Investigation into Memory Behavior on van der Waals Heterostructure for the Development of Neuromorphic Device

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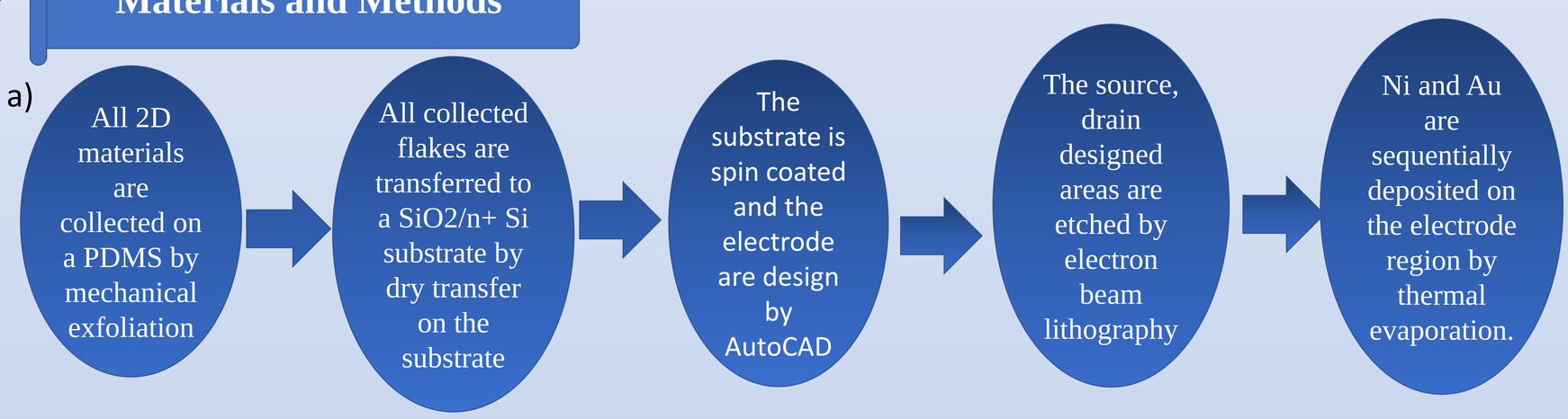
Abstract

Neuromorphic computation has been developed using biological behavior as a model for computers for decades. The separated memory and data processing in neuromorphic devices based on traditional von Neumann architecture is not able enough to reach the satisfactory outcome of analog and continuous information processes in the brain. In this study, a van der Waals heterostructural field effect transistor (VH-FET) using graphene (Gr), hexagonal boron nitride (h-BN) and molybdenum disulfide (MoS_2) was introduced with a high on/off ratio (~ 10^6) and endurance from ~ 50 program/erase cycles. The hysteresis behavior of the VH-FET performed a huge memory window (~120 V) and non-volatile characteristics. Finally, the memory characteristic of VH-FET was applied in order to emulate neuromorphic behavior.

