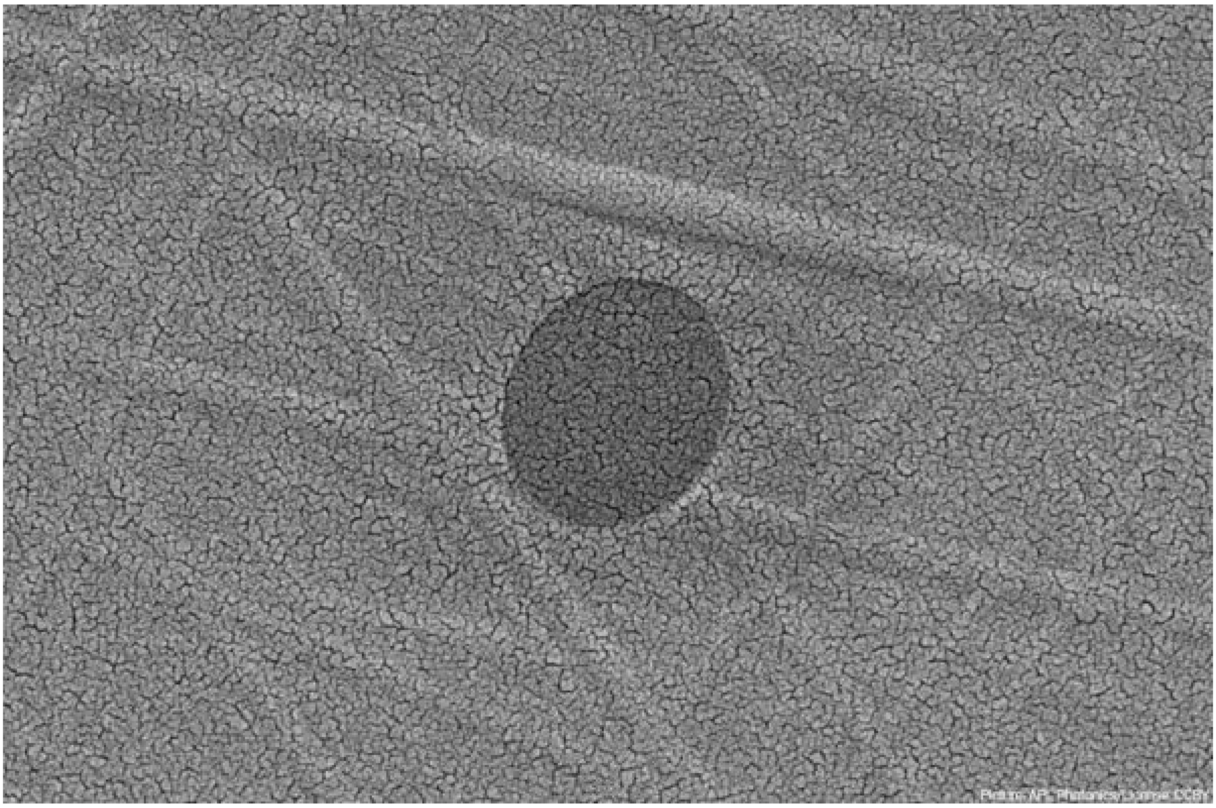
ICFO



Researchers develop the first photon pair quantum source based on a silicon core fiber platform

A team of researchers from ICFO and the Royal Institute of Technology (KTH) from Sweden reports on APL Photonics the first demonstration of a photon pair source based on a silicon core fiber. The novel platform offers a unique combination of low propagation losses, high nonlinearity and compactness making it a promising candidate for scalable quantum applications.

October 01, 2024

Quantum technologies demand photon sources with exceptional characteristics: high brightness, minimal losses and high scalability. While bulk optics and silicon photonic integrated circuits (PICs) have been the traditional choices when third-order nonlinear parametric effects are used, they often fall short in meeting all these criteria simultaneously. Silicon core fibers, however, are showing great potential as a viable platform for quantum applications, particularly in the realm of quantum communications. The highly nonlinear core material, i.e. silicon, together with the low propagation and coupling losses of the fiber structure, make silicon core fibers a compelling option for achieving the standards required by quantum technologies.

