Scalable Al-Ge Hybrid Heterostructures for Next-Generation Superconducting Quantum Devices

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Hybrid superconductor-semiconductor systems offer a highly promising platform for quantum information processing. We present a top-down fabrication strategy for Al-Ge-Al quantum devices on GeOI substrates, enabling scalable integration of complex superconducting circuits with atomically abrupt, oxide-free interfaces[1]. Ge structures are defined via optical and e-beam lithography, etched with RIE, and contacted using sputtered Al followed by thermal annealing (Fig. 1). Building on prior results from bottom-up grown Al-Ge-Al nanowires demonstrating gate-tunable supercurrents and Multiple Andreev Reflections[2] (Fig. 2), the top-down platform now enables systematic exploration of temperature-dependent transport in defined Ge channels. This approach supports complex device geometries and large-scale integration for advanced quantum and cryogenic nano-electronic applications.

References

[1] Wind, L. et al. ACS Appl. Mater. Interfaces 13, 12393–12399 (2021).
[2] Delaforce, J. et al. Advanced Materials 33, 2101989 (2021).

Figures

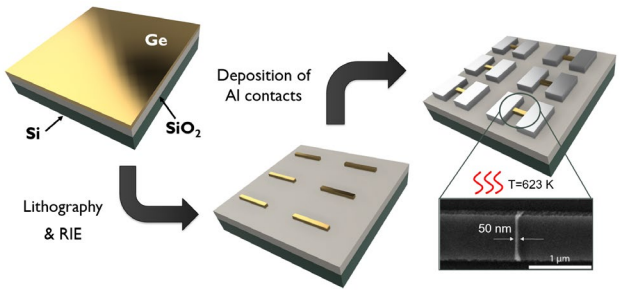

Figure 1: Top-down fabrication process: GeOI substrates are patterned using optical or e-beam lithography, followed by Reactive Ion Etching (RIE). Al contacts are deposited via sputtering and thermally annealed to form sharp Al-Ge interfaces[1].

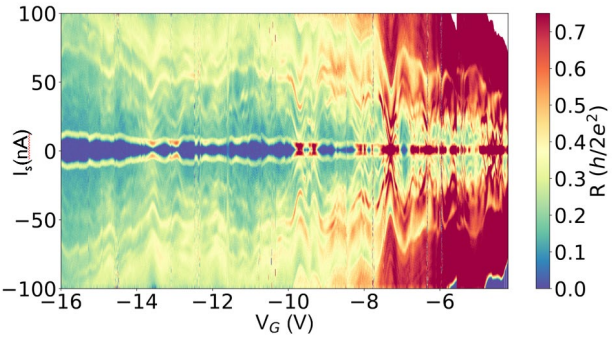

Figure 2: Differential resistance vs. bias current and gate voltage in bottom-up Al-Ge-Al nanowires at 390 mK. Gate-tunable supercurrents and Multiple Andreev Reflections confirm superconducting transport in earlier NW devices[2].