Design of van der Waals Interfaces for Broad-Spectrum Optoelectronics

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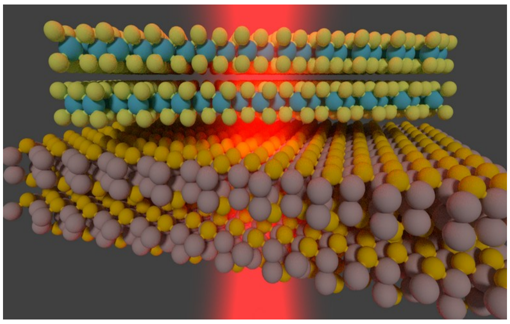
Abstract

Van der Waals(vdW) materials offer new ways to assemble artificial electronic media with properties controlled at the design stage, by combining atomically defined layers into interfaces and heterostructures. Their potential for optoelectronics stems from the possibility to tailor the spectral response over a broad range by exploiting interlayer transitions between different compounds with an appropriate band-edge alignment. For the interlayer transitions to be radiative, however, a serious challenge comes from details of the materials –such as lattice mismatch or even a small misalignment of the constituent layers– that can drastically suppress the electron-photon coupling. The problem was evidenced in recent studies of heterostructures of monolayer transition metal dichalcogenides, whose band edges are located at the K-point of reciprocal space. Here we demonstrate experimentally that the solution to the interlayer coupling problem is to engineer type-II interfaces by assembling atomically thin crystals that have the bottom of the conduction band and the top of the valence band at the Γ-point, thus avoiding any momentum mismatch. We find that this type of vdW interfaces exhibits radiative optical transition irrespective of lattice constant, rotational/translational alignment of the two layers, or whether the constituent materials are direct or indirect gap semiconductors. The result, which is robust and of general validity, drastically broadens the scope of future optoelectronics device applications based on 2D materials.

Figures



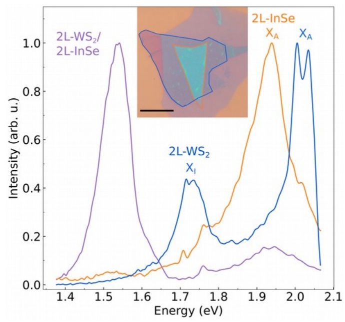


Figure 1: (left) Artistic representation of a Γ-point vdW interface. (right) Measured photoluminescence spectra of bare 2L-InSe (orange line), bare 2L-WS_2 (blue line), and of their interface (purple line). The inset shows an optical microscope image of a hBN-encapsulated 2L-InSe/2L-WS_2 interface (the scale bar is 10 μm).