Advantages of 1064 nm Raman Excitation Compared to 785 nm Raman for Military and Safety/ Security Applications

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Rigaku
Analytical Devices

Raman spectroscopy has become an essential tool in field-based material identification for military, law enforcement, and security professionals. Among the key system design choices is the excitation wavelength—most commonly 785 nm or 1064 nm. While 785 nm excitation offers strong Raman signal intensity, it is also highly susceptible to fluorescence interference from many real-world materials. In contrast, 1064 nm excitation provides dramatically improved fluorescence suppression, enabling clearer, more reliable spectra in complex and colored samples.

Rigaku's **CQL** Series and **Icon** Series handheld Raman analyzers are engineered to leverage the advantages of 1064 nm excitation, providing enhanced performance in demanding operational environments where sample variability, background contamination, and rapid decision-making are critical.

Introduction: Raman Spectroscopy

Raman spectroscopy identifies molecular vibrations unique to a substance, producing a "spectral fingerprint" for chemical identification. The technique relies on inelastic light scattering from a laser interacting with molecular bonds. The choice of excitation wavelength strongly affects signal quality, fluorescence interference, and overall usability in field conditions.

Historically, 785 nm Raman instruments became popular due to their balance of sensitivity and manageable fluorescence. However, as field applications expanded to more complex and colored materials—such as narcotics, explosives, dyes, and improvised compounds—the limitations of 785 nm excitation became increasingly apparent.

Comparison of 785 nm vs. 1064 nm Excitation

Fluorescence suppression

Fluorescence is the most significant source of spectral interference in Raman spectroscopy, particularly for colored or organic materials.

- **785 nm Raman** can frequently induce strong fluorescence in real-world samples, which can overwhelm the Raman signal and render spectra unusable.
- **1064 nm Raman,** operating further into the near-infrared region, dramatically reduces fluorescence excitation, producing cleaner baselines and usable spectra even from strongly fluorescing samples such as dyes, biological matrices, and complex mixtures.

For field operators, this means fewer failed measurements and less time spent attempting to collect usable data.

Spectral quality and signal intensity

While Raman scattering intensity decreases with increasing wavelength (scaling as λ^{-4}), the improved signal-to-noise ratio achieved by eliminating fluorescence often more than compensates for the theoretical reduction in Raman signal at 1064 nm. The optical spectrometer also plays an important role in the light throughput/collection efficiency and therefore the Raman signal. Volume Phase Grating (VPG) based spectrometers used by some 1064 nm devices have higher optical efficiency, while less efficient optical spectrometers are commonly used in 785 nm devices. Spectral resolution for handheld systems is typically similar and results in sufficient spectral resolution to enable robust identification, when combined with advanced data collection and processing. Handheld Raman systems are not trace identification tools, the difference in sensitivity between 785 nm and 1064 nm is low and is as much to do with the specific hardware configurations. Advanced systems scan in an automated manner and are often driven by scan quality, which removes the need for users to make determinations about scan parameters. Inferior systems that are more simplistic and require users to determine scan parameters, often result in inferior scan data and identification capabilities.

The benefit of 1064 nm is **feature-rich, interpretable spectra** for a broader range of samples, especially under uncontrolled conditions.

Detector technology

785 nm systems typically employ silicon-based detectors, which are sensitive in the visible to near-infrared range but limited beyond 1000 nm. 1064 nm systems use InGaAs detectors optimized for longer wavelengths. Although historically more expensive, modern InGaAs detector technology has matured, allowing portable instruments like Rigaku's CQL variants and Icon-X to deliver robust 1064 nm performance in compact, field-ready form factors.

Mixture analysis

In real-world samples, mixtures are very common to encounter. Utilizing a device with automated mixture analysis is very important. Where users have to determine if the sample is a mixture and then configure the device appropriately and where mixture analysis is only able to identify two or three components is very limited and prone to error, when conducting analysis in the field.

Onboard spectral libraries

To achieve the best performance, handheld Raman devices that leverage purpose-built spectral libraries, developed and tested on those specific devices afford the best analytical performance. This also allows algorithms to be developed and tuned for superior onboard identification and mixture analysis. Reference libraries are available, often large spectral libraries are from third parties. They have typically not been developed and tested on handheld devices and often result in inferior spectral identification in mixtures.

Advantages for Military and Safety/Security Applications

Broad material coverage

Security and military users frequently encounter materials that fluoresce strongly—such as illicit drugs, cutting agents, explosives, dyes, lubricants, and environmental contaminants.

1064 nm Raman systems can identify these materials directly, without the need for sample pretreatment, dilution, or destructive testing.

Operational reliability in field conditions

In tactical or forensic environments, speed and reliability are paramount. Device ruggedness is an important aspect of handheld analyzers. The analyzer should be able to withstand use in many harsh conditions. Systems should have a MIL-STD 810G/H rating for temperature, shock and drop conditions, as well as ingress rating (IP68) that ensures the analyzer is water-tight during use and decontamination.

1064 nm Raman minimizes measurement failures caused by fluorescence, enabling consistent, rapid identification across a wide variety of unknowns.

This is particularly advantageous during:

- **EOD and CBRNE response,** where accurate identification of explosive residues or chemical precursors is critical.
- **Law enforcement and customs operations,** where agents must analyze samples of uncertain origin and purity.
- **Military field analysis,** where time-sensitive decision-making depends on accurate chemical recognition.

Reduced false negatives

Because fluorescence can mask Raman signals at 785 nm, critical materials may go unidentified or misclassified. By using 1064 nm excitation, fluorescence is minimized, improving classification accuracy and reducing false negatives—vital for operator safety and mission success.

Rigaku Implementation:
CQL and Icon Systems

Rigaku has optimized the advantages of 1064 nm Raman excitation in its **CQL** and **Icon** handheld analyzers, designed specifically for military, homeland security, and field-based chemical identification.

Rigaku CQL

- Utilizes a 1064 nm laser to achieve superior fluorescence suppression.
- Engineered for **hazardous materials, narcotics, and explosive detection.**
- Provides a broad and expandable spectral library of relevant substances, supporting mission-critical decisions.

Rigaku Icon

- Leverages the same 1064 nm excitation technology in a **compact, ruggedized form factor.**
- Designed for **frontline and tactical operations,** where speed, portability, and reliability are key.
- Incorporates advanced algorithms for **real-time spectral interpretation,** reducing operator burden and improving confidence in results.

Both systems embody Rigaku's 1064 nm Raman design philosophy: minimizing fluorescence, maximizing reliability, and delivering accurate identification of complex, real-world substances.

Summary and Conclusion

For military and safety/security applications, where users encounter diverse and often highly fluorescing materials, **1064 nm Raman spectroscopy provides clear operational advantages over 785 nm systems.**

These include:

- Dramatically reduced fluorescence interference
- Broader material applicability
- Enhanced field robustness and usability

Rigaku's **CQL** and **Icon** analyzers harness these benefits to deliver consistent, actionable chemical identification in challenging environments. By adopting 1064 nm Raman excitation, operators can achieve higher confidence, faster decision-making, and improved mission safety—making it the optimal wavelength choice for modern field-deployed spectroscopy.

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