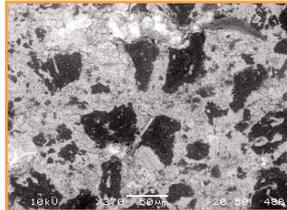
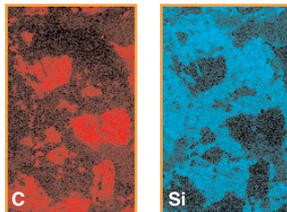


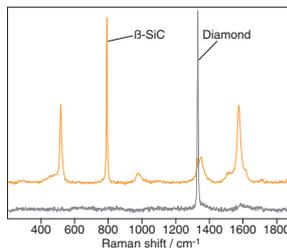
# Renishaw's SEM-Raman system



SEM image shows morphology.



EDX analysis indicates C and Si distributed throughout the sample.



Raman spectroscopy allows dark and light regions in the SEM image to be identified as diamond and  $\beta$ -SiC respectively.

## Introduction

Renishaw's SEM-Raman system unites two well-established technologies, scanning electron microscopy (SEM) and Raman spectroscopy, resulting in a powerful new technique which allows morphological, elemental, chemical, physical, and electronic analysis without moving the sample between instruments.

### SEM

SEM is an established vacuum method of examining and analysing samples at a variety of magnifications. The recent development of SEMs that can operate at higher pressures (poor vacuum) or with field emission electron guns (FEGs) has extended their suitability to a wider range of samples and applications, such as hydrated and insulating samples, and applications where features as small as 10 Å need to be studied.

SEMs have two main imaging modes, secondary electron imaging (SEI) and backscattered electron imaging (BEI) - the former is the principal imaging mode, providing the best spatial resolution, and deriving contrast mainly from surface topography. BEI requires an auxiliary detector and, depending on operational circumstances, derives contrast either from mean atomic number of the substrate, or from topography - specifically line-of-sight to the detector.

Most SEMs are routinely fitted with energy-dispersive X-ray (EDX) analysis equipment, and whilst this has proven a very valuable technique, it yields only elemental information. Furthermore, EDX is rather insensitive to light elements (sodium and below), making the analysis of organic compounds meaningless.

### Raman spectroscopy

Laser Raman spectroscopy is an analytical technique that uses light-scattering to identify molecular vibrations in a sample.

Typically a sample is illuminated using a micrometer-sized laser spot, and the light scattered from the sample is directed into a

spectrometer. Most of the light hitting the sample is scattered without change in frequency - Rayleigh scattering. A small proportion, however, transfers energy to the sample, initiating molecular vibrations, and therefore scatters with different frequencies. This process is known as Raman scattering and the differences in frequencies correspond to vibrational energy levels in the sample.

The spectrometer filters out the Rayleigh scattered light (which has lost no energy to the sample), and analyses the Raman scattered light to produce a Raman spectrum. Thus, a Raman spectrum comprises peaks that are shifted (the Raman shift) from the incident beam frequency by an amount equal to the frequency of the molecular vibrations.

For laboratory applications, micro-sampling is usually achieved using a standard optical microscope for laser light delivery and collection: fibre optic probes are coupled to the spectrometer to allow remote micro-sampling.

### SEM-Raman spectroscopy

Renishaw's technology (patents applied for) combines both techniques into one system, so that users can take full advantage of the high spatial resolution afforded by the SEM, and the chemical information revealed by Raman.

Renishaw is the only manufacturer to supply a SEM-Raman system that enables the spectrometer to "see" the same area as the SEM - a micron-scale laser spot projected onto the surface of a sample visible in the SEM image.

## Compatibility

Renishaw's SEM-Raman hardware can be fitted to most SEMs without compromising the SEM performance in any way. The nature of Raman spectroscopy means that its performance is unaffected by the SEM environment - high vacuum (HV), low vacuum (LV), environmental (ESEM), and high or low (cryogenic) temperatures.



## SEM-Raman spectroscopy advantages

- **SEM overcomes limitations of optical microscopy**

- depth of field  
SEM retains good depth of field even at high magnifications
- contrast  
SEM contrast mechanisms can easily distinguish optically identical or similar materials
- spatial resolution  
SEM spatial resolution is typically 3-4 orders of magnitude better than optical microscopy

- **Raman spectroscopy meets unfulfilled SEM/EDX analytical requirements**

- EDX yields elemental information only  
Raman provides structural, chemical, and physical information
- EDX is poor for light elements  
Raman is sensitive to light element chemistry
- BEI indicates mean atomic number only  
Raman reveals chemical composition

- **simultaneous SEM, EDX, and Raman spectroscopy**

Users can target features in the SEM image with the laser spot and identify them rapidly and unambiguously with Raman; they can also acquire EDX spectra, maps, and a white light image, without moving the sample or collection optics.

- **photoluminescence (PL) and cathodoluminescence (CL) studies**

The SEM-Raman collection optics are fully compatible with both PL and CL spectroscopies. The former uses a laser as the excitation source, the latter the electron beam. Each technique can reveal both electronic and physical information about the sample, and CL is sensitive to very subtle changes in composition and residual strain.

## Example applications

- **Materials science**

- corrosion studies, electronic materials, polymers, composites

- **Semiconductors**

- particle contamination identification

- **Pharmaceuticals**

- coating, filler and excipient identification, polymorphism studies

- **Forensic science**

- identification of explosives, drugs, fibres, pigments

## Specifications

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### SEM compatibility

Consult your local Renishaw office or agent

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### Mechanical

Repeatability	<1 $\mu\text{m}$ for X, Y, and Z
Stability (over 8 hours)	<2 $\mu\text{m}$ for X, Y, and Z
Insertion/retraction time	$\leq 5$ s per 100 mm
Intermediate retraction position	10 mm to 20 mm (<1 s)

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### Excitation sources

Lasers*	
Visible	514 nm, 532 nm, 633 nm
Near infrared	785 nm, 830 nm
(includes PL for each wavelength)	
*up to two as standard, more available on request	

Electron beam for CL

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### Raman shift<sup>a</sup>

<200  $\text{cm}^{-1}$  to 3600  $\text{cm}^{-1}$

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### PL coverage<sup>a,b</sup>

200 nm to 1  $\mu\text{m}$

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### CL coverage<sup>b</sup>

200 nm to 1  $\mu\text{m}$

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### Spatial resolution<sup>a</sup>

<2  $\mu\text{m}$

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### Spectrometer specifications

All spectrometer specifications are as for Renishaw's inVia Raman microscopes

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<sup>a</sup>wavelength dependent

<sup>b</sup>grating dependent

## Why choose Renishaw?

Renishaw is an established world leader in metrology, and has been providing high performance solutions for measurement and control since 1973. In 1992, Renishaw combined several new technologies, including its metrology expertise, with Raman spectroscopy and rapidly became a world leader in the design and manufacture of Raman spectroscopy systems.

Renishaw has a global network of subsidiary companies, distributors, and agents, providing a level of service second to none. Its teams of highly qualified engineers and scientists can provide you with rapid and comprehensive product, technical, and application support.

Renishaw is continually improving its products and reserves the right to change specifications without notice.