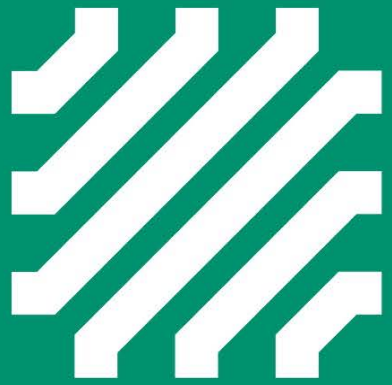

Forschungsfabrik Mikroelektronik Deutschland

Fraunhofer Group for Microelectronics in Cooperation with Leibniz Institutes FBH and IHP

Forschungsfabrik Mikroelektronik Deutschland

Photonics for the Internet and Datacenter

Martin Schell, Fraunhofer HHI

A cooperation of

Fraunhofer MIKROELEKTRONIK

FBH Ferdinand Braun Institut

ihp

HHI's origin: Long Reach (~100s-1000s km) Telecom

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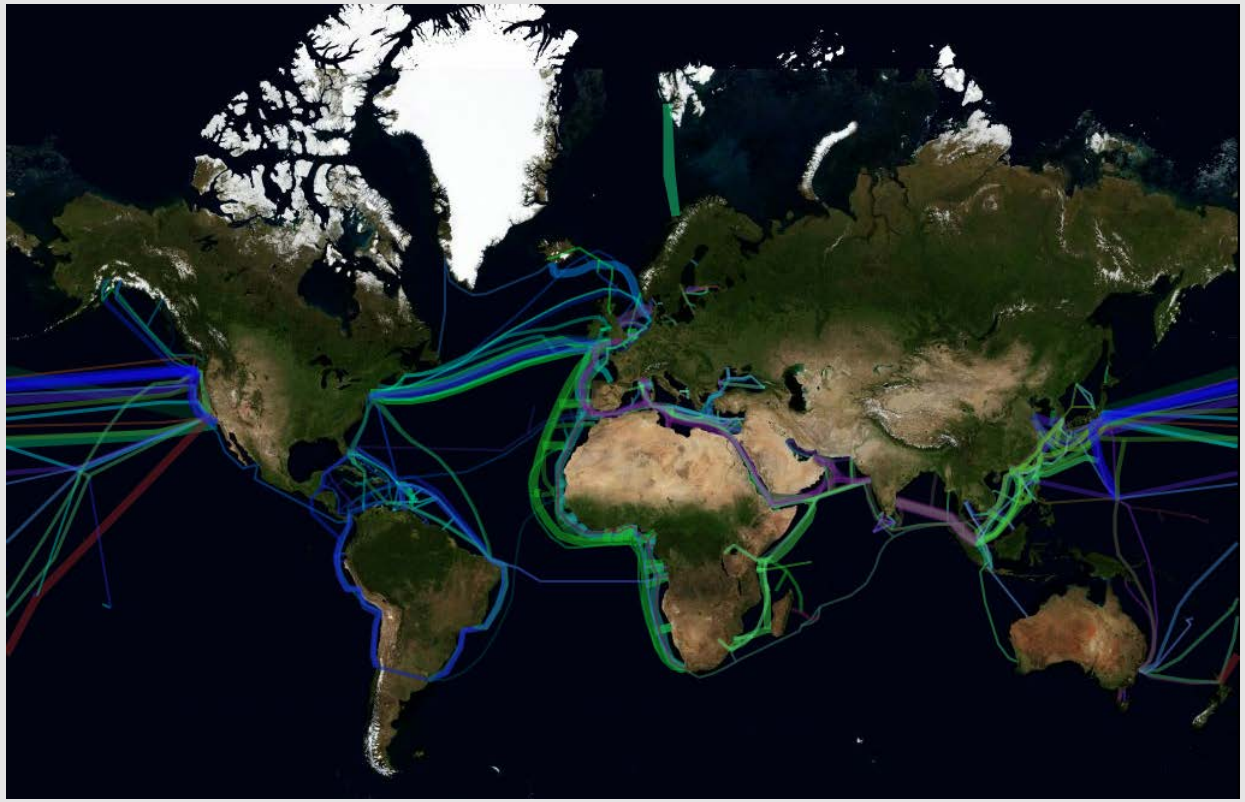

Traffic growth 40% to 60% p.a. since a couple of decades

Small market sizes of 100.000s pcs p.a. worldwide

Optochip performance is paramount

Long Reach: Dispersion is our Challenge … and problems grow quadratically with speed

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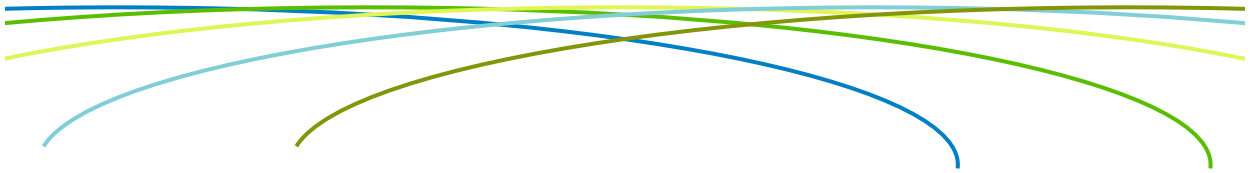
At fiber input, 1 bit is ~ 1 cm long …

