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# Cryogenic near-field imaging and spectroscopy at the 10-nanometer-scale

Two-dimensional materials like graphene, boron-nitride or transition-metal dichalcogenides are of rising interest for novel plasmonic and opto-electronic applications due to their unique characteristics and their broad application range. However, being highly sensitive to the local environment, their properties can strongly vary on the nanometer length scale, severely limiting the macroscopic performance of such novel devices. Scattering-type scanning near-field optical microscopy (s-SNOM) and nanoscale FTIR spectroscopy (nano-FTIR) systems have become the key technology to understand and resolve these limitations by measuring the optical and electronic properties of such nanostructures down to the 10-nanometer length scale.
SNOM [1-8] and nano-FTIR [1,2] have already proven themselves vital for modern nanoscopy and have been used in applications such as chemical identification [2], free-carrier profiling [3], or the direct mapping of propagating plasmons [4,5,8] and polaritons [6]. It enables extraction of key information such as the local conductivity, intrinsic electron-doping, absorption or the complex-valued refractive index, all at the nanoscale.
Within this talk we will introduce the newest technological breakthrough in the field of near-field optics - Cryogenic near-field imaging and spectroscopy. Pioneered by the group of Dimitri Basov [7,8], this novel approach extends ambient near-field measurements to the cryogenic temperature range (<10-300 Kelvin, [1]) and opens a complete new world for nanoscale optical microscopy and spectroscopy. This technology enables for example the direct mapping of phase-transitions in strongly correlated materials [7,9] or the detection of low-energy elementary excitations at the surface of solid-state systems such as graphene [8].

## References

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## Figures

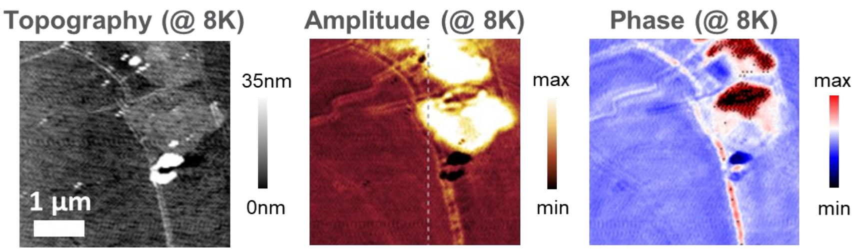


**Figure 1: Cryogenic near-field optical microscopy.** Topography, near-field amplitude, and near-field phase image of an epitaxial graphene sample measured at an excitation wavelength of 9.7µm. The sample temperature for these measurements is set to 8.0 Kelvin. Clear interference pattern of propagating surface-plasmon polaritons are visible at grain boundaries and defect sites [3,4].