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Silicon Quantum photonics

Developing components for quantum communications and computing

What is Quantum photonics?

Quantum photonics is key to ensure ultra-safe data transmission. It also has recently emerged as a potential path towards quantum computing.

Ensuring large-scale integration is necessary to enable quantum applications. To achieve massive integration, CEA-Leti leverages its mature Si and SiN photonics platform for the development of low-loss quantum photonic hardware.

CEA-Leti specifically develops quantum-grade photonic integrated components & circuits for the generation, fast encoding, coherent manipulation & detection of photonic qubits. CEA-Leti components are compatible with discrete or continuous variable approaches.

Applications

CEA-Leti's quantum photonics platform enables the development of next-generation technologies for key industries such as:

- Finance
- Health care
- Energy
- Telecommunications
- Defense

The goal?

CEA-Leti aims at contributing to the future generation of miniaturized ultra-secure quantum communication systems, either fiber-based or in free-space, by developing integrated quantum transmitter and receiver circuits matching the specifications of the most advanced quantum communication protocols, such as device-independent ones.

CEA-Leti also aims at contributing to the development of integrated quantum photonic processors relying for example on measurement-based quantum computing protocols. We address the heart of the programmable quantum processor while ensuring seamless generation of entangled photon cluster states and their high-efficiency detection on-chip.

What does it require?

CEA-Leti's experts are developing key integrated components and circuits to enable advanced quantum key distribution protocols and quantum processing:

Single photon generation
- Hybrid III-V/Si lasers delivering weak coherent pulses [1]
- High-Q ring resonators delivering heralded single photons (currently MHz rate, targeting GHz rate)[2]

Photon fast encoding and coherent manipulation
- Loss-free thermo-optic phase shifters
- Fast phase shifters based on free-carrier plasma dispersion
- Towards fast & low-loss Pockels phase shifters

Single photon detection
- HgCdTe avalanche photodiodes[3] with a world-record speed for the detection of mesoscopic photon states
- Optimized NbN material[4] for superconducting nanowire single photon detectors with high efficiency and low dark counts

Key facts

State of the art capabilities
- Design, Process integration in 200/300 mm, Test, Packaging

Versatile platform
- Comprehensive library of mature components @ 1310 and 1550 nm
- Integration of new materials (NbN, $LiNbO_3$...)

Record low optical losses
- Si waveguides: 0.2-1.1 dB/cm
- SiN waveguides: 0.05 dB/cm

Publications

1. C. Agnesi et al., Hong-Ou-Mandel interference between independent III-V on silicon waveguide integrated lasers, Opt. Exp. 44, 271 (2019)

2. H. El Dirani et al., Low-loss silicon technology for high-Q bright quantum source, proc. of IEEE Group IV Photonics Conference (2019)

3. J. Rothman et al., Meso-photonic detection with HgCdTe APDs at high-count rates, J. of Electron. Mat., https://doi.org/10.1007/s11664-020-08461-8, 2020

4. R. Rhazi et al., Improvement of critical temperature of niobium nitride deposited on 8-inch silicon wafers thanks to an AlN buffer layer, Superconduct. Sc. and Technol. 34, 045002 (2021)

Interested in this technology?

Contact:
Eleonore Hardy
eleonore.hardy@cea.fr
+33 438 782 639

CEA-Leti, technology research institute
17 avenue des Martyrs, 38054 Grenoble Cedex 9, France
cea-leti.com

@CEA-Leti

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