… at output, it has smeared out to ~ 1 m and overlaps with 100 others



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Fourier transforming allows for Compensation but Requires Detecting Phase and Amplitude

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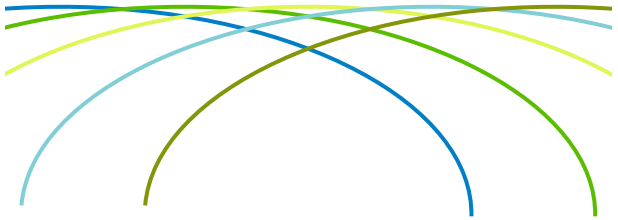

$$\text{FFT} \Rightarrow e^{iD\omega^2} \Rightarrow \text{IFFT}$$

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InP monolithic QPSK receiver

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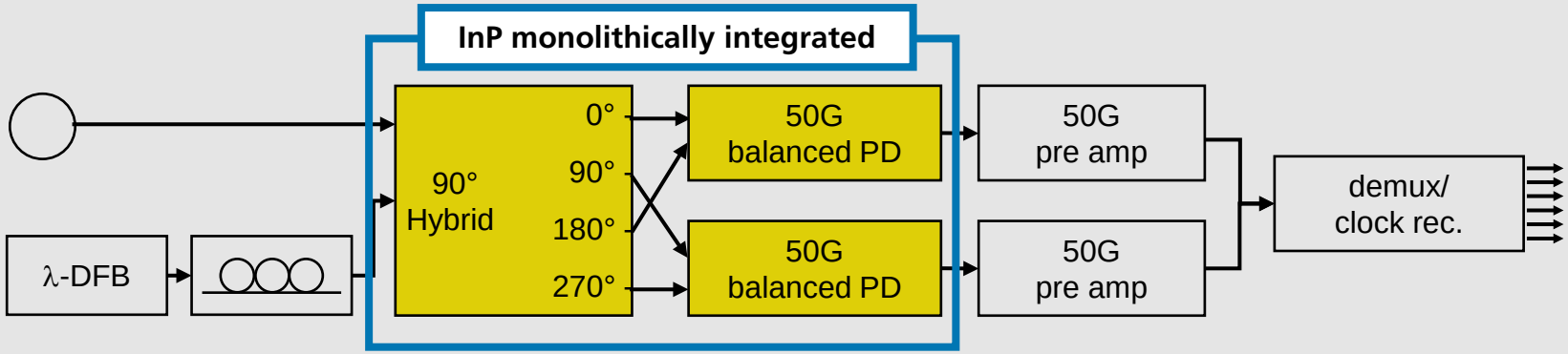

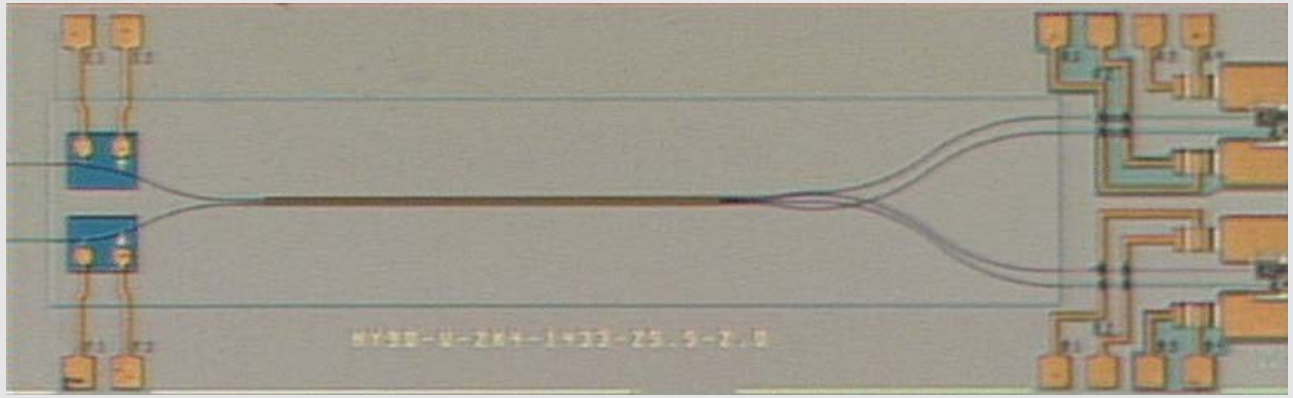

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InP monolithic QPSK receiver - Phase difference of input signals determines output ports

