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01 3D Confocal Raman Imaging

Outstanding performance in speed, sensitivity, and resolution with the confocal Raman microscope alpha300 R



The WITec Raman Imaging systems combine an extremely sensitive confocal microscope with an high-throughput spectroscopy system for unprecedented chemical sensitivity. It facilitates, in combination with an excellent depth resolution and a strongly reduced background signal, the generation of depth profiles and 3D images with exceptional spectral and spatial resolution. This outstanding performance in speed, sensitivity and resolution can be jointly applied without compromises.





APPLICATIONS

Excitation laser

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05 Filter set

Optical fiber







Raman depth-profiling (x-z direction) of a multilayered polymer coating with corresponding spectra. 50 μm x 100 μm scan range, 200 x 200 pixels, 24 000 spectra, acquisition time per spectra: 50 ms.

3D confocal color-coded Raman image of an emulsion of oil (Green), alkane (Magenta) and water (Blue). 30 μm x 30 μm x 11.5 μm , 150 x 150 x 23 pixels, 517 500 single Raman spectra, total acquisition time: 23 min.



Further reading

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- C. M. Girish, A. Sasidharan, G. S. Gowd, S. Nair, M. Koyakutty, Confocal Raman Imaging Study Showing Macrophage Mediated Biodegradation of Graphene In Vivo. Advanced healthcare materials, (2013); (10.1002/adhm.201200489).
- M. Ashtikar, C. Matthaus, M. Schmitt, C. Krafft, A. Fahr, J. Popp, Non-invasive depth profile imaging of the stratum corneum using confocal Raman microscopy: First insights into the method. European journal of pharmaceutical sciences (2013); (10.1016/j.ejps.2013.05.030).

02 Near-field Raman Imaging

Raman Imaging beyond the diffraction limit with the confocal microscope alpha300 RS



Some particular applications require Raman information with resolutions below the diffraction limit (< 200 nm). WITec microscope systems are ideally suited for these purposes due to their capability to combine several microscopy techniques within one microscope setup to overcome the diffraction limit.

Near-field-Raman Imaging is an exceptional microscopy technique which links chemical Raman information to high-resolution Scanning Near-field Optical Microscopy (SNOM). Near-field-Raman allows for the acquisition of complete high-resolution confocal Raman images. Typically, lateral resolutions of below 100 nm can be achieved. Through the unique combination of a high-throughput spectroscopic system with the cantilever-based SNOM technique of the alpha300 RS microscope, an unrivaled sensitivity and imaging quality can be provided by a single microscope setup.

The principle of WITec Near-field-Raman Imaging

The excitation laser light is focused through the SNOM-tip resulting in a "Near-field" (evanescent field) on the far side of the aperture. While the sample is moved on a piezo-driven scan stage, the transmitted light is spectroscopically detected point by point and line by line in order to generate an hyperspectral image. The optical resolution of the transmitted light is thereby only limited by the diameter of the aperture (< 100 nm). Using a beam deflection setup as in AFM contact mode, it is ensured that the cantilever is always in contact with the sample. In addition the topography is recorded simultaneously to the measurement.

THE WITec ADVANTAGES

Generation of high-quality Raman images with an optical resolution beyond the diffraction limit paired with the ease-of-use and reliability of the established WITec cantilever SNOM-probe technique.







Working principle of WITec Near-field-Raman Imaging



APPLICATIONS









Near-field Raman measurements of exfoliated graphite

a) Video image of exfoliated graphite flake b) Single Raman spectra acquired through the SNOM-tip (Near-field-Raman) with 5s total integration time. c) Line scan showing the integrated intensity of the G-Band (near 1600 rel. cm-1) along the line trace indicated in Red in a). The dimensions of the graphite flake can be determined by the increase in the intensity of the G-Band. Complete length of the line trace: 20µm; 400 measurement points; 1s integration time per spectrum. d) Line trace zoom-in on the edge region of the graphene flake. The single measurement points can be distinguished and a lateral resolution of < 100 nm can be determined.



e) Topography image of exfoliated graphite simultaneously determined during the Near-field-Raman measurement.

f) The corresponding topography curve along the blue line shows a height of ~10 nm of the graphite flake and displays the small size of the graphite sample.

g) Near-field-Raman Image of the G-Band intensity (same sample area as shown in a).

h) The graph shows the G-band intensity along the red line and reveals the measurable signal variations between the small sample and the substrate.

Due to the extremely sensitive measurement technique a total laser power of $-5 \mu W$ at the sample and an illuminated area < 100 nm was sufficient for image generation with only 0-53 seconds total integration time (Scan range: 5 x 1.7 µm, image size: 100 x 35 pixels).

Further reading

- S. Hosaka. Scanning Near-Field Raman Spectroscopic Microscope, Advances in Solid State Circuit Technologies, Paul K Chu (Ed.), ISBN: 978-953-307-086-5, InTech, DOI: 10.5772/8639. (2010)
- J. Kasim, Y. Ting, Y. Y. Meng, L. J. Ping, A. See, L. L. Jong, S. Z. Xiang, Near-field Raman imaging using optically trapped dielectric microsphere. Optics Express 16, (2008).
- N. Anderson, A. Hartschuh, L.Novotny. Near-field Raman microscopy. Materials Today 8, Issue 5, Pages 50–54, ISSN: 1369 7021, Elsevier Ltd, (2005).

03 TERS



Tip-enhanced Raman spectroscopy (TERS) with the confocal microscope alpha300 RS

Tip-enhanced Raman spectroscopy (TERS) enables the acquisition of chemical information with a lateral resolution far below the diffraction limit.

The TERS measurement technique is a combination of surface-enhanced Raman scattering (SERS) with scanning probe microscopy (SPM) techniques such as Atomic Force Microscopy (AFM). Microscopes with integrated Raman-AFM techniques are therefore ideally suited for TERS experiments.

To obtain the TERS effect a metal coated AFM-tip can be used as a nanostructure. The excitation laser light is focused onto the tip-apex to enhance the Raman signal in close proximity to the tip. The lateral resolution is thereby dependent on the tip-apex size (10 - 20 nm). The TERS effect is assumed to be based on surface plasmons and chemical resonance effects resulting in enhanced electrical fields and increased Raman signal intensities.

The TERS tip illumination can be applied from either above, below or from the side. The WITec alpha300 microscope series provides the beam path geometry for all excitation approaches: The inverted microscope is ideal for TERS experiments on transparent samples while the upright microscope and the side illumination enable TERS measurements of opaque samples. Thus WITec's unique alpha300 microscope systems with Raman and AFM techniques combined in one instrument provide optimized instrumentation for TERS experiments.

THE WITec ADVANTAGES

- Unique integrated Raman-AFM technique ideally suited for TERS
- Flexible sample illumination from either above, below, or from the side

WORKING PRINCIPLE



WITec alpha300 TERS configurations: Excitation from the side, above and below; detection from the side, above and below

APPLICATIONS

Working principle of TERS







TERS study of a carbon nanowire

a) AFM image of a carbon nanowire used for the TERS experiments. b) Tip-enhanced Raman spectroscopy study using an Ag-coated Si-AFM-tip. Blue spectrum: tip retracted, red spectrum: tip approached. c) Zoom-in indicating a Raman signal enhancement of up to a factor of 12. More detailed information about this TERS study can be found in the WITec TERS Application Note: http://www.witec.de/assets/Downloads/raman/WITecTERS.pdf



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BEAM PATH



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