Emergent materials properties, such as reconfigurable surface interactions, topography-induced resonant optical absorption, strain engineered excitons, and flexoelectricity, are enabled by unique topography and/or straining of the architecture of atomically-thin materials. Such emergent properties can be dynamically reconfigured by mechanical stretching/releasing, leading to mechanically reconfigurable materials properties.

Reconfigurable Surface Interactions

We explored the dynamic modulation of surface energy using reversible topography by crumpling/flattening architectured atomically-thin materials (*Nano Letters* **17**, 1756 (2017)). Based on the shrink-manufacturing of architectured atomically-thin MoS2 film, we demonstrated that the wettability of corrugated MoS2 can be dynamically modulated and is also reversible by controlling the micro/nano-scale crumples using a stretchable elastomer substrate. More specifically, we demonstrated that the wettability of corrugated atomically-thin MoS2 can be dynamically and reversibly controlled through applied strain, and remains robust over 1,000 stretch/release cycles. Our study provides new insights in the design and control of surface roughness and wettability of MoS2. These insights can be used to advance coating and interface materials utilizing MoS2-based materials.

Reconfigurable Resonant Optical Properties of Architectured 2D Materials

We used crumpled architectures of graphene (*i.e*., 2D graphene gratings) to excite surface plasmon polaritons (SPPs) with electromagnetic radiation (*Light: Science & Applications* **7**, 17 (2018)). The mechanism by which periodic corrugation triggers SPPs in these crumpled systems is similar to the usual influence of a periodic atomic potential on electronic states in materials. To investigate the resonant plasmonic properties of crumpled graphene structures, my research team has carried out finite element-based electromagnetic simulations as well as nano-optical experimental investigations of crumpled graphene plasmonics. Our unique topography-induced excitation of surface plasmons of graphene allows us to reconfigure resonant optical properties as we crumple/flatten the topography by mechanical actuation, and enables dynamically ‘reconfigurable’ meta-materials. This new research direction opens up innovations in dynamically tunable (reconfigurable) optical filters and sensors for communications, imaging, and many other applications.