application note

Cobolt
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Feel like you're missing Raman signal – 405 nm can help see more

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In recent years, Raman spectroscopy has attracted worldwide attention as an analytical technique applicable for a wide range of markets, from materials and life sciences applications to point of care analysis, industrial screening to pure R&D. Thanks to compact laser sources, high sensitivity cameras and ultra-light compact spectrometers, Raman systems in recent years have been further miniaturized with increased sensitivity while becoming multifunctional. In this application note, we show what performance improvements can be achieved by using a 405 nm laser compared to the longer wavelengths lasers used more conventionally.

Not absent, just buried

A general challenge in Raman spectroscopy is that the inherently weak Raman signal is often hidden by the influence of fluorescence. In order to minimize the effects of fluorescence, lasers in the NIR (785 nm-1064 nm) are often used. However, since the Raman scattering intensity is inversely proportional to the fourth power of the laser wavelength, longer NIR wavelengths have the disadvantage that the Raman scattering intensity decreases. In addition, since the sensitivity of silicon sensors decreases in the wavelength region > 800 nm, an expensive InGaAs type sensor is required at these wavelengths and the device configuration can become more complicated.

Another alternative for avoiding the influence of fluorescence is to use shorter wavelengths. Instruments employing 532 nm have become increasingly popular over the recent years for this reason. However, at 532 nm there are still many materials for which the fluorescence from the absorption of laser light overshadows the weaker Raman signal.

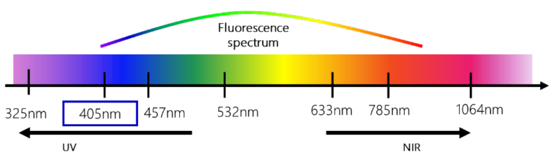

Fig. 1: Typical material fluorescence spectrum.

For instance, for such materials, eg polyimide, it could be a better solution to go to even shorter wavelengths. When the laser wavelength is further shifted to 405 nm, the Raman signal is strengthened ($1/\lambda^4$ dependence) and becomes less susceptible to the influence of fluorescence. So the Raman signal strengthens, the influence of fluorescence can be reduced and finally a silicon sensor for the visible range can be used. Furthermore, by using a 405 nm laser, composite analysis of Raman peaks and photoluminescence is made possible.

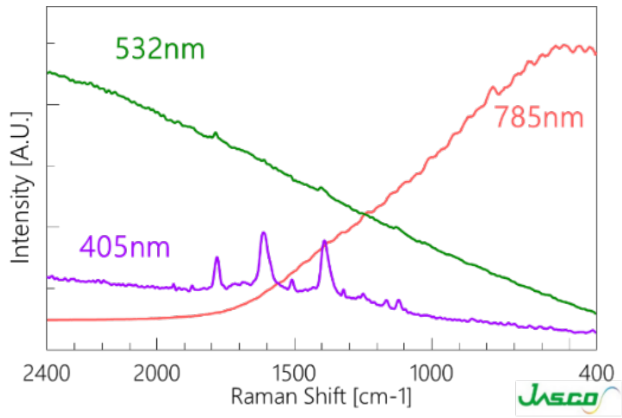

Fig. 2: Raman spectrum of polyimide being easily resolved when using 405 nm excitation. The Raman signal is buried in fluorescence for 532 nm and 785 nm laser excitation.

Lasers for Raman spectroscopy

By far the most popular wavelength used for Raman spectroscopy is 785 nm, as in many cases it offers the best balance between Raman scattering efficiency, avoiding fluorescence, absorption of the laser light and therefore heating effects and the limits to detector sensitivity. However, depending on the application and the material under investigation, it is also important to consider the advantage of adopting wavelengths that may not yet be so common in Raman spectroscopy.

