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High-Fidelity Two-Qubit Gates in a Surface Ion Trap[1] DANIEL LOBSER, MATTHEW BLAIN, ROBIN BLUME-KOHOUT, KEVIN FORTIER, JONATHAN MIZRAHI, ERIK NIELSEN, KENNETH RUDINGER, JONATHAN STERK, DANIEL STICK, PETER MAUNZ, Sandia National Labs — Microfabricated surface traps are capable of supporting a variety of exotic trapping geometries and provide a scalable system for trapped ion Quantum Information Processing (QIP). However, the feasibility of using surface traps for QIP has long been a point of contention because the close proximity of the ions to trap electrodes increases heating rates and might lead to laser-induced charging of the trap. As surface traps continue to evolve at a remarkable rate, their performance is rapidly approaching that of macroscopic electrode traps. Using Sandia's High-Optical-Access surface trap, we demonstrate robust single-qubit gates, both laser- and microwave-based. Our gates are accurately characterized by Gate Set Tomography (GST) and we report the first diamond norm measurements near the fault-tolerance threshold[2]. Extending these techniques, we've realized a Mølmer-Sørensen two-qubit gate[3] that is stable for several hours. This stability has allowed us to perform the first GST measurements of a two-qubit gate, yielding a *process* fidelity of 99.58(6)%.

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[2]P. Aliferis and A. W. Cross, Phys. Rev. Lett. 98, 220502 (2007)
[3]A. Sørensen and K. Mølmer, Phys. Rev. Lett. 82, 1971 (1999)

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