Hybrid Polymer THz Receiver PIC with Waveguide Integrated Photoconductive Antenna: Concept and 1st Characterization Results

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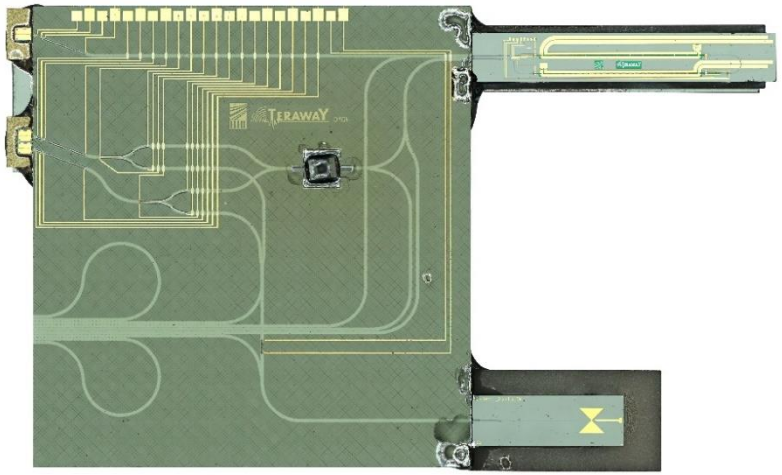

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Outline

1. Motivation
2. Our approach: hybrid photonic integration with waveguide integrated PCA
3. Demonstration of key building blocks of the THz Rx PIC
4. Summary and next steps

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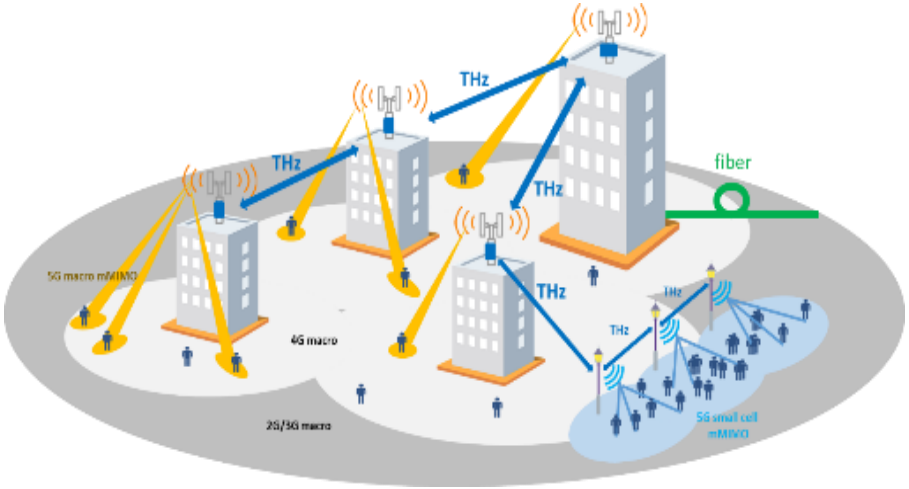
Photonic Integration and THz Frequencies

Why are they so important in Next-Gen wireless networks?

- Mobile services with ever increasing bandwidth demand
- Larger aggregated capacities in fronthaul
- Fiber deployment not possible / not economically viable everywhere



→ Photonics enable the demanded bit rates (> 100 Gb/s)

→ Going to THz frequencies enables carriers with high bit rates

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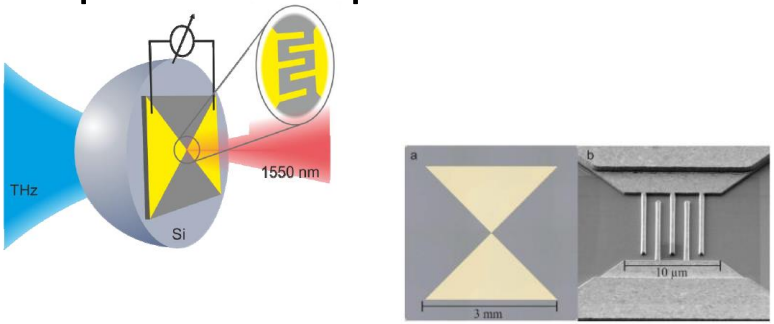
A Key Challenge: Photonic THz Detection

