Light-Matter Interactions in 2D Materials

Tony Low
IBM Thomas J. Watson Research Center, USA
Electrical and Computer Engineering, Yale University, USA
Electrical and Computer Engineering, Columbia University, USA

Recent discovery of a new class of two-dimensional (2D) crystals, with widely diverse and unique electrical, mechanical and optical properties, carries great potentials for major advancements in nano-electronics and nano-photonics. In this talk, I will describe our recent work on the understanding and engineering of light-matter interactions in graphene, drawing upon both theoretical and experimental studies [1-8]. I will discuss how strong coupling of electromagnetic waves with an electric dipole carrying excitation, such as plasmon, phonons or excitons, can lead to various types of surface polaritons in 2D materials. In particular, I will describe how plasmons in graphene disperses and damps, and how the coupling with remote phonons can strongly modify the plasmonic character. Furthermore, these plasmon- and phonon-polaritons resides within the technologically important terahertz to mid-infrared spectrum, allowing for interesting active devices such as light benders, photodetectors, and sensing of molecular layers. Lastly, I will discuss light-matter interaction in new 2D materials beyond graphene. I will illustrate how going from monolayer to bilayer graphene can lead to interesting plasmonic effects such as phonon-induced transparency and an optical-like plasmonic mode. Black phosphorus, a layered material like graphene, was also re-discovered recently. This material exhibits optical properties that vary sensitively with thickness, doping, and light polarization across the mid- to near-infrared spectrum. In addition, it exhibits a highly anisotropic plasmonic mode not seen in any other plasmonic materials.

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