RENISHAW
apply innovation™

Renishaw's EasyConfocal™ Raman microscope method

Simple and effective confocal performance

Renishaw's Raman microscopes have been designed to offer users the best confocal performance without sacrificing efficiency or ease of use.

Confocal optical systems define in a precise way the sampling volume - the volume from which the light is collected. Confocal systems restrict the sampling volume by placing an aperture or apertures at suitable points before the detector, blocking (rejecting) out-of-focus and off-axis light from outside the sampling volume. The amount of out-of-focus and off-axis light blocked - "the degree of confocality" - is strongly affected by the collection optics; if high-magnification objectives and small aperture sizes are used, the highest degree of confocality is achieved.

Confocal operation using the inVia™ Raman microscope is routine. By exploiting the advantages of the imaging spectrograph and the CCD array detector to the full, the Renishaw EasyConfocal method eliminates the need for classical pinhole-based confocal microscope optics to collect the scattered light.

The EasyConfocal method uses a unique combination of two apertures - one physical (the spectrograph entrance slit) and one defined in software (the height of the captured image on the CCD) - to spatially filter the scattered light and give the required depth and lateral resolutions. Using this approach, full confocal capability is achieved, with data quality as good as that of a pinhole based system, but with additional advantages.

By using both the slit and the CCD area control, which are integrated parts of the spectrograph, the instrument maintains full confocal performance throughout the UV-visible range, without the need for realignment or refocusing of the pinholes used in older system designs. The method gives full flexibility in choosing the degree of confocality (unlike fixed size pinholes) and is also faster to align.

> **"Using slits instead of pinholes makes it easier to make the optical alignments needed for confocal Raman measurements.**
>
> K. Ajito & K. Torimitsu, NTT, Japan, Trends in Analytical Chemistry vol. 20, no. 5 (2001)"

The need for confocal performance

Confocal Raman spectroscopy is useful in a variety of applications, from fundamental research to everyday routine analysis, where enhanced spatial resolution is beneficial.

Applications fall into two major categories:

Inclusion-in-a-matrix	Laminates and thin layers
• Active drug in an excipient • Carbon fibre in epoxy resin • Fluid and solid inclusion in geological sections and gem stones • Surface and subsurface defect analysis	• Thin polymer films • Sectioned biomaterials • Semiconductor heterostructure junctions

Depending on the topography and optical properties (refractive index and absorption cross section), optical sectioning of the sample may be possible. You can then use the encoded sample stage to create 2D or 3D confocal Raman images.

The EasyConfocal method: performance

Theoretically calculating the confocal volume of the optical system is a complex task, requiring modelling of the response of the optics to a well-characterised sample under well-defined illumination. This method is rarely used because it is complex and does not easily give a figure that has meaningful experimental value.

You can determine the confocal performance experimentally, normally by plotting the rate at which the Raman signal drops as the sample is moved out of focus. The test material should be thinner than the confocal volume and transparent to the Raman excitation wavelength being used.

Example 1: mineralogical inclusions

Analysing a multi-phase inclusion in quartz consisting of mixed CO_2/H_2S gases (purple), liquid CO_2 (red), and solid sulfur (yellow), all within an aqueous phase (green).

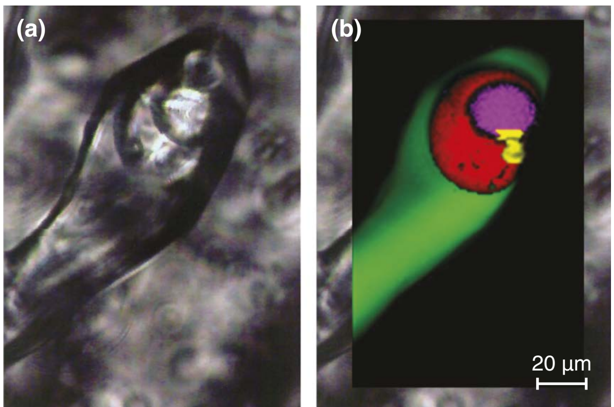

Figure 1. Multi-phase inclusion in quartz.
(a) Transmitted white light optical image.
(b) Overlaid 2D Raman chemical images.

