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Monolithic Miniature 3D Linear Trap for Cavity Integration

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Scalability represents an ongoing challenge for the trapped ion quantum computing platform. The photonic interconnect architecture was proposed to address the scalability issue using trapped ions [1]. The efficiency of the architecture relies on the remote entanglement rate between different nodes. The figures of merit of the architecture are the entanglement generation rate and fidelity of this entanglement. To this end, the cavity-mediated photon generation scheme has demonstrated great potential. By reducing the cavity length, the increased ion-cavity coupling is estimated to result in two orders of magnitude improvement over the current record for remote entanglement rate [2]. Despite the potential for such improvement, the introduction of the cavity in a trapped ion system is hindered by stray charges accumulated on the dielectric mirror surfaces [3], the increased heating rate due to the dielectric materials [4] and the distortion of trapping potential [5]. These detrimental effects from the cavity necessitate a miniature trap to shield it sufficiently. We present our recent progress in developing a monolithic miniature 3D linear trap that integrates a miniature optical cavity and can serve as a building block for a scalable trapped ion quantum processor. Fabricated with selective laser-induced etching has allowed for a monolithic design with virtually no misalignment of the electrodes where we have successfully trapped single ions. This work is supported by JST Moonshot R&D Grant No. JPMJMS2063 and MEXT Quantum Leap Flagship Program (MEXT Q-LEAP) Grant No. JP-MXS0118067477.

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