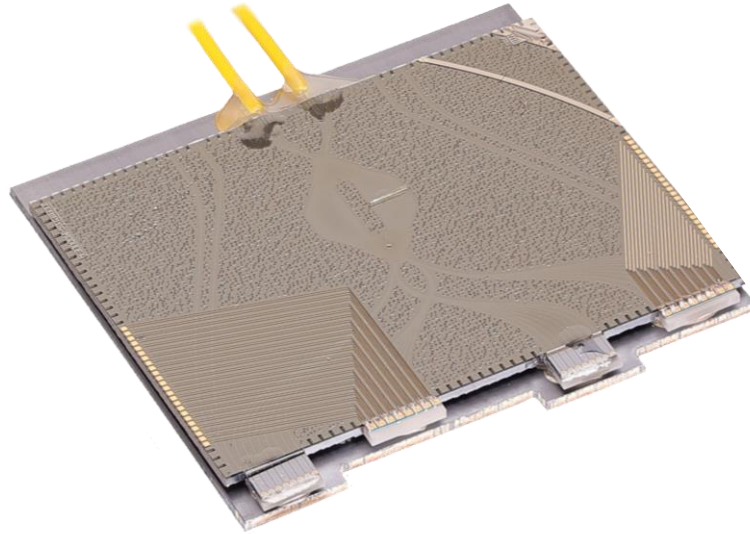

Hybrid Photonic Integration for High-End Optical Transceivers

David de Felipe

Fraunhofer Heinrich Hertz Institute



Fraunhofer HHI: Video, AI, Networks, and Photonics

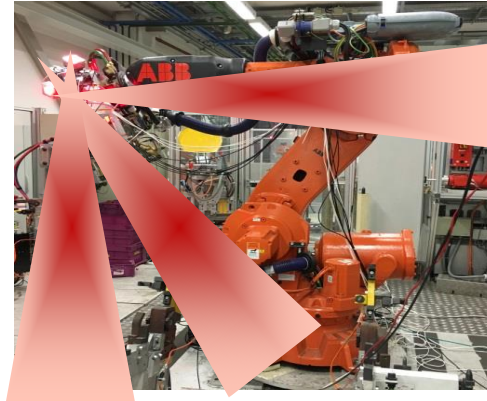
100+ Mio € Budget, 800+ people, 80% self-financed

Video Compression



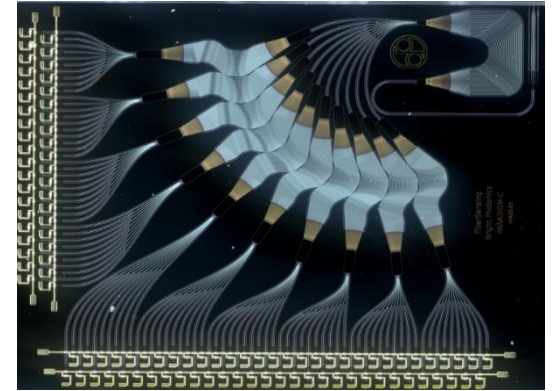
H.265 / HEVC: 4th Emmy received
~5B devices

Photonic and 5/6G Networks



LiFi for high speed data in EMI environments
Quantum networks

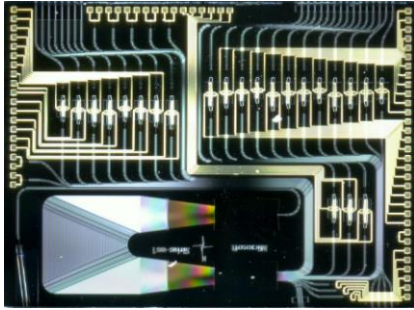
PICs



Up to 145 GHz
Terahertz sensing
QKD components

Fraunhofer HHI's Photonic Integration Technologies

InP



For classical telecom wavelengths

Lasers
Photodiodes
Modulators
PICs

TFLN



High-speed for a broad wavelength range

High-speed phase shifters
On-chip resistors
TO phase shifters
MMIs & directional couplers