State of the art of photonic THz receivers

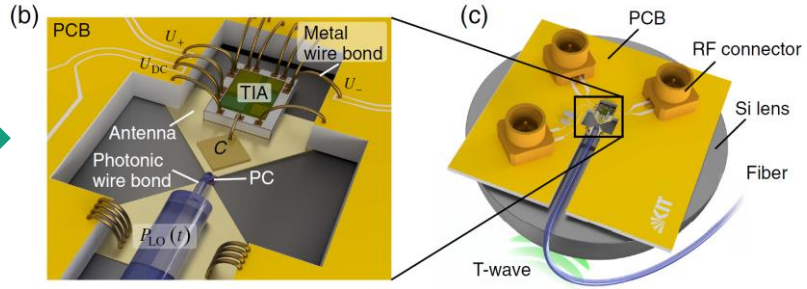
InP top-illuminated photoconductive antenna



S. Nellen et al., *Optics Express* (2021)

- \+ Large frequency coverage (4.5 THz) and dynamic range (112 dB)
- \- Vertically illuminated, hinders the photonic integration with other components

THz receiver module for communications



Harter, T. et al., *Optica* (2019)

- \+ Fiber-based module co-integrated with electronics (TIA)
- \- Optical sources and other photonic functions have to be external

Co-integration with other photonic functions (e.g. lasers) is still an issue

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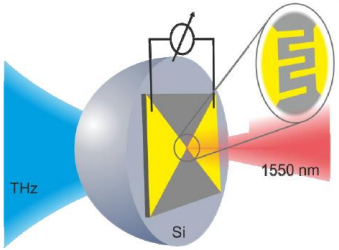
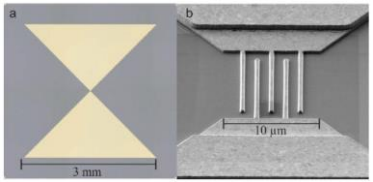
A Key Challenge: Photonic THz Detection

Waveguide integrated photonic THz receiver

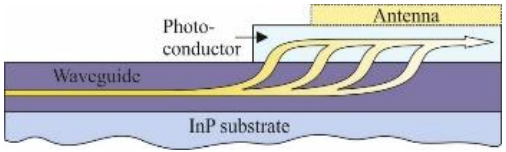
InP top-illuminated photoconductive antenna

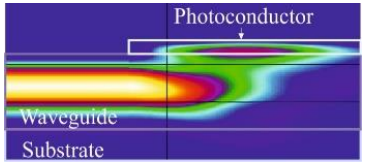




S. Nellen et al., *Optics Express* (2021)

This work: InP waveguide integrated photoconductive antenna





\+ Large frequency coverage (4.5 THz) and dynamic range (112 dB)

\- Vertically illuminated, hinders the photonic integration with other components

Novel waveguide-based PCA enables PICs!

