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Nano-scale electronic and optoelectronic devices based on 2D crystals

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In the last few years, the research community has been rapidly growing interests in two-dimensional (2D) crystals and their applications. The properties of these 2D crystals are diverse — ranging from semi-metal such as graphene, semiconductors such as MoS_2, to insulator such as boron nitride. These 2D crystals have many unique properties as compared to their bulk counterparts due to their reduced dimensionality and symmetry. A key difference is the band structures, which lead to distinct electronic and photonic properties. The 2D nature of the material also plays an important role in defining their exceptional properties of mechanical strength, surface sensitivity, thermal conductivity, tunable band-gap and their interaction with light. These unique properties of 2D crystals open up a broad territory of applications in computing, communication, energy, and medicine. In this talk, I will present our work on understanding the electrical properties of graphene and MoS_2, in particular current transport and band-gap engineering in graphene, interface between gate dielectrics and graphene, and gap states in MoS_2. I will also present our work on the nano-scale electronic devices (RF and logic devices) and photonic devices (plasmonic devices and photo-detectors) based on these 2D crystals.