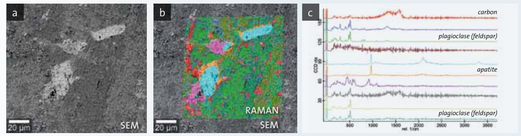
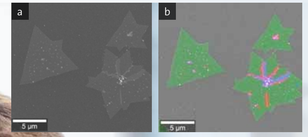
APPLICATIONS

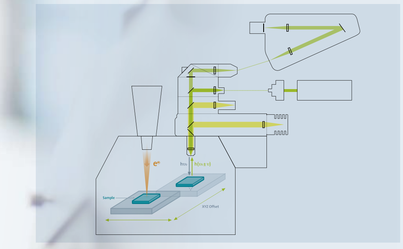


a) SEM image of a geological sample (diorite). **b)** SEM image overlaid with the Raman image. The different colors in the Raman image illustrate the various molecular compounds. Raman image: 100 x 100 µm², 300 x 300 pixels = 90,000 spectra, integration time: 34 ms/spectrum.
c) The corresponding color-coded Raman spectra display each molecular component of the sample. *(1) Sample courtesy of Dr. Christine Heim, Geowissenschaftliches Zentrum, University of Goettingen, Germany*



a) SEM image of CVD grown MoS_2 on Si/SiO_2 acquired with the SE (secondary electron) detector. The MoS_2 crystals grow in a triangular shape due to the symmetry of the unit cell of the molecule. Bright areas in the SEM image correspond to borders or overlapping regions of the MoS_2 crystals. **b)** RISE image of the MoS_2 crystals. This image was obtained by overlaying the Raman image (image parameters: 20 x 20 µm², 100 x 100 pixels = 10,000 spectra, integration time 0.15 s/spectrum) onto the SEM image. The RISE image demonstrates that the Raman spectra of MoS_2 are extremely sensitive to borders (red) and overlapping (blue) regions. *(2)*

RISE microscopy done with SEMs from (1) Tescan Brno s.r.o, Czech Republic, or (2) Carl Zeiss Microscopy GmbH, Germany



Principle of RISE Microscopy

For RISE microscopy samples are automatically transferred from one measuring position to the other within the vacuum chamber of the SEM for the entirety of the measurement procedure, thus streamlining the workflow and drastically improving the instrument's ease of use. The beampath of the Raman microscope is shown in light green.

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RISE Microscopy

Fully-integrated Raman Imaging and Scanning Electron Microscopy

Correlative Scanning Electron and confocal Raman imaging for comprehensive sample analysis

A new dimension in imaging: ultra-structural SEM complemented with chemical compound information and molecular Raman imaging

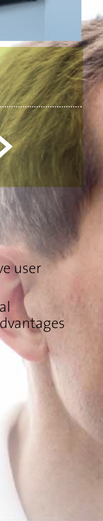
RISE Microscopy is well suited for ...

...Raman newcomers as they will benefit from the intuitive user interface and straighter measurement procedure.

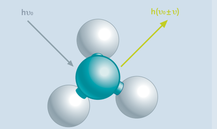
...experienced users as they will appreciate the exceptional correlative microscope performance encompassing the advantages of both techniques in one instrument.

Materials science, nanotechnology, polymer science, geosciences, life sciences, pharmaceutical industry ...

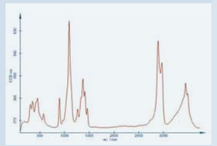
...are among the fields that can benefit from RISE microscopy with its unique imaging capabilities.



RAMAN IMAGING



Inelastic scattering of light from a molecule.



Example Raman spectrum of cellulose.

The Raman Principle

- Raman spectroscopy is a well-established and non-destructive method to analyze the chemical composition of a sample.
- A Raman spectrum shows the energy shift of the excitation light (laser) as a result of inelastic scattering by the molecules in a sample.
- Each molecule and chemical compound results in a specific Raman spectrum and can be easily identified by its unique Raman 'fingerprint'.

Additional sample information from the Raman spectrum:

a. Peak intensity: Quantity/amount of a specific compound

b. Peak shift: Identification of stress and strain states

c. Peak width: Degree of crystallinity

d. Polarization state: Crystal symmetry and orientation

Confocal Raman Imaging

- The WITec confocal Raman microscopy and imaging system combines Raman spectroscopy with confocal microscopy and enables confocal Raman imaging with the information of a complete Raman spectrum at every image pixel and a lateral resolution at the diffraction limit (~200 nm).
- Confocal Raman imaging with unprecedented performance in speed, sensitivity, and resolution
- Outstanding depth resolution ideally suited for 3D image generation and depth profiles
- Ultrahigh-throughput lens-based spectroscopic system for highest sensitivity and best performance in spectral resolution
- Ultra-fast Raman imaging option with only 0.76 ms integration time per spectrum
- Non-destructive imaging technique: no staining of fixation of the sample required

SCANNING ELECTRON MICROSCOPY

RISE Microscopy – The Instrument

The microscope combines all features of a stand-alone SEM and a top-class confocal Raman imaging microscope within one instrument.

