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Two-dimensional materials-based double heterojunction bipolar transistors with high current amplification

Two-dimensional material (2DM) based heterojunctions have received great attention because of their fundamental physical and electrical properties. Especially, the properties of 2DMs with weak van der Waals interaction, atomically sharp interface and no dangling bond make them a suitable material for the heterojunction devices. These characteristics also have advantages to fabricate high-performance devices such as heterojunction bipolar transistors (HBTs), which have been difficult to implement in conventional epitaxy due to the problems of lattice constant mismatch.

In our study, we successfully fabricated npn double HBTs by vertically stacking MoS_2 (n-type) and WSe_2 (p-type) flakes. At first, bottom n-type MoS_2 flake was dry-transferred onto the SiO_2/Si substrate. Then p-type (WSe_2) and n-type (MoS_2) flakes were vertically stacked in order on to the previously transferred MoS_2 flake using micro-manipulator. After that, electrodes (Ti/Au for MoS_2 and Pt/Au for WSe_2) for the emitter, base, and collector were fabricated using standard e-beam lithography. The formation of the two p-n junctions in base-emitter and base-collector was experimentally observed. Our fabricated npn double HBT showed excellent electrical characteristics with highly amplified current modulation (β = ~100, α = ~1), which is comparable to that of conventional semiconductor devices. The detail of our experiment and results will be presented at the conference.

References

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[2] Novoselov, K. S. *et al*, Science, 353 (2016) aac9439
[3] Lee, G. *et al*, ACS appl. Mater. Inter., 10 (2018) 10347

Figures

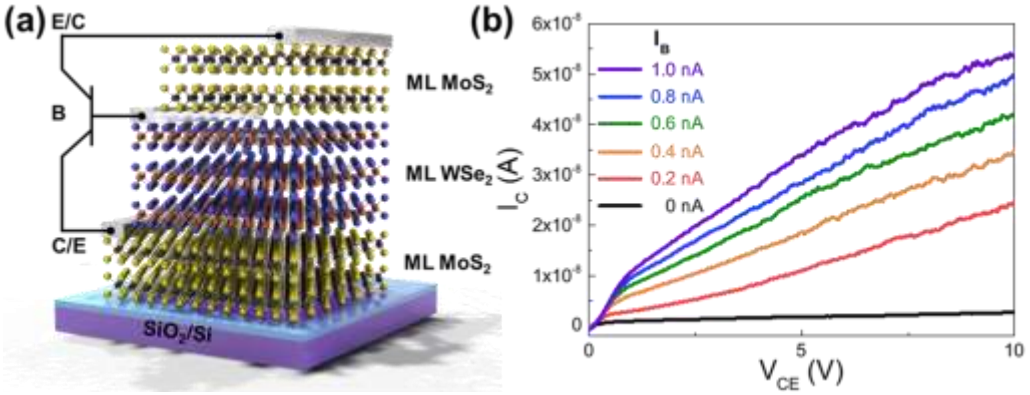

Figure 1: (a) schematic of an npn double HBT (b) output characteristics of a fabricated npn double HBT