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# POLYIMIDE-FLEX FOR HIGH SPEED RF-CHIP INTERCONNECTS

<https://www.hhi.fraunhofer.de>

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# Fraunhofer-Gesellschaft

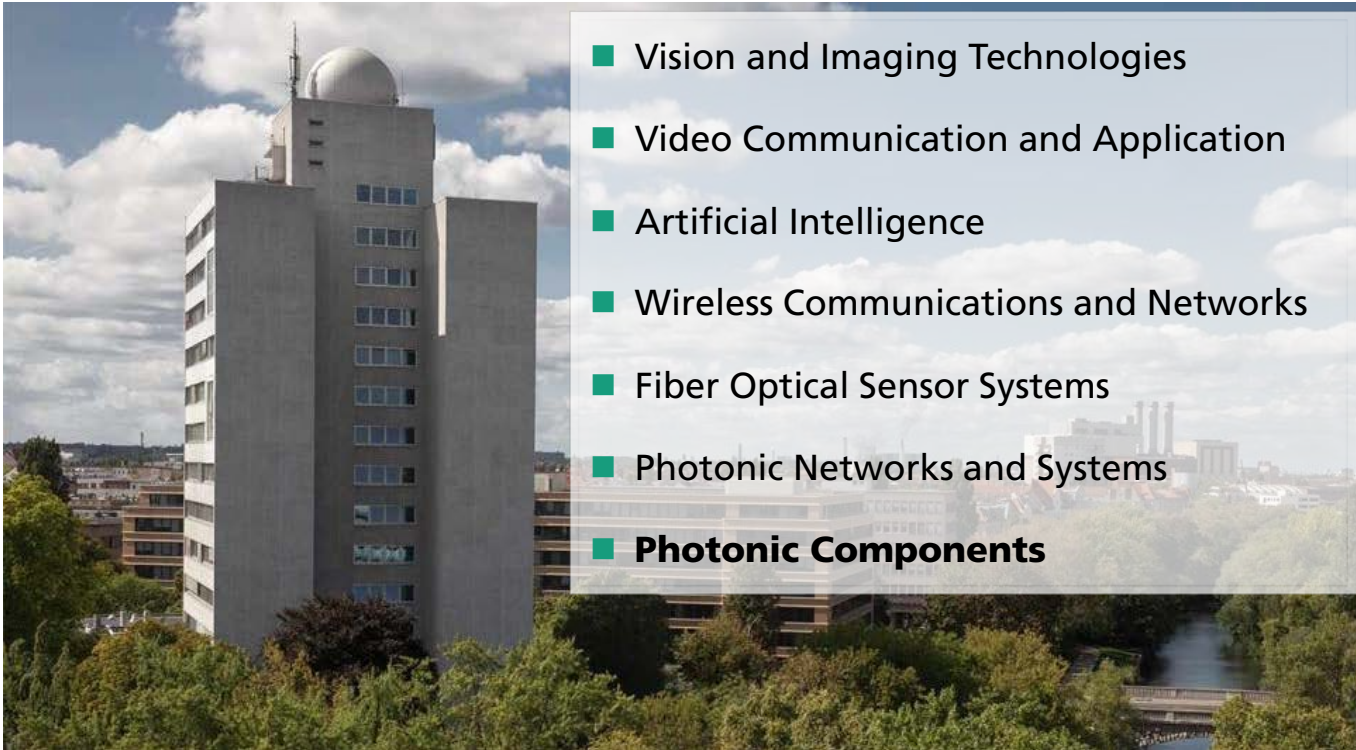


**Fraunhofer is Europe's largest organization for applied research.**

- 75 institutes and research units in Germany
- Research cooperation around the world
- 29 000 staff members
- Budget: more than 2.7 billion €
- Research highlights:  
MP3 audio codec, H.264, H.265 video codec,  
LTE mobile communications standards

