Twist-tunable polaritonic nanoresonators

A. I. F. Tresguerres-Mata[2†*]
O. G. Matveeva[1†], R. V. Kirtaev[1], K. V. Voronin[1], J. Taboada-Gutiérrez[2,3], C. Lanza-García[2], J. Duan[2,3], J. Martín-Sánchez[2,3], V. S. Volkov[1,4], P. Alonso-González[2,3*], A. Y. Nikitin[5,6*].
[1]*Center for Photonics and 2D Materials, Moscow Institute of Physics and Technology, Dolgoprudny 141700, Russia.*
[2]*Department of Physics, University of Oviedo 33006, Spain.*
[3]*Center of Research on Nanomaterials and Nanotechnology, CINN (CSIC-Universidad de Oviedo), El Entrego 33940, Spain.*
[4]*GrapheneTek Skolkovo Innovation Center, Moscow 143026, Russia.*
[5]*Donostia International Physics Center (DIPC), Donostia/San Sebastián 20018, Spain.*
[6]*IKERBASQUE, Basque Foundation for Science, Bilbao 48013, Spain.*
*anaiftresguerresmata@uniovi.es; pabloalonso@uniovi.es; alexey@dipc.org
† *These authors contributed equally to this work.*

Optical nanoresonators are fundamental building blocks in a number of nanotechnology applications (e.g. in spectroscopy) due to their ability to efficiently confine light at the nanoscale. Recently, nanoresonators based on the excitation of phonon polaritons (PhPs) – light coupled to lattice vibrations – in polar crystals (e.g. SiC or h-BN) have attracted much attention due to their strong field confinement, high-quality factors, and potential to enhance the photonic density of states at mid-infrared (IR) frequencies [1]. Here, we go one step further by introducing PhPs nanoresonators that not only exhibit these extraordinary properties but also incorporate a new degree of freedom: twist tuning, i.e. the possibility to be spectrally controlled by a simple rotation (Fig. 1a). To that end, we both take advantage of the low-loss-in-plane hyperbolic propagation of PhPs in the van der Waals crystal α-MoO_3 [2], and realize a dielectric engineering of a pristine α-MoO_3 slab placed on top of a metal ribbon grating, which preserves the high quality of the polaritonic resonances. By simply rotating the α-MoO_3 slab in the plane (from 0 to 45º), we demonstrate by far- and near-field measurements that the narrow polaritonic resonances (with quality factors Q up to 200) can be tuned in a broad range (up to 32cm^{-1}, i.e. up to~6 times its full width at half maximum, FWHM~5 cm^{-1}) (Fig 1b). Our results open the door to the development of tunable low-loss nanotechnologies at IR frequencies with application in sensing, emission, or photodetection.

References

[1] Li, Peining. *et al.*, Science, 359 (2018) 892-896.
[2] Ma, W. *et al.*, Nature, 562 (2018) 557-562.

Figures

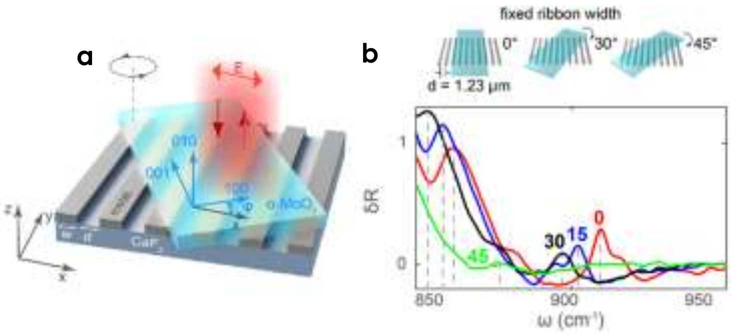

Figure 1: PhPs nanoresonators in α-MoO_3 defined by placing a pristine α-MoO_3 slab on top of metal ribbons. **a.** Schematics of the studied structure that allows defining the nanoresonators by ''dielectric engineering'' and controlling them by a twist angle, φ. **b.** Measured relative reflection spectra, δR for twist angles φ =0,15,30 and 45º.