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UNIQORN

Affordable Quantum Communication for Everyone

PICs for quantum communication the UNIQORN perspective

Joint Quantum Flagship & Photonics21 Focus Group

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QUANTUM

PHOTONICS21

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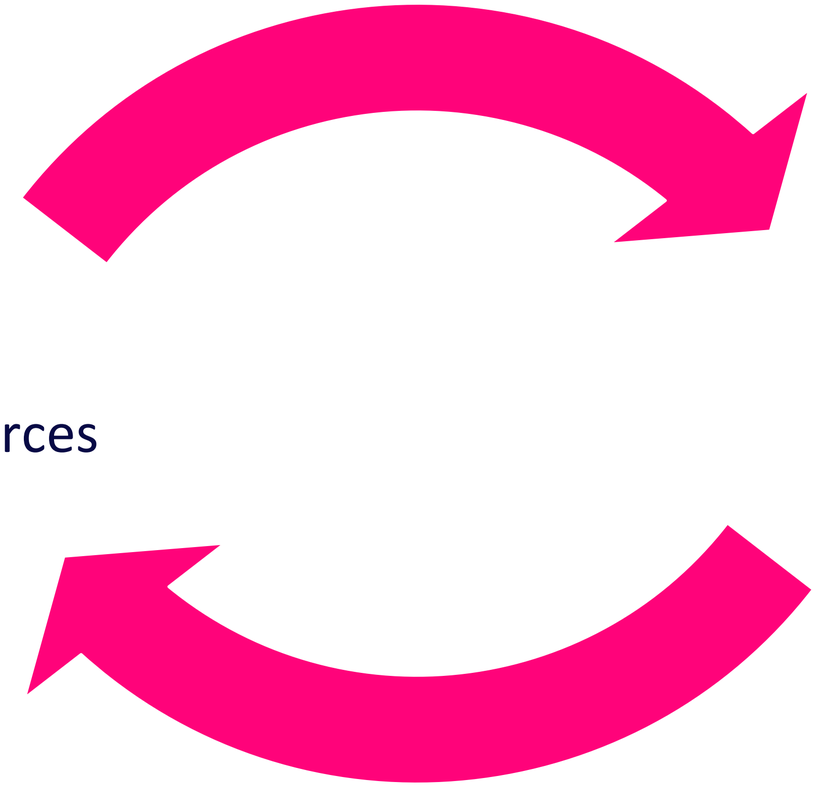
a very brief overview

Quantum Eco-System from

Fabrication

- Photonic integration
  - DV QKD
  - CV QKD
  - Non-classical light sources
- Enabling technology

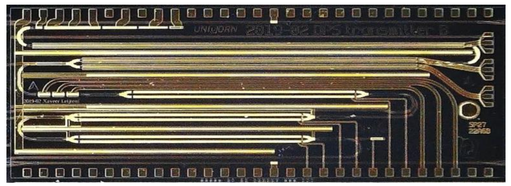


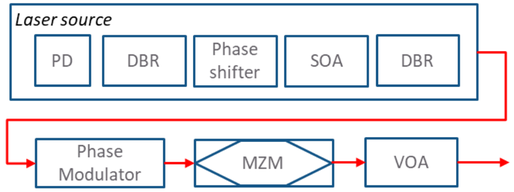
Applications

- QKD (coexistence and network routing)
- One-time programs
- Oblivious transfer
- QRNG integration on commerscial network devices (NIC)
- Privacy preserving data base access

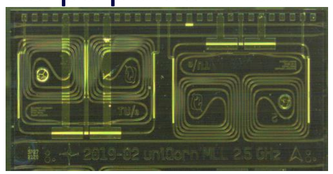
Monolithic QPICs

- **InP QPIC**
  - QKD transmitter chip (DV and CV)
    - Laser
    - Modulators (Phase, amplitude, I/Q)
    - Passive elements (couplers, variable optical attenuators)