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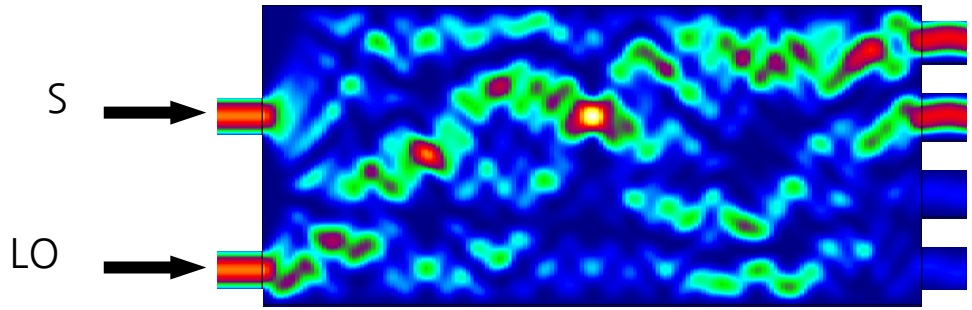
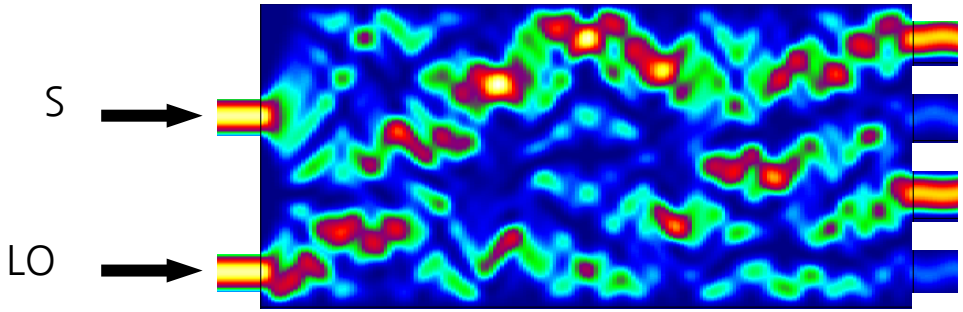
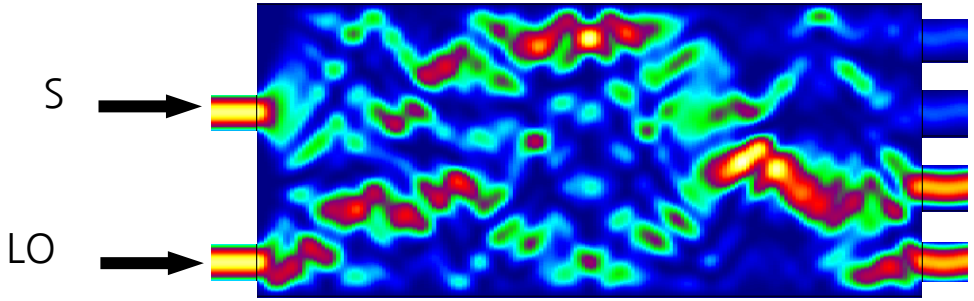
Δφ = 0deg



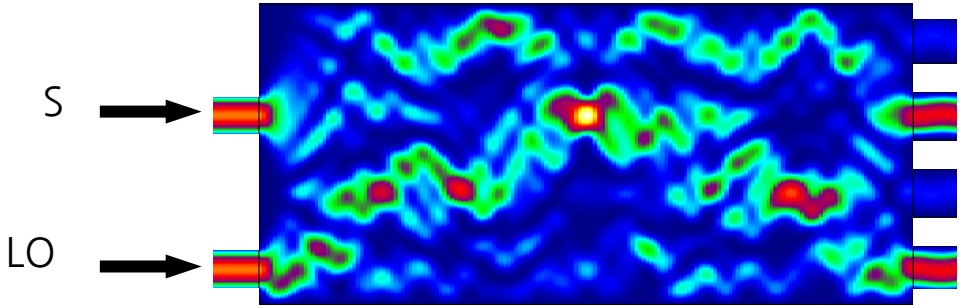
Δφ = 90deg



Δφ = 180deg



Δφ = 270deg



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HHI's target: Intra Datacenter

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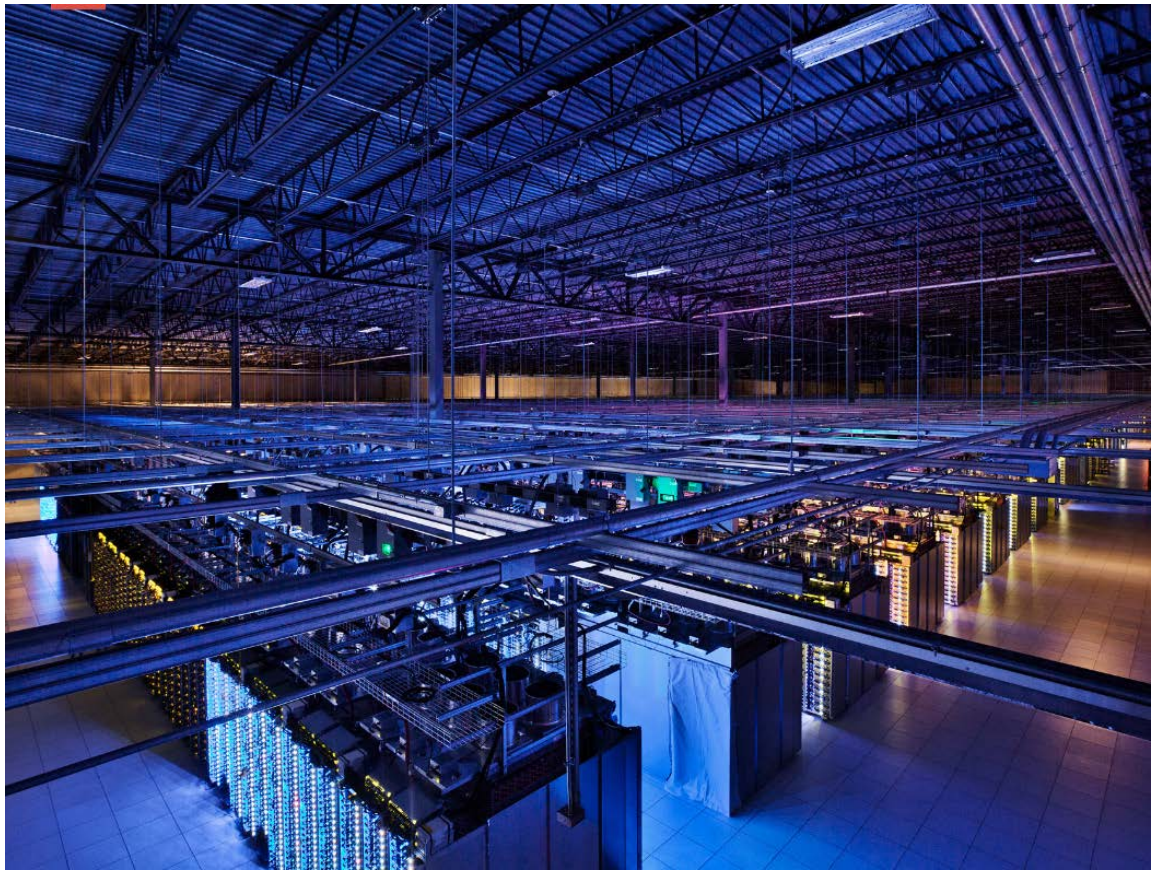

