

Diode laser-based beam sources and photodetectors

1 Laser diodes

InP technology

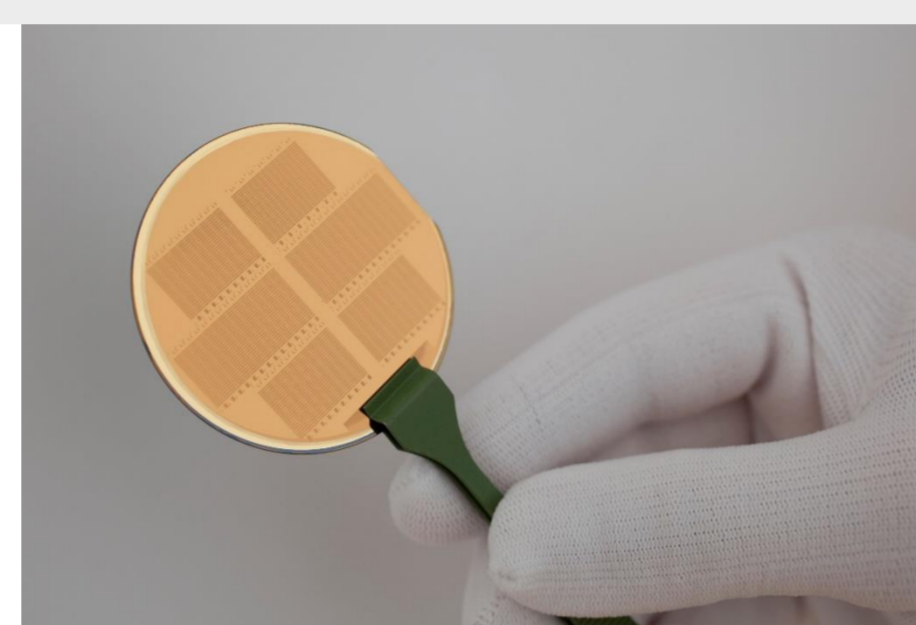
- wavelength: 1250 nm ... 1750 nm
- optical power: 10 mW ... > 1 W
- Fabry-Perot, DFB, DBR, TPA, VCSEL

GaAs technology

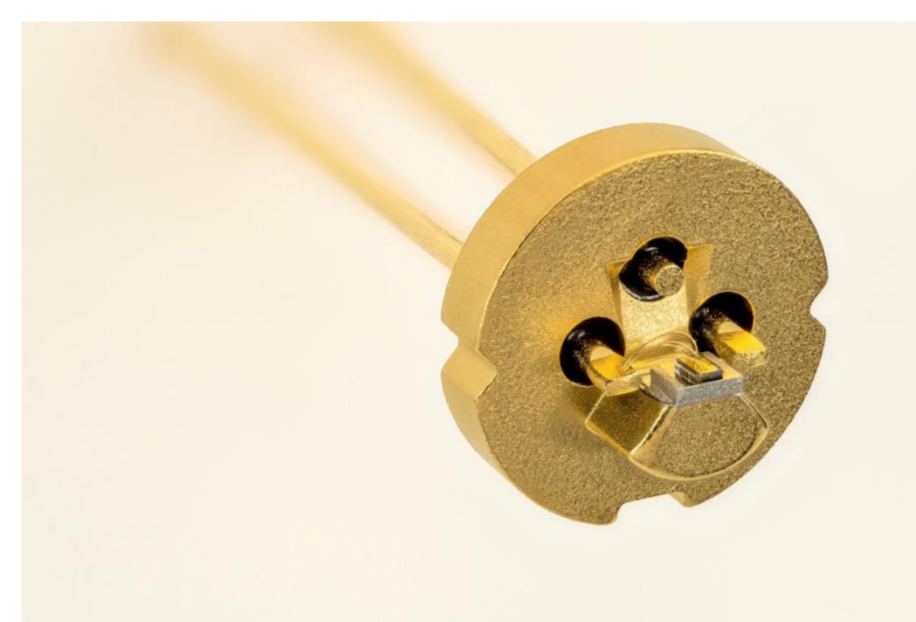
- wavelength: 630 nm ... 1180 nm
- optical power: 10 mW ... > 1 W
- Fabry-Perot, DFB, DBR, TPA, VCSEL

