Infrared hyperbolic metasurface based on nanostructured van der Waals materials

Peining Li

[1] *CIC nanoGUNE, 20018 Donostia–San Sebastián, Spain,*

p.li@nanogune.eu

Hyperbolic metasurfaces with strongly anisotropic optical properties supports deep subwavelength-scale confined surface polaritons, which present a hyperbolic dispersion [1,2]. They could extremely enhance light-matter interaction at mid-infrared and terahertz frequencies (corresponding to energies of molecular vibrations, and thermal emission and absorption) for photonic and thermal applications, such as heat management, chemical sensing and deep subwavelength imaging [2]. However, hyperbolic metasurfaces working at these frequencies have not been developed yet due to the required challenging fabrication.

In this work, we realize the first mid-infrared hyperbolic metasurface by nanostructuring a thin layer of hexagonal boron nitride —a prototypical van der Waals (vdW) polar material, which supports mid-infrared phonon polaritons with strong electromagnetic field confinement, ultraslow group velocities and long lifetimes [3,4]. We used scattering-type scanning near-field optical microscopy to directly observe phonon polaritons emerging from the hot spot at the extremity of an infrared antenna and propagating through the metasurface with in-plane hyperbolic dispersion (Figure 1), which assembles the concave (anomalous) wavefronts of a diverging polariton beam (Figure 1.C). These results show that near-field microscopy can be applied to reveal the exotic wavefronts of polaritons in anisotropic materials, and demonstrate that nanostructured vdW materials can form a highly variable and compact platform for hyperbolic infrared metasurface devices and circuits [5].

References

[1] A. V. Kildishev et al., *Science* **339**, 1232009 (2013).
[2] J. S. Gomez-Diaz, et al., *Phys. Rev. Lett,* **114**, 233901 (2015)
[3] S. Dai, et al., *Science*, **343**, 1125-1129 (2014).
[4] P. Li, et al., *Nat. Commun.* **6**, 7507 (2015).
[5] P. Li, et al., *Science*, **359**, 892–896 (2018).

Figures

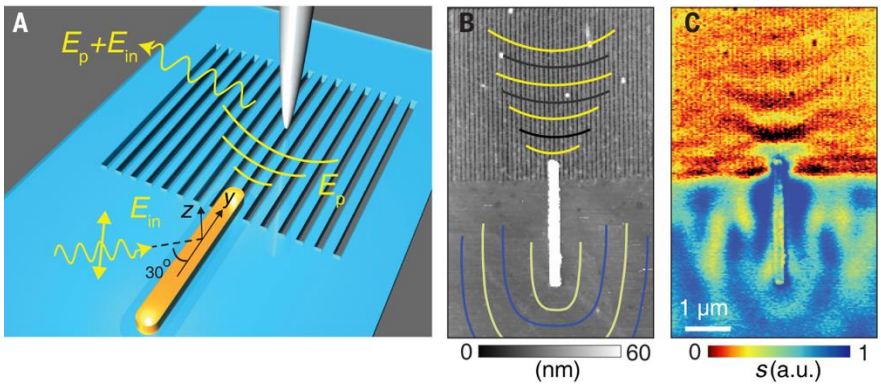

Figure 1. (A) Schematic of the experiment. (B) Topography image. The lines illustrate wavefronts of phonon polaritons on the hyperbolic metasurface (yellow and black) or phonon polaritons on the unpatterned flake (yellow and blue). (C) Near-field optical image. It clearly reveals concave wavefronts of phonon polaritons emerging from the rod's upper extremity.