Infrared nanoimaging and nanospectroscopy

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With the development of scattering-type scanning near-field optical microscopy (s-SNOM) [1], the analytical power of visible, infrared and THz imaging has been brought to the nanometer scale. The spatial resolution of about 10 - 20 nm opens a new era for modern nano-analytical applications such as chemical identification, free-carrier profiling and plasmonic vector near-field mapping.

s-SNOM is based on elastic light scattering from atomic force microscope tips. Acting as an optical antenna, the tips convert the illuminating light into strongly concentrated near fields at the tip apex (nanofocus) (Figure 1), which provides a means for localized excitation of molecule vibrations, plasmons or phonons in the sample surface. Recording the tip-scattered light as a function of sample position subsequently yields nanoscale resolved optical images, beating the diffraction limit in the infrared spectral range by more than two orders of magnitude.

Using broadband IR illumination and Fourier-transform spectroscopy of the tip-scattered light [2,3], IR spectra with 20 nm spatial resolution can be acquired (nano-FTIR). Near-field images and near-field absorption spectra of molecular vibrations in mid-infrared fingerprint region allow for chemical mapping, identification of polymer [3] and protein [4] nanostructures, and for quantitative measurement of the complex-valued local dielectric function [5]. Latest technical developments enable hyperspectral infrared nanoimaging and application of multivariate spectral data analysis.

References

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Figures

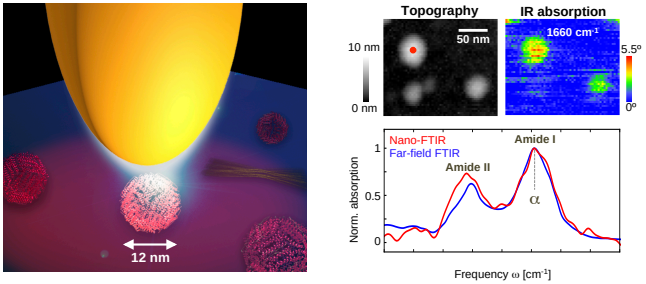

Figure 1: Infrared nanoimaging of a single protein complex (ferritin, 5000 C=O bonds, 1 attogram mass). Left: Illustration of the infrared illuminated tip of a near-field microscope on top of a ferritin complex. Right: Topography and infrared absorption image of three nanoparticles reveals that only two of them are protein complexes. The nano-FTIR spectrum (red) was taken on the complex marked by the red dot in the topography image.