Near-field imaging of hyperbolic shear polaritons in gallium oxide

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Polaritons – quasi-particles composed of light and a coherently oscillating charge – enable compression of electromagnetic waves to scales well below the diffraction limit [1]. In particular, strong anisotropy of phonon resonances in van der Waals materials has been shown to lead to the emergence of hyperbolic phonon polaritons, featuring a peculiar dispersion with open band structure which supports extreme light confinement and directional propagation. However, research thus far focussed on high-symmetry hexagonal and orthorhombic systems.

Recently [2], we showed that lower-symmetry monoclinic crystals, such as beta-phase gallium oxide (bGO), give rise to a new polariton class - the hyperbolic shear polaritons (HShP). These polaritons unveil new features associated with shear phenomena at the microscopic scale, which emerge due to broken symmetries in their phonon response. Specifically, they support strong frequency-dependent directionality and asymmetric propagation patterns.

In my talk, I will report on the first near-field imaging of HShP in bGO using the FELBE scattering-type near-field optical microscope. Sub-diffractional gold discs were fabricated on the bGO substrate, which we the used as localized emitters of propagation polariton waves. We successfully imaged the broken-symmetry polaritons. By scanning the IR wavelength, we observe the rotation of the propagation direction. Our experimental data agrees extremely well theory predictions. Finally, our data shows how to enhance and even engineer the HShP anisotropy, which has great potential for unidirectional energy routing in future nanophotonic technology.

References

[1] Basov, D. N. et al. Nanophotonics **10**, 549 (2021)

[2] N. C. Passler, et al., Nature **602**, 595 (2022).