Exotic Physics of Indium Selenide Based van der Waals Heterostructures

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The pressing demand for miniaturize devices can be fulfilled by two-dimensional (2D) semiconducting materials. Among the 2D semiconducting materials, indium selenide (InSe) compounds are attracting great attention due to their desirable electronic and optical properties [1-2]. InSe compounds can exist with different stoichiometries (e.g. InSe, In2Se3 and In4Se3) and polytype phases (α, β, γ, etc.), providing band gaps tuneable from the near-infrared to the visible range (1.2 - 2 eV) of the electromagnetic spectrum [2], a high electron mobility at room temperature (> 0.1 m2 /Vs) [1], room temperature ferroelectricity [3] and strong carrier correlations in atomically thin layers due to an inverted "Mexican hat" valence band 4].

Here, we review our recent work on In-Se based van der Waals heterostructures of interest for optoelectronics, thermoelectrics and nanoelectronics. Both InSe/GaSe and InSe/In_2O_3 heterojunctions exhibit room temperature electroluminescence and spectral response from the near-infrared to the visible and near-ultraviolet ranges. This demonstrates the technological potential of heterostructures based on InSe with an optical response over an extended wavelength range [5-6]. On the other hand, the nanoscale thermal properties of InSe layers shows an anomalous low and anisotropic thermal conductivity, which is smaller than that of low-κ dielectrics, such as silicon oxide [7]. The thermal response of free-standing InSe layers and layers supported by a substrate, reveals the role of interfacial thermal resistance, phonon scattering, and strain. These thermal properties are critical for future technologies, such as field-effect transistors that require efficient heat dissipation or thermoelectric energy conversion with both low thermal conductance and high electron mobility 2D materials, such as InSe. Furthermore, we report on the ferroelectric semiconductor α-In_2Se_3 embedded between two single-layer graphene electrodes. We show how the ferroelectric polarization of the In_2Se_3 layer can modulate the transmission of electrons across the graphene/In_2Se_3 interface, leading to memristive effects that are controlled by an applied voltages and/or by light [8].

References

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