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Novel concepts in infrared imaging at nanoscale resolution

THOMAS TAUBNER, RWTH Aachen

Within the recent years, various novel optical concepts have been invented to improve the diffraction-limited resolution of optical microscopy. The first approach of scanning near-field optical microscopy (SNOM) employed a small, subwavelength-sized aperture that is scanned close to the object of interest, capable of a resolution of about 50 nm. More advanced concepts rely on the light scattering of a sharp tip probing the sample, allowing for higher resolution (10-30 nm) and the use of longer wavelengths. Another exciting new imaging device, a planar slab of a material with negative permittivity called a superlens, allows for subwavelength resolved imaging over large areas. I will focus on the latter two systems that operate with *infrared light* and offer the capability of chemical sensing by directly probing molecular vibrations. Particularly, I will present the latest results on superlensing that became accessible by *phase-sensitive* infrared near-field microscopy and thus provide new insight into the imaging process of a such a device [1]. I will also explain the basics of scattering-type near-field optical microscopy (s-SNOM) and present various examples of unambiguous nanoscale material characterization from various areas such as semiconductor analysis, materials science, chemistry, and biology [2-4]. In these examples, the use of infrared spectroscopy allows to sense molecular vibrations as well as collective excitation of lattice vibrations ("phonons") in polar crystals [5]. Currently, the main limitation of this technique comprises of the low signals that demand tunable laser sources and restrict the spectral range of operation. Consequently, I will introduce new concepts for increasing the sensitivity of infrared near-field spectroscopy to ultimately allow for a broadband operation.

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