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In Datacenters, ‘normal’ Lasers Compete Well: One single 3“ InP Laser wafer can transport the internet

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White paper
Cisco public

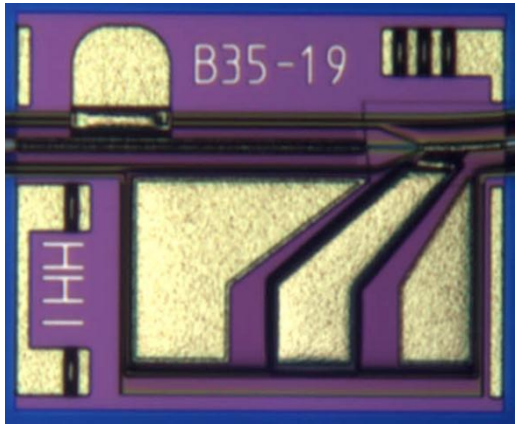
cisco

The Zettabyte Era: Trends and Analysis

June 2017

„Annual global IP traffic will reach 3.3 ZB per year by 2021, … . In 2016, the **annual runrate … was 1.2 ZB per year“**

500µm x 400µm



About 20.000 chips per 3“ wafer, 56 GBit/chip
A single InP 3” Wafer can support 3 ZB/year

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Single Laser supports 100 Gb/s on/off

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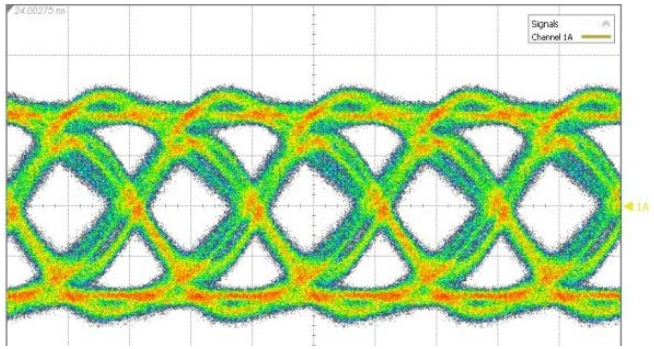
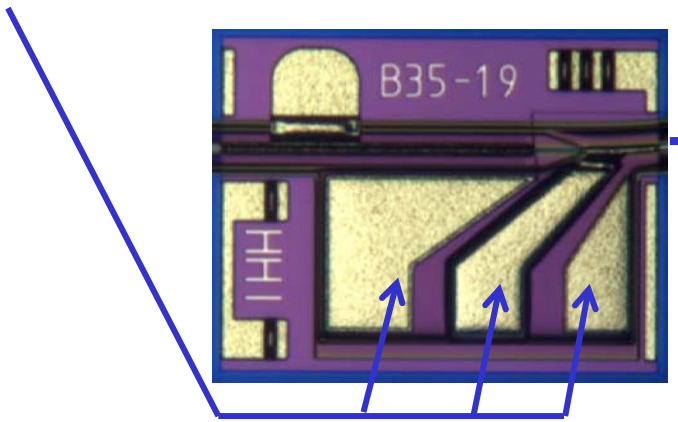
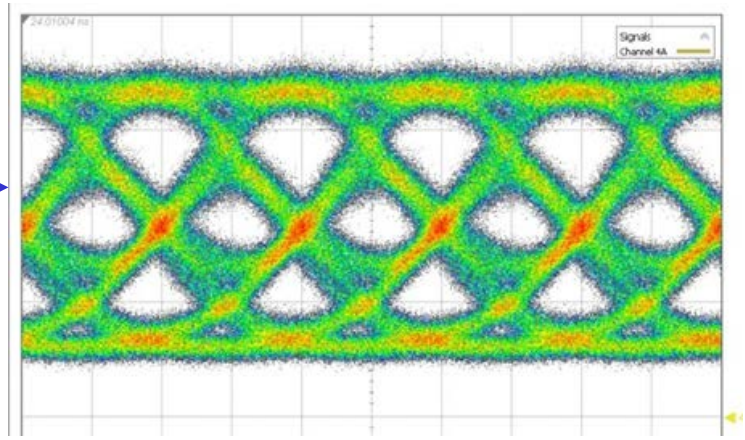