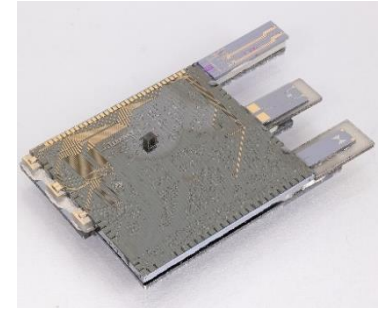
SiN



Passives for a broad wavelength range

Micro-ring resonators
Grating couplers for passive fiber coupling
MMIs
Gratings

Hybrid PICs



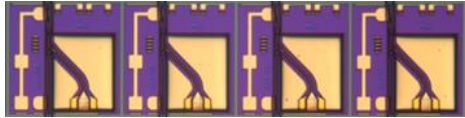
Best material for the function

Multi-platform chip-to-chip integration
On-chip μ -optical functions (Isolator, NLO)
Automatable integration

Transceivers for Data Centers

InP for 200 Gbps/lane and polymer for MUX/DEMUX

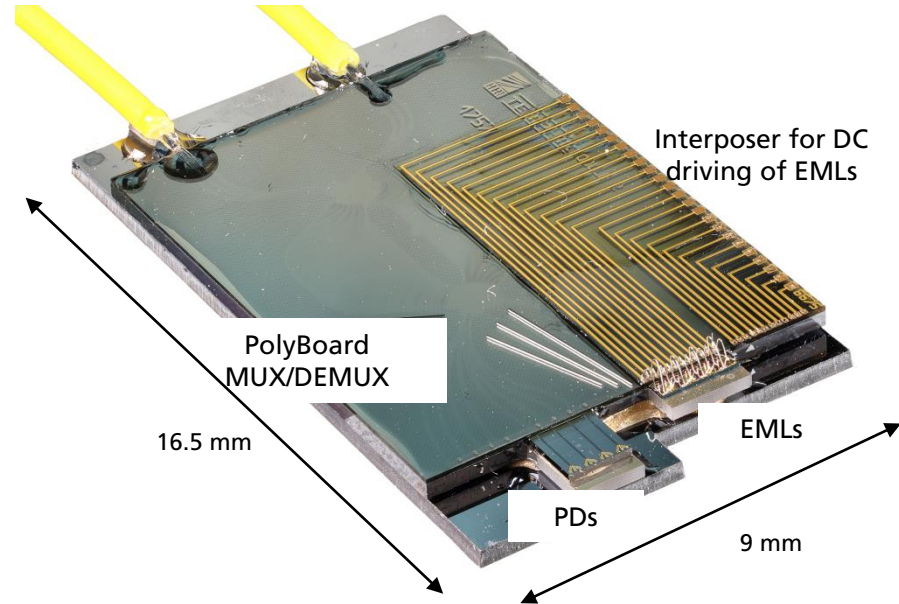
EML Array



Waveguide PD Array



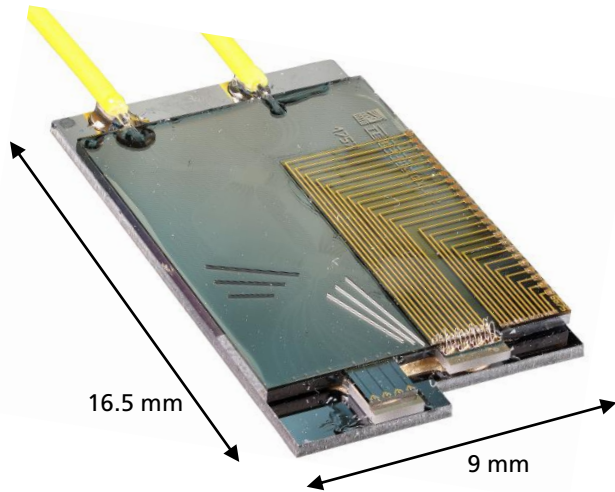
PolyBoard AWGs



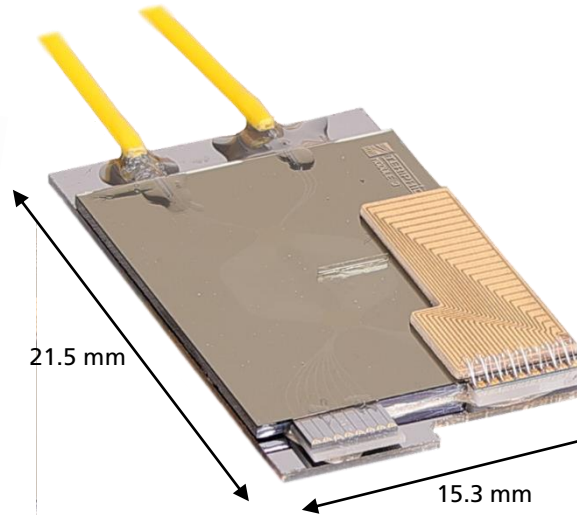
Scalability of the TRx Hybrid PIC

Towards > 1.6 Tb/s Transceivers

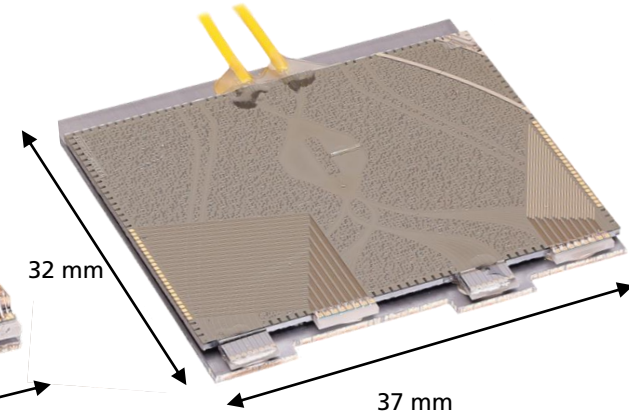
4-Channel
(1x 4-fold EML/PD arrays)



8-Channel
(1x 8-fold EML/PD arrays)

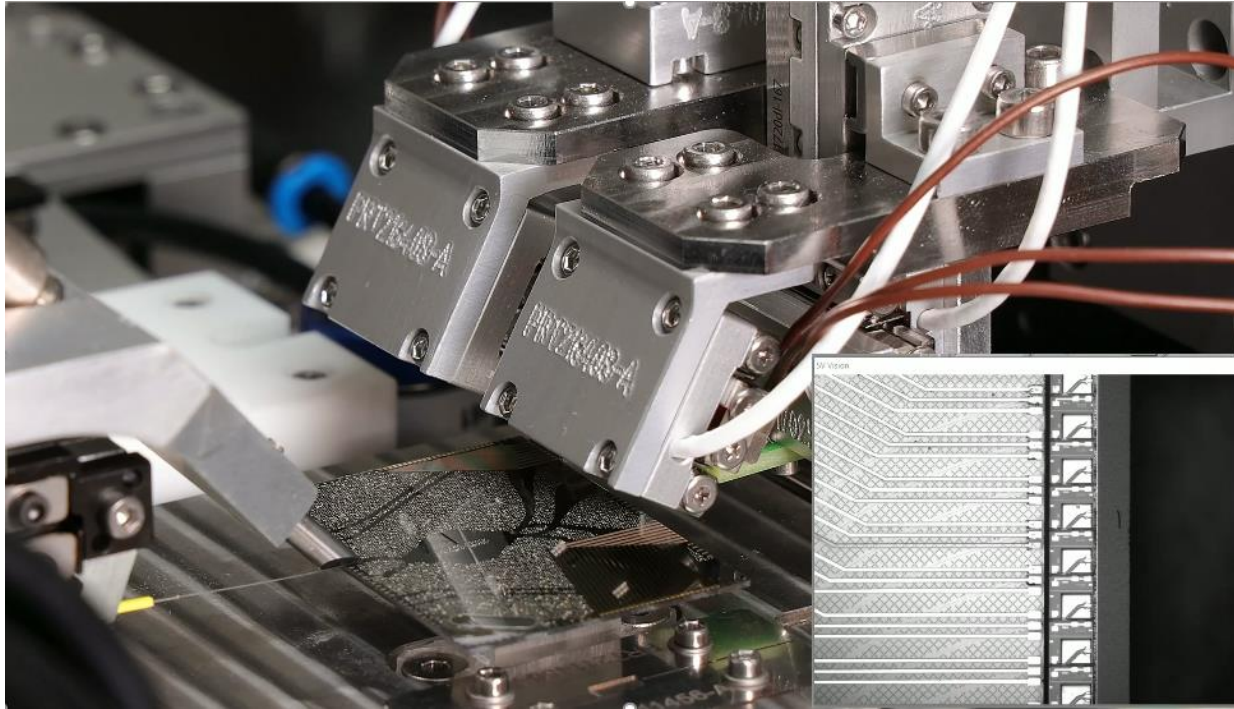


16-Channel
(2x 8-fold EML/PD arrays)