Now, ICFO researchers Davide Rizzotti, Stefano Signorini and ICREA Professor at ICFO Valerio Pruneri, together with Clarissa Harvey and Michael Fokine, researchers at the Royal Institute of Technology (KTH, Sweden) have been able to fabricate and demonstrate for the first time a quantum source of photons based on spontaneous four-wave mixing (SFWM) in a silicon core fiber. Their achievements are described in a new study recently published in the journal APL Photonics. The new device combines the low loss and low cost of the fiber platform with the high nonlinearity and compactness of silicon PICs.

In their experiment, the researchers fabricated a 58 mm long silicon core fiber with a crystalline silicon core with a diameter of 1   m and surrounded by a pure silica cladding. B pumping the fiber with a continuous wave laser at 1551 nm (a telecommunication standar wavelength), they generated photon pairs through SFWM. A filtering system separated th idler and signal photons into two telecom channels and two detectors were used to detec them separately. A time tagger device measured the coincidences between the photo detectors, a standard technique to study the correlation within the generated photon pairs To characterize the loss performance of the silicon core fiber as a quantum light source, th team developed a new method that directly estimates the coupling and propagation losses This novel approach allowed the estimation of losses without the need for auxiliary fibers o destructive techniques, such as the standard cutback technique

The silicon core fiber demonstrated exceptional performance, operating at roo temperature and achieving an intrinsic brightness of 570 kHz/nm/mW² and low propagati n losses of approximately 0.3 dB/cm, lower than the state of the art of silicon PIC . Additionally, a measured coincidence to accidental ratio (CAR) of 133, a parameter th t estimates the signal to noise ratio of photon pair sources, shows that the source fulfills t e requirements for practical quantum application . According to the study authors, these low propagation losses "pave the way for effecti e fiber-based quantum sources in the telecom band." The researchers highlighted the potenti l of this platform "for future applications, particularly in the field of quantum communications

"**B'y characterizing the brightness and propagation losses of the photon pair source, we have shown how silicon core fibers can bridge the technology and application gaps between PICs and optical fibers**," said Davide Rizzotti, the first author of the study. "**The new sources based on silicon core fibers have great potential as a quantum source thanks to the high nonlinearity of silicon and the potential of loss-less integration with the existing optical fiber network**".

ï¿½In quantum photonics is now clear that one ideal material platform does not exist, a d hybrid solutions are needed to guarantee scalable and efficient devices. This study highligh s the potential of the silicon core fiber as a key component in future hybrid quant

m technologies.i¿½said Stefano Signorini, researcher at ICFO.

"**While further developments are needed to reduce losses and improve the scalability of the platform, our study represents a significant step towards realizing the full potential of silicon core fibers in practical quantum applications, especially in the field of quantum communications,**" concluded Valerio Pruneri, ICREA professor at ICFO and co-author of the study.

This research has been conducted as part of Davide Rizzotti's individual research project within the European funded NANO-GLASS project and the QSNP. Rizzotti's research is focused on the study and development of new fiber-devices for quantum communications, with the aim of reaching super low-loss devices. Indeed, low propagation and coupling loss can bring significant benefits in preserving quantum signals and increasing the efficiency of quantum communications. This research has already been conducted within the framework of the Quantum Secure Network Partnership (QSNP), an European Quantum Flagship project that aims to develop quantum cryptography technology to secure the transmission of information over the Internet.

Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Sk?odowska-Curie Grant Agreement No. 956419. This work was funded by the Swedish Foundation for Strategic Research (Grant No. RMA15-0135), the Horizon 2020 Framework Program (Grant Nos. 820466 and 820405), and the European Union (Grant Nos. QSNP 101114043 and ONAIR 101065309). Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union, European Commission-EU or European Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them. This project is funded by the Departament de Recerca i Universitats de la Generalitat de Catalunya (2021 SGR 01458). This work was partially funded by CEX2019-000910-S (MCIN/AEI/10.13039/501100011033), Fundacio Cellex, Fundacio Mir-Puig, and Generalitat de Catalunya through CERCA. This study was supported by MCIN with funding from European Union NextGenerationEU(PRTR-C17.I1)- Plan Complementario de Comunicaciones Cuanticas - and by Generalitat de Catalunya.

Original Article

Davide Rizzotti, Stefano Signorini, Clarissa Harvey, Michael Fokine and Valerio Pruneri. (2024) **Silicon core fibers: a new platform for quantum light generation**. APL Photonics. DOI: https://doi.org/10.1063/5.0220647