# Advances in Growth and Integration of Nanowires for Small Quantum Circuits – Superconductor-Semiconductor Junctions and Chains of Hybrid Quantum Dots

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The recent, extraordinary progress in hybrid semiconductor-superconductor platforms has been motivated by studies of topological systems, exotic bound states, new superconducting qubits, supercurrent diodes and transistors as well as other quantum devices ranging from single junctions to complex microwave devices.

In terms of materials platforms, pioneering experiments have been realized with semiconductor nanowires (for reviews, see e.g. [1,2]), while more recently, focus have largely turned towards scalable 2D platforms that seem more attractive for technological applications. However, the best device performances have still been reached with bottom-up grown nanowires, notably III-V nanowires interfaced with superconductors. Key examples are gate tunable qubits (gatemon and Andreev qubits), Cooper pair splitters, and coupled hybrid quantum dots used to demonstrate topological model systems, Andreev molecules and other bound state phenomena.

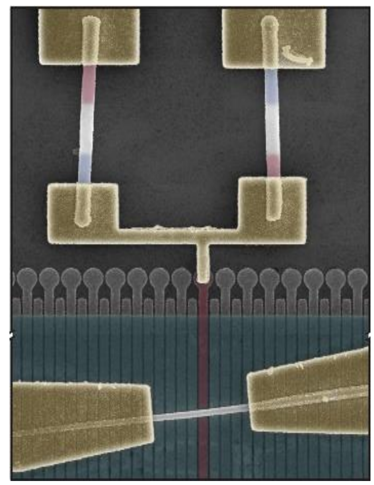

Fig.1. Circuit based on different types of III-V semiconductor nanowires.

With nanowires being ideal for these fundamental experiments, it is interesting to investigate prospects for building circuits based on several nanowires. Surprisingly, it is straight forward to construct controlled assemblies of several nanowires for electronic devices using micromanipulation. Thus scaling for research purposes is feasible. We will show examples of integration of multiple nanowires in circuits, optoelectronics [3], and in superconducting microwave resonators, e.g. enabling long range coupling of Andreev qubits [4].

We will also touch upon the progress in MBE growth of crystal phase defined quantum dots and epitaxial superconductor-semiconductor interfaces [5]. Such techniques can be combined to grow in-situ Josephson junctions [6] and hybrid quantum dot arrays [7] with prospects for quantum simulations.

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