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Nano-photonic phenomena in van der Waals heterostructures

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abstract:
Layered van der Waals (vdW) crystals consist of individual atomic planes weakly coupled by vdW interaction, similar to graphene monolayers in bulk graphite. These materials can harbor superconductivity and ferromagnetism with high transition temperatures, emit light and exhibit topologically protected surface states. An ambitious practical goal is to exploit atomic planes of vdW crystals as building blocks of more complex artificially stacked heterostructures where each such block will deliver layer-specific attributes for the purpose of their combined functionality. We investigated van der Waals heterostructures assembled from atomically thin layers of graphene and hexagonal boron nitride (hBN). We observed a rich variety of optical effects due to surface plasmons in graphene [*Nature 487, 82 (2012), Reviews of Modern Physics 86, 959 (2014)*] and hyperbolic phonon polaritons in hBN [*Science 343, 1125 (2014)*]. We launched, detected and imaged plasmonic, phonon polaritonic and hybrid plasmon-phonon polariton waves in a setting of an antenna based nano-infrared apparatus. Peculiar properties of hyperbolic phonon polaritons in hBN enabled sub-diffractional focusing in infrared frequencies. Because electronic, plasmonic and phonon polaritonic properties in van der Waals heterstructures are intertwined, gate voltage and/or details of layer assembly enable efficient control of nano-photonic effects. I will also discuss an ability to manipulate plasmonic response of in these structures at femto second time scales that we have demonstrated using a novel technique of pump-probe nano-infrared spectroscopy [*Nano Letters 14, 894 (2014*

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