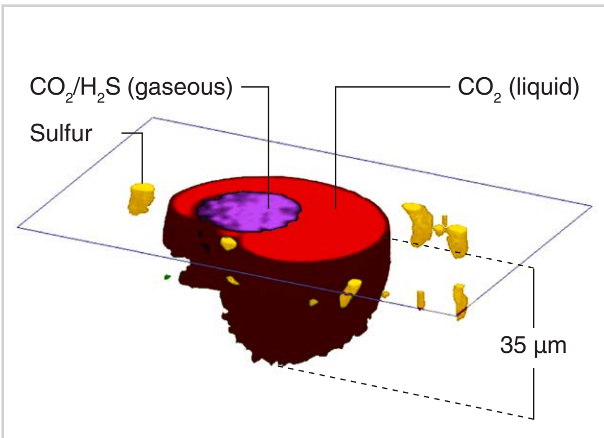

Figure 2. 3D volume image of multi-phase inclusion in quartz.

Example 2: profiling of polymer layers

Polymer laminates are used extensively in packaging applications. Combinations of different polymers are laminated to obtain the required mechanical, optical, and chemical properties.

It is important for manufacturers to have the ability to verify layer thicknesses and compositions, preferably without time consuming sample preparation (such as mechanical sectioning). Figure 3 shows depth profiles from a complex foil-backed polymer laminate. The poly(diallyl isophthalate) bonding layers between the foil, nylon, and thick polyethylene layer, are clearly resolved. This shows the high confocal performance, even when measuring deep within the material.

You can use an oil immersion objective to optimise the confocal performance and Raman data collection efficiency when looking deep into transparent materials. You can also calculate layer thickness directly as refractive index effects between the air and material are minimised.

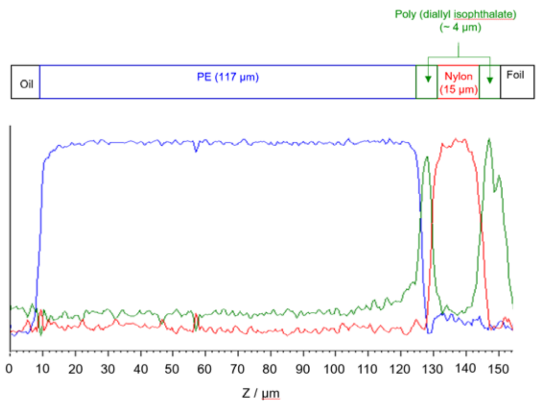

Figure 3. Raman depth profiles from a complex foil-backed polymer laminate.

Example 3: volume analysis of SiC inclusion

It is important in SiC device manufacturing to detect sub-surface defects and inclusions. This enables material quality and uniformity to be optimised, and therefore improves device performance. Figure 4 shows confocal Raman volume images of a 3C-SiC polytype inclusion within 4H-SiC. The sub-surface pipe-like feature within the epitaxial layer is difficult to see using other techniques. Defects, inclusions, and stress and strain can be routinely determined using confocal Raman microscopy.

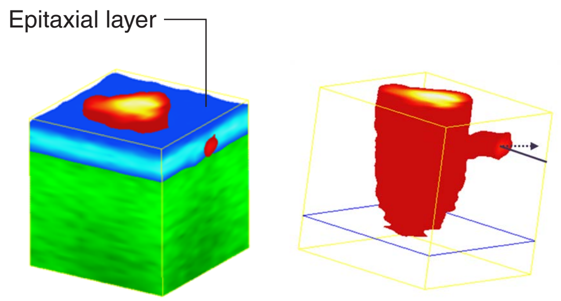

Figure 4. Raman volume images of a 3C-SiC polytype inclusion within 4H-SiC.

The benefits of Renishaw's EasyConfocal method

- No compromise in performance throughout the whole of the UV-visible spectral range
- Confocal optics are standard parts of the system
- Minimal set-up time, maximal analysis time
- Highest possible optical efficiency from a single pinhole-less stigmatic spectrograph
- Operable by non-expert users on a routine basis
- Compatible with immersion lenses

You can acquire excellent quality Raman data quickly, enabling you to not only perform point measurments, but also depth profiles and area- and volume-maps.

RENISHAW
apply innovation™

Want to learn more? Contact our spectroscopy team to discuss your specific requirements.

raman@renishaw.com

TN076(EN)-01-A