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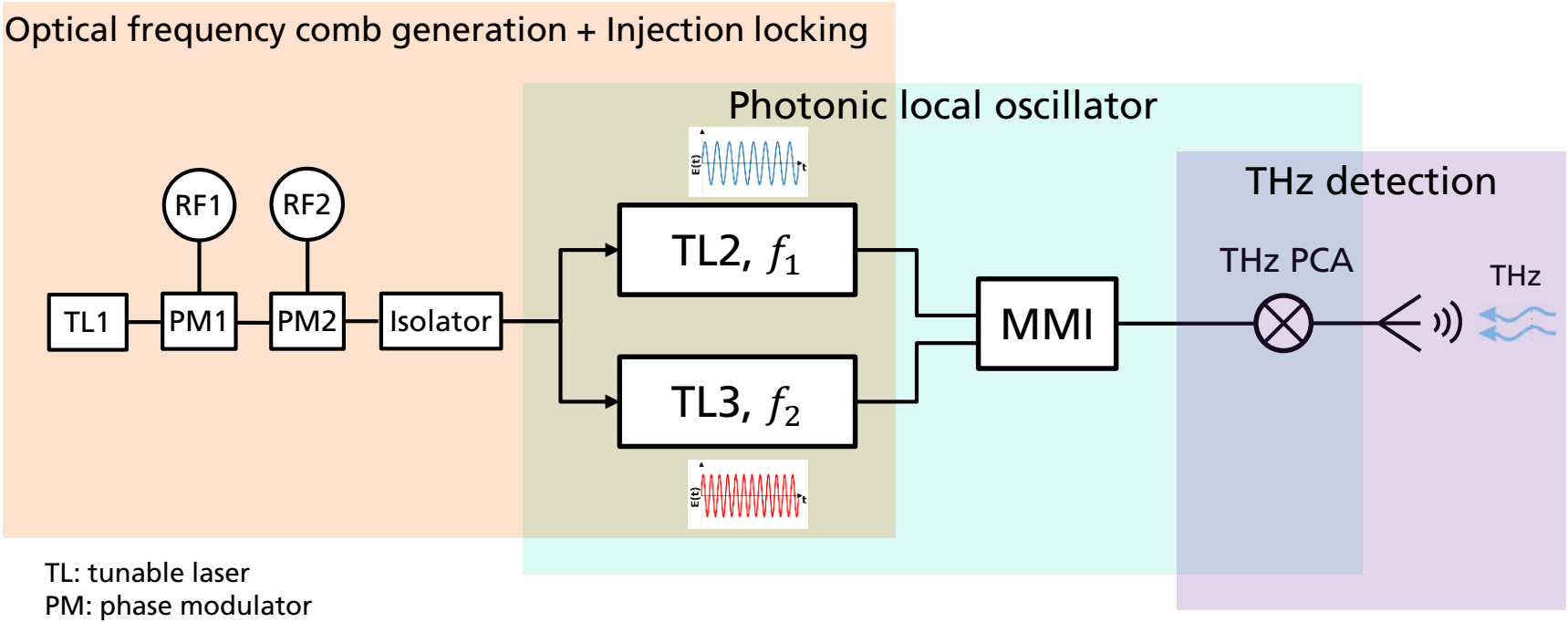
Targeted THz Receiver PIC

Functional Scheme



TL: tunable laser
PM: phase modulator
RF: sinusoidal modulation signal
PCA: photoconductive antenna

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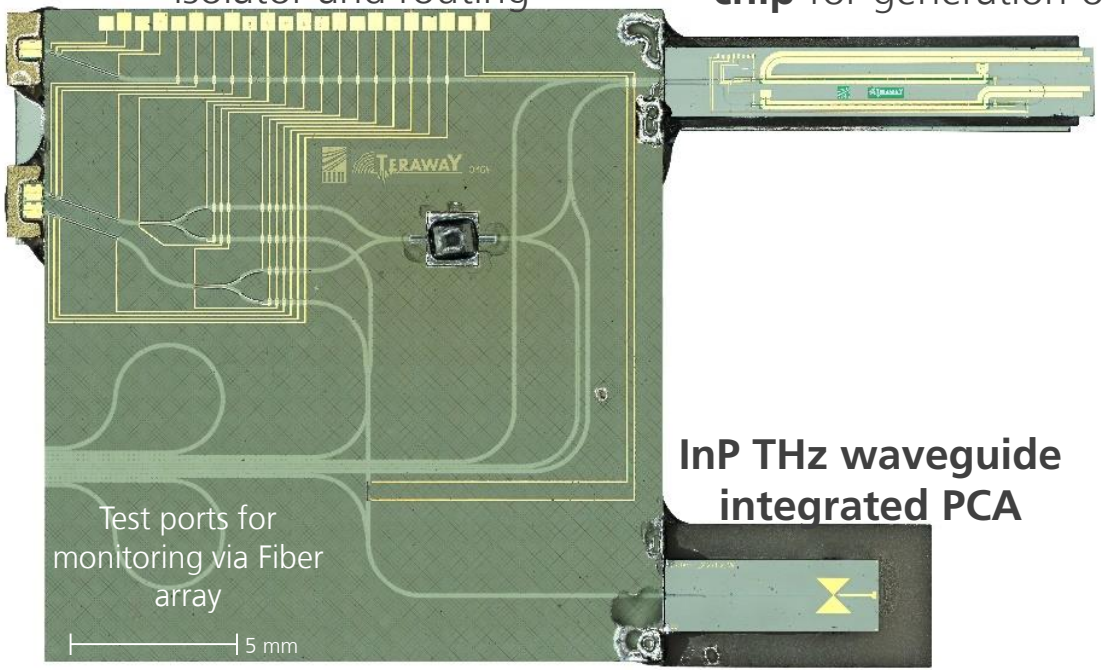
THz Receiver Hybrid PIC

