High Speed Detectors

Andreas Umbach

ECOC 2009, Workshop 7

Monolithic and Hybrid Photonic Integrated Transceivers for Advanced Modulation Formats

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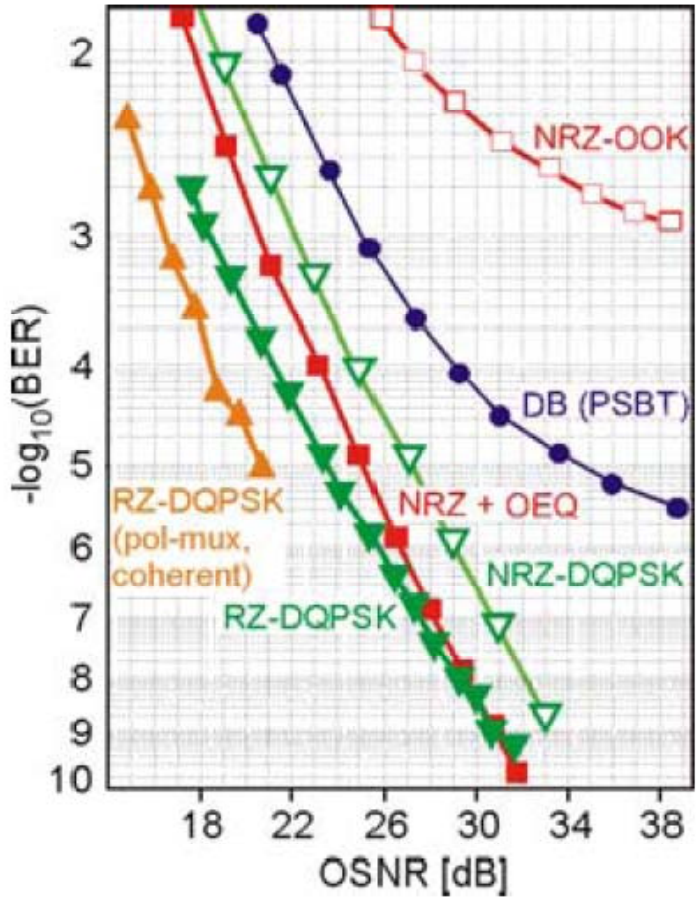
100 Gbit/s Long-Haul Transport

Optical networks use "standardized" optical transmission lines, i.e. 50 GHz channels of 10 Gbit/s DWDM systems and ROADMs



Back-to-back BER comparison for 100 Gbit/s modulation formats

→ PolMux DQPSK with coherent detection gives best OSNR performance

(Source: G. Raybon, P. Winzer, Alcatel-Lucent, ECOC 2007)

100G Hardware Complexity

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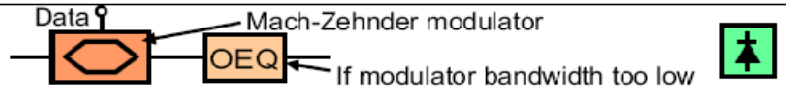
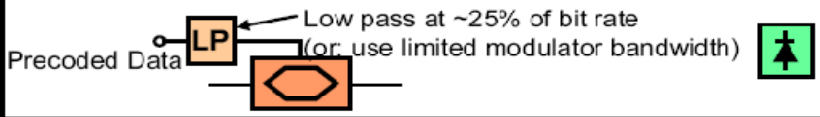
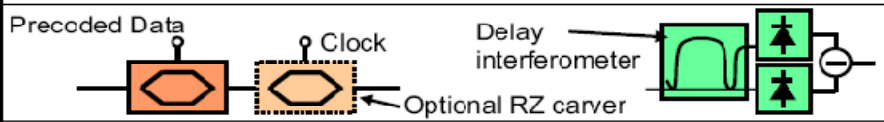
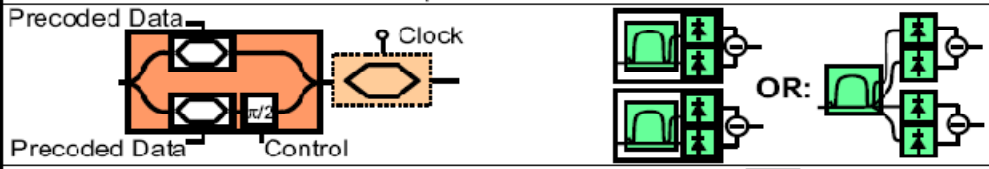
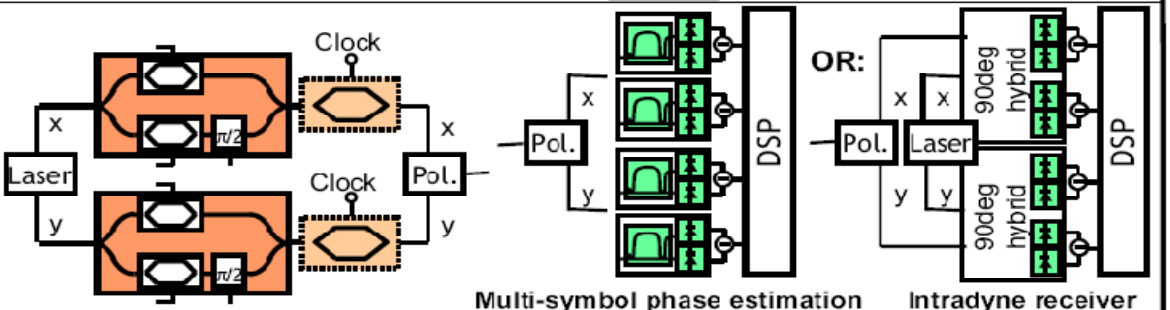
Transponder hardware comparison (prominent 100G options)

Modulation format	TX Hardware complexity RX
NRZ-OOK	
Duobinary	
(RZ-)DPSK	
(RZ-)DQPSK	
Polarization-mux'ed QPSK w/ coherent RX	

"System intelligence" has to be built into the optoelectronics,

→ higher value creation AND higher cost of the components

Integration Imperative

- Phase and polarisation information has to be maintained in the entire receive path

