Semiconductor-Superconductor-Ferromagnetic heterostructure as a Platform for Topological Superconductivity

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Hybrid structures comprising semiconducting (SM) nanowires, epitaxially grown superconductors (SC), and ferromagnetic-insulator (FI) layers have been experimentally and theoretically explored as alternative platforms for achieving topological superconductivity at zero magnetic field [1]. In this work [2], we analyze a tripartite SM/FI/SC heterostructure realized in a planar stacking geometry, where the thin FI layer acts as a spin-polarized barrier between the SM and the SC. We optimize the system's geometrical parameters using microscopic simulations to find the range of FI thicknesses for which the hybrid system can be tuned into a quasi-one-dimensional topological regime. Within this range, and due to the vertical confinement provided by the stacking geometry, trivial and topological phases alternate regularly as the external gate is varied, displaying a hard topological gap that can reach half of the SC gap. This represents a significant improvement compared to setups using hexagonal nanowires. Additionally, we propose a specific x-y pattern for the SC that would enable the development of a quasi-two-dimensional topological superconducting phase on this platform. Our results offer new possibilities for designing topological superconducting devices without the need for a magnetic field.

References

[1] Saulius Vaitiekėnas *et al*., Nature Physics, 17 (2022) 43.
[2] Samuel D. Escribano *et al*., npj Quantum Materials, 7 (2022) 81.

Figures

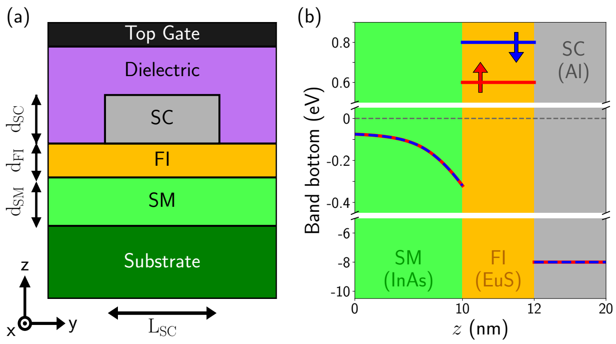

Figure 1: (a) Sketch of the device: 2D semiconductor (SM)/ferromagnetic insulator (FI)/superconductor (SC) heterostructure stacked in the *z*-direction. The top gate can be used to confine the wavefunction below the grounded SC. (b) Schematics of the conduction-band bottom along the heterostructure stacking direction for a specific choice of materials (InAs/EuS/Al). Red and blue colors represent different spin directions.