Growth and device applications of in-plane heterostructures based on layered chalcogenides

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Conventional semiconductor heterojunctions with two-dimensional (2D) interfaces have been an important topic, both in modern solid state physics and in electronics and optoelectronics applications. Recently, the in-plane heterostructures based on two-dimensional materials (Fig.1a) are expected to provide a novel one-dimensional (1D) interface with unique physical properties and applications. Even though many studies on such heterostructures have been reported, there are still important challenges such as the development of a growth process of high quality heterostructures and the demonstration of functional devices. For this purpose, we have conducted the studies on chemical vapor deposition (CVD) growth and characterization of transition metal dichalcogenides (TMDCs) [1-9]. In this presentation, we report on our recent progresses of growth of TMDC-based heterostructures and their applications to light emitting diodes (LEDs). In particular, the use of organic liquid precursors enables the formation of in-plane heterostructures with atomically-sharp itnerface (Fig.1b) and nanometer-width quantum wires. We also fabricated electric double layer light-emitting diodes (EDLEDs) of TMDC heterostructure and observed linear electroluminescence (EL) from the 1D interface (Fig.1c-e). Furthermore, the interface EL shows circular polarization for WS_2 exciton peak even at room temperature [9]. The present results highlight the potential of TMDC-based 1D heterointerfaces for advanced applications in the fields of electronics and opto-electronics.

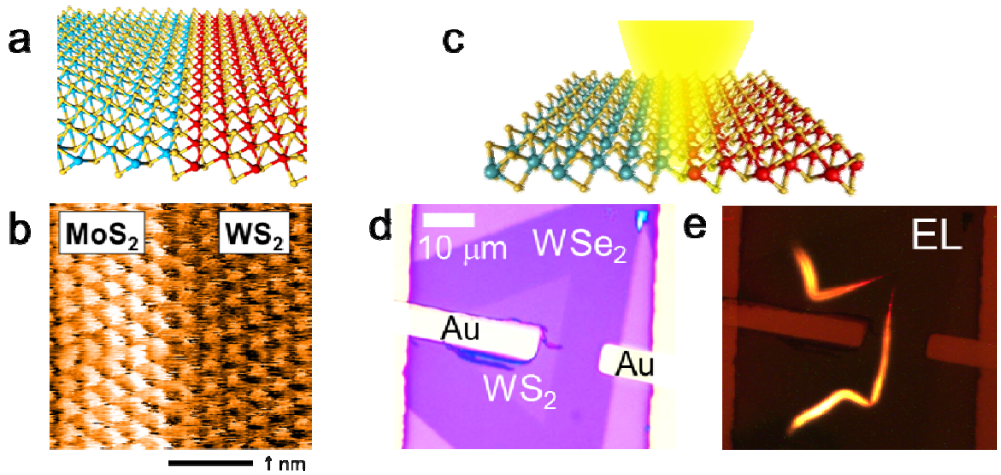

Figure 1: (a) Schematic illustrations of TMDC-based in-plane heterostructure. (b) Scanning tunneling microscopy (STM) image of MoS_2/WS_2 heterointerface. (c) Schematic illustrations of light emitting from 1D interface, (d) optical image, and (e) electroluminescence image of TMDC-based light-emitting diode.

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