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Hybrid superconducting-mechanical circuits with phononically-engineered silicon-nitride membranes

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Superconducting quantum circuits have enabled the generation and the manipulation of non-classical states of microwave radiation, which was in particular made possible by the control of artificial two-level systems. This offers interesting prospects both in the domain of quantum information technology and in the fundamental study of quantum mechanics. Recently, this quantum control has been extended to the motional degrees of freedom of mechanical resonators [1], pioneering the exciting field of quantum accousto-dynamics.

We aim to leverage to full potential of hybrid superconducting-mechanical systems by coupling highly coherent factor silicon-nitride membranes, shown in Figure 1, to quantum circuits. Through phononic engineering, the mechanical modes are strongly decoupled from their environment, and can support excitations for prolonged periods of time. In our work, we identify for the first time performance-destroying parasitic effects [2], and propose measures for countering them. We show that following our protocol enables ultracoherent membranes to be reliably fabricated, thus paving the way for studies of nonclassical mechanical states with long lifetimes.

[1] Y. Chu et al. Nature **563** 666-670 (2018).
[2] E. Ivanov et al. APL

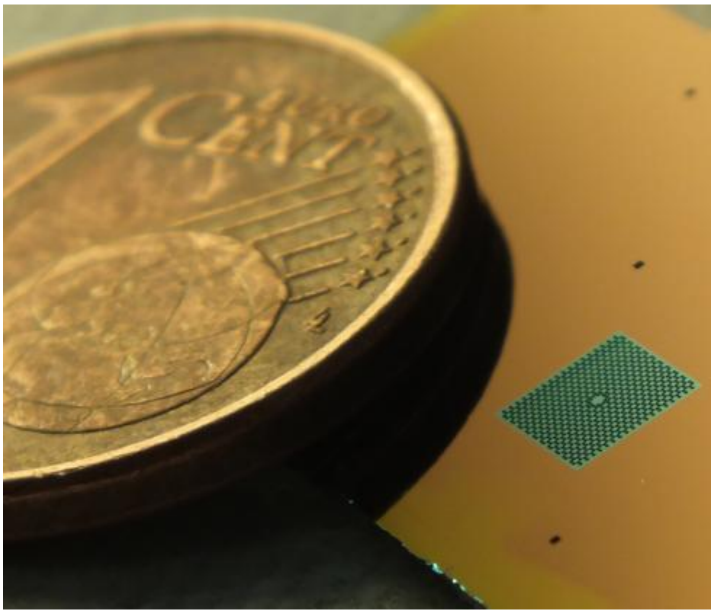

Figure 1 : Photograph of a silicon-nitride membrane (bottom right), with a 1 euro-cent coin for scale.