Materials and Methods



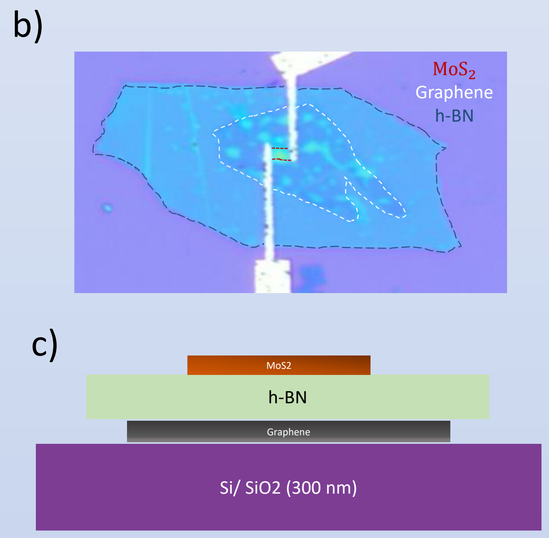
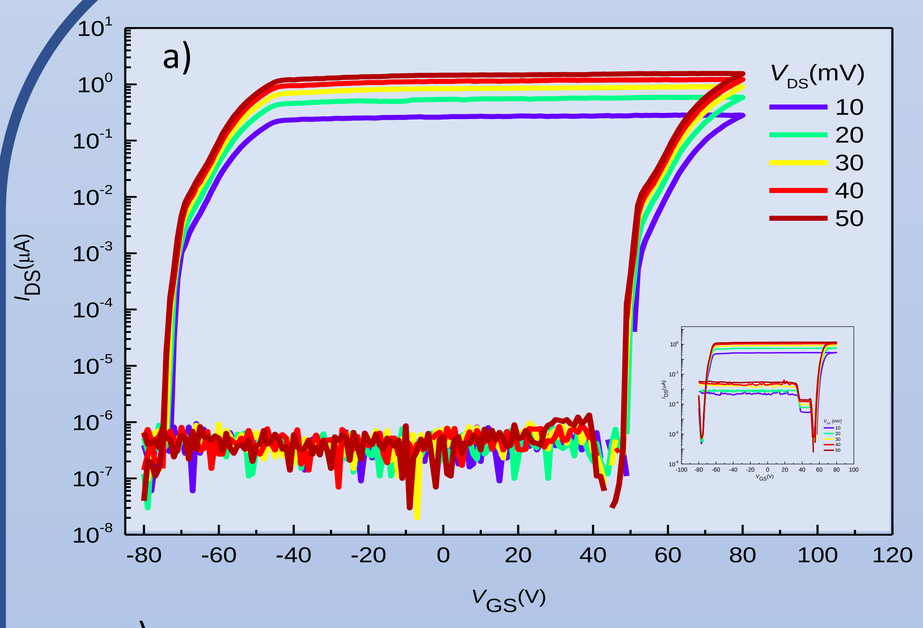
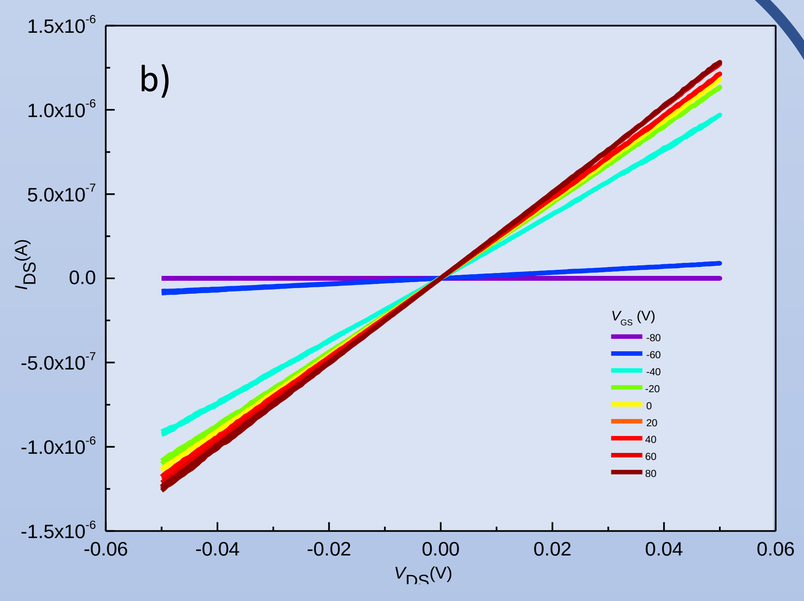
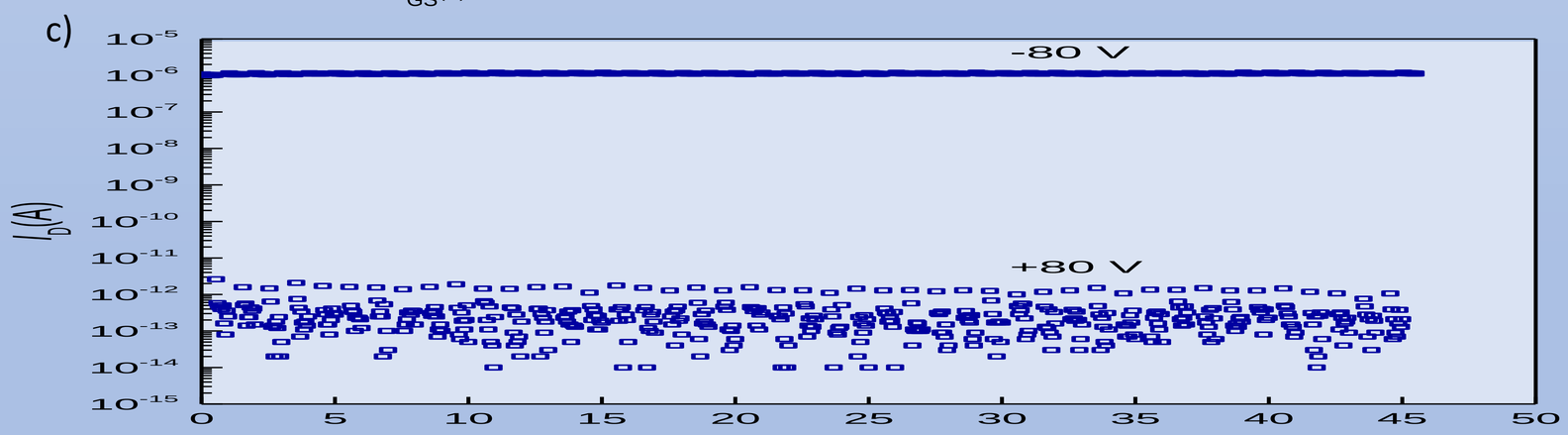