GaN technology

- wavelength: ~ 400 nm
- optical power: a few 10 mW
- Fabry-Perot, DFB



GaN wafers with laser diodes



Laser diode mounted in TO housing

3 Wafer-level integrated solutions

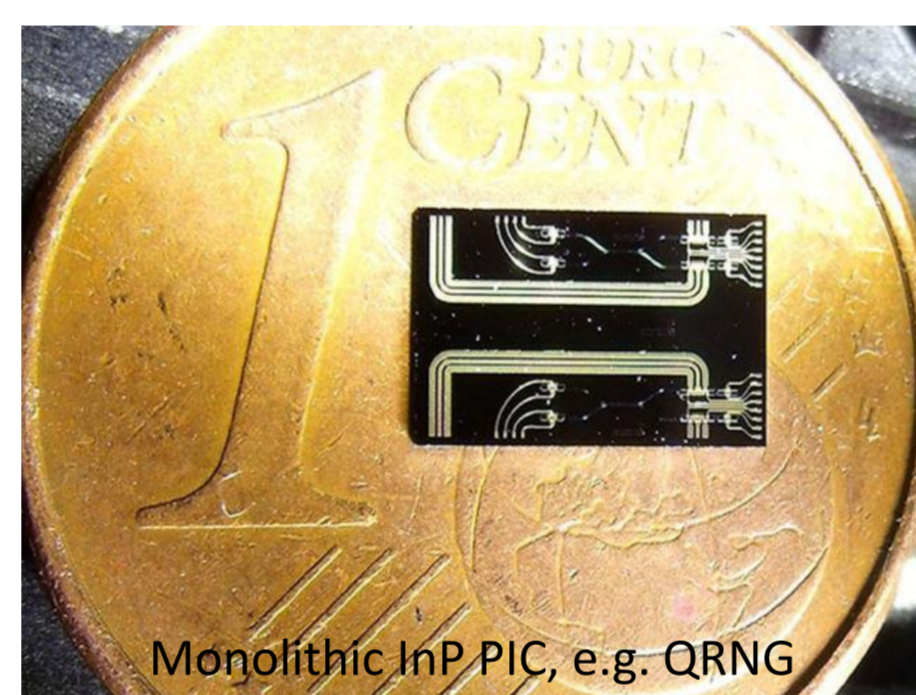
Photonic integrated circuits (PIC) of active and passive components

Monolithic integration of PICs

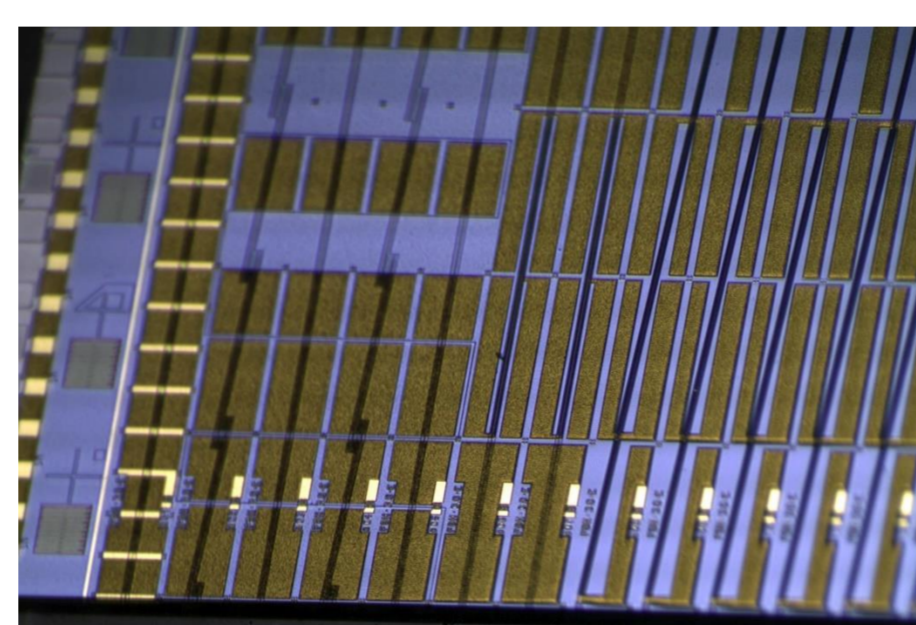
- on InP and GaAs:
- laser
- Mach-Zehnder modulator
- Photodiode

Hybrid integration

- thermo-compression bonding with nanoporous gold and gold-gold
- perpendicular-assisted self-alignment with AuSn
- indium bumps with large differences in the thermal expansion



Monolithic InP PIC, e.g. QRNG



ECDL monolithically integrated in GaAs

5 Outlook

Task: Development of scalable manufacturing technologies for complex beam sources

Wafer-level hetero-integration,

- Co-integration with Light Control Units & Physics Package
- Flip-chip assembly, transfer printing, wafer-to-wafer bonding

