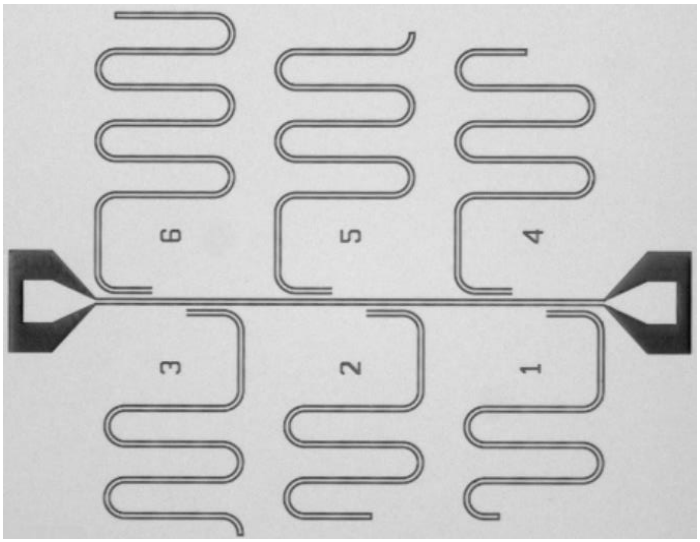
High-Quality, Planar Superconducting Resonators for Continuous-Variable Quantum Computing
MSc thesis project

202Q-lab, Quantum Technology Laboratory

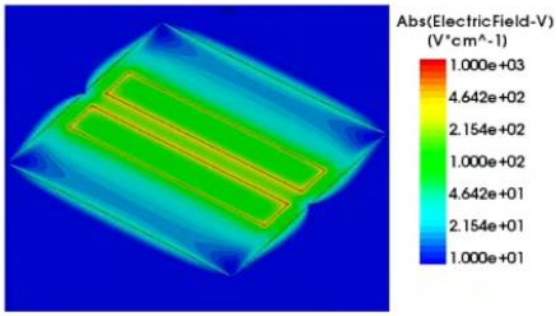
The 202Q-lab is looking for a MSc student who is interested in superconducting quantum circuits.

Background – Continuous-variable (CV) quantum computing aims to utilize harmonic oscillators for quantum information processing. We have explored CV quantum computing in three-dimensional (3D) microwave cavities [1,2]. However, 3D cavities are large, and it is difficult to engineer connectivity between multiple cavities. On the contrary, planar circuits are compact and offer versatile connectivity but are lacking in ultra-long coherence times.

The challenge – In order to build CV quantum circuits on chip, we need to compare and validate different resonator designs. The aim is to select a resonator design with the lowest losses i.e., the highest quality factor. Quality factor describes the losses in the resonator. It depends on materials and processes used to fabricate the resonator; however, for a given combination of materials and processes, it can be affected by the resonator design. For example, altering the amount of electric field energy that is stored on the surface of the substrate, or on the metal-to-air interface, can have a big impact on the quality factor [3].



Superconducting coplanar waveguide resonators in a multiplexed readout setup. Multiple resonators can be characterized on the same chip.



Finite-element-method simulation of a superconducting resonator shows the electric field density.

The project – The main task of the project is to benchmark different planar resonator designs. The candidate will design and simulate different types of planar circuits using electromagnetic finite-element-method simulation software. The candidate will design the chips that are then fabricated by the other members of the group. Finally, the candidate will perform measurements of the devices at millikelvin temperatures inside a cryostat. The device performance is validated through quality factor measurements.

About us – We are part of the Quantum Technology Laboratory, a division of the Department of Microtechnology and Nanoscience (MC2) at Chalmers University of Technology. We are also part of the Wallenberg Centre for Quantum Technology (WACQT).

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References

[1] Kudra *et al.*, *High Quality Three-Dimensional Aluminum Microwave Cavities*, Applied Physics Letters 117, (2020).
[2] Kudra *et al., Robust preparation of Wigner-negative states with optimized SNAP-displacement sequences,* PRX Quantum, 3(3), 030301, (2022)
[3] Wang, *et al., Surface participation and dielectric loss in superconducting qubits*, Applied Physics Letters 107, 162601, (2015)