# Fraunhofer Heinrich Hertz Institute, HHI

## 7 Departments



# HHI Photonic Components

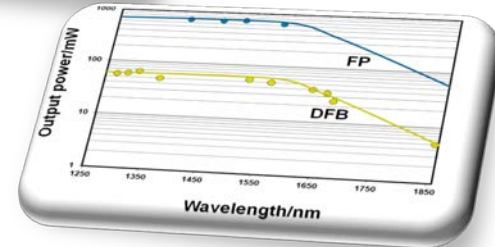
Mach Zehnder / IQ modulators



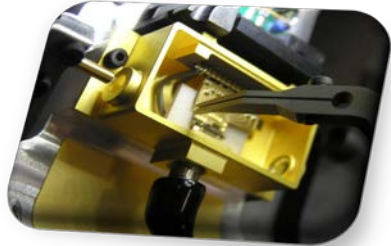
Detectors and 90° Hybrids



Lasers

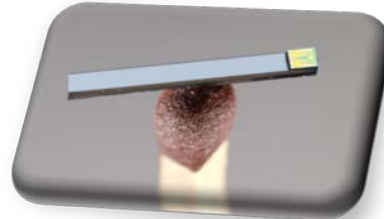


Prototype Packaging

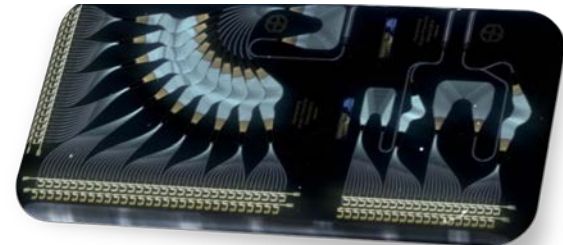


- 85 Employees
- 70 Students
- InP Epitaxy & Fab
- Polymer Fab

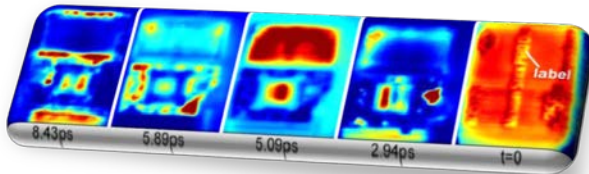
Polymer Hybrid PICs



InP PIC foundry

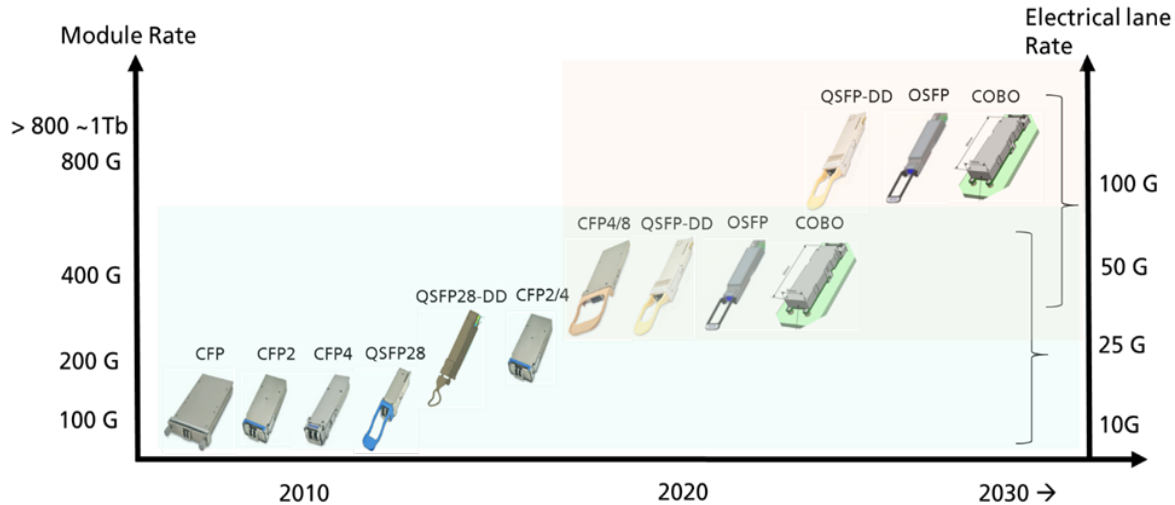


Terahertz sensing



# Motivation

... Evolution of optical transceivers: faster, lower-power, smaller size



Target:

- Baud rate > 90 Gbaud
  - Lower power consumption
- ↓
- Heterogeneous Integration
  - Holistic Design Approach:

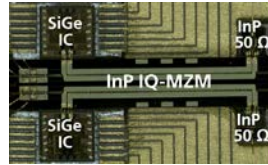
Co-design of  
PIC, IC & RF-interconnect

