Topological transistors for electronic applications

E.G. Marin*, D. Marian*, G. Iannaccone, G. Fiori
*These authors contributed equally

Dip. di Ingegneria dell'Informazione, Universita' di Pisa, v. Girolamo Caruso 16, 56122, Pisa, Italy)

gfiori@mercurio.iet.unipi.it

The closest relatives to graphene, i.e the family of 2D-Xenes [1] are awakening the interest of the community due to the possibility of having topological phases, localized edge states, and magnetic phases, especially when cut into zig-zag nanoribbons. Here, we investigate, using first principle calculations and a multiscale approach, tunnel field effect transistors (TFETs) based on topological stanene as channel material. In particular, thin (~1nm) stanene nanoribbons are predicted to be potentially stable in an anti-ferromagnetic (AFM) configuration [2]. In the AFM state the band-structure presents a small gap (E_g=0.3eV, but sufficient to switch off a tunnel device) and localized edge states in correspondence with the conduction and valence bands. These edge states enable the operation of purely one dimensional (1D) channel TFET devices (comprised of only a 1D chain of atoms as in Figure 1a) demonstrating good performance, (SS<20mV/dec and ON-OFF ratio ~10e3, Figure 1b), but more importantly paving the way through ultra-scale 1D transistors [3]. More interestingly, when the TFET gate is placed at both sides of the channel (instead of above and beneath it) generating a lateral electric field as in the scheme of Figure 1b, it is possible to take advantage of the AFM configuration to independently modulate the gap for spin up and spin down carriers and therefore tune the tunnelling transmission resulting in highly-polarized spin currents up to 95% for gate voltages of just 0.35V (Figure 1b) [4].

References

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Figures

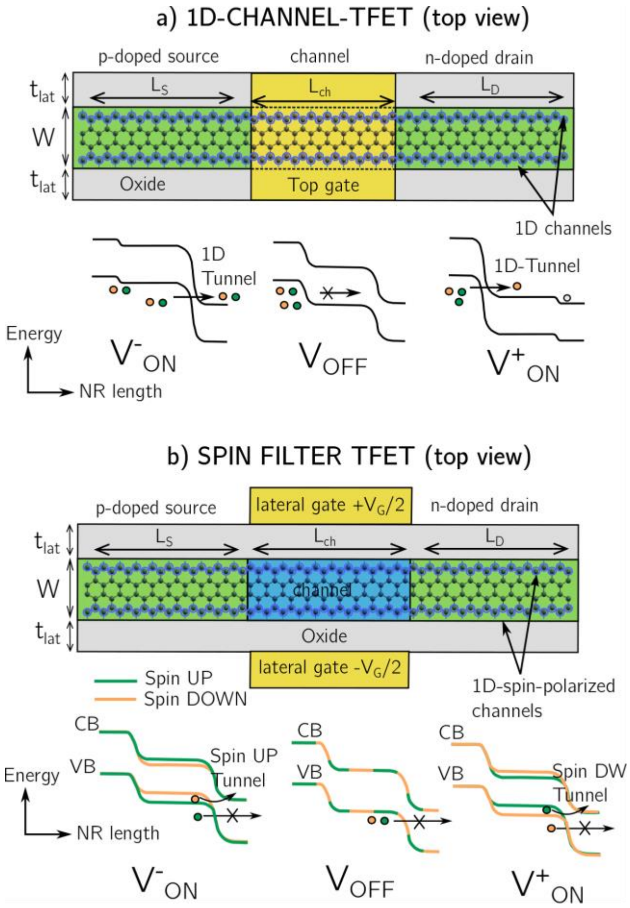

Figure 1: Scheme of the two stanene TFETs devices, and band diagrams illustrating their operation under different gate biases.

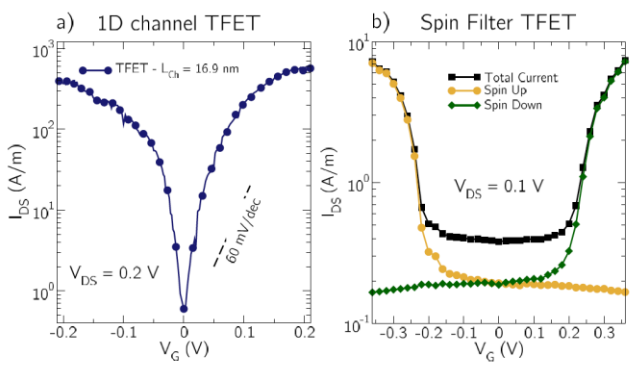

Figure 2: I-V response a) of the 1D channel TFET with subthreshold swing < 20mV/dec and ON-OFF ratio ~10^3 and b) the spin filter TFET showing spin up (circles), spin down (diamonds) and total (squares) currents.