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Integrated multi-wavelength photonic addressing of trapped ion qubits ROBERT NIFFENEGGER, JULES STUART, COLIN BRUZEWICZ, ROBERT MCCONNELL, MIT Lincoln Laboratory, GAVIN WEST, GARRETT SIMON, Physics, Massachusetts Institute of Technology, DAVE KHARAS, CHERYL SORACE-AGASKAR, SURAJ BRAMHAVAR, JEREMY SAGE, JOHN CHIAVERINI, MIT Lincoln Laboratory — Integrating quantum and classical technologies with systems like trapped ions is critical to enable the Moore's law like scaling of qubits necessary to develop practical quantum computers. For instance, individual addressing of trapped ion qubits typically requires bulky free space optics to tightly focus multiple laser beams onto single ions within linear chains, limiting scalability. Here we have designed and fabricated an ion trap chip with integrated photonic waveguides and grating out-couplers for integrated addressing in all of the infrared, visible, and ultraviolet wavelengths required to cool and control ^{88}Sr+ trapped ion qubits. The combination of recently developed low loss UV photonic waveguides made from Al_2O_3 with more typical SiN waveguides for IR and visible wavelengths within multiple layers of the chip enables integration of light at all the wavelengths required for ion control. We study the interaction of these new multi-wavelength photonics with a single ion qubit towards demonstration of a two qubit gate controlled via integrated technologies, a key component of a scalable trapped ion quantum information processor.

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