# Fraunhofer HHI MZM / EML with co-designed SiGe Driver-IC

## Non-standard impedance design - demands close proximity PIC/IC integration

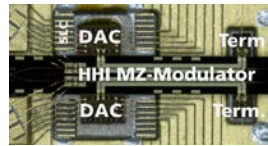


**9.1 pJ/bit**



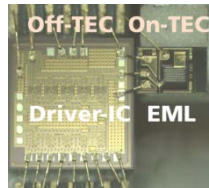
100 Gbit/s

**2.3 pJ/bit**

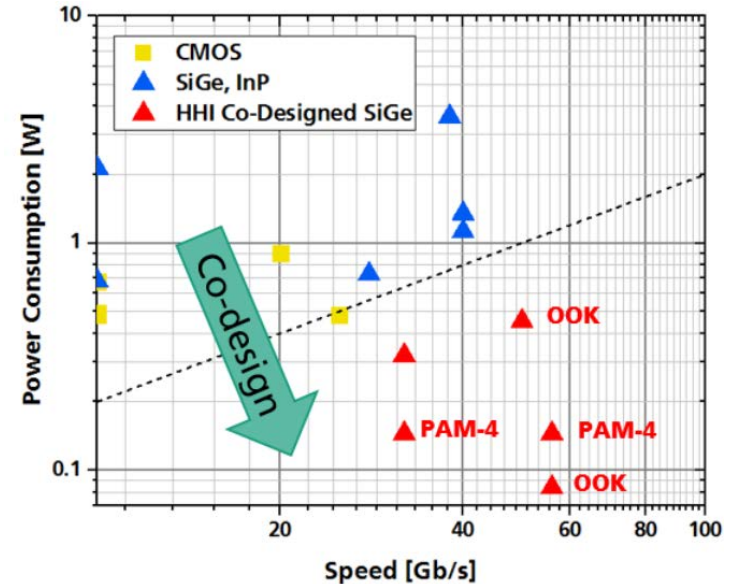


128 Gbit/s

**1.3 pJ/bit**



56 Gbit/s



Data from: S. Nakano, et al., "A 25-Gb/s 480-mW CMOS Modulator Driver using Area-Efficient 3D Inductor Peaking," IEEE Asian Solid-State Circuits Conf., paper 17-5, Nov. 9-11, 2015, Xiamen, Fujian, China

# Transceiver development towards > 90 Gbaud @ low power

## Requirements for RF chip-interconnects

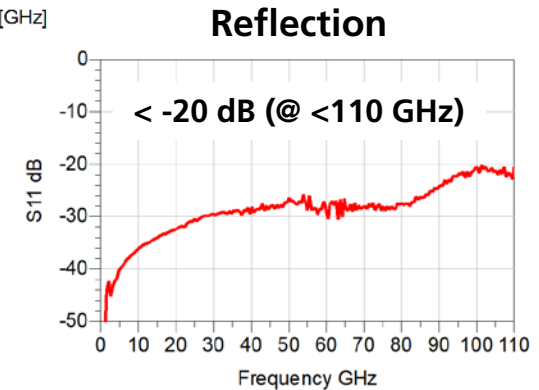
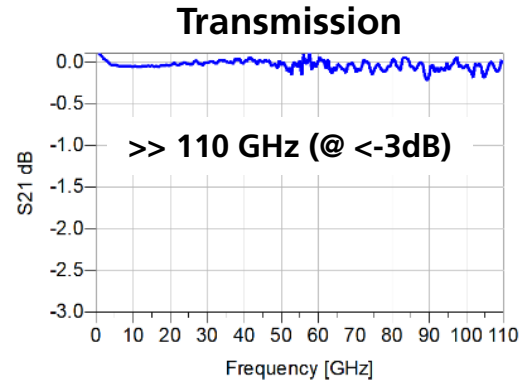
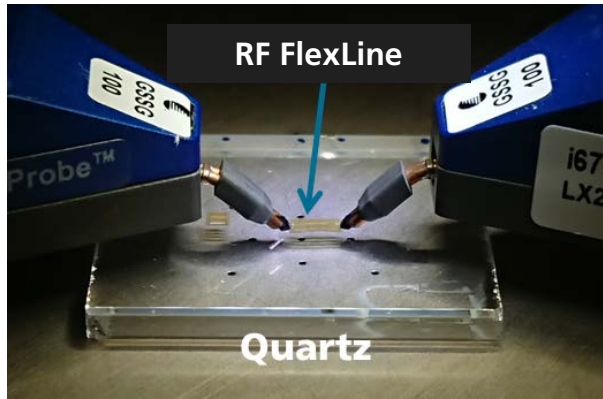
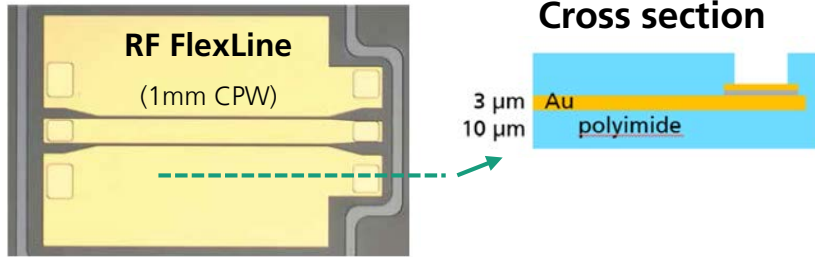
- Co-design
  - co-packaging of Driver IC and PIC  
...to allow low power designs (e.g. open collector)
- Match required RF-Impedance (e.g. 2 x 25 Ohm)
  - Good thermal and mechanical "isolation" (PIC / TEC ↔ driver passively cooled)
  - Multiple channels (array)