1st-ever integration of all photonic functionalities

PolyBoard for tunable lasers, isolator and routing

InP phase modulator chip for generation of OFC



InP THz waveguide integrated PCA

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THz Receiver Hybrid PIC

1st-ever integration of all photonic functionalities

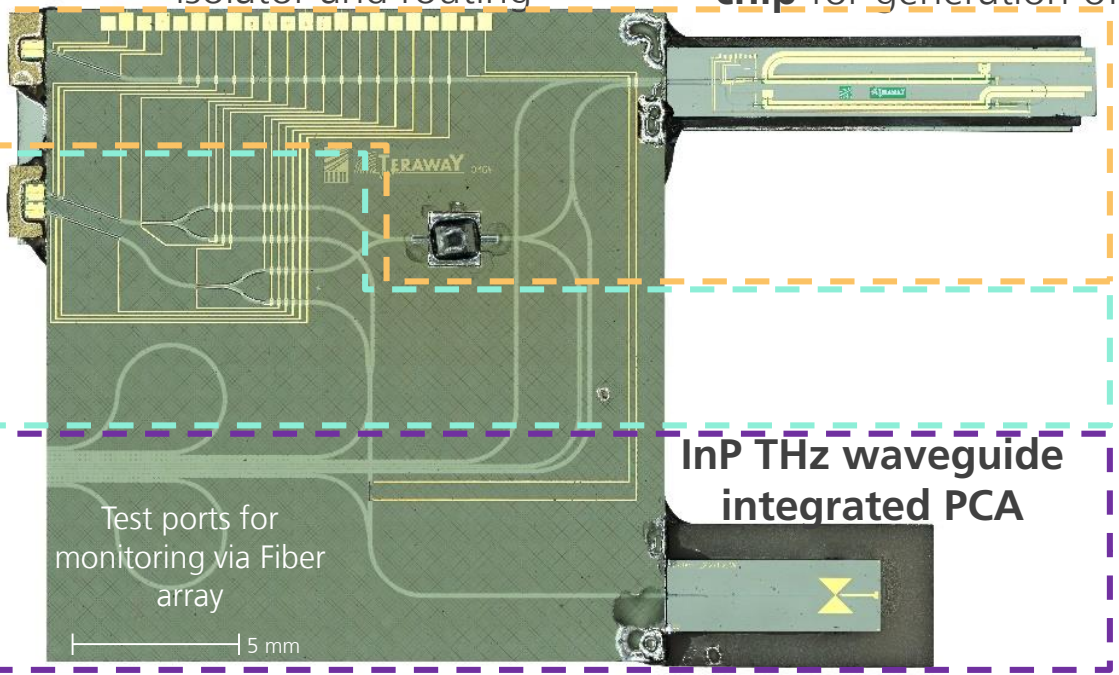
PolyBoard for tunable lasers, isolator and routing

