An integrated microwave-to-optics interface for scalable quantum computing

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Superconducting qubits hold great potential as building blocks for reliable quantum computers. However, their operating frequency in the microwave range poses challenges for scalability. Converting a microwave signal into an optical signal allows us to address some of these challenges. The connections between different quantum processors become less noisy over an optical link and the cabling for a single quantum processor requires less space and dissipates less heat when the coaxial lines are replaced by multiplexed optical fibres.
We present here a piezo-optomechanical transducer that couples a silicon photonic crystal cavity through a lithium niobate block to a tuneable superconducting microwave resonator. We use a mechanical intermediary, which is predominantly in the ground state. We achieve an input referred added noise of 6 photons by using an optical pulse power of 5 fJ [1]. Additionally, we show that we can use it to read out a superconducting qubit using a demolition multi-shot readout technique [2]. This scalable design paves the way not only for scaling up a single quantum processor but also for distributed quantum computing.

References

[1] Weaver, M.J., Duivestein, P., Bernasconi, A.C. et al., Nat. Nanotechnol., (2023) 1-7
[2] van Thiel, T. C., et al., arXiv preprint arXiv:2310.06026 (2023)

Figures

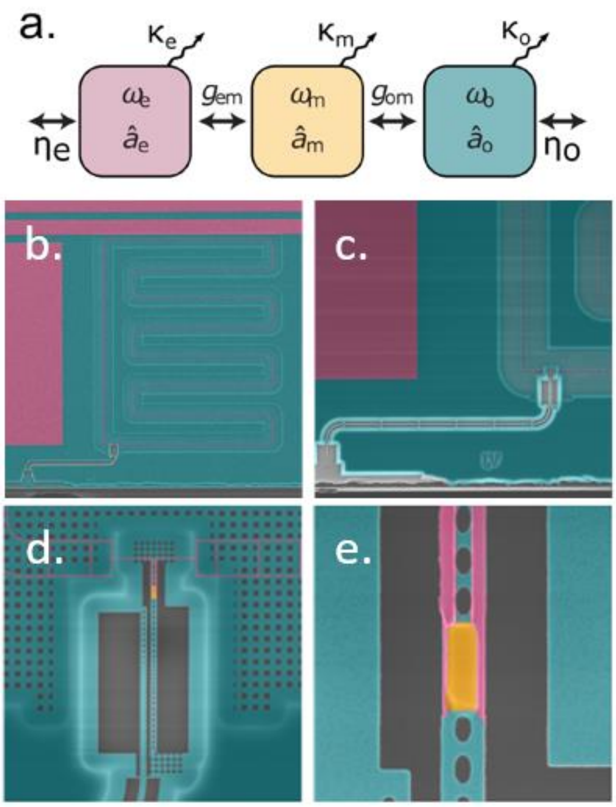

Figure 1: a. Bosonic modes that make up the optomechanical transducer: electromechanical mode (magenta) couples with gem to mechanical mode (yellow) that couples with gom to optical mode (cyan). They each have a frequency of ω/2π and a loss rate of κ/2π. b.-e. scanning electron microscope images of the transducer. [1]