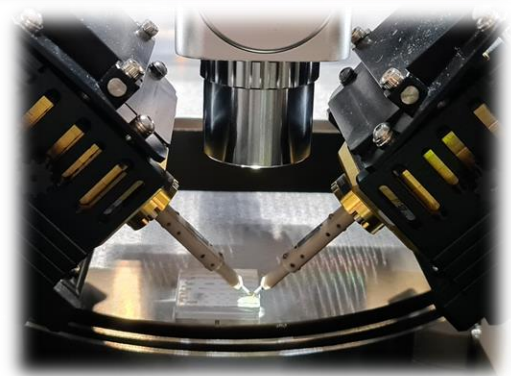
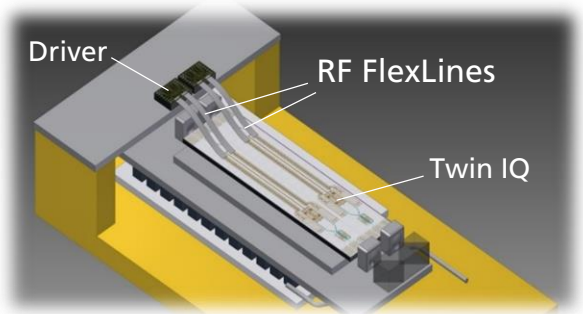
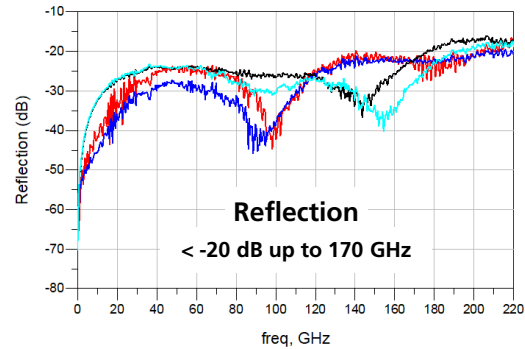
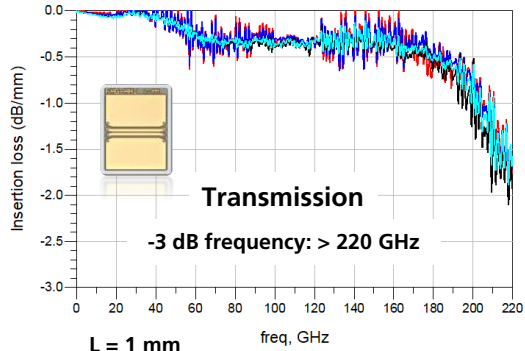
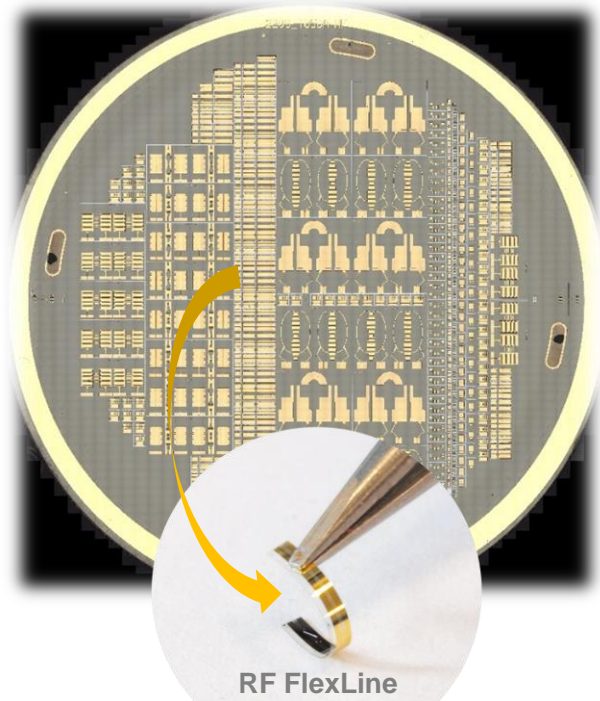
Automated Hybrid Integration Process

