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Scattering-type scanning near-field optical microscopy for polariton visualization.

The excitation and investigation and manipulation of polaritons at the surface of van der Waals materials is a growing field with ever-increasing interest in both the fundamental science behind the phenomenon and the potential applications. For different materials different oscillations can be excited and subsequently different types of polaritons, such as plasmon polaritons, phonon polaritons, as well as exciton polaritons, among others. Possible applications range from the guidance of light through matter over sensing applications[1] to quantum computing[2].

For polaritons in low-dimensional and layered van der Waals materials one of the most important methods of characterization is scattering-type scanning near-field optical microscopy (s-SNOM). This has been demonstrated to great effect by the excitation and spatial mapping of graphene plasmon-polaritons[3,4] and with a broad range of follow-up studies since. This includes the photocurrent nanoscopy of THz graphene plasmons[5], phonon polaritons in boron nitride[6], as well as exciton polaritons in $MoSe_2$ waveguides. The method has also recently been used to image the effect of polaritonic photonic devices, such as polaritonic lenses[8] and nanoresonators[9].

For s-SNOM a metal-coated standard atomic force microscopy (AFM) probe is illuminated with light, which creates a nanofocus at the tip apex in which the electrical field of the incident light is amplified. The back-scattered light contains the information of the interaction of the sample with the nanofocus, with a spatial resolution dependent only on the tip apex radius[5]. In this nanofocus polaritons can be excited and the polariton interferences at the material edges, defects and dedicated structures will influence the back-scattered light, making it possible to map the interference patterns.

This talk will show how our neaSNOM microscope has been designed to excite and image polaritons with light from the visible range to THz frequencies. Finally this talk will show how the development of a scattering-type SNOM operating at low sample temperatures opens up new avenues towards understanding polaritons[11] and how we contribute with our closed-cycle cooled cryo-neaSNOM[12] which was already successfully used to record s-SNOM images of single layer graphene at 8 K, as shown in figure 1.

References

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Figure

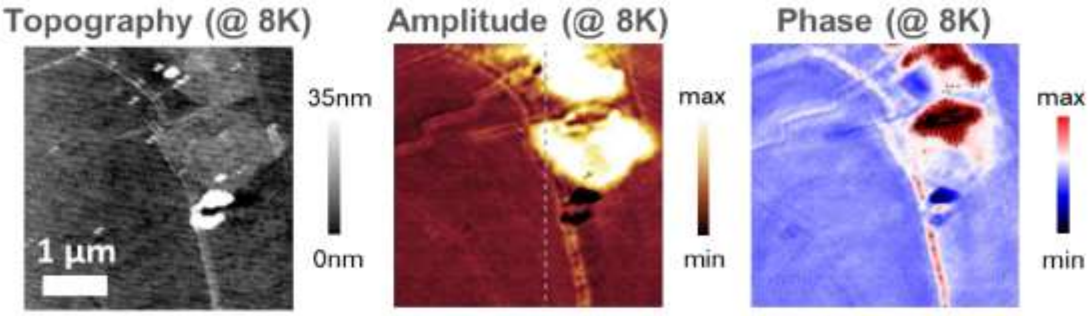

Figure 1: AFM and s-SNOM amplitude and phase images of a single layer graphene sample at 8 K sample temperature. Excitation wavelength is 9.7 µm. The near-field images, amplitude as well as phase, clearly show surface plasmon polaritons reflected at grain boundaries that are not visible in the topography image.