InP phase modulator chip for generation of OFC

Optical frequency comb generation + Injection locking

Photonic local oscillator

THz detection



InP THz waveguide integrated PCA

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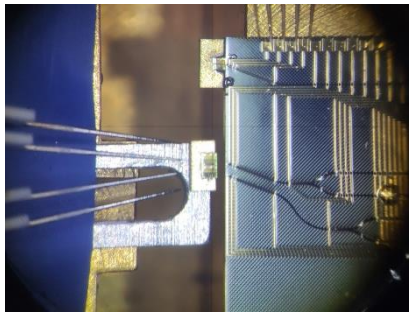
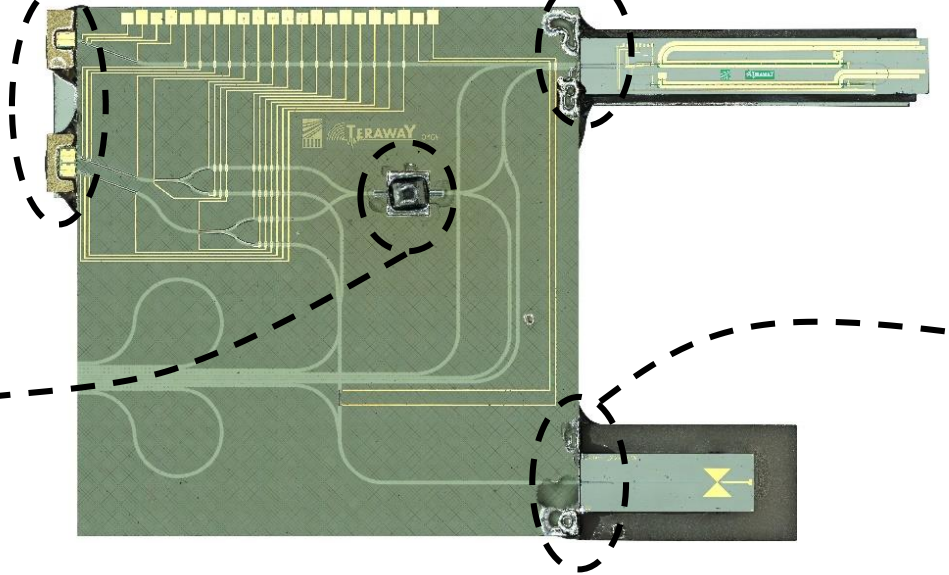
THz Receiver Hybrid PIC

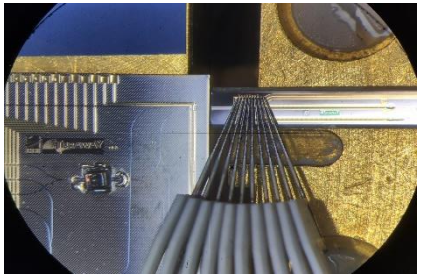
Assembly: active alignment and micro-optical bench on PolyBoard

