Ferromagnetic hybrid nanostructure and its zero-field application

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Material development plays a vital role in the search for topological states that have been predicted to be formed in semiconductor (SE) nanowires coupled to conventional superconductors (SUs) [1-2]. This prediction has been followed by a series of experiments that are consistent with the predictions [3-4]. In the system, the Zeeman energy, that is required for hybrid nanowires to enter the topological phase, is provided by external magnetic fields exceeding the induced gap, which is detrimental to the parent super-conductivity. Is it possible to further develop hybrid materials and thus minimize the need for the external field? It is well-known that materials combining ferromagnetism and semi-conductivity, that is ferro-magnetic insulators (FMIs), have been developed for spin-based electronics, and intrinsic magnetism can be induced by them. The ferromagnetic hybrid nanowires, which integrates a FMI into SE–SU NWs, i.e. SE–SU–FMI NWs, is derived from this idea. In this talk, I will present our recent works on epitaxial SE–SU–FMI InAs-Al-EuS hybrid nanowires in-situ grown in a molecular beam epitaxy system [5-6]. The results suggest that these hybrid NWs have a superconducting hard gap, a hysteresis transport behaviour and a shape-defined magnetic single domain structures based on well-controlled epitaxy. They can strongly support the zero-field applications of quantum devices, e.g., revealing the evidence of zero-field topological superconductivity in InAs-Al-EuS NW based devices [7].

References

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Figures

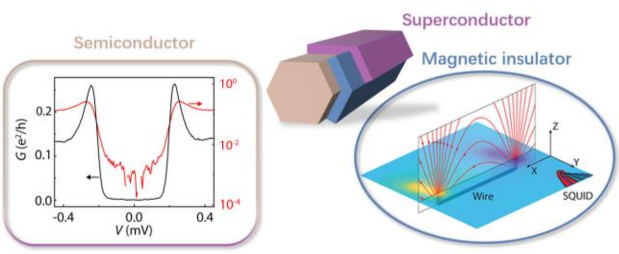

Figure 1: SE–SU–FMI NWs as a promising platform for zero-field applications. Middle panel: schematic of InAs-Al-EuS NWs; left panel: superconducting hard gap of InAs-Al-EuS NWs; right panel: magnetic single domain of InAs-Al-EuS NWs.