Optical power and peak wavelength are of particular importance in diode laser characterization. The obvious approach is to slap a photodiode and fiber-coupled wavelength measurement device on a baffle-free integrating sphere, perform calibration, and start measuring. Unfortunately, it’s not that simple. If you want to have confidence in your measurements, you must give careful consideration to location of the diode laser, photodiode, and fiber.

A diode laser emits radiation in an ellipse. The diode laser should be close enough to the integrating sphere that the sphere collects the emitted optical flux, yet far enough away to minimize back reflection. This distance is typically dictated by the geometric constraints of the test bench. Another consideration is the size of the entrance port of the integrating sphere. The port must be large enough to collect the total emitted flux from the laser under test. Remember, entrance port size drives sphere diameter; a good rule of thumb is not to exceed a port fractional area of 5%.

Based on the optical flux $\phi_{\lambda}$ introduced into the integrating sphere wall, we can estimate radiance $L$ using

$$L = \frac{\phi_{\lambda}}{A_s (1 - f_j)}$$

where $\phi_{\lambda}$ is the input flux, $\rho$ is the sphere wall reflectance factor, $A_s$ is the sphere area, and $f_j$ is the sphere port fractional area. We can measure peak wavelength by adding a fiber port to the integrating sphere in addition to the photodiode. To ensure flux input reproducibility, position the fiber such that it collects uniform radiance; in other words, ensure the beam spot of the diode laser (first-strike radiance) on the sphere wall does not fall within the numerical aperture of the fiber. This geometry involves trade-offs, the most important being reduced optical efficiency. In this case, we can estimate the flux $\phi_f$ incident on a fiber of area $A_f$ as

$$\phi_f = L A_f \pi (NA)^2$$

where $E$ is the irradiance on the sphere wall. This configuration can effectively increase the optical efficiency by a factor of six for the same sphere diameter and wall coating. In many cases, however, it is still not efficient enough for measurements with the 62.5-µm-diameter fibers typical for spectrum analyzers and wavemeters.

This leads us to a third alternative, which is positioning the fiber opposite the sphere entrance port. In this geometry the flux incident on the fiber is

$$\phi_f = E A_f$$

Placing the fiber opposite the entrance port comes with a trade-off, however. A photodiode is mounted on the integrating sphere to measure the radiant flux from the diode laser entering the sphere. Unlike the case of a fiber, a photodiode mounted on an integrating sphere for optical radiation measurements must be positioned to collect only integrated radiance. One way to achieve this condition is to place the detector forward and with its optical axis perpendicular to the entrance port optical axis (see figure). That gives us a flux incident on the detector of

$$\phi_d = L A_d \pi \sin^2 \theta$$

where $\phi_d$ is the flux incident on the detector, $A_d$ is the detector active area, and $\theta$ is the half-angle field of view. Another option is to place the photodiode behind an optical diffuser mounted flush with the sphere wall, in which case the flux incident on the detector is

$$\phi_d = T L A_d \pi \sin^2 \theta$$

where $T$ is the diffuser transmission.

To ensure the optimal measurement for your application, you should consider the advantages and trade-offs of the various integrating sphere and component geometries presented and determine the best option.

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