Ultimate Thickness Limit of Optical Waveguiding and Resonators for Visible Photons

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Room temperature stable excitons in transition metal dichalcogenides (TMDs) offer a unique route for engineering light and matter interactions. An interesting but often overlooked feature for such materials engendered by excitons is the very high refractive index (n~5) at visible frequencies. This unique feature opens up a new possibility for pushing the thickness limit towards sub-nanometer length scales for optical dielectric waveguides. To this end, we have demonstrated experimentally that a single guided mode exists in a monolayer WS_2 with an exciton-polaritonic origin. This limit for photons resembles a delta function potential supporting a single bound state for electrons. We will talk about how one can experimentally achieve this limit by utilizing Fano resonances arising from second order diffraction in a photonic crystal patterned in TMD materials reaching the sub-nanometer scale. Such light guiding at the ultimate limit will open up new possibilities for exciton-polariton physics and optoelectronic applications.

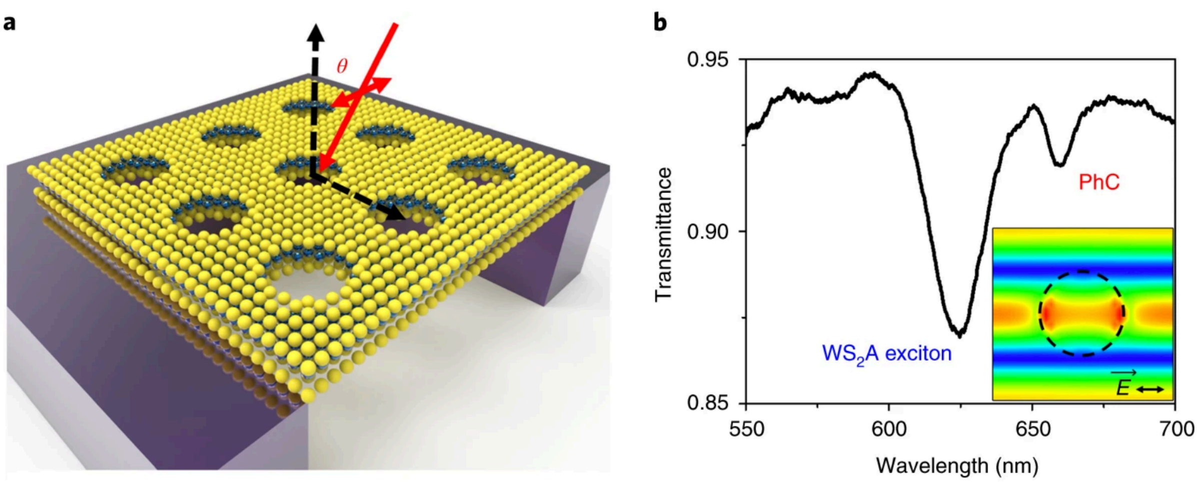

***Figure 1 a**, A schematic of a suspended monolayer (1L) WS2 photonic crystal (PhC) membrane, which supports optical resonances. **b**, The measured transmission spectra for a bilayer (2L) WS2 PhC membrane. Two spectral features as dips are observed in the transmission spectra: the one near 620 nm is due to the WS_2 A exciton absorption and the one near 660 nm corresponds to the PhC guided-mode resonance. Inset: The simulated electric field distribution on resonance.*

References

[1] X. Zhang, C. De-Eknamkul, J. Gu, A. L. Boehmke, V. M. Menon, J. Khurgin, and E. Cubukcu*, "Guiding of visible photons at the ångström thickness limit," Nature Nanotechnology, **14**, 844 (2019).