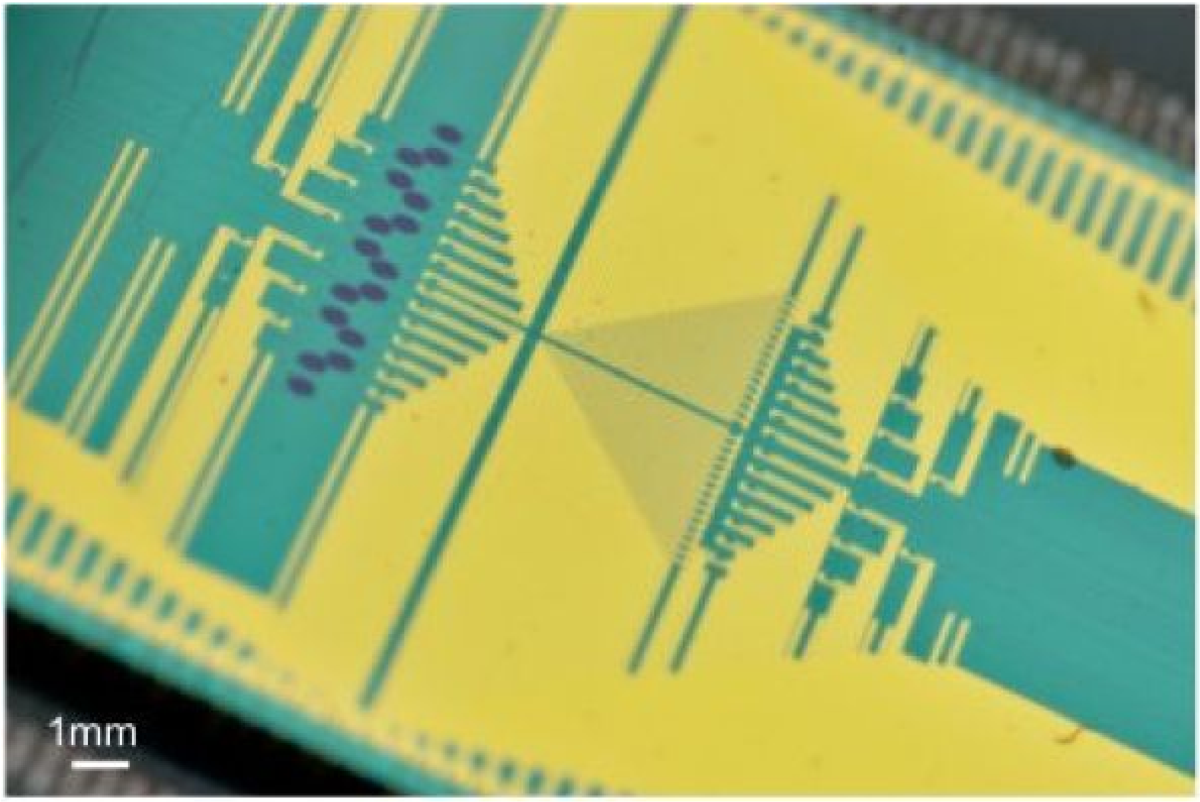


# Scaling silicon quantum photonics technology

## The study, published in Science, reports on the development of a large-scale integrated silicon-photonics quantum circuit for the precise and general control of multidimensional entanglement.

March 09, 2018

Integrated Quantum Photonics allows the routing and control of single particles of light with intrinsically high stability and precision, however to date it has been limited to small-scale demonstrations in which only a small number of components are integrated on a chip. It is thus in high demand to scale up the integrated photonic circuits and increase the complexity and computational power of modern quantum information processing technologies that would enable many revolutionary applications.

An international team of researchers led by scientists from the Uni. of Bristol?s Quantum

Engineering Technology Labs has demonstrated the first ever large-scale integrated quantum photonic circuit, which can generate, control and analyze high-dimensional entanglement with unprecedented high precision and generality. The quantum chip was realised using a scalable silicon photonics technology, similar to today?s electronic circuits, which would provide a path to manufacture massive components for the realization of an optical quantum computer. The work, in collaboration with Peking Uni., Technical Uni. of Denmark (DTU), ICFO - The Institute of Photonic Sciences, Max Planck Institute of Quantum Optics (MPQ), Polish Academy of Sciences (PAS) and Uni. of Copenhagen, has been published recently in the journal Science.

Coherently and precisely controlling large quantum devices and complex multidimensional entanglement systems has been a challenging task owing to the complex interactions of correlated particles in large quantum systems. Significant progress towards large-scale quantum systems has been recently reported in a variety of platforms including photons, superconductors, and ions, among others. In particular, photonics allows a system to naturally encode and process multidimensional qubit states within a photon?s different degrees of freedom. In this work, a programmable bipartite path-encoded multidimensional entangled system with dimension up to 15×15 is demonstrated, where each photon exist over 15 optical paths at the same time and the two photons are entangled with each othe there. This multidimensional entanglement system is achieved by scaling up th silicon-photonics quantum circuits via a single chip integration of 550 optical component including 16 identical photon-pair sources, 93 optical phase-shifters, 122 beam-splitters among other optical elements.

Lead author, Dr Jianwei Wang, said: "It is the maturity of today?s silicon-photonics that allows us to scale up the technology and reach a large-scale integration of quantum circuits. This is the most beautiful thing of quantum photonics on silicon. As a result, our quantum chip allows us to, for the first time, reach the unprecedented high precision and universality of controlling multidimensional entanglement, a key factor in many quantum information tasks of computing and communication."

ICFO researchers Alexia Salavrakos and Antonio Acin say that "distributing and detecting quantum correlations in a controlled manner is an enabling step to design more robust and secure quantum communication technologies".

Professor Mark Thompson, leader of the Bristol team, has emphasized that "the photonic circuits on silicon, the same material used in our electronic circuits, allow the processing of information carried by a single particle of light. This silicon quantum photonics technologies are allowing us to scale up quantum devices and systems in an incredibly rapid speed, and in the near future it will reach an integration of tens of thousands of elements on a single chip that can promise numerous quantum applications."