InP active sections for tunable lasers

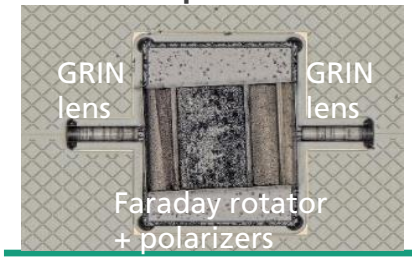




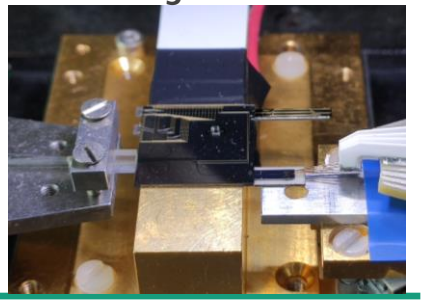
InP phase modulator chip



Optical isolator on micro-optical bench



InP waveguide integrated PCA



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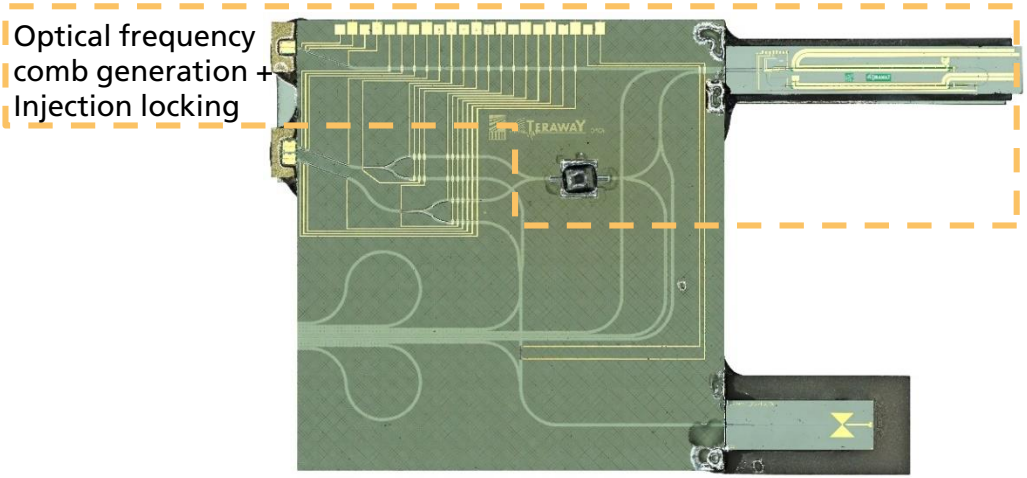
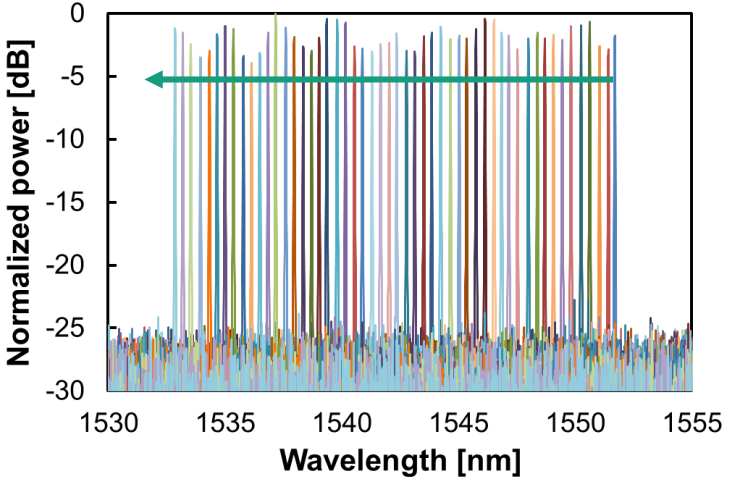
THz Receiver Hybrid PIC

Tunable laser coupled to cascaded phase modulators for OFC generation



Characterisation of laser after going through InP modulator chip

(measured at fiber monitoring port)



Hybrid integration of InP/polymer tunable laser and InP PMs successful

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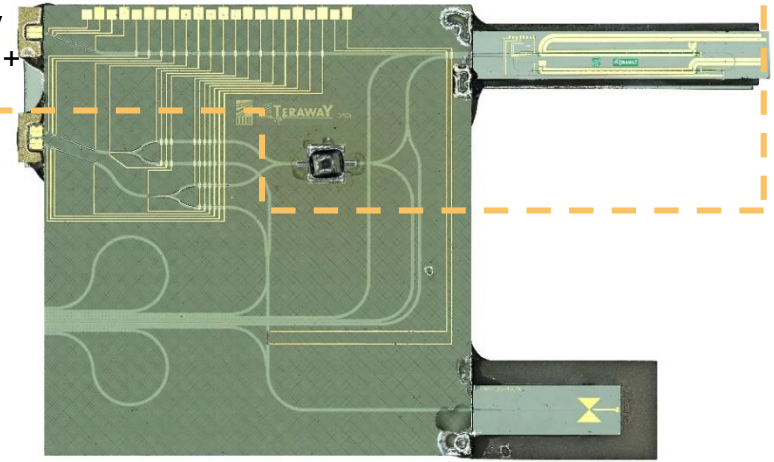
THz Receiver Hybrid PIC

