A 20-mode quantum photonic processor based on Silicon Nitride waveguides

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Abstract

Photonics is one of the most attractive approaches to quantum computing, having gained momentum thanks to recent experimental results demonstrating a quantum advantage in photonics [1,2]. The strengths of photonics as quantum computing platform are as follows: first, quantum states of light are characterized by inherently low decoherence due to their weak interaction with the surrounding environment; second, photonic quantum states maintain their coherence at room temperature; third, photonic quantum computing can exploit the high maturity of existing classical integrated photonics technologies. These factors together mean that integrated photonics represents a scalable approach to large-scale quantum computing.

Integrated photonics is an essential technology for optical quantum computing. Universal, phase-stable, reconfigurable multimode interferometers (quantum photonic processors) enable manipulation of photonic quantum states and are one of the main components of photonic quantum computers in various architectures. In this paper, we report the realization of the largest quantum photonic processor to date. The processo enables arbitrary unitary transformations on its 20 input modes with a fidelity of F_{Haar} = 97.4% and F_{Perm} = 99.5%, an optical loss of 2.9 dB averaged over all modes, and high-visibility quantum interference V_{HOM} =98%. The processor is realized in Si_3N_4 waveguides and operates at telecom wavelength.

[1] Han-Sen Zhong et al. "Quantum computational advantage using photons". In: Science 370.6523 (2020). _eprint: https://www.science.org/doi/pdf/10.1126/science.abe8770, pp. 1460–1463.
[2] Hailong Zhou et al. "Self-Configuring and Reconfigurable Silicon Photonic Signal Processor". In: ACS Photonics 7.3 (Mar. 2020). Publisher: American Chemical Society, pp. 792–799.

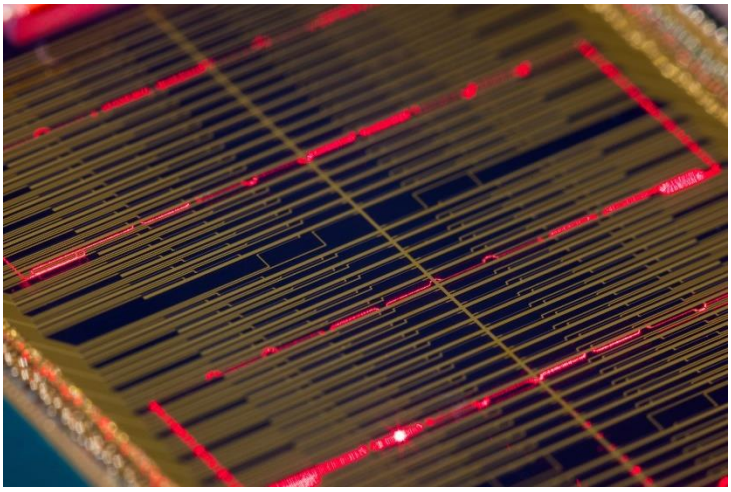

Figure 1 Photograph (zoom in) of the 20-mode quantum photonic processor when illuminated with visible red light. One of the waveguide paths is illuminated showing detailed features such as small spirals and directional couplers.