10km

100Gb/s Optical Signal



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Farer future: Optical Switch Matrices
1.6 Mio Cores to be Connected

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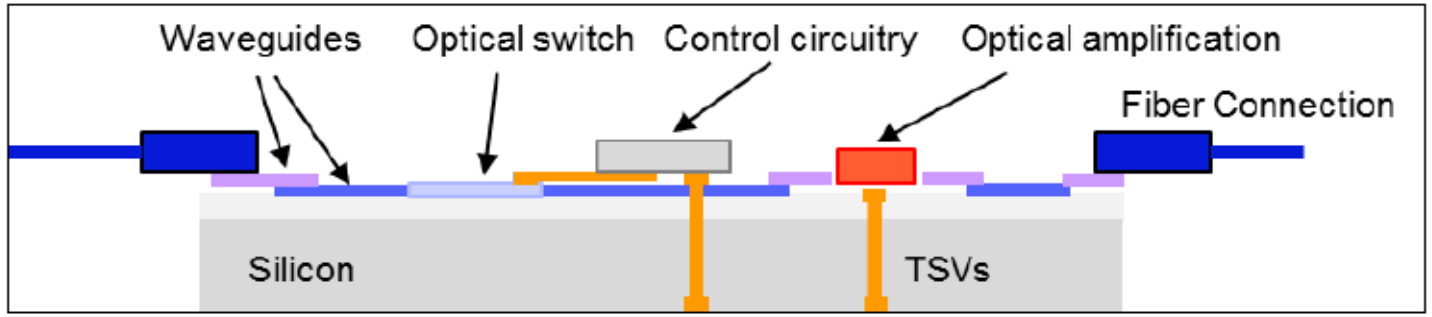
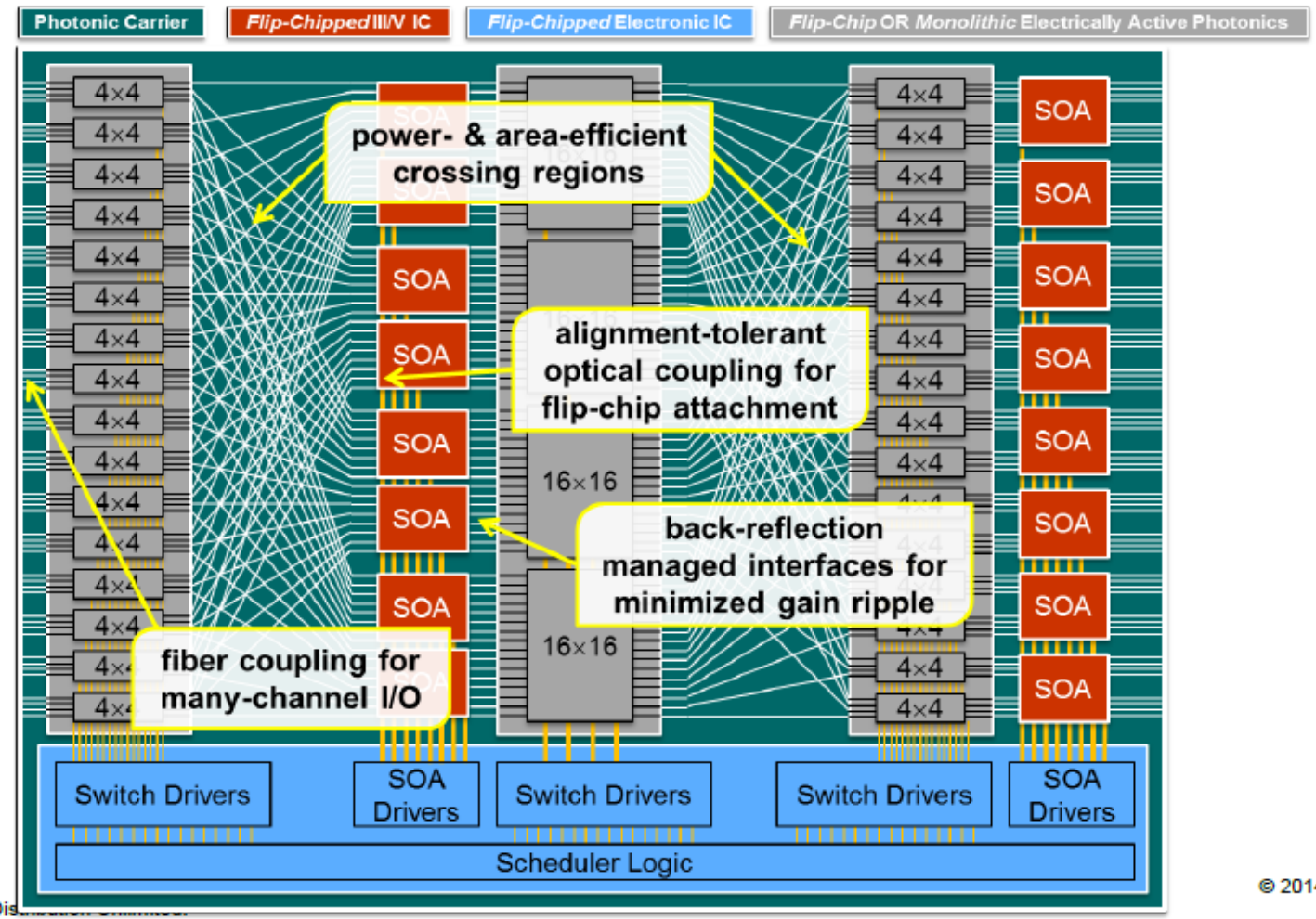
SOA Integration into Active Photonic Switches