Polyimide RF-Flexline fulfills these requirements



# RF FlexLine Development

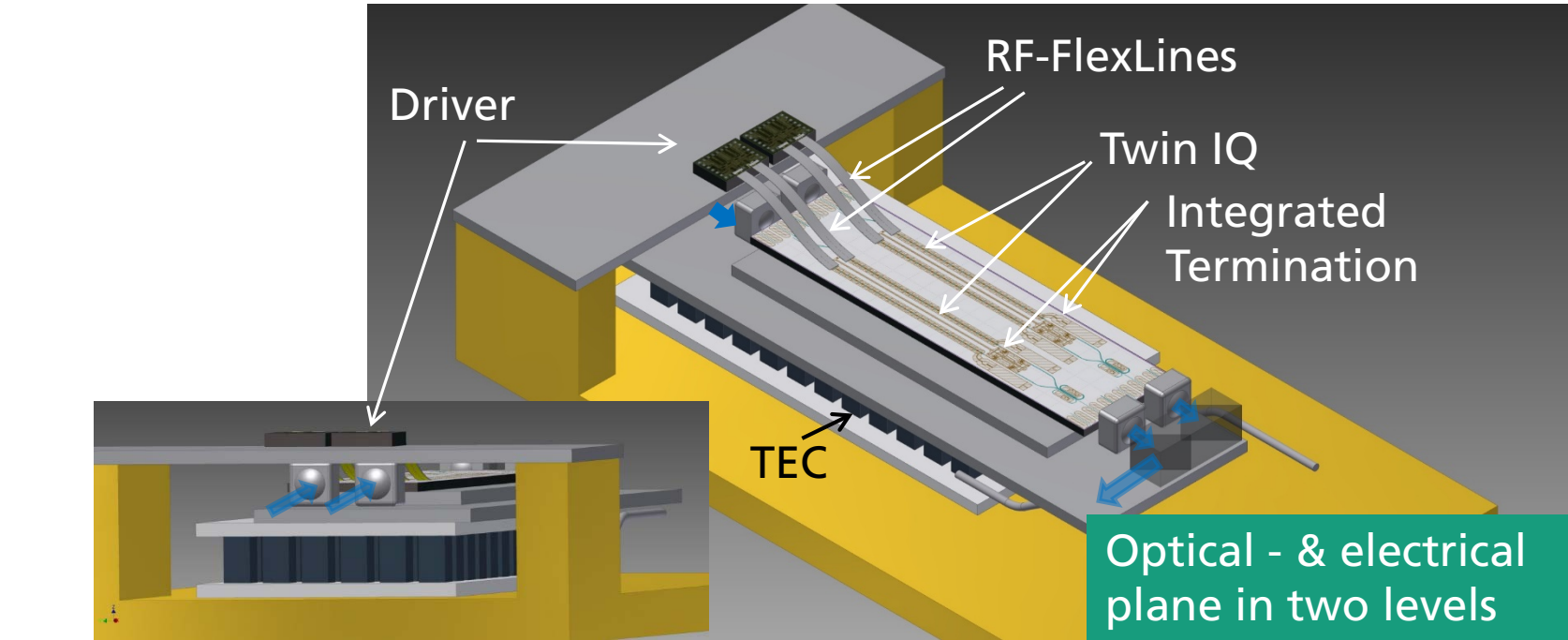
## Technology, design and characterization at HHI