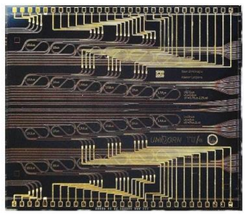




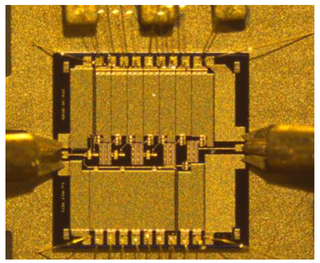
  - Mode-locked laser
    - 1550nm, 2.5 GHz rep. rate, 15 ps pulse width

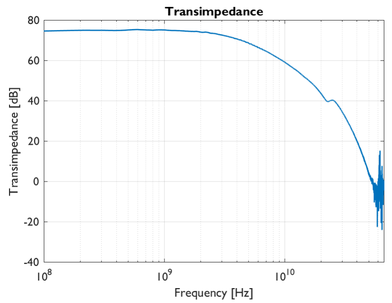


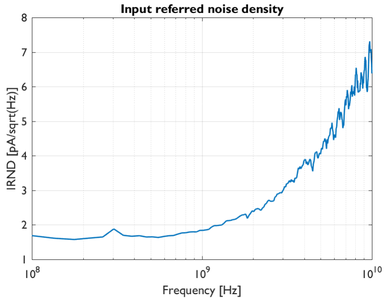
  - Balanced photo detector
    - LO: 60 kHz, 30 nm tuning



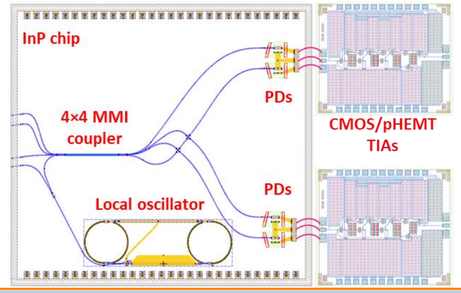
- **CMOS PICs**
  - pHEMT Trans impedance amplifier (CV quantum information processing)



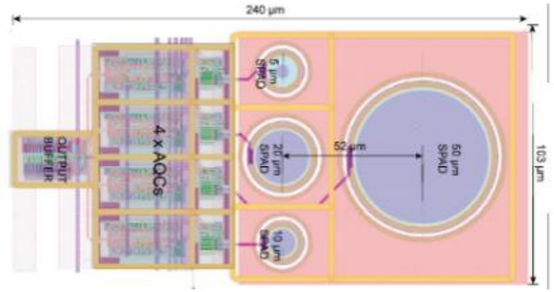




  - Bandwidth: 1 GHz; Noise: < 2.5 pA/sqrt (Hz), >22 dB clearance
  - CV receiver based on hybrid integration of balanced detector and TIA



- **CMOS detector PIC**
  - 32 x 1 Si-SPAD array
  - Room temp operation
  - 65%@500nm;12% @800nm
  - On board coincidence logic
  - Variable SPAD size



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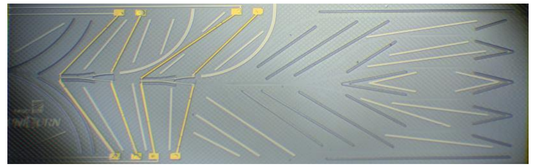
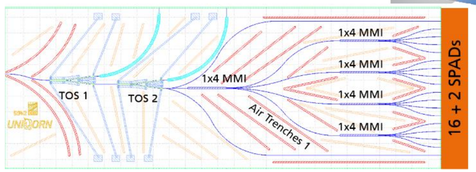
Hybrid QPICs