Discrete heterointegration

- for solutions that cannot (yet) be integrated at wafer level

2 Photodetectors

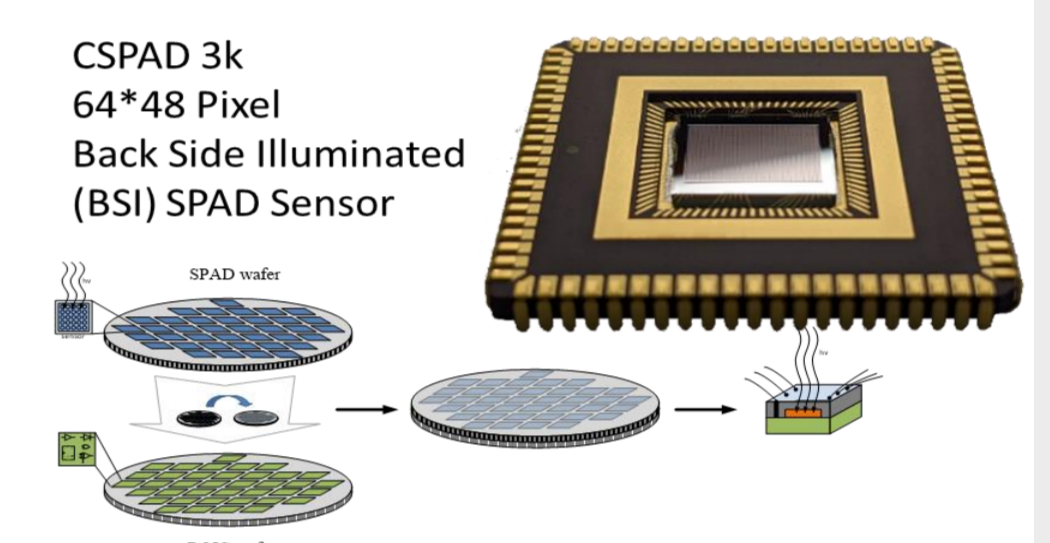
InP technology

- wavelength: 820 nm ... 2500 nm
- low-noise photodiodes with
- high quantum efficiency (> 99%)
- Single photon detectors (SPAD) for 1064 nm to 1550 nm



CMOS integrated SPADs (CSPAD)

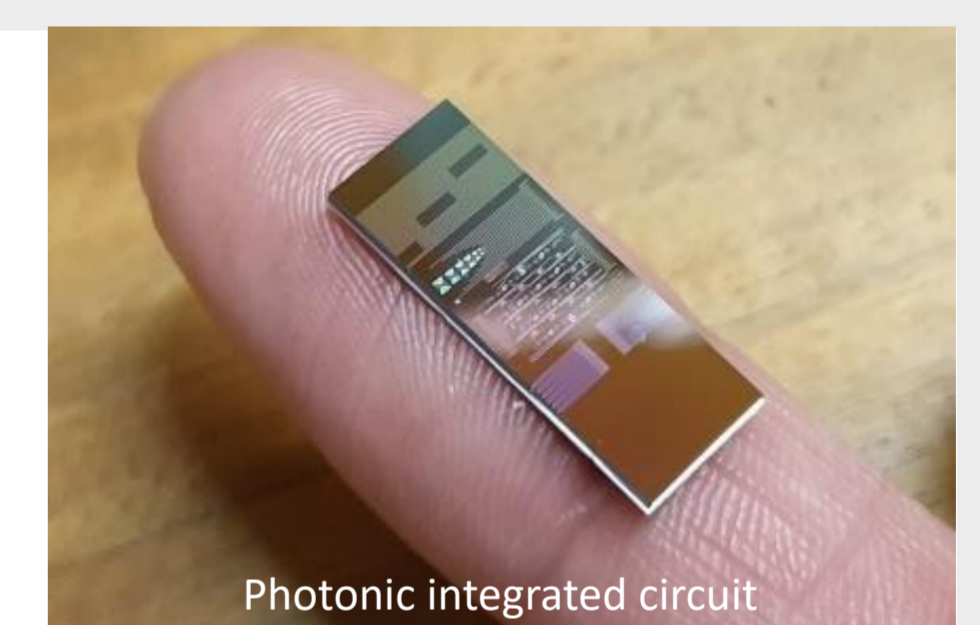
- single photon detectors integrated in CMOS electronics (directly or through 3D integration)
- wavelengths: 300-1000 nm
- high photodetection efficiency > 60%
- low dark count rate < 0.1 counts/s



