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Infrared and Terahertz Nanoscopy

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During the last years, near-field microscopy based on elastic light scattering from atomic force microscope tips (scattering-type scanning near-field optical microscopy, s-SNOM [1]) has become a powerful tool for nanoimaging of local dielectric material properties [2-5] and optical near fields of photonic nanostructures [6-8]. After an introduction of s-SNOM, I will discuss recently developed applications in materials sciences and nanophotonics. I will focus particularly on IR and THz imaging at wavelengths λ around 10 and 118 μm, where we typically achieve a wavelength-independent resolution better than 40 nm, corresponding to $\lambda/250$ and $\lambda/3000$, respectively [3]. Using metal-coated tips, the strong field enhancement at the tip apex probes the local dielectric properties of a sample, allowing for the simultaneous recognition of materials and free-carrier concentration in semiconductor nanodevices [3] and nanowires [5]. Quantitative free-carrier mapping is enabled by near-field plasmon-polariton spectroscopy, which can be also applied to study strain-induced changes of carrier concentration and mobility [4]. Nanoscale imaging of strain and nanocracks in ceramics can be achieved by near-field infrared phonon-polariton spectroscopy [4]. I will also discuss the capability of s-SNOM to image the vectorial near-field distribution of photonic nanostructures. In this application, a dielectric tip scatters the near fields at the sample surface. I will discuss how the amplitude and phase-resolved measurement of different near-field components allows for mapping of the polarization state in nanoscale antenna gaps [8], of near-field modes in loaded infrared gap antennas [7] and of mid-infrared energy transport in nanoscale transmission lines.

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