Controlled interfaces in 2D materials

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Interfaces are ubiquitous in material science and technologies. For example, grain boundaries often dominate the mechanical and electrical properties in crystalline materials, while interfaces between dissimilar materials form the fundamental building blocks to diverse technologies, such as building electrical contacts in transistors and PN diodes in solar cells. Interfaces become even more important in 2D materials such as graphene and transition metal dichalcogenides, where the lack of dangling bonds enables material stability down to a single monolayer. In this entirely surface-dominated limit, the usual rules governing 3D interface devices, such as depletion regions, break down.

In this talk, we will discuss our work on engineering in- and out-of-plane 2D materials interfaces, and taking advantage of the outstanding mechanical properties of atomic sheets to build novel devices. We will examine the structure of atomically-thin membranes and the impact of in-plane and out of plane interfaces such as grain boundaries and heterostructures on the mechanical, optical, and electronic properties, and discuss how to utilize interlayer interactions to tailor band alignment and build new optoelectronic devices such as tunable photodiodes. In addition, atomic membranes represent the ultimate limit of mechanical devices. We will discuss our progress on engineering devices utilizing 3D deformations of 2D sheets. Looking to the future, the rapidly expanding family of 2D materials with a diverse set of electronic properties provide a promising palette for discovering emergent phenomena and a motivation for developing overarching design principles for understanding, controlling and manipulating lower dimensional interfaces in 1D, 2D and 3D.

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