Emerging 2D Lateral Heterostructures: Opportunities and Challenges

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Atomically thin two-dimensional (2D) materials such as graphene and transition metal dichalcogenides (TMDs) have opened a new and rich field with exotic properties and exciting potential applications in the "flatland".[1,2] There are enormous possibilities in combining diverse 2D layered material for the unique design of ultra-smart and flexible optoelectronic devices, including light-emitting diodes, photovoltaics, photodetectors, and quantum emitters. Considerable efforts have been devoted to the van der Waals hetero-integration of different 2D layered materials to form vertical superlattices via transfer of their exfoliated or as grown flakes. On the other hand, lateral heterostructure can offer exciting opportunities for engineering the formation, confinement, and transport of electrons, holes, exciton, and phonon at the ultimate thickness limit. These major challenges will be discussed in this lecture. We recently reported a substantial advance that allows the direct synthesis of seamless, high-quality TMD-based multi-junction lateral heterostructures with a controlled number of atomic layers in the chemical-vapor-deposition process.[2-6] These TMD heterostructures are extensively characterized through Raman and Photoluminescence spectroscopy and correlated with the electrical, optical, and structural information.[2-7] Bilayer heterostructures are shown to be a more robust system in terms of optoelectronic characteristics such as observation of room temperature electroluminescence.[3] Using photon energy-resolved photoconductivity mapping, long-term carrier accumulation in MoS_2-WS_2 lateral heterostructures was observed.[4] These studies will further supplement the quantitative evaluation of optical properties of various 2D heterostructures to develop more complex and atomically thin superlattices and optoelectronic devices.

References:

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