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Integrated Microsystems Approach to Trapped Ion Quantum Information Processing[1]

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Trapped atomic ions are the leading candidate physical system for quantum information processing, featuring high quality qubits capable of high fidelity operations including state preparation, detection and quantum logic gates. A major remaining challenge is the task of constructing experimental systems where all operations necessary for quantum information processing can be performed in a scalable way. I will discuss a three-tier approach to construct such scalable hardware utilizing technologies that are available today. Arbitrary qubit gate operations in a linear ion chain ($< 10^2$ ions) can be realized with control beams that can address individual ions in the chain. Shuttling of ions between such chains enable qubit gates between several chains (~ 10 chains) implemented in a single chip trap. One can then connect a large number ($\sim 10^3$) of such trap chips using reconfigurable photonic network. Complex microfabricated ion trap chips integrated with various optical components such as reflectors, lenses and optical cavities are crucial in realizing efficient interfaces for these experiments, and micromirrors can provide fast and flexible beam delivery system with individual addressing capability. I will present the progress in ion qubit manipulation on microfabricated chip traps, the integration effort with optical components, and potential application in scalable quantum computer and quantum repeater realization.

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