Negative transconductance differential in $MoSe_2$/hBN/WSe_2 vertical structure

Hai Yen Le Thi[1], Inayat Uddin[2], Nhat Anh Nguyen Phan[2], Kenji Watanabe[3], Takashi Taniguchi[4] and Gil-Ho Kim[1,2]

[1]*Sungkyunkwan Advanced Institute of Nano Technology (SAINT), Sungkyunkwan University (SKKU), Suwon 16419, Republic of Korea*

[2]*Department of Electrical and Computer Engineering, Sungkyunkwan University (SKKU), Suwon 16419, Republic of Korea*

[3]*Research Center for Functional Materials, National Institute for Materials Science, 1-1 Namiki, Tsukuba 305-0044, Japan*

[4]*International Center for Material Nano Architectonics, National Institute for Materials Science, 1-1 Namiki, Tsukuba 305-0044, Japan*

ghkim@skku.edu

Extensive research has been conducted on negative differential transconductance (NDT) devices due to their promise in many applications, such as low-power logical circuits, memory, oscillation, and high-speed switching [1–4]. This study demonstrates the fabrication of a heterojunction between $MoSe_2$ and coupled hBN/WSe_2. The heterojunction exhibits a broken gap band alignment, resulting in the formation of electrostatically controlled NDT on multilayered $MoSe_2$, showing in the extensive range of temperature. The NDT behavior observed in the multilayer $MoSe_2$ can be explained by a vertical potential barrier influenced by the temperature and bias voltage. The NDT operation results from the interaction between intralayer lateral transport and interlayer vertical transport, representing a novel working mechanism. To get a deeper understanding of the transport mechanisms of the NDT device under different bias situations, an investigation was conducted on the electrical transport characteristics at low temperatures (77–300 K). This approach significantly streamlines the circuit design process compared to traditional technologies to develop frequency doublers and phase shift keying circuits [5,6].

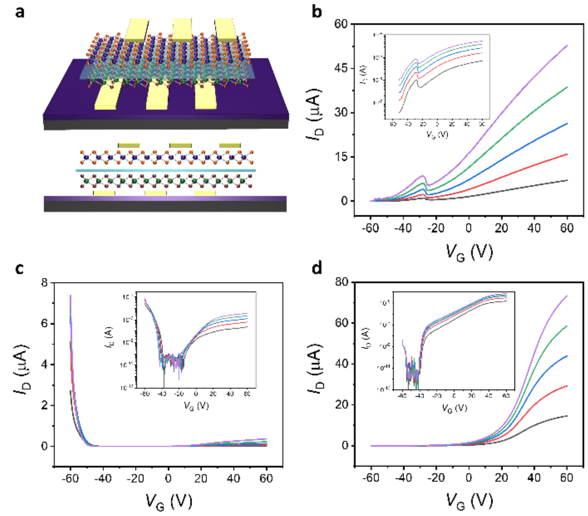

Fig.1. Conceptual framework and transport characteristics of the negative differential transconductance device. a. Schematic diagram of the NDT device. b. Transfer characteristics of a device in linear and log scale (inset), respectively. c,d. Output curves of the $MoSe_2$/WSe_2 and the $MoSe_2$/hBN device were measured at the gate voltage range.

References

[1] T. Lee, Adv. Mater. 2310015 (2024).
[2] C. J. Lee, Adv. Mater. Interfaces **8**, 2101109 (2021)
[3] S. Seo, Adv. Mater. **34**, 2202799 (2022).
[4] S. Park, Adv. Funct. Mater. **32**, 2108737 (2022).
[5] H. Yao, Appl Phys Lett **117**, 123103 (2020).
[6] S. Das, Adv. Mater. **34**, 2203753 (2022).