Conceptual cross-section:



Topological view:



A Gain-Integrated Silicon Photonic Carrier with SOA-Array for Scalable Optical Switch Fabrics

L. Schares[(1)], T. N. Huynh[(1)], M. G. Wood[(1,2)], R. Budd[(1)], F. Doany[(1)], D. Kuchta[(1)], N. Dupuis[(1)], B. G. Lee[(1)], C. L. Schow[(3)], M. Moehrle[(4)], A. Sigmund[(4)], W. Rehbein[(4)], T. Y. Liow[(5)], L. W. Luo[(5)], G. Q. Lo[(5)]

*(1) IBM – Watson Research Center, Yorktown Heights NY, USA. Email: schares@us.ibm.com. (2) The Ohio State Univ., Columbus, OH, USA. (3) Univ. of California, Santa Barbara, CA, USA. (4) Fraunhofer HHI, Berlin, Germany. (5) A*STAR – Institute of Microelectronics, Singapore.*

Abstract: We built a 4-channel photonic carrier with input/output SiN waveguides and a flip-chip-attached SOA array, incorporating end-to-end reflection-management and mode-matching. All channels demonstrate fiber-to-fiber gain of >10dB and support error-free 4-λ x 25-Gb/s WDM links.

OCIS codes: (200.0200) Optics in computing; (230.4480) Optical Amplifiers; (200.4650) Optical interconnects

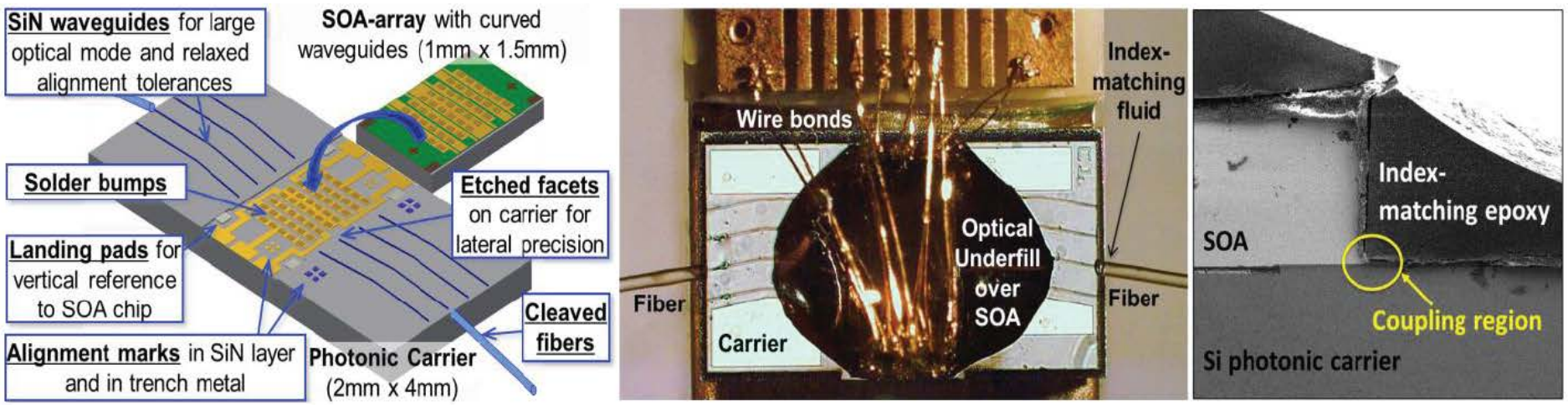
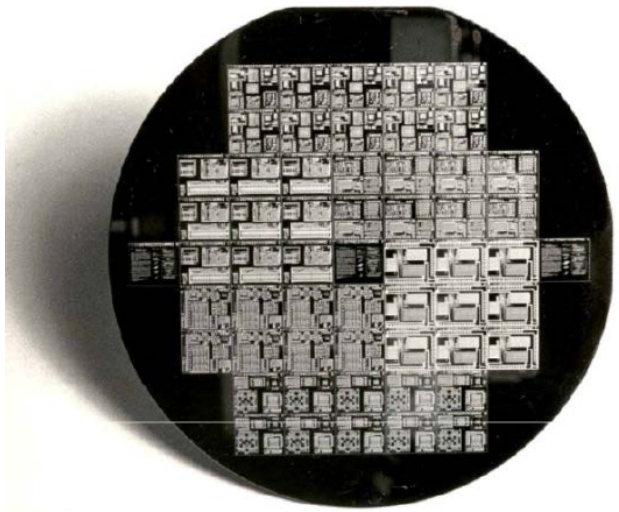