4 Discrete heterointegrated solutions

Photonic integrated circuits of passive waveguide networks

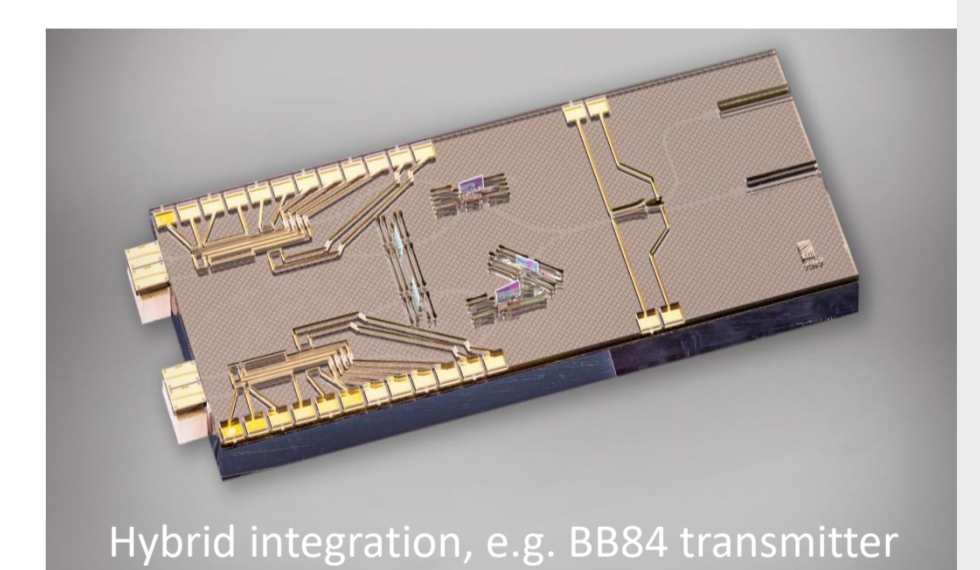
- SiN-on-insulator
- AlN, Al₂O₃ (previously only 1550 nm)
- LiNbO₃-on-insulator
- integrated resonators and gratings in glass platforms for narrowband lasers (ECDL)



Photonic integrated circuit

Hybrid integration

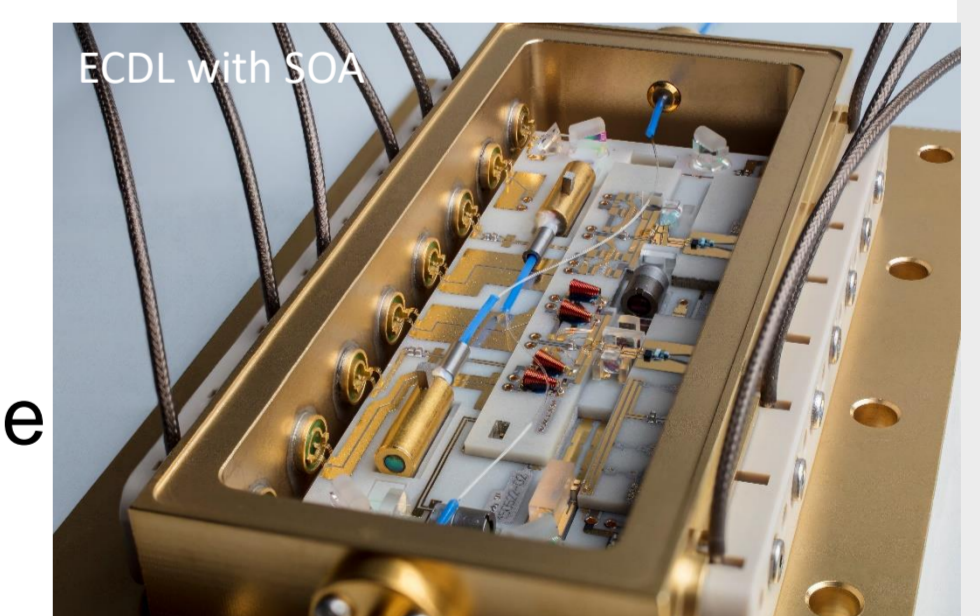
- sub-assemblies of active components such as lasers and photodiodes with passive photonic integrated circuits



