'Building block' of quanutm networks created

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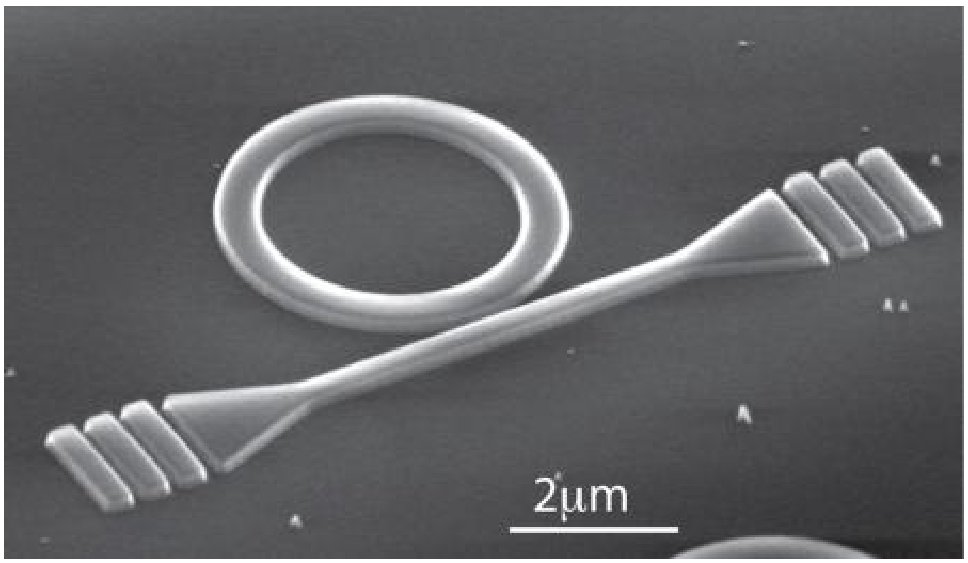

A scanning electron microscope image of one of the quantum photonic devices andrei faraon and his colleagues created. It features a micro-ring resonator coupled to a waveguide. Credit: Faraon/Caltech

(Phys.org)—A proof-of-concept device that could pave the way for on-chip optical quantum networks has been created by a group of researchers from the US.

Presenting the device today, 8 February, in the Institute of Physics and German Physical Society's New Journal of Physics, it has been described as the "building block of future quantum networks."

In an optical quantum network, information is carried between points by photons – the basic unit of light. There is a huge potential for this type of network in the field of quantum computing and could enable computers that are millions of times faster at solving certain problems than what we are used to today.

This new device, which combines a single nitrogen-vacancy centre in diamond with an optical resonator and an optical waveguide, could potentially become the memory or the processing element of such a network.

A nitrogen-vacancy centre is a defect in the lattice structure of diamond where one of the carbon atoms is replaced by a nitrogen atom and the nearest neighbour carbon atom is missing. The nitrogen-vacancy centre has the property of photoluminescence, whereby a substance absorbs photons from a source and then subsequently emits photons.

The emitted photons are special in that they are correlated, or entangled, with the nitrogen-vacancy centre that they came from, which as the researchers state is crucial for future experiments that will look to examine this correlation. You cannot get these correlated photons from a normal light source.

In this device, the photons are produced from a nitrogen-vacancy centre within a diamond microring resonator. The nitrogen-vacancy centre is located inside the diamond resonator as it is more likely to emit photons than when it is located in the waveguide or just in plain diamond. Moreover, the photons emitted in the resonator are easier to couple into an on-chip waveguide.

The cotton bud-shaped waveguide sends the photons out into a desired direction through gratings at either end.

"One of the holy grails in quantum photonics is to develop networks where optical quantum emitters are interconnected via photons," said lead author of the study Andrei Faraon.

"In this work we take the first step and demonstrate that photons – the information carriers – from a single nitrogen-vacancy centre can be coupled to an optical resonator and then further coupled to a photonic waveguide. We hope that multiple devices of this kind will be interconnected in a photonic network on a chip."

The study, undertaken by researchers from the California Institute of Technology, Hewlett Packard Laboratories and University of Washington, tested the device by cooling it to temperatures below 10K and shining a green laser onto the nitrogen vacancy to evoke photoluminescence.

The entire device was etched in a diamond membrane that was around 300 nanometres thick.

"The whole idea of these devices is that they are able to be produced en masse. So far the procedure for mass fabrication is still at the proof-of-concept level, so there is still plenty of work to be done to make it reliable," continued Professor Faraon.

More information: "Quantum photonic devices in single crystal diamond," Andrei Faraon et al., *New J. Phys.* 15 025010, 2013. iopscience.iop.org/1367-2630/15/2/025010/article