Van der Waals tunnel field effect transistors with misoriented layers

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Thanks to their thinness, the absence of dangling bonds and the large band structure variety, 2D materials are very promising for the realization of ultra-low-power tunnel field effect transistors (TFETs) [1]. In this contribution, we simulate quantum transport in a vertical TFET based on a MoS_2/WTe_2 van der Waals heterojunction [2] with misoriented layers, see Fig. 1. To this aim, we make use of an effective mass Hamiltonian model and of the nonequilibrium Green's function approach self-consistently coupled with the 3D Poisson equation for an accurate description of the system electrostatics. The electron-phonon interaction is included within the self-consistent Born approximation. As reported in Fig. 2, the source-drain current decreases when increasing the misorientation angle, while the subthreshold swing turns out to be almost unaffected. This behaviour follows from the relative shift of the valleys of the two materials in the Brillouin zone, and the consequent increased momentum variation required for electrons to tunnel between the layers. The tunnelling can be assisted by short-range disorder, which allows for a large momentum transfer. In this perspective, we investigate the role of edges, see Fig. 3, and electron-phonon coupling [3].

References

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Figures

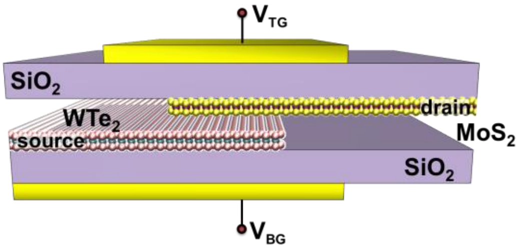

Figure 1: Simulated van der Waals TFET. Tunnelling, driven by the top gate potential V_{TG}, occurs in the (20nmx20nm) overlap region.

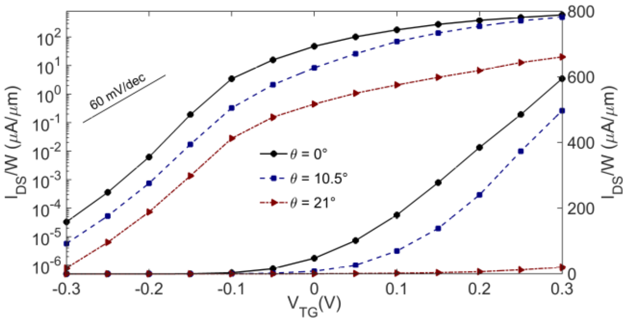

Figure 2: Source-drain current vs top gate voltage for different misorientation angles θ. For large angles, the TFET does not work properly.

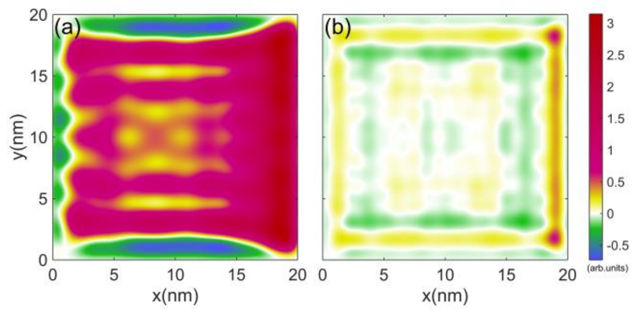

Figure 3: Spatial distribution of the inter-layer tunnelling current in the on state (V_{TG}=0.2V) for misorientation angles of 10.5° (a) and 21° (b). For large angles, tunnelling is concentrated along the edges of the region of overlap between the two layers.