Two-Dimensional Materials, Heterostructures, and Devices

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Abstract

Two-dimensional layered materials (2DLMs), such as graphene or molybdenum disulfide, represent ideal 2D materials systems for exploring fundamental chemistry and physics at the limit of single atomic thickness. With *van der Waals* interactions between neighboring layers, different 2DLMs can be flexibly integrated without the limitation of lattice mismatches. This approach therefore opens up vast possibilities to combine materials nearly arbitrarily and to control distinct properties at the atomic scale, enabling entirely new opportunities beyond the reach of existing materials. I first give a brief overview of our research efforts in rational design and synthesis of a wide range of 2D materials and heterostructures with exquisite control of chemical composition, physical dimension, heterostructured interfaces, and electronic/optic properties. I then discuss exploring these 2D materials and their heterostructures as new platforms for diverse areas of application, including electronics, biomedical sensing, and energy technologies. Examples discussed include: ultra-high speed transistors; a new design of vertical transistors for ultra-flexible electronics; new types of tunable photonic devices; and graphene-molecule conjugates for band-gap engineering, molecular sensing, catalysis, and energy storage.