Solid-state Quantum Light Sources: booster of quantum photonics technologies

Valérian Giesz
Cofounder
The future is Quantum.

The Second Quantum Revolution is unfolding now, exploiting the enormous advancements in our ability to detect and manipulate single quantum objects.

Credits: www.qt.eu
Quantum Communications
Quantum Simulations
Quantum Sensing
Quantum Computing

Credits: www.qt.eu
Photonics is a promising platform for Q Computing
More and more players believe in the Linear Optical Quantum Computing
Manipulation of the Qbit at any temperature

Connect quantum devices
Modular design
Quantum Internet

Generation of cluster states (loss resilience)

Long coherence time
Simplified architecture of a OQC

- Single photon sources
- Optical Circuits
- Efficient Detectors
- Classical control - Feedback
  - Analogic Control
  - Digital correlations

Logos from LIGENTEC, BRIGHT PHOTONICS, and other companies.
Since 2017

We are experts in semiconductor nanostructures and quantum photonics

Cofounded by

Prof. Pascale Senellart (CSO)

Dr. Niccolò Somaschi (CTO)

Dr. Valérian Giesz (CEO)

Spin-off from the Centre for Nanoscience and Nanotechnology in Paris-Saclay

a laboratory of C2N and of 3000 m² clean room
Disruptive architecture to extract the light from a Quantum Dot

Quantum photonic chip

Single photon source

Single & identical photons

Photonic cavity

Semiconductor quantum dot (QD)
Disruptive architecture to extract the light from a Quantum Dot

**Near-optimal single-photon sources in the solid state**

Disruptive architecture to extract the light from a Quantum Dot

Near-optimal single-photon sources in the solid state

N. Somaschi\textsuperscript{19}, V. Giesz\textsuperscript{15}, L. De Santis\textsuperscript{12}, J. C. Lorodo\textsuperscript{3}, M. P. Almeida\textsuperscript{3}, G. Hornecker\textsuperscript{13}, S. L. Portalupi\textsuperscript{3}, T. Grange\textsuperscript{5}, C. Antón\textsuperscript{3}, J. Demory\textsuperscript{1}, C. Gómez\textsuperscript{3}, I. Sagnes\textsuperscript{1}, N. D. Lanzillotti-Kimura\textsuperscript{3}, A. Lemaitre\textsuperscript{1}, A. Aufiueves\textsuperscript{4}, A. G. White\textsuperscript{1}, L. Landi\textsuperscript{1} and P. Senellart\textsuperscript{12,15}

Our technology would accelerate Quantum Computing platforms with a high number of Qbits

Compatible with III-V semiconductor industry
A lot of bright single photon sources on one cm² chip

Robust and reproducible performance (during years)

High fabrication yield
The ideal single photon source

Required features for Q tech:

- High brightness (high probability that a pulse contains one photon)
The ideal single photon source

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\[ g^{(2)}(0) = A_0 \approx P(n > 1) \]
The ideal single photon source

Required features for Q tech:

- High brightness (high probability that a pulse contains one photon)
- High single photon purity
- High photon indistinguishability and entanglement fidelity
Multi-photon manipulation on-chip

3-photon source in a tuneable tritter:
laser - 43 Hz // eDelight - 3.8 kHz (speed x 88)

Interfacing scalable photonic platforms: solid-state based multi-photon interference in a reconfigurable glass chip
Anton et al., Optica, 6, 12, 1471-1477 (2019)
Performance for OQC

Multi-photon manipulation on-chip

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Exponential Speed-up for Quantum Computing

Interfacing scalable photonic platforms: solid-state based multi-photon interference in a reconfigurable glass chip
Anton et al., Optica, 6, 12, 1471-1477 (2019)

Enlarge the number of entangled photons

<table>
<thead>
<tr>
<th></th>
<th>Source Laser</th>
<th>Source eDelight</th>
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<tbody>
<tr>
<td>3 photons</td>
<td>2 weeks</td>
<td>30 minutes</td>
</tr>
<tr>
<td>4 photons</td>
<td>1 year (estim.)</td>
<td>1 hour</td>
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Sequential generation of linear cluster states from a single photon emitter
Istrati et al., arXiv:1912.04375
We will develop a European Optical platform for Q Computing
Single photons are the building block of Optical QC
Single photons are the building block of Optical QC.

Toward a Measurement Based Quantum Computer using a classical feedback control.

Credits: Mercedes Gimeno Segovia
2\textsuperscript{nde} livraison
Janvier 2020

Merci.
Performance of a typical source in the Quandelab

**Very efficient:**
More than 65% of emitted polarized photons are coupled in a single-mode fiber.

More than **32M of indistinguishable photons per second** (pulsed excitation rate: 500MHz)

More than **5M indistinguishable photons per second** (pulsed excitation rate: 80MHz)

**Ultra stable:**
The count rate is stable (+90%) during more than 3 days.