Transport in vertically stacked hetero-structures from 2D materials

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The fast growth of information technology has been sustained by continuous scaling of silicon-based MOSFETs. The scaling of transistors face two major challenges nowadays: the degradation of gate gate control (device electrostatics) and fundamental thermionic limitation of the steepness of sub-threshold swing (SS). 2D materials have emerged as promising candidates to replace silicon, as they can maintain excellent device electrostatics at much reduced channel length and thickness [1]. Tunnel field effect transistors (TFETs) based on band to band tunneling has been demonstrated to break the thermionic limitation of SS [1]. However, planar TFETs with Transistion Metal Dichalcogenide (TMD) as channel material suffer from low current levels. To increase the tunneling current, a double gated TFET based on vertically stacked 2D TMD materials (as shown in Fig1. a) has been proposed [3]. Yet, a fully systematic device design guideline is still needed.

In this work, we investigate this device structure by the means of atomistic quantum transport simulations based on Non-Equilibrium Green's Function (NEGF) [3]. Self consistent solution of 3D Poisson and NEGF equations within tight binding description has been obtained through our NEMO5 tool [3]. The results show that the subthreshold slope below the thermionic limit can be achieved (Fig. 1b). The atomically thin vertical PN heterojunction can be electrostatically modulated from a type II heterojunction in the OFF-state of the device to a broken bandgap alignment in the ON-state. A systematic study is performed on the impact of device design parameters such as doping, channel length, gate underlap to provide a comprehensive understanding of the device physics and design guideline.

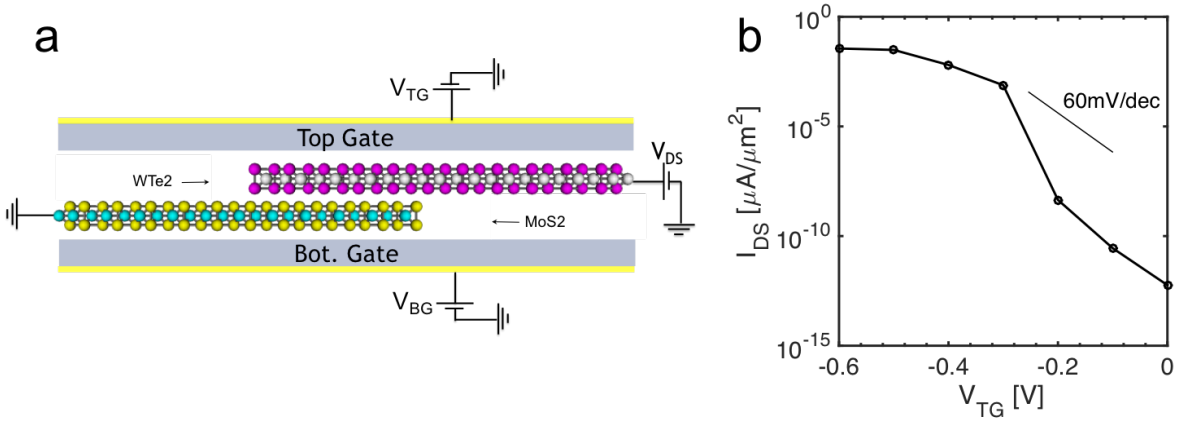

Fig. 1. a) Device Structure. b) Transfer characteristics

References

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