Near-field imaging of resonating hyperbolic polaritons in nanorod antennas made of boron nitride

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The properties of polaritons in layered materials, such as van der Waals (vdW) materials, differ fundamentally from that of polaritons in conventional isotropic materials. Due to the layered structure of the materials, polaritons present hyperbolic dispersion, enabling unusual optical phenomena such as subdiffraction imaging and spontaneous emission engineering. Here, we present the first near-field study of Fabry-Perot resonances in linear antennas made of a hyperbolic material. Specifically, we study hyperbolic phonon polaritons in rectangular waveguide antennas made of hexagonal boron nitride (h-BN) [1,2].
Through nanoimaging and spectroscopy experiments we reveal spectrally sharp resonances, exhibiting atypical modal near-field patterns that have no analogue in conventional linear antennas, such as the puzzling near-field oscillations across the h-BN rods as observed in Fig. 1. We will discuss a detailed experimental and theoretical analysis of the sharp resonances and near-field patterns, showing that the oscillations can be attributed to a single waveguide mode resonating along the longitudinal axis of the antenna. We will also discuss its physical origin.
Our work establishes a solid experimental and theoretical basis for the understanding of propagating and resonating hyperbolic polaritons in waveguides, which could lead to the development of novel, ultra-compact photonic devices [3].

References

[1] Dai, S. et al. *Science* **343**, (2014) 1125-1129
[2] Caldwell, J.D. et al., *Nat Commun* **5** (2014), 5221
[3] Alfaro-Mozaz, F.J. et al. (submitted)

Figures

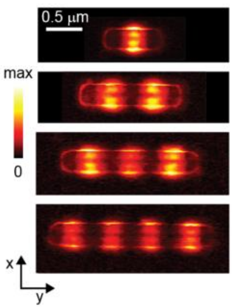

Figure 1: s-SNOM images of a set of linear h-BN antennas of different length L. Imaging frequency ω = 1432 cm-1. The nominal width and thickness of each antenna is 230 nm and 64 nm , respectively. From top to bottom, L= 746 nm, L= 1327 nm, L= 1713 nm and L= 2210 nm.