) nearly flat spectral response in the source spectral band, 3) extremely low, < 0.01% per °C, temperature coefficients, and 4) low time drift (~=1% per year, per tests by NIST). The responsivity, S(λ), of the photodetector is a determining factor of the operating spectrum. Responsivity (S) is the ratio of photocurrent in Amperes (A) from a detector divided by the light power in Watts (W) incident on it, e.g. $S = A\ W^{-1}$.

Optical filters are used to reject visible light so that it will not saturate (swamp) detectors. The transmittance spectra of these filters must be factored into the sensor design because the product of emitter power, transmittance, and responsivity give the relative spectral value for each wavelength common to the sensor components. The resulting operating spectrum for our laser-based instruments is shown in Figure 1 and the spectrum for IRED-based instruments looks like the one shown in Figure 2. Detectors and daylight-rejection filters are selected to minimize their effects on the emitter spectra, that is their spectra are nearly flat in the operating band. Even with these filters, NIR radiation in sunlight can saturate a sensor when it is exposed to direct sunlight or reflective surfaces illuminated by the sun. Maintaining consistent operating spectra is essential to obtaining high measurement precision.

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