- Quick and convenient switching between Raman and SEM measurement
- Automated sample transfer from one measuring position to the other
- Integrated software interface for user-friendly measurement control
- Correlation of the measurement results and image overlay
- No compromise in SEM and Raman imaging capabilities

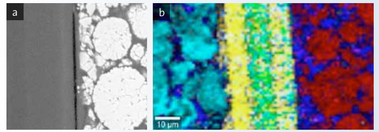
01 Fully integrated confocal Raman microscope with excellent imaging capabilities and outstanding performance in speed, sensitivity, and resolution.

02 The GM chamber is designed to integrate the Raman extension for RISE measurements for extended analytical potential.

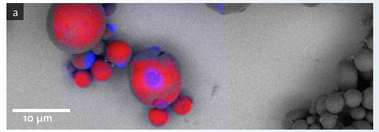
03 Once positioned on the scan table, the sample is automatically transferred and re-positioned between the measuring procedures.

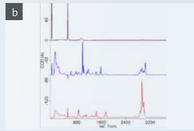
04 The sample remains inside the vacuum chamber during the complete measurements to ensure a convenient work flow with ease-of-use.

APPLICATIONS



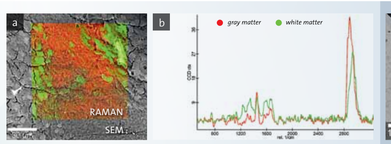
RISE analysis of a Lithium-ion battery structure consisting of anode material along with a tri-layered polymeric separator and a mineral phase. a) SEM image and **b)** color-coded Raman image of the same region. Anode material: graphite (light blue) and amorphous carbon (dark blue); Separator: polypropylene (yellow) and polyethylene (green); Mineral phase (red). *(2)*



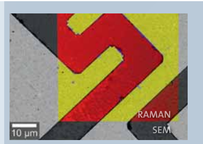


a) RISE image of labeled micro-particles. The SEM image was acquired with the backscattered electron detector and reveals patterned micro-spheres. A small area was measured in Raman imaging mode (image parameters: 30 x 30 µm², 150 x 150 pixels = 22,500 spectra, integration time 0.05 s/spectrum) and overlaid onto the SEM image, leading to the color patterned area in the RISE image. *(1)*

b) The two different colors correspond to polyethylene (red) and polystyrene (blue) as highlighted in the Raman spectra acquired from the sample. The substrate for the particles is Si. *(1)*



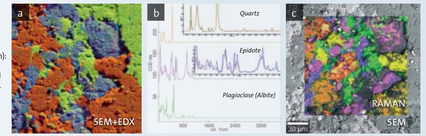
a) Raman-SEM image overlay of a hamster brain tissue sample. In the color-coded Raman image the white brain matter is shown in green and the gray brain matter in red. Raman Image: 100 x 100 µm², 300 x 300 pixels = 90,000 spectra, 50 ms integration time per spectrum. **b)** The corresponding Raman spectra reveal the different spectral characteristics of the white and gray brain matter. *(1)*



Raman-SEM image overlay of a LT GaAs sample. In the color-coded Raman image the gold substrate (yellow) can be clearly distinguished from GaAs (red) correlated with the ultra-structure of the sample. Raman image: 50 x 50 µm², 300 x 300 pixels = 90,000 spectra, 34 ms integration time per spectrum. *(1)*

COMPARISON BETWEEN RISE MICROSCOPY AND ENERGY-DISPERSIVE X-RAY SPECTROSCOPY (EDX)

RISE Microscopy and EDX analysis of a geological sample: a) Overlaid SEM-EDX image: Three different element groups can be distinguished (Si, O: orange; Si, Al, Fe, Ca: grey; Na: green). **b)** Raman spectral imaging of same sample area (22,500 spectra; integration time: 0.08 s spectrum): Three spectral clusters can be differentiated (quartz, epidote, albite). The inserts show spectral variations through different mineral orientations. **c)** Overlaid color-coded Raman-SEM image shows the distribution of the molecular compounds quartz in different orientations (yellow/orange), epidote in different orientations (blue/purple), albite (green). *(1)*



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