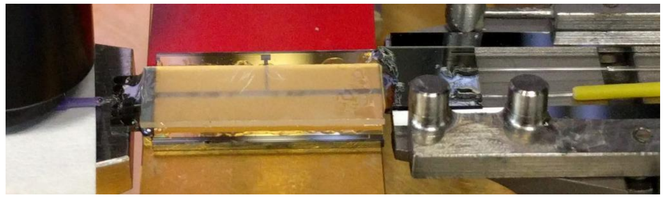
- **Polymer platform “PolyBoard”**
  - Integration of micro optics
    - Passive elements (lenses, mirrors, filters, polarisation handling, etc.)
    - Active elements (switches)
  - Integration of nonlinear optical elements (ppLN, ppKTP, AlGaAs)
  - Hybrid assembly of PolyBoard and Si-APD array

- **PolyBoard modules**
  - Quantum Random Number Generator
  - Heralded single-photon source (waveguide ppLN)
  - Entangled photons sources (polarization and time-bin)
  - Squeezed light sources
  - Add-on modules
    - Reconfigurable add-drop multiplexer
    - Polarization analyser
    - Phase tuneable aMZI
    - Wavelength converter

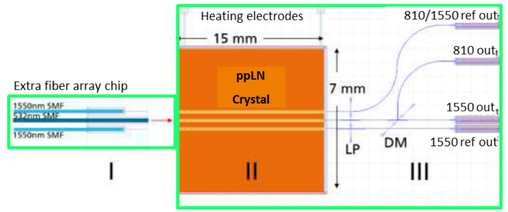


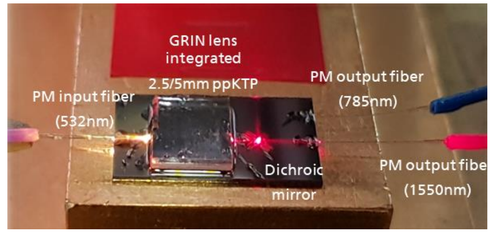
QRNG chip



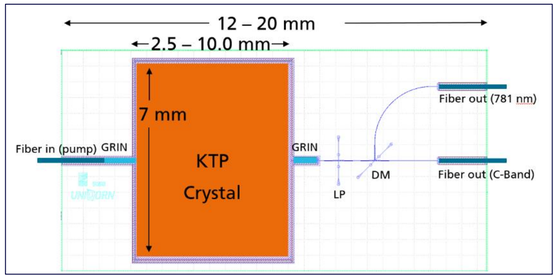


Heralded photon source

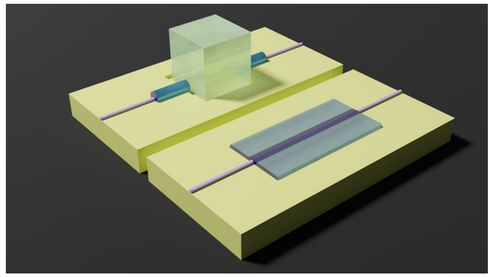




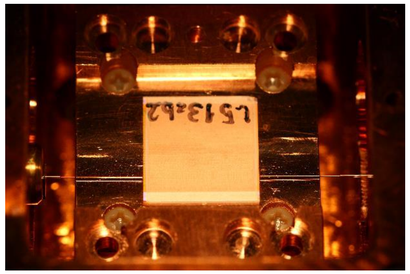
Polarisation entangled photon source



Switchable add/drop WDM



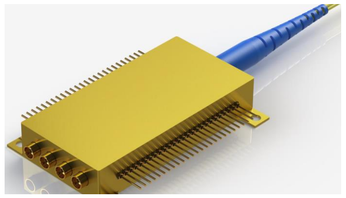
Squeezed light source based on bulk ppKTP and waveguide ppLN