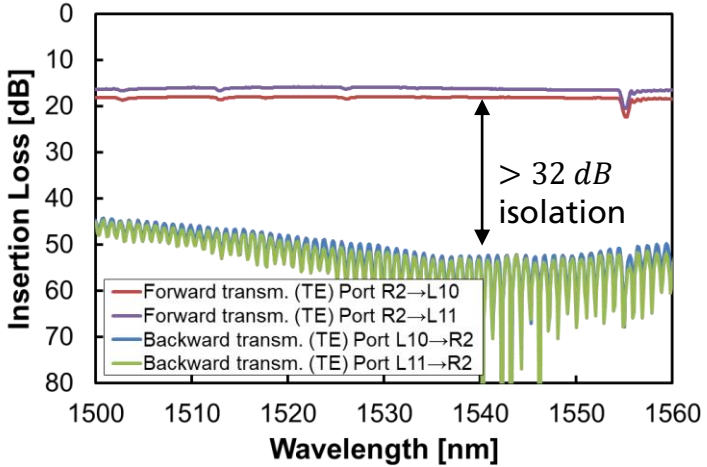
On-chip optical isolator as key element for injection-locking scheme

Optical frequency comb generation + Injection locking



Characterisation of isolator

(before coupling active sections of photonic LO tunable lasers)



On-Chip optical isolator functional

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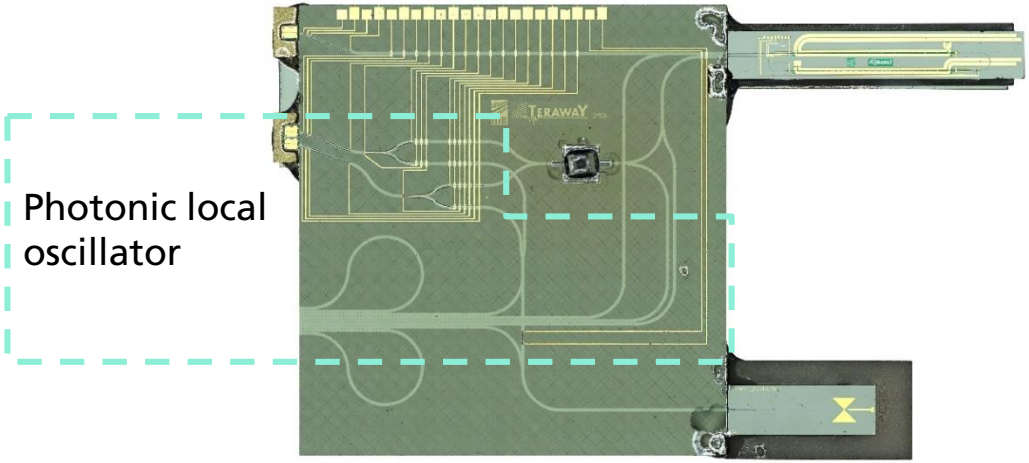
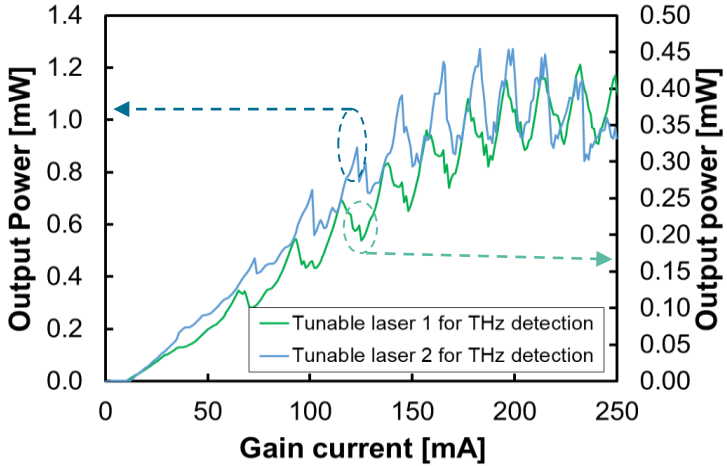
Tunable lasers for photonic local oscillator



Characterisation of tunable lasers

(measured at fiber monitoring port)