Towards large-volume manufacturability of hybrid PICs

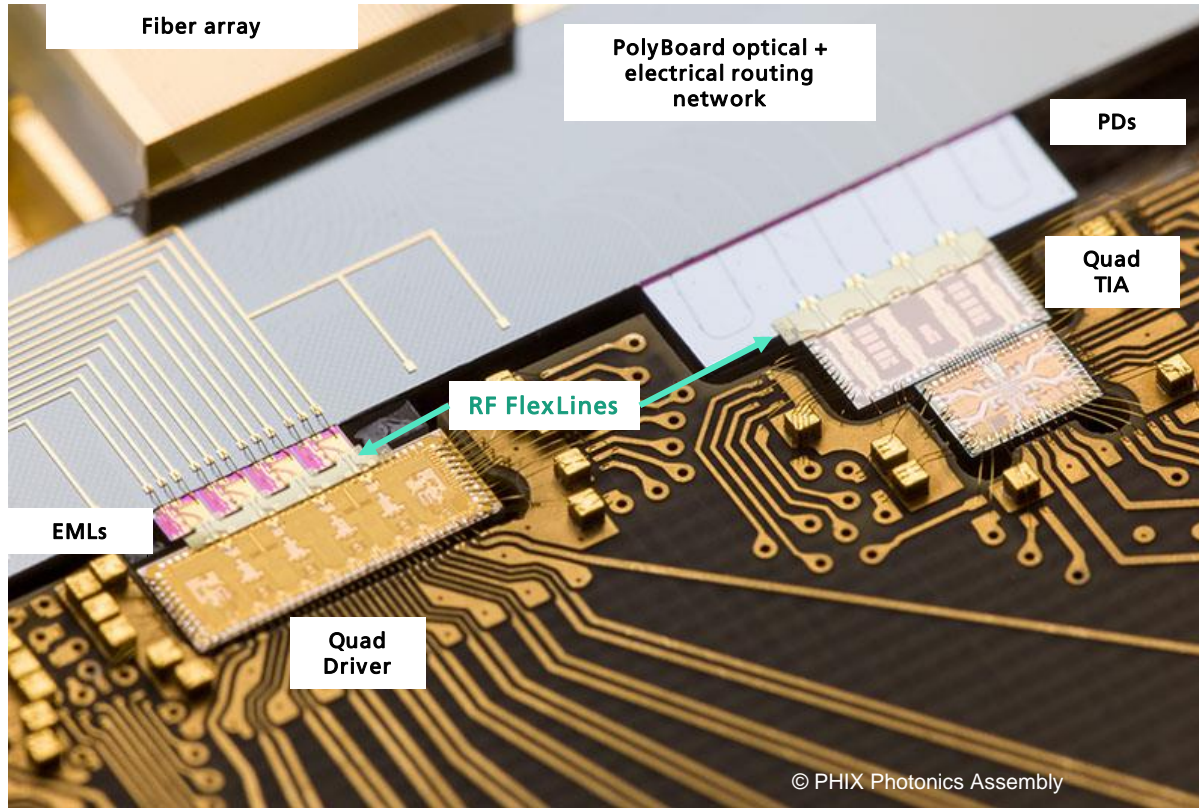


Polymer-based FlexLines for PIC-IC Connectivity

For > 200 GHz bandwidth electrical interconnects in high-speed TRx

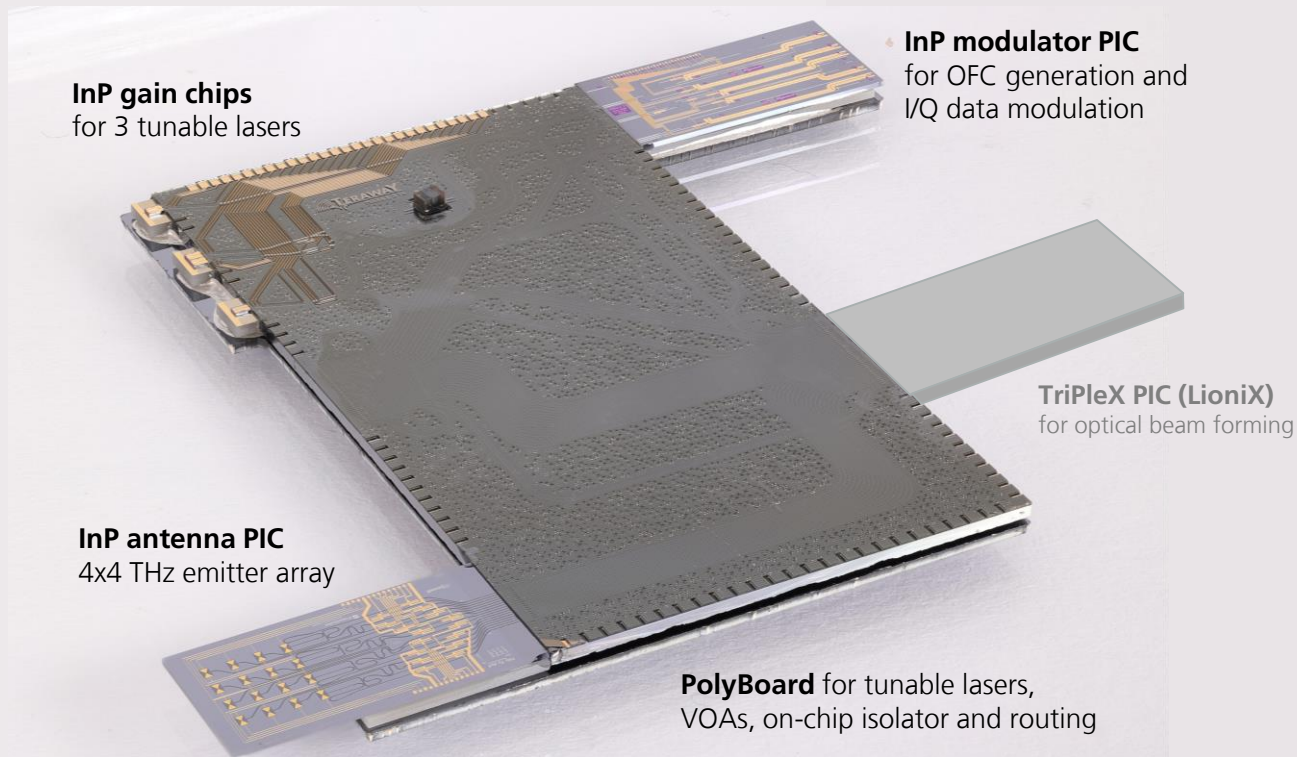