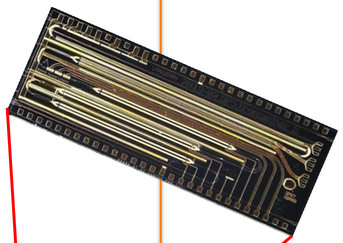


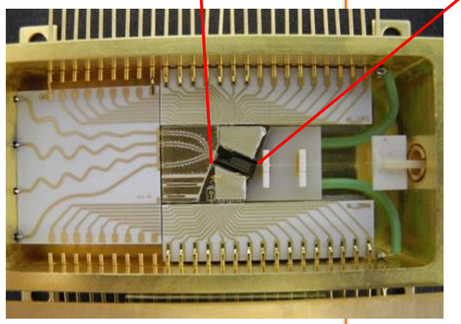
Squeezed light on waveguide ppLN

QPIC Packaging

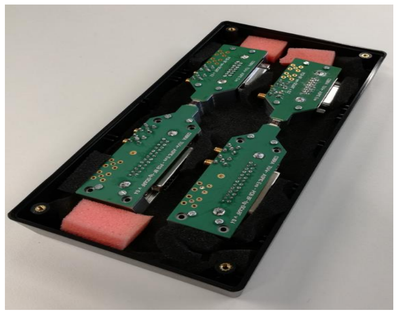
- **Transmitter chip**
  - 4 RF lanes
  - SMF output fiber
  - DC ports for laser control, bias controls and and attenuation
  - TEC cooling



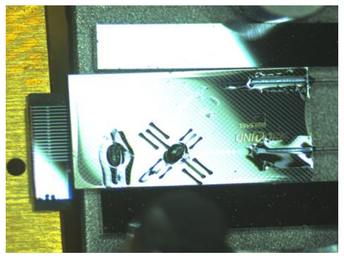


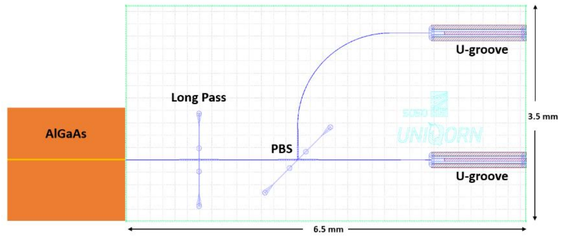


- **Mode-locked laser**
  - Mounted and wire bonded
  - SMF output fiber

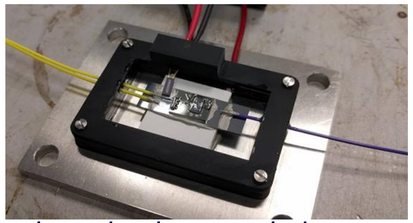


- **PolyBoard packaging**
  - Bonding of optical in/output fibers
  - TEC cooler
  - Off-chip components

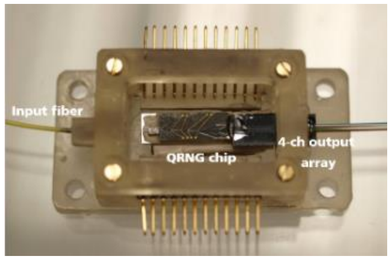




Coupling of AlGaAs and PolyBoard (assembly photo)

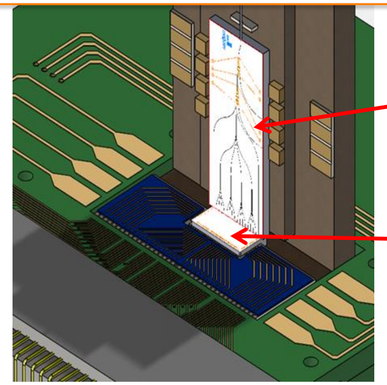


Packaged pol. entangled source



Packaged QRNG

- **SPAD – PolyBoard Hybrid Integration**
  - Bonding of optical in/output fibers



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Lessons learned

so far…

- No universal platform for all functions
- Move to hybrid manufacturing, but requires delicate assembly procedure
- Detailed specifications necessary for production process
- Performance reproducibility
- Quantum communication devices extremely loss sensitive
  - Needs to be addressed during production and packaging
- Long turn around times, especially for MPW
- Packaging and co-integration needs to be addressed
  - Bare die vs. packaged system characterisation

The UNIQORN team:

Thank you very much for your attention!