LED APPLICATION NOTE

Optical Interference Filters for Applications using a LED Light Source

Overview

Light Emitting Diodes, or LEDs, are high efficiency sources of electro-magnetic energy with a wide range of available wavelengths and very high brightness. These devices directly convert electrons to photons, rather than producing photons through blackbody radiation as a consequence of electron conversion to heat. As a result, there is little associated thermal pollution, or wasted energy.

LED CHARACTERISTICS

Although very effective at producing luminous power for scientific applications, LEDs have an assortment of limitations that must be considered. The primary limitation is that although they are very bright in lumens per unit area, they are quite limited in absolute power. A related limitation results from the fact that as current is increased across the light producing junction, the temperature also increases, causing a thermal shift of output wavelength. Whether caused by a change in the temperature of the environment, or by the residual heat of driving the junction to produce more photons, the consequence is that the output wavelength drifts.

Consistency limitations are exacerbated by the tendency of the output wavelength to vary from batch to batch. Minor variations in host impurities result in lot variations of Center Wavelength (CWL) of as much as 10nm, with occasional lots falling outside this range. Selection is a possible solution, but may result supply chain, inconsistencies.

At low levels of output, LEDs exhibit bandwidth (FWHM or HBW) which is typically 30nm. At greater power outputs, they produce coherent emission which has a distinctive spectral power function. The characteristic of this emission is a region of intense spikes of energy superimposed on the continuum. These spikes have bandwidths which are typically 1 nm and can occur in groups of up to ten bands within a region of 5nm of a central peak.

Although much of the energy of LEDs is emitted in the specified region, there typically are secondary regions of light output. Usually these regions of secondary output are at significantly longer wavelengths, with infrared output at nominally twice the primary wavelength.

Without filtering the secondary spectral output of LEDs makes them unsuitable for devices designed for low level photon conversion, such as fluorescence or Raman scattering. Even if the secondary output is six orders of magnitude less than the primary, it would contribute a critical error in these applications, made even more serious by the enhanced IR sensitivity of silicon based detectors.

FILTER RECOMMENDATIONS

In very few cases is the output of an LED adequately monochromatic to be used in a critical application without an additional filter device. For applications using LED sources, a minimum requirement is a filter which controls and attenuates photons in the spectral region containing the desired signal photons.

- Omega Alpha Shortpass (ASP) filters are ideal in this application. These filters will attenuate the wavelengths greater than 1.03 times the cut-off to a minimum of OD 5.0 and can be used to isolate all near-band wavelengths. For those wavelengths that occur 2x the value of the primary wavelength and within the limits of CCD detection a complimentary attenuation strategy may be necessary depending on the performance and specifications of the detector.

- Additionally, a bandpass or longpass filter is usually required to resolve the desired emission band and to give adequate signal-to-noise (S/N).