FlexLines for PIC-to-IC Connection in Transceivers



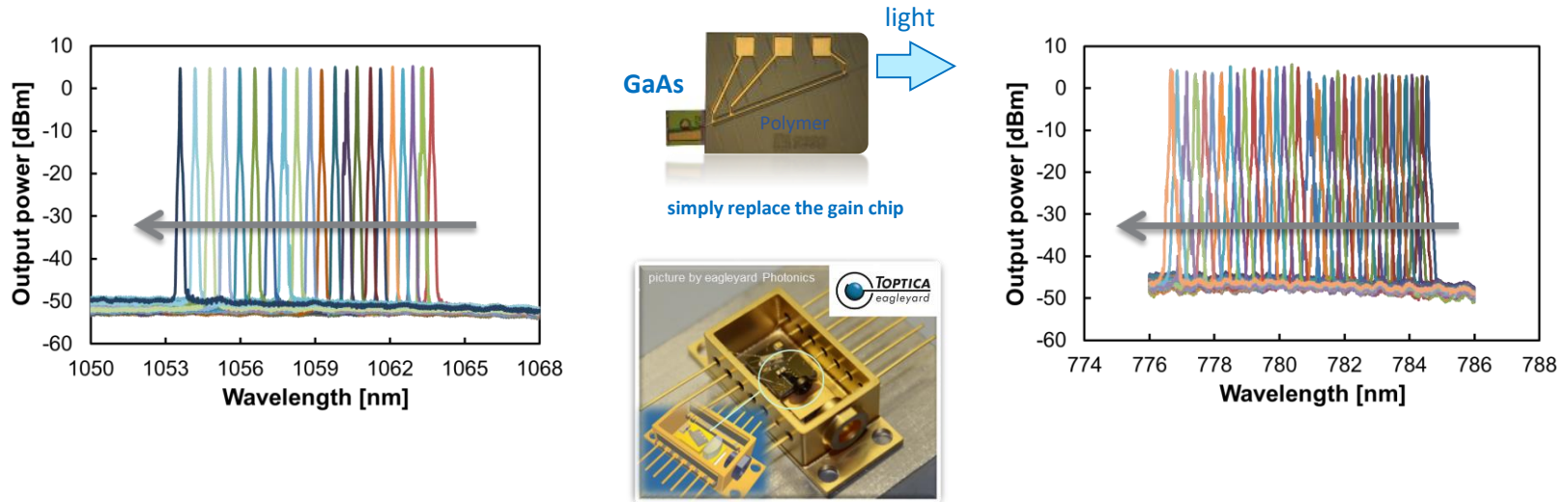
Beam Steerable Tx for Wireless Communications

Hybrid PICs Including THz components



Many Other Applications for Hybrid PICs ...

