Superresolution nanoscopy using mid-infrared light

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Abstract

Mid-infrared (wavelength λ = 10 µm) nanoscopy now reaches routinely 20 nm spatial resolution, that is 250x below the classical diffraction limit given by Abbes criterion of λ /2. This lecture describes in its first part how this is made possible by using plasmonics, especially, by launching infrared surface waves on a converging wire such that a greatly subwavelength "hot spot" of near-field forms below the very wire tip.

The wire is realized by the tip of an AFM (atomic force microscope), and a sample scanned in close proximity under the tip conveys two signals in parallel, and thus two simultaneous images, of (i) the ups and downs of the surface ("topography"), and (ii) the back-scattered infrared (amplitude and phase).

The second part of the lecture describes how this s-SNOM (scattering-type near-field microscope) can be operated with a continuum of infrared wavelengths spanning the full "fingerprint" spectral range of molecular resonances, abbreviated as nano-FTIR (for nanoscale Fourier-transform spectroscopic microscopy). Furthermore, how the registered infrared signals uniquely determine the local absorption, and thus, unambiguously identify the local molecular content.

The final part of the lecture will discuss infrared-molecular biosensing on a 100-nm scale, especially the spectroscopic imaging of living cells in aqueous environment. This possibility has only recently been introduced and successfully demonstrated by us, by using a thin (10 nm) membrane which allows to separate the observation space (above the membrane) from the liquid sample space (below the membrane).