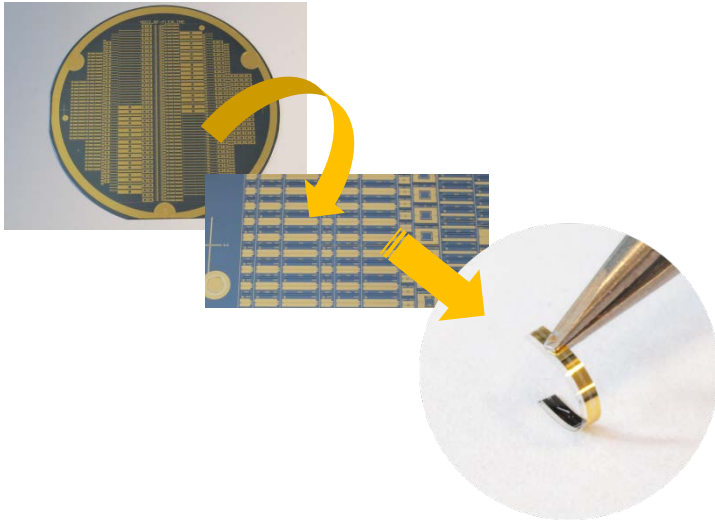
# 3D-Design study – for a high Baud rate TOSA

... artists view



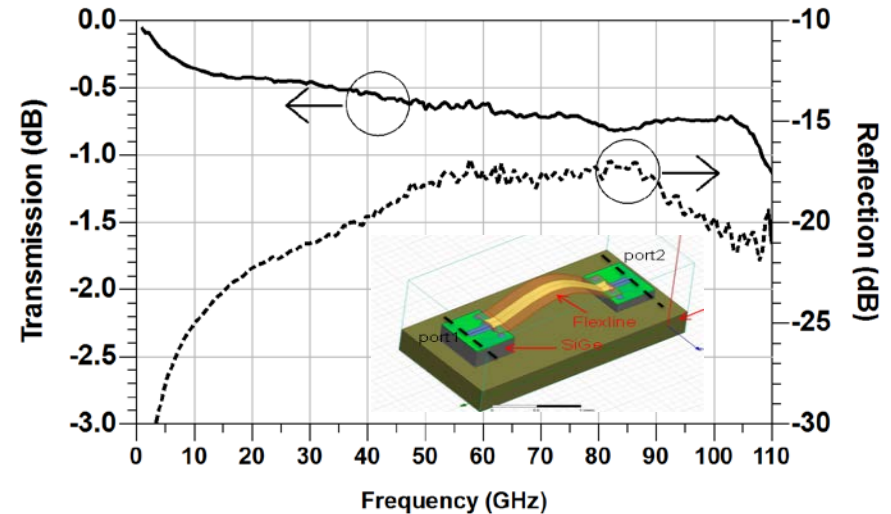
# RF-FlexLine

Different designs: coplanar; CPS; differential...



- Customized design
- 4"-wafer fabrication

## S-Parameters



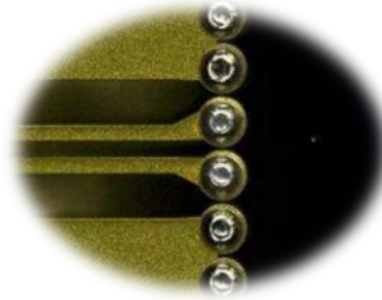
- - 3dB frequency: > 110 GHz

# RF-FlexLine enables Heterogeneous Integration

## .. of the best of breed PIC & IC technologies

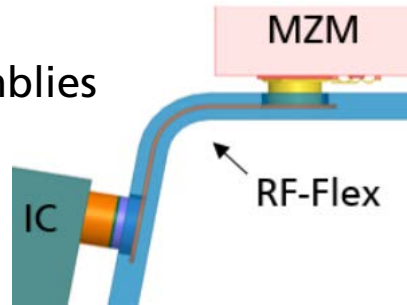
Connecting RF-FlexLine:

- Au stud bumps
- Solder spheres (SAC; AuSn)
- Au pillar & ACF
- ...



RF-FlexLine  
Differential waveguide  
with applied SAC solder spheres

RF-FlexLine envisions  
small-size 3D RF-assemblies



For Baud rates > 90 Gbaud  
Polyimide RF-Flex delivers  
one of the best suited  
RF-interconnect technology