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Improving integration of high-Q silicon nitride membrane resonators into electro-opto-mechanical devices for hybrid quantum systems K. CICAK, NIST - Boulder, R.W. ANDREWS, P.-L. YU, R.W. PETERSON, T.P. PURDY, P.S. BURNS, C.A. REGAL, K.W. LEHNERT, JILA: University of Colorado and NIST, Boulder, R.W. SIMMONDS, NIST - Boulder — Macroscopic high-stress silicon nitride membranes can be implemented as ultra-high-quality-factor mechanical resonators operating in the quantum regime with average phonon occupancy below one quantum. Mechanical motion of these resonators can be engineered to simultaneously couple both to (THz) light in free-space optical cavities and to microwave (GHz) fields in superconducting circuits. Exploiting this parametric coupling to realize quantum information transfer between these domains entails construction of devices with challenging requirements. These devices must integrate the membranes with superconducting circuits operating at cryogenic temperatures in proximity of free space optical photons while meeting demands for various quantum and coupling requirements. Here we show how to construct such "hybrid quantum devices" by microfabricating and assembling chip-based structures that can be inserted into high-finesse optical cavities compatible with low temperatures. We include an overview of recent fabrication improvements of membranes mechanically isolated from environment by phononic band-gap crystals.

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