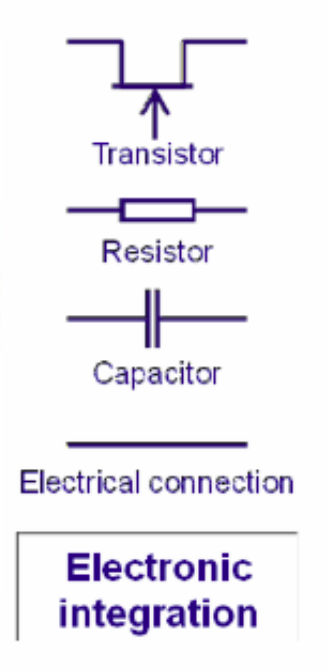
Fig.1. Left: SOA / photonic substrate integration test vehicle. Center: Assembled carrier with SOA embedded in optical underfill. Right: SEM image of cross-sectioned assembly showing the index matching epoxy between SOA and SiN waveguides.

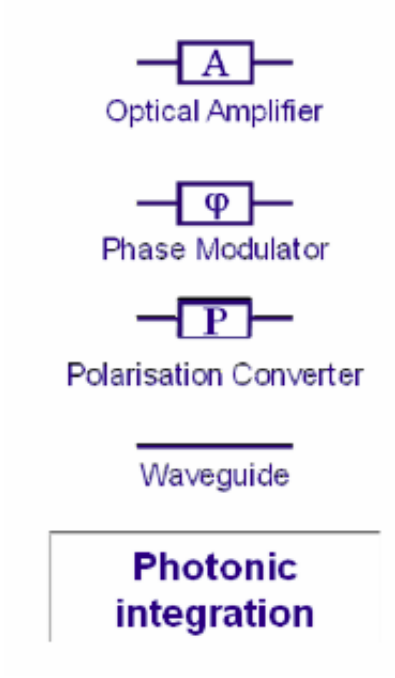
Adopt foundry model widely used with Silicon ICs to InP PICs

