Forschungsfabrik Mikroelektronik Deutschland

Fraunhofer Group for Microelectronics in Cooperation with Leibniz Institutes FBH and IHP
Photonics for the Internet and Datacenter

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

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

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

… at output, it has smeared out to ~ 1 m and overlaps with 100 others
Fourier transforming allows for Compensation but Requires Detecting Phase and Amplitude.

\[ \text{FFT} \Rightarrow e^{iD\omega^2} \Rightarrow \text{IFFT} \]
InP monolithic QPSK receiver

\[ \text{λ-DFB} \rightarrow 90° \text{ Hybrid} \rightarrow 0° \quad 90° \quad 180° \quad 270° \]

50G balanced PD
50G pre amp

demux/ clock rec.

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

\[ \Delta \phi = 0\text{deg} \]

\[ \Delta \phi = 180\text{deg} \]

\[ \Delta \phi = 90\text{deg} \]

\[ \Delta \phi = 270\text{deg} \]
HHI’s target: Intra Datacenter
In Datacenters, ‘normal’ Lasers Compete Well: One single 3” InP Laser wafer can transport the internet

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

About 20,000 chips per 3” wafer, 56 GBit/chip
A single InP 3” Wafer can support 3 ZB/year
Single Laser supports 100 Gb/s on/off

100Gb/s Optical Signal

10km
Farer future: Optical Switch Matrices
1.6 Mio Cores to be Connected

620,000 VCSELs/fibers
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

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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
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

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 transferring ideas from TRL1 to TRL9

One of the three worldwide accessible InP Photonic Integrated Circuits foundries
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