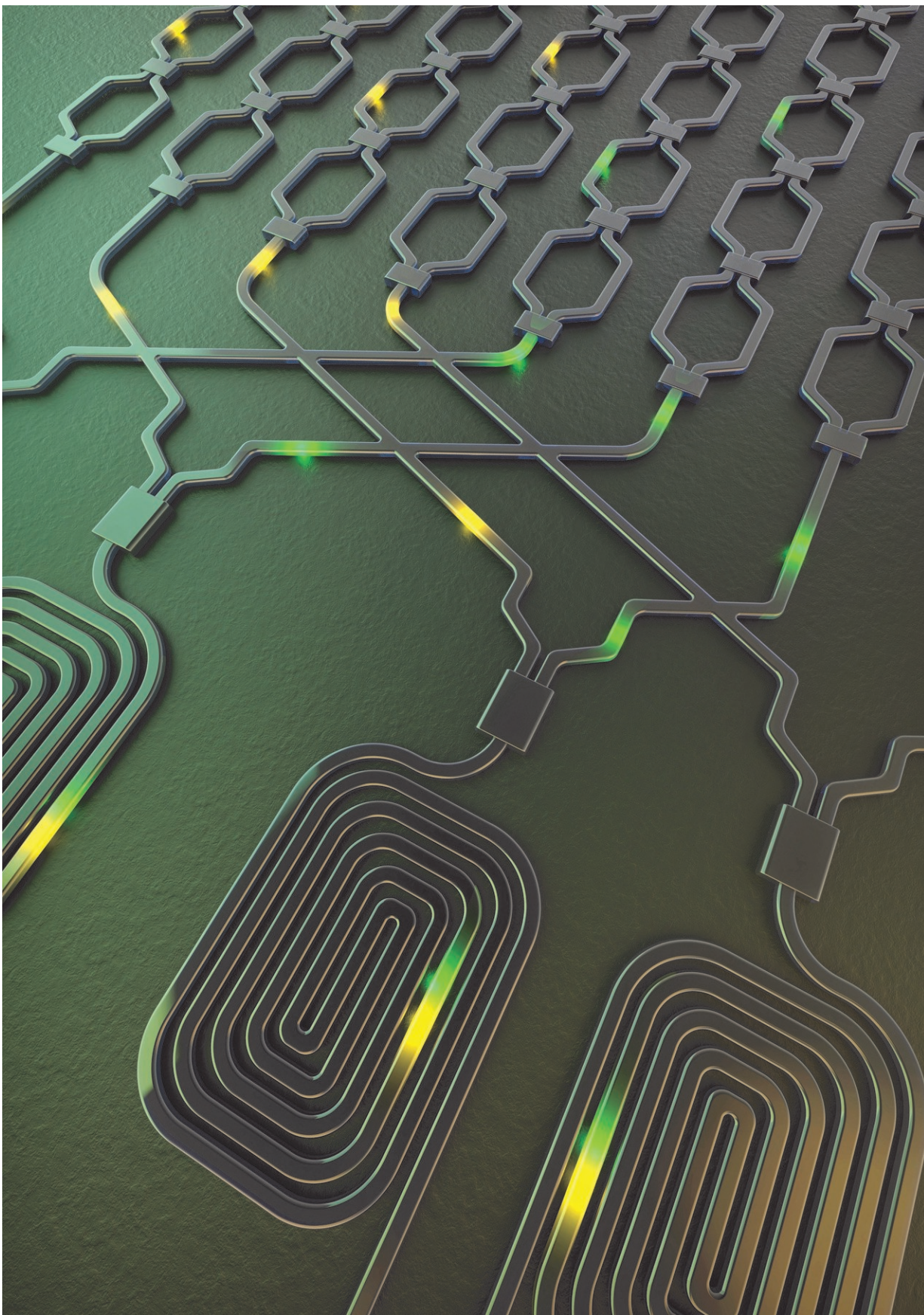


Multi-purpose silicon chip created for quantum information processing

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Tracks called waveguides guide photons in silicon, much like an optical fiber. Spirals of these waveguides are used to generate photons (quantum particles of light) that are then routed around the processor circuit to perform different tasks. Credit: Xiaogang Qiang/University of Bristol

An international team of researchers led by the University of Bristol have demonstrated that light can be used to implement a multi-functional quantum processor.

This small [device](#) can be used as a scientific tool to perform a wide array of quantum information experiments, while at the same time showing the way to how fully functional quantum computers might be engineered from large scale fabrication processes.

They did this by engineering a silicon chip that guides single particles of light, called photons in optical tracks called waveguides to encode so-called quantum-bits of information called "qubits".

International effort is growing to develop quantum computers as the next step in computing power, to increase the types of tasks that computers can solve for us.

In today's desktop computers, super-computers and smartphones, bits take the form of either being a "1" or a "0" and they are the fundamental building block on which all computers currently used in society are based.

Quantum computers are instead based on "qubits" that can be in a superposition of the 0 and 1 states. Multiple qubits can also be linked in

a special way called quantum entanglement. These two quantum physical properties provide the power to quantum computers.

One challenge is to make quantum computer processors that can be re-programmed to perform different tasks, just as we have computers today that can be re-programmed to run different applications.

A second challenge is how to make a quantum computer in a way that its many parts can be made with very high quality and ultimately at low cost.

The Bristol team has been using silicon photonic chips as a way to try to build [quantum computing](#) components on a large scale and today's result, published in the journal *Nature Photonics*, demonstrates it is possible to fully control two qubits of information within a single integrated chip. This means any task that can be achieved with two qubits, can be programmed and realised with the device.

Lead author, Dr. Xiaogang Qiang, who undertook the work whilst studying for a Ph.D. at the University of Bristol, and now works in the National University of Defence Technology in China, said: "What we've demonstrated is a programmable machine that can do lots of different tasks.

"It's a very primitive processor, because it only works on two qubits, which means there is still a long way before we can do useful computations with this technology.

"But what is exciting is that it the different properties of silicon photonics that can be used for making a quantum computer have been combined together in one device.

"This is just too complicated to physically implement with light using

previous approaches."

The integrated photonics effort started in 2008 and was an answer to the growing concern that individual mirrors and optical elements are just too big and unstable to realise the large complex circuits that a quantum [computer](#) will be built.

Dr. Jonathan Matthews, a member of the research team based at the Quantum Engineering Technology (QET) Labs at the University of Bristol, added: "We need to be looking at how to make quantum computers out of technology that is scalable, which includes technology that we know can be built incredibly precisely on a tremendous scale.

"We think silicon is a promising material to do this, partly because of all the investment that has already gone into developing silicon for the micro-electronics and photonics industries. And the types of devices developed in Bristol, such as the one presented today, are showing just how well quantum devices can be engineered.

"A consequence of the growing sophistication and functionality of these devices is that they are becoming a research tool in their own right—we've used this device to implement several different [quantum](#) information experiments using nearly 100,000 different re-programmed settings."

The study is published in *Nature Photonics*.

More information: Large-scale silicon quantum photonics implementing arbitrary two-qubit processing, *Nature Photonics* (2018). [DOI: 10.1038/s41566-018-0236-y](https://doi.org/10.1038/s41566-018-0236-y) , www.nature.com/articles/s41566-018-0236-y

Provided by University of Bristol

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