Andreev Bound States in Ge-Si Core-shell Nanowires

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Abstract

Ge-Si core-shell nanowires are semiconductors with large potential for both quantum and topological research. In this work, we employ an original interlayer approach instead of conventional diffusion method [1] to induce superconductivity in these wires (Figure 1). Subsequently, the intact Si shell not only prevents metallization [2] with controllable proximity gap for the advantage of topological studies, but also enables a rich interplay between superconductivity and energy quantization. For the latter, long ballistic channels facilitate the emergence of multiple Andreev bound states beneath the 2 µm long electrodes, forming a diverse subgap spectrum combined with quantization levels (Figure 2). Additionally, we observed a singlet-to-doublet ground state transition under increasing external magnetic field. Finally, we attribute an anomalous critical current enhancement with increasing magnetic field to quasiparticle cooling (Figure 3), supported by both experimental evidence and a theoretical model.

References

[1] Ridderbos, J. et al, Nano Letters, (2020) pp. 122–130.
[2] Reeg, C. et al, *Physical Review B*, (2018) p165425.

Figures

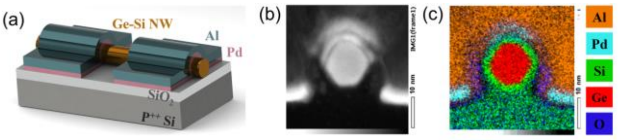

Figure 1: (a) Schematics of an Al/Pd/Ge-Si/Pd/Al device. (b) TEM image and (c) EDX mapping of a lamella cut on the cross section of a device as (a). TEM studies were performed by our collaborators at Eindhoven Technical University.

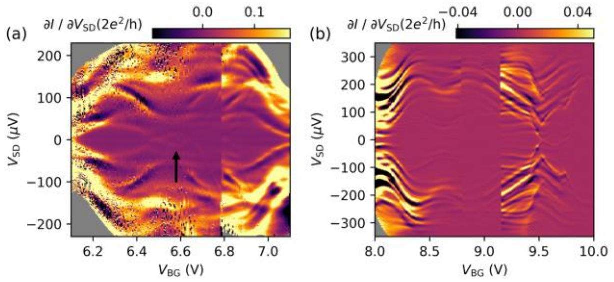

Figure 2: Subgap states in the device. (a) and (b) Differential conductance versus bias voltage and backgate voltage at two different gate ranges. The black arrow highlights an eye-shape subgap state.

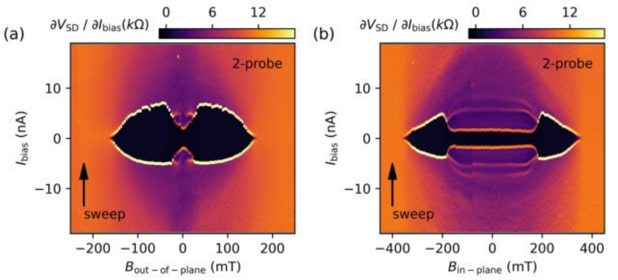

Figure 3: Magnetic field dependence of the device. Differential resistance versus bias current and magnetic field rotated along (a) out-of-plane and (b) in-plane.