1 & 2DM Conference and Exhibition
January 29-30, 2019

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Carrier Transport Mechanisms in Atomically Thin van der Waals Tunnel Field-Effect Transistors and Its Potential for Applications

Van der Waals (vdW) heterostructures present a promising application for tunneling devices.[1,2] Here, we demonstrate vertical broken-gap (type-III) BP/MoS_2 vdW heterostructure, as shown in Figure 1, for the investigation of its transport mechanism. Through temperature dependent electrical measurements, the band-to-band tunneling (Figure 2A) as well as negative differential resistance (Figure 2B) can be observed in our vdW transistors. Besides, a low subthreshold swing can be achieved using such the type-III transistor (Figure 2C). We further interpret the carrier transport mechanism in detail using the variation of energy band diagrams (Figure 2D). This work undoubtedly gives insight into the fundamental understanding of carrier transport in the type III heterostructure transistors and also pave an avenue for developing power-saving electronics.

References

[1] Geim, A. K. & Grigorieva, I. V., Nature. 499 (2013), 419-425.
[2] Fang, H. et al., Proc. Natl. Acad. Sci. U. S. A., 111 (2014), 6198-6202.

Figures

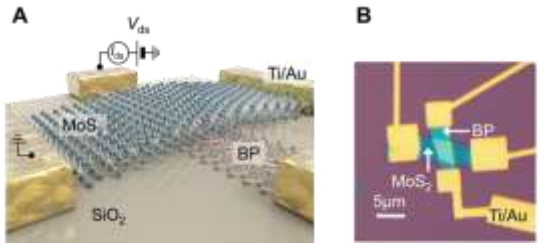

Figure 1A: Schematic of a BP/MoS_2 vdW transistor with a circuit load.
Figure 1B: An optical image of the as-fabricated vdW transistor.

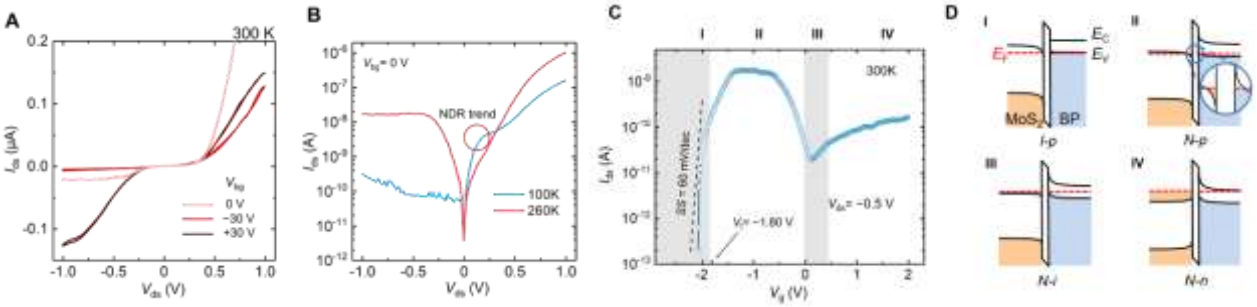

Figure 2A: Output characteristics of the vdW transistor in linear scale at different V_{bg} at 300 K.
Figure 2B: Output characteristics in log scale at various temperatures under V_{bg}= 0 V.
Figure 2C: Transfer characteristic of the vdW transistor with a top gate configuration at V_{ds}= –0.4 V at room temperature.

Figure 2D: Energy band diagram variations of the BP/MoS_2 vdW transistor at various V_g conditions.