From nanoscale spectroscopy towards photocurrent nanoscopy

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Nanoparticles, nanocrystal and single-layer materials like graphene are of fundamental interest for novel plasmonic and opto-electronic devices due to their unique size-dependent characteristics, their tunability and their broad application range. Depending on the local environment, their properties can, however, strongly vary on the nanometer length-scale, reducing the macroscopic performance of such novel devices. The need to resolve and understand local influences calls for analysis tools, which are capable of capturing the optical and electronic properties on the 10-nanometer length-scale.

This talk introduces the latest advances in the field of scattering-type scanning near-field optical microscopy (s-SNOM) to perform standard Fourier transform infrared spectroscopy with an unprecedented spatial resolution of ~10 nm (nano-FTIR). This technique has already proven itself vital for modern nanoscopy and has been used in applications such as chemical identification [1], free-carrier profiling [2], or the direct mapping of propagating plasmons [3,4] and polaritons [5]. nano-FTIR allows us for the first time to directly trace the optical properties of e.g. single layer materials within the entire mid-infrared spectral range with highest spatial resolution, routinely extracting valuable information like the local conductivity, intrinsic electron-doping, absorption or the complex-valued refractive index.

Recently, nano-FTIR has been extended towards ultrafast experiments with up to 10-femtosecond temporal resolution. Carrier-relaxation dynamics in semiconductors [6], graphene [7,8], or intricate materials like vanadium dioxide [9] can now directly be observed on their natural time *and* length-scale, revealing key insights into the role of surface potentials, the number of layers, and local strain on the electron dynamics in such materials.

Latest developments in s-SNOM even incorporate correlation microscopy by combining near-field microscopy with photocurrent nanoscopy [10]. The symbiosis of such complementary measurement techniques opens up a complete new research field for nano-spectroscopy, bringing together optical, opto-electronic and electronic analysis on the nanoscale in a complete non-destructive and non-invasive way.

References

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