Figure 1. a) Flow chart of the device fabrication process. b) Optical Microscopic image of the fabricated VH-FET. c) Schematic diagram of the fabricated device.

Results and Discussions







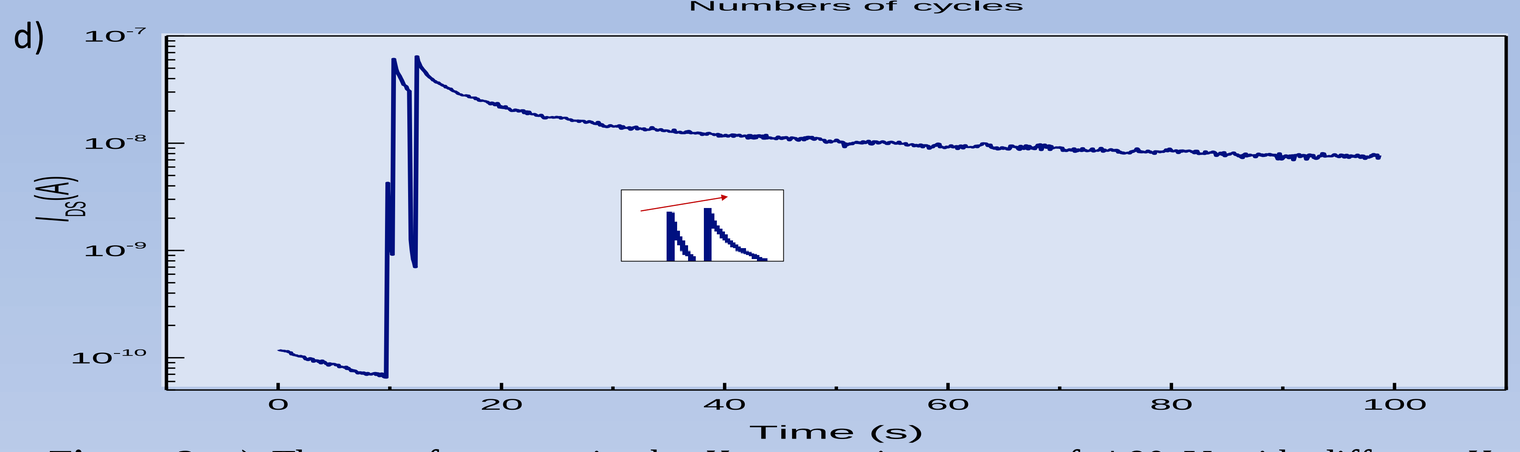


Figure 2. a) The transfer curve in the V_{GS} sweeping range of ±80 V with different V_{DS} values(Inset: transfer characteristics for thicker MoS_2) b) Output characteristics shows ohmic nature with the V_{GS} variations c) The endurance nature to test the device durability and operability of the device d) paired-pulse facilitation of our VH-FET

Conclusion

In summary, here we fabricated VH-FET which is able to show a high on/off ratio where the non-volatile memory property proves its utility as a memory device. With the channel layer thickness control, better performance of the device can be achieved.

Acknowledgment

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