Inas quantum dots and surface acoutsic wave cavities for quantum transduction

Autry, Travis[1], Berweger[1], Samuel, Sletten[2], Lucas, Mirin, Richard[1], Kabos, Pavel[1], Lehnert, Konrad[2], Silverman, Kevin [1,*]

[1]NIST, Physical Measurement Laboratory, Boulder, CO USA
[2]JILA, National Institute of Standards and Technology and the University of Colorado, Boulder, Colorado 80309, USA
**e-mail: kevin.silverman@nist.gov*

Quantum information technology based on superconducting microwave technology is progressing rapidly and is now widely adopted by large corporations and small startup firms. These components operate at extremely cold (<20mK) temperatures requiring an isolated environment. Therefore, a critical problem is the transfer of quantum information out of and into the cryostat. Currently, the only viable method for transporting quantum information ~km distances is via optical photons. Subsequently, efficient and noise-free microwave-optical conversion is required. Recently, progress has been made by simultaneously coupling the light and microwave degrees of freedom to nanomechanical resonators. A successful approach is to place a SiN membrane in a high-Q Fabry-Perot cavity [1]. The motion of the membrane parametrically modulates the frequency of the cavity light via the index of refraction.

Here, we present progress on a new type of transducer where the optical cavity is replaced with an InAs quantum dot and the membrane is exchanged for a surface acoustic wave cavity (SAWc). Recently, hybrid quantum devices involving SAW cavities and superconducting qubits have been successfully integrated [2]. In a SAWc, phonons will parametrically modify the resonance frequency of a QD via strain [3]. In this work, we demonstrate progress in developing state-of-the-art, stable SAWc operating at ~ 3.4GHz. We demonstrate a reduction in the SAWc mode volume by using focusing SAW mirrors (Fig. 1). These devices are characterized using atomic force measurements of SAWc cavity-modes demonstrating high-quality focusing phononic wavefronts. Finally, we discuss reducing bulk scattering, theoretical coupling rates and discuss efficient photon extraction.

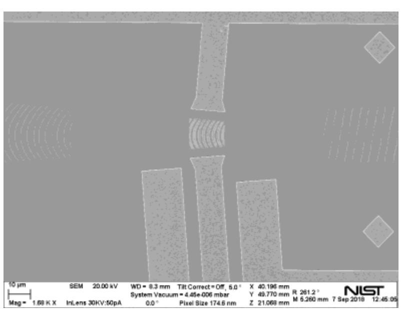

Fig. 1. SEM image of SAWc device.

References

[1] R. W. Andrews, et al,, *Nature Physics*, 2014, **10**, 321.

[2] K. J. Satzinger, et al., *Nature*, 2018, **563**, 661.

[3] M. Metcalfe, S.M. Carr, A. Muller, G.S. Solomon, and J.Lawall, *Physical Review Letters,* 2010, **105**, 037401