

# PHOTONICS spectra®

## WHITE PAPERS & APPLICATION NOTES

### "Fingerprint" vs Handheld Raman applications and the different Optical Filters that enable them

Raman spectroscopy is a powerful and increasingly ubiquitous analytical tool capable of identifying molecular constituents of samples under test and, when combined with microscopy, exploring specific cellular structures and functions. Non-invasive, non-contact, requiring no sample preparation or chemical tagging – it is no wonder that Raman has established a presence as an invaluable analytical technique both in labs and in the field.

The exchange of energy between photons and vibrational modes of molecules that defines Raman scattering occurs for approximately one in a million incident photons. This exchange in energy between incident photon and molecule results in a shift in wavelength of the Raman scattered photon relative to the excitation wavelength, either a "Stokes" shift to lower energy, longer wavelength or "anti-Stokes" shift to higher energy, shorter wavelengths. The low probability of this event makes detection of this information, but elusive, Raman scattered signal from the dominant Rayleigh scattered photon signal like finding a photon's needle in a brightly illuminated haystack. This is where optical filters enter the story; wavelength selective optical filters can be used to block the dominant Rayleigh scattered light and transmit only the Raman scattered photons providing "more signal, with less background" to the detector. However, in order to appropriately balance the technical (performance) and commercial (cost and supply) needs of different markets and applications different optical filters are required, striking the balance between filters with steeper slopes and smaller cutoff values for out-of-edge technical performance but at higher cost and another lower cost family of filters with larger cutoff values and wider angle tolerances that enable the use of lower cost laser sources and compact lower cost optics used in high volume, low cost instruments to clearly identify the molecules being investigated.

#### Details matter – High precision Raman

Raman analysis has been recognized to have the potential to identify the molecular make-up of many unknown different chemicals including drugs and pharmaceuticals (along with their counterparts). The signature Raman spectral "fingerprints" of chemical species can be observed using high precision, analytical laboratory tools such as Confocal Raman Microscopes, critical in research environments. However, many of the details that make this molecular species identification possible are associated with small energy exchanges between the incident and Raman scattered photons. As a consequence, access to this "fingerprint" region of the Raman spectrum requires detection of the Raman signal, extraordinarily close to the laser line wavelength and thus requires extremely steep edge pass filters with accurate "cutoff" wavelength positions filtering.

"Cutoff" is defined as the spectral shift in wavenumbers ( $\text{cm}^{-1}$ ) between an optical density blocking of six orders of magnitude at the laser line wavelength (00% or  $\pm 0.0001\%$  of the laser line power) and the

### "Fingerprint" vs Handheld Raman Applications and the Different Optical Filters That Enable Them

Raman spectroscopy is a powerful non-invasive, non-contact tool capable of identifying molecular constituents of samples. Wavelength selective optical filters are used to block the dominant Rayleigh scattered light and transmit only the Raman photons providing "more signal, with less background" to the detector. It is critical to balance the performance and commercial needs of different markets and applications when selecting the optical filters for each application.

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