Like Electronics: Make Building Blocks, Separate Design from Process

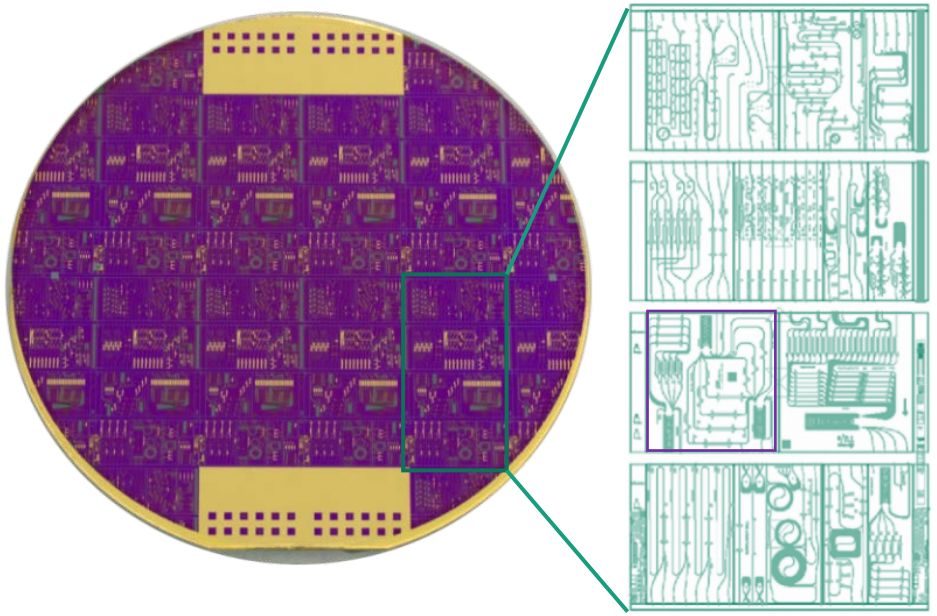
Silicon ICs ~1979





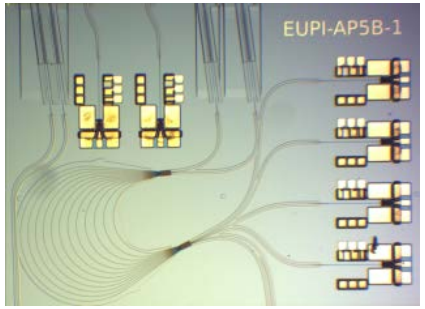


InP Photonic ICs ~2014

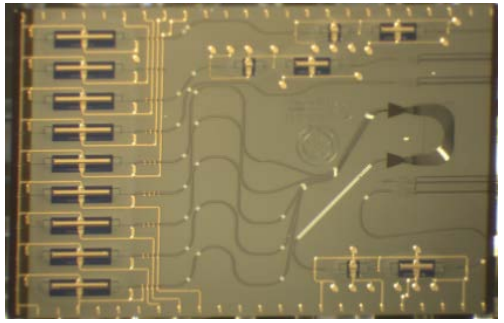


martin.schell@hhi.fraunhofer.de

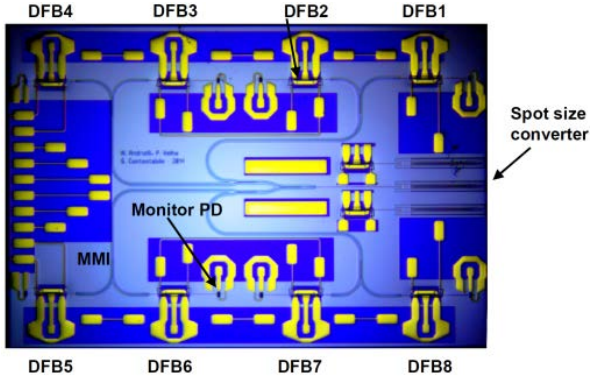
PIC Examples From Fraunhofer HHI Fab



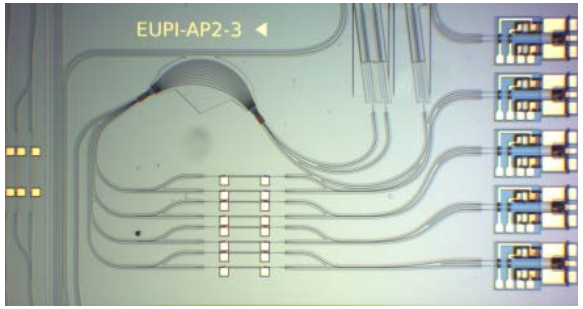
WDM receiver for FTTH
(Genexis)



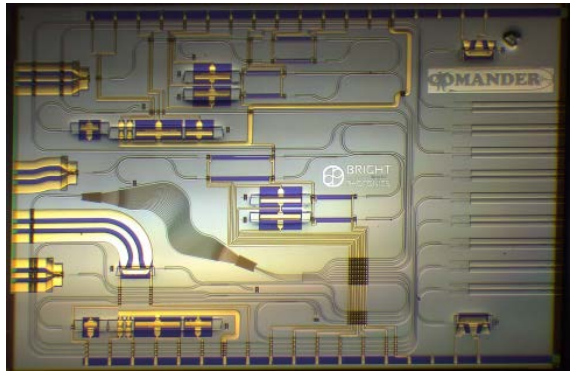
AWG-based harmonic mode-locked laser
(Chinese Acad. of Sciences)



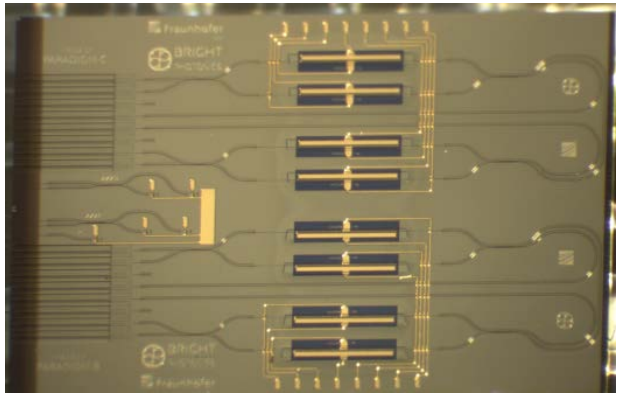
Multi-Wavelength transmitter
(Scuola Superiore Sant´Anna)



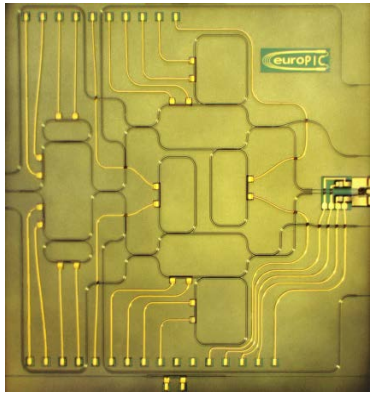
FBG-readout
(Fibresensing)



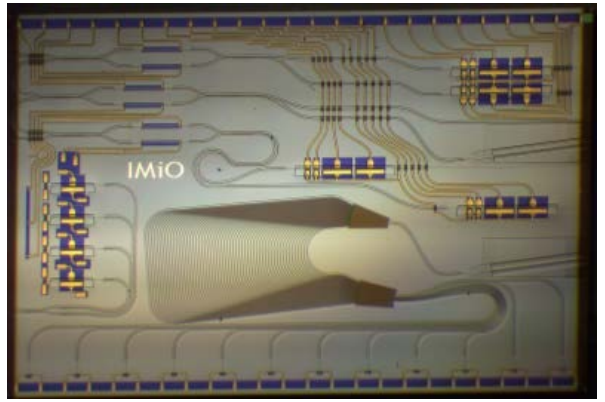
Integrated Tunable Filter
(EU Commander)



5Gb/s Optical Flip-Flop Chip
(Uni Thessaloniki)



Optical frequency discriminator
(U Valencia/VLC)



Photonic integrated interrogator
for fiber-optic sensor networks
(Uni Warsaw)

Summary

Forschungsfabrik Mikroelektronik Deutschland

InP Optochips for all communication needs – long reach to intra-datacenter

Current focus on TOR connections 500 m – 2 km

Small chip size gives volume capability even to 3” fab

Eye-safe 1.3µm..1.5µm LIDAR

Proven history in transfering ideas from TRL1 to TRL9

One of the three wordwide accessible InP Photonic Integrated Circuits foundries

Your Contact

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