

Emerging Tech

Roland Piquepaille

March 30th, 2008

Silicon chips for optical quantum computing

Posted by Roland Piquepaille @ 10:00 am

UK researchers at Bristol University have shown that it is possible to control single photons on a silicon chip. The team developed ‘the world’s smallest optical controlled-NOT gate — the building block of a quantum computer.’ As said the lead researcher, ‘This is a crucial step towards a future optical quantum computer, as well as other quantum technologies based on photons.’ But read more...



This research work has been led by Dr Jeremy O'Brien, Senior Research Fellow in Physics and Electrical Engineering at Bristol University, who is pursuing experimental quantum information science and technology. You can see a picture of O'Brien on the left. He worked with his colleagues at the Centre for Quantum Photonics and his PhD student Alberto Politi. He also worked with other Bristol University researchers, Dr Martin Cryan, Professor John Rarity and Dr Siyuan Yu.

As you probably all know, quantum technologies are based on the unique properties of quantum mechanics. And “photons are an excellent choice for quantum technologies because they are relatively noise free.” O'Brien used them since 2003 to build ‘conversations’ between two — and then four photons.

So what's new behind these silica-on-silicon wave-guide quantum circuits? “Despite these and other impressive demonstrations, quantum optical circuits have typically relied on large optical elements with photons propagating in air, and consuming a square metre of optical table. This has made them hard to build and difficult to scale up,’ said Alberto Politi. ‘For the last several years the Centre for Quantum Photonics has been working towards building controlled-NOT gates and other important quantum circuits on a chip to solve these problems,’ added Dr O'Brien. The team's chips, fabricated at CIP Technologies, [Ipswich, Suffolk, UK,] have dimensions measured in millimeters. This impressive miniaturisation was permitted thanks to the silica-on-silicon technology used in commercial devices for modern optical telecommunications, which guides light on a chip in the same way as in optical fibers.

For more information, the results of this research have been published in *Science Express* as an advanced online publication of *Science* on March, 27 2008 under the name “Silica-on-Silicon Waveguide Quantum Circuits.” Here is a link to the abstract. “Quantum technologies

based on photons will likely require an integrated optics architecture for improved performance, miniaturization, and scalability. We demonstrate high-fidelity silica-on-silicon integrated optical realizations of key quantum photonic circuits, including two-photon quantum interference with a visibility of $94.8 \pm 0.5\%$; a controlled-NOT gate with an average logical basis fidelity of $94.3 \pm 0.2\%$; and a path entangled state of two photons with fidelity of $>92\%$. These results show that it is possible to directly “write” sophisticated photonic quantum circuits onto a silicon chip, which will be of benefit to future quantum technologies based on photons, including information processing, communication, metrology, and lithography, as well as the fundamental science of quantum optics.” Here is a link to the full paper (PDF format, 5 pages, 729 KB).

Another article by O’Brien has been recently published by *Science*, “Optical Quantum Computing” (Volume 318, Number 5856, Pages 1567-1570, December 7, 2007). Here is the abstract. “In 2001, all-optical quantum computing became feasible with the discovery that scalable quantum computing is possible using only single-photon sources, linear optical elements, and single-photon detectors. Although it was in principle scalable, the massive resource overhead made the scheme practically daunting. However, several simplifications were followed by proof-of-principle demonstrations, and recent approaches based on cluster states or error encoding have dramatically reduced this worrying resource overhead, making an all-optical architecture a serious contender for the ultimate goal of a large-scale quantum computer. Key challenges will be the realization of high-efficiency sources of indistinguishable single photons, low-loss, scalable optical circuits, high-efficiency single-photon detectors, and low-loss interfacing of these components.” And here is a link to the full paper (PDF format, 5 pages, 659 KB).

Finally, O’Brien puts most of his papers on arXiv.org. Here is a link to a partial list of his publications. If you’re interested by his research works, please read “An All Optical Fibre Quantum Controlled-NOT Gate.” Here are two links to the abstract and to the full paper (PDF format, 4 pages, 779 KB).

Sources: University of Bristol news release, March 27, 2008; and various websites

You’ll find related stories by following the links below.

- Computers
- Engineering
- Optics
- Photonics
- Physics
- QuantumWorld
- Science

Roland Piquepaille lives in Paris, France, and he spent most of his career in software, mainly for high performance computing and visualization companies. For disclosures on Roland's industry affiliations, click here.

Copyright © 2008 CNET Networks, Inc. All Rights Reserved. Privacy Policy | Terms of Use