The semiconductor diode lasers on the market today at 405 nm typically have broad linewidths (>1 nm). However, narrow linewidth characteristics and excellent wavelength stability as well as low noise are indispensable to obtain Raman signals and to resolve individual Raman bands. A narrow linewidth 405 nm semiconductor diode laser can be realised by using volume Bragg grating (VBG) technology but careful alignment of the VBG element and sensitive temperature control is needed to achieve stable performance. The Cobolt 08-NLD 405 nm laser is based on VBG stabilization of a 405 nm diode. Thanks to Cobolt's proprietary HTCure™ manufacturing method, which combines high precision alignment with excellent thermo mechanical stability, stable locking of the wavelength can be achieved resulting in linewidths of <20 pm (<1.2 cm^{-1}) at output powers of 30 mW over a large temperature range.

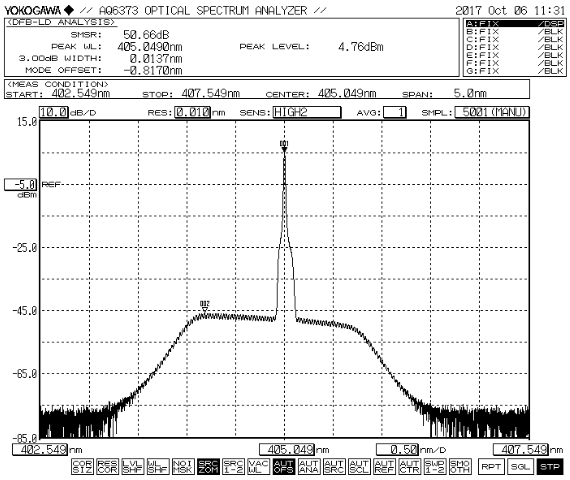

Fig 3: Typical spectrum of the Cobolt 08-NLD laser (FWHM <20 pm), output power 30 mW.

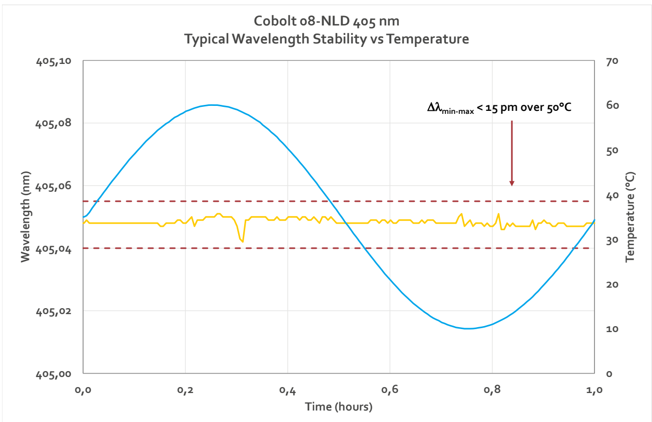

Fig 4: Wavelength stability of the Cobolt 08-NLD 405 nm over 50C (<15 pm pk-to pk).

In addition, an internal optical isolator reduces any risk of reflected light from the sample returning through the system and thereby risking damage to the laser and filters ensure >75 dB side mode supression for wavelengths >2 nm from the peak. The Cobolt 08-NLD 405 nm laser addresses all of these important performance features in a compact footprint while ensuring reliability thanks to HTCure™.

Fig. 5 : Cobolt 08-NLD laser.

Conclusions

By using a stable and narrow linewidth 405 nm laser for Raman spectroscopy, it is possible to not only obtain a stronger Raman signal by reducing the influence of fluorescence inherent to specific samples, but also to use conventional silicon detectors often standard in Raman systems. This enables simplification of set-ups and allows for more cost competitive systems. In addition, it's expected that with an improved signal to noise ratio and potentially higher sensitivity this will result in shorter acquisition times.

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About JASCO

JASCO specializes in analytical instruments with over 50 years of experience within the academic, pharmaceutical, forensic, biotechnology, and industrial markets worldwide.Read more at www.jascoinc.com

About Cobolt AB

Cobolt, a part of HÜBNER Photonics, supplies high performance CW and Q-switched lasers, for stand-alone use or OEM integration in equipment for fluorescence analysis, Raman spectroscopy, interferometric metrology, micromachining and environmental monitoring. Using proprietary HTCure™ manufacturing technology, the lasers display outstandingly tolerance to demanding environmental conditions and ensured lifetime. Cobolt is based in Stockholm, Sweden. Read more at www.coboltlasers.com