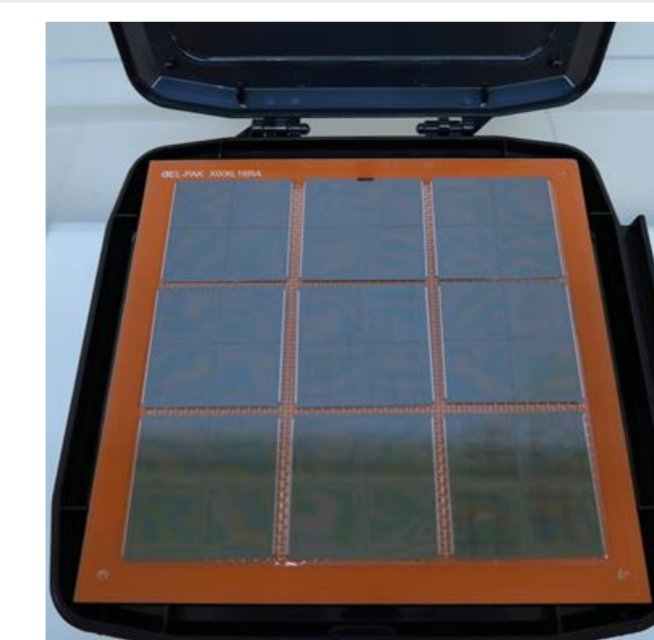
Hybrid integration, e.g. BB84 transmitter

Micro-assembly

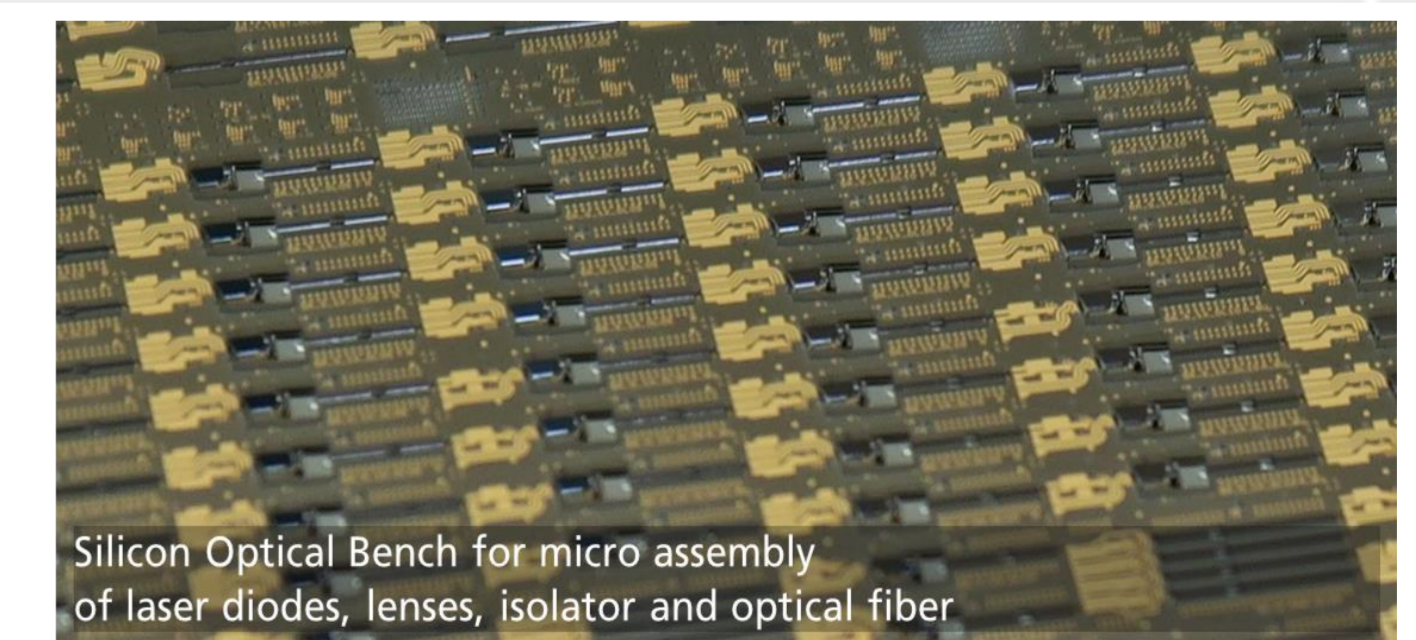
- ultra-precise (< 100 nm) micromounting
- adhesive bonding, robust & compact
- integrated optical build-up platforms made of glass with hermetic encapsulation



ECDL with SOA



RD53 collaboration
<https://rd53.web.cern.ch/RD53/>
ATLAS collaboration
<https://atlas.cern/atlascollaboration>



Silicon Optical Bench for micro assembly of laser diodes, lenses, isolator and optical fiber



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