Tunable lasers for photonic LO functional

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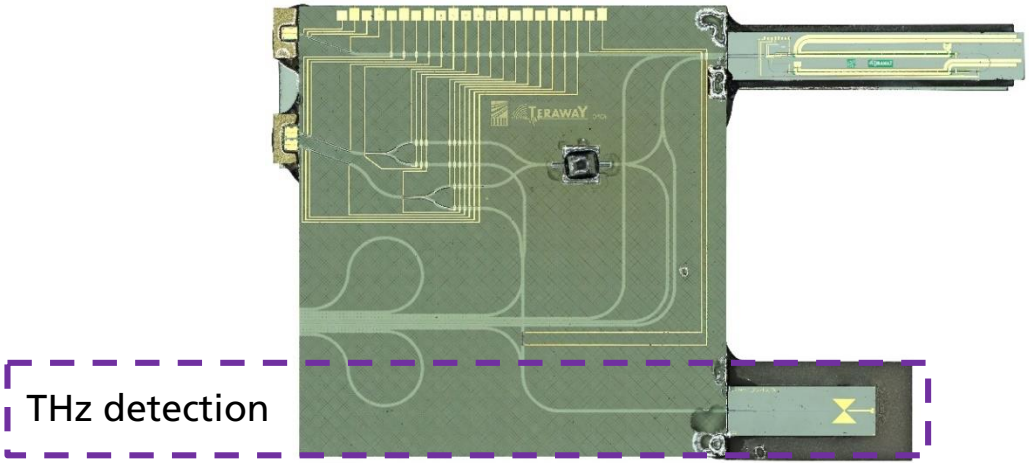
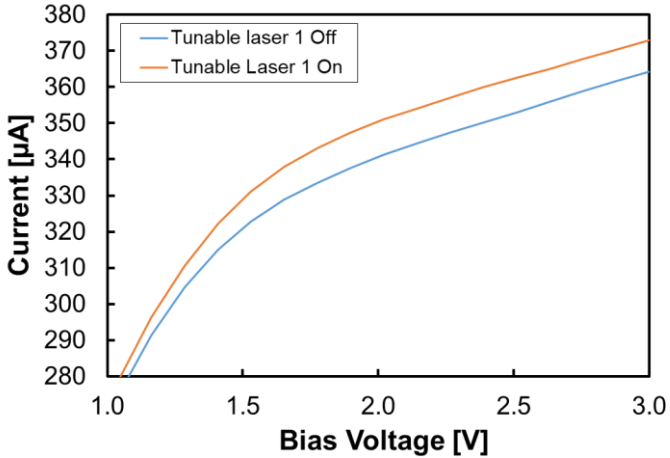
THz Receiver Hybrid PIC

Waveguide-based photoconductive antenna for THz detection



Photocurrent generated at waveguide-based PCA from photonic LO tunable lasers



1st ever integration of PCA on a THz Rx PIC demonstrated

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Summary and Future Perspectives

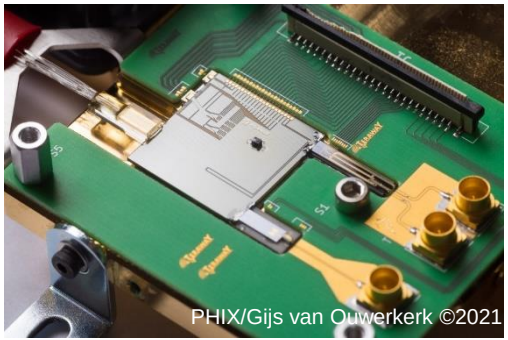
Hybrid THz Receiver PIC

- Waveguide integrated THz Receiver allows for hybrid integration
  → Use of best material for each function
- Hybrid integration approach using HHI's InP and PolyBoard platforms enables 1st-ever THz Rx PIC with all photonic functionalities
- 1st characterization show the functional key components after assembly

What's next?

- Testing of THz detection on packaged devices
- Next-Gen of THz receivers: improve power budget
  → Tunable Lasers and/or SOA on waveguide integrated PCA

Packaged THz Rx PIC



Packaged THz Tx PIC counterpart

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Fraunhofer HHI – Hybrid PICs Group

THANK YOU

Acknowledgement:

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Learn more at the OFC 2022 PIC Workshop
(Wednesday 09 March, 17:45 – 20:30, Room 29)

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