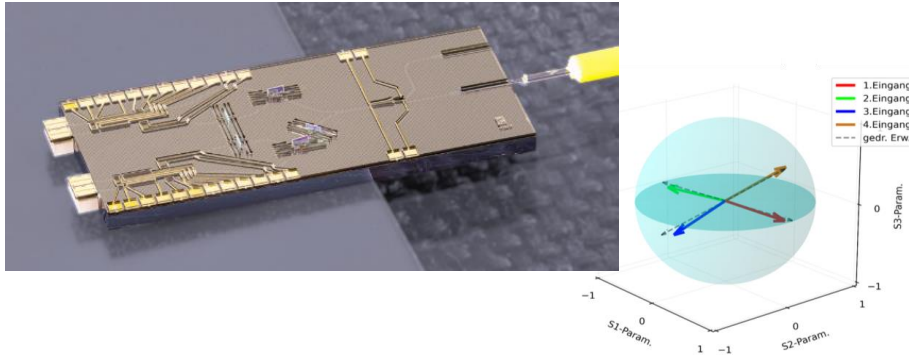
... e.g. Tunable DBR lasers @1064 nm and @785 nm, VIS in work



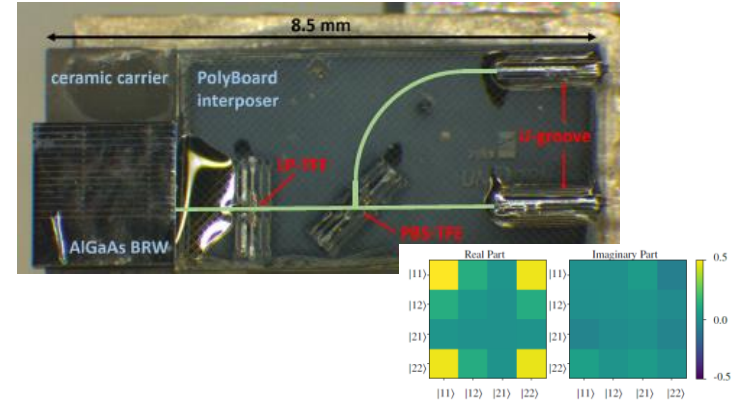
PolyBoard PICs for life science and quantum technologies

Hybrid PICs for the Quantum World

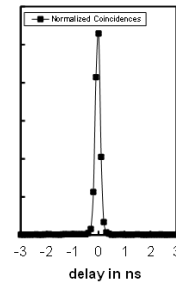
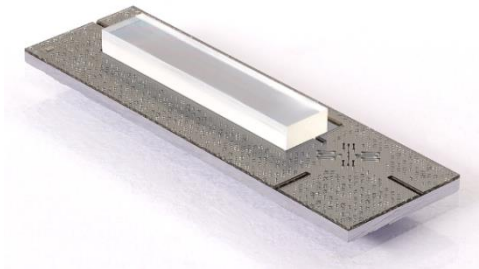
QKD Transmitter for polarization encoding



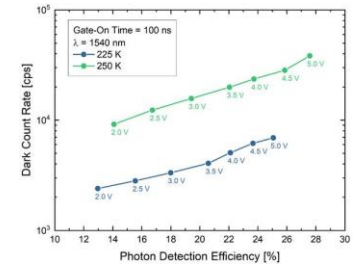
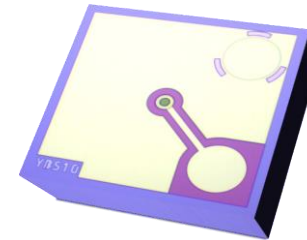
Time-bin entangled photon source



1550-nm Photon Pair Source



... and receivers as well: SPADs



Conclusions

- Polymer Hybrid PICs allow for the combination of the best optical materials for each optical functionality
- Assembly process can be automatized, including single-mode accuracy adjustment
- Polymer FlexLines allow for parallel 200+ GHz electrical connections
- EU TERIPHIC: photonic engine and automated hybrid integration process for > 1 Tb/s transceivers
- EU TERAWAY: demonstration of a hybrid-PIC-based beamsteerable THz Tx
- Hybrid photonic integration opens the way for e.g. tunable lasers down to VIS and PICs for Quantum

Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute, HHI

**WE PUT SCIENCE
INTO ACTION.**

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