Two-terminal Self-gating Diode with Ultralow Ideality Factor based on Two-dimensional van der Waals Heterostructures

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Abstract

Two dimensional materials such as graphene, transition metal dichalcogenide(TMD), h-BN have been studied in various fields and their stacking heterostructures have also received great attention. However, devices fabricated by stacking two-dimensional materials have an issue about ideality factor that cannot reach unity in comparison with PN junction diode. To solve this problem, we fabricated a two-terminal diode without forming the heterojunction or doping, just simply connecting the gate and drain. When the drain and gate are not connected, it does not show diode characteristics. However, after connecting the drain and gate, it works like a diode. The mechanism is like this: When a negative voltage is applied to drain-gate, graphene bottom gate is negatively charged and thereby lowering the electron concentration so that current flow can be suppressed. In contrast, when a positive voltage is applied to drain-gate, which is forward bias, electrons accumulate to the channel and tunnelling barrier becomes thin, allowing current to flow easily. This is further confirmed by low-temperature I-V measurement and hall-bar measurement with varying drain-gate voltage sweeps [1]. We also confirmed this structure also works well with various insulators and channel materials. Among them, WSe_2 shows the best performance - high on/off ratio (~10^6), and near-unity ideality factor (~1.08).

References

[1] Chiu, Fu-Chein, *Advances in Materials Science and Engineering*, 2014 (2014)

Figures

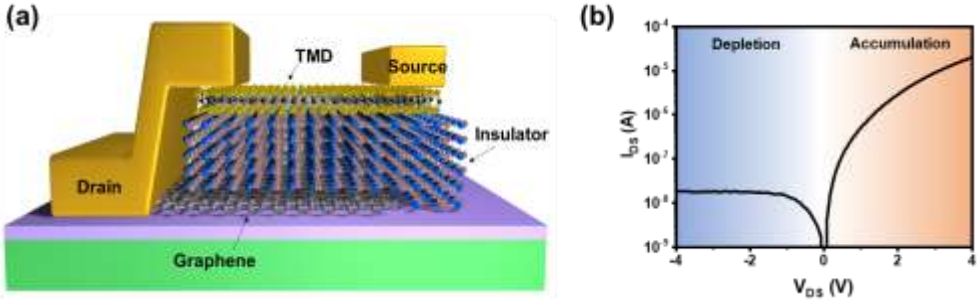

Figure 1: structure and I-V characteristic of two-terminal self-gating diode