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High-fidelity operations in microfabricated surface ion traps[1]

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Trapped ion systems can be used to implement quantum computation as well as quantum simulation. To scale these systems to the number of qubits required to solve interesting problems in quantum chemistry or solid state physics, the use of large multi-zone ion traps has been proposed [1]. Microfabrication enables the realization of surface electrode ion traps with complex electrode structures. While these traps may enable the scaling of trapped ion quantum information processing (QIP), microfabricated ion traps also pose several technical challenges. Here, we present Sandia's trap fabrication capabilities and characterize trap properties and shuttling operations in our most recent high optical access trap (HOA-2). To demonstrate the viability of Sandia's microfabricated ion traps for QIP we realize robust single and two-qubit gates and characterize them using gate set tomography (GST). In this way we are able to demonstrate the first single qubit gates [2] with a diamond norm of less than 1.7×10^{-4}, below a rigorous fault tolerance threshold for general noise of 6.7×10^{-4} [3]. Furthermore, we realize Mølmer-Sørensen two qubit gates with a process fidelity of 99.58(6)% also characterized by GST. These results demonstrate the viability of microfabricated surface traps for state of the art quantum information processing demonstrations. [1] D. Kielpinski, C. Monroe, and D. J. Wineland, Nature 417, 709 (2002). [2] R. Blume-Kohout et al. arXiv:1606.07674. [3] P. Aliferis and J. Preskill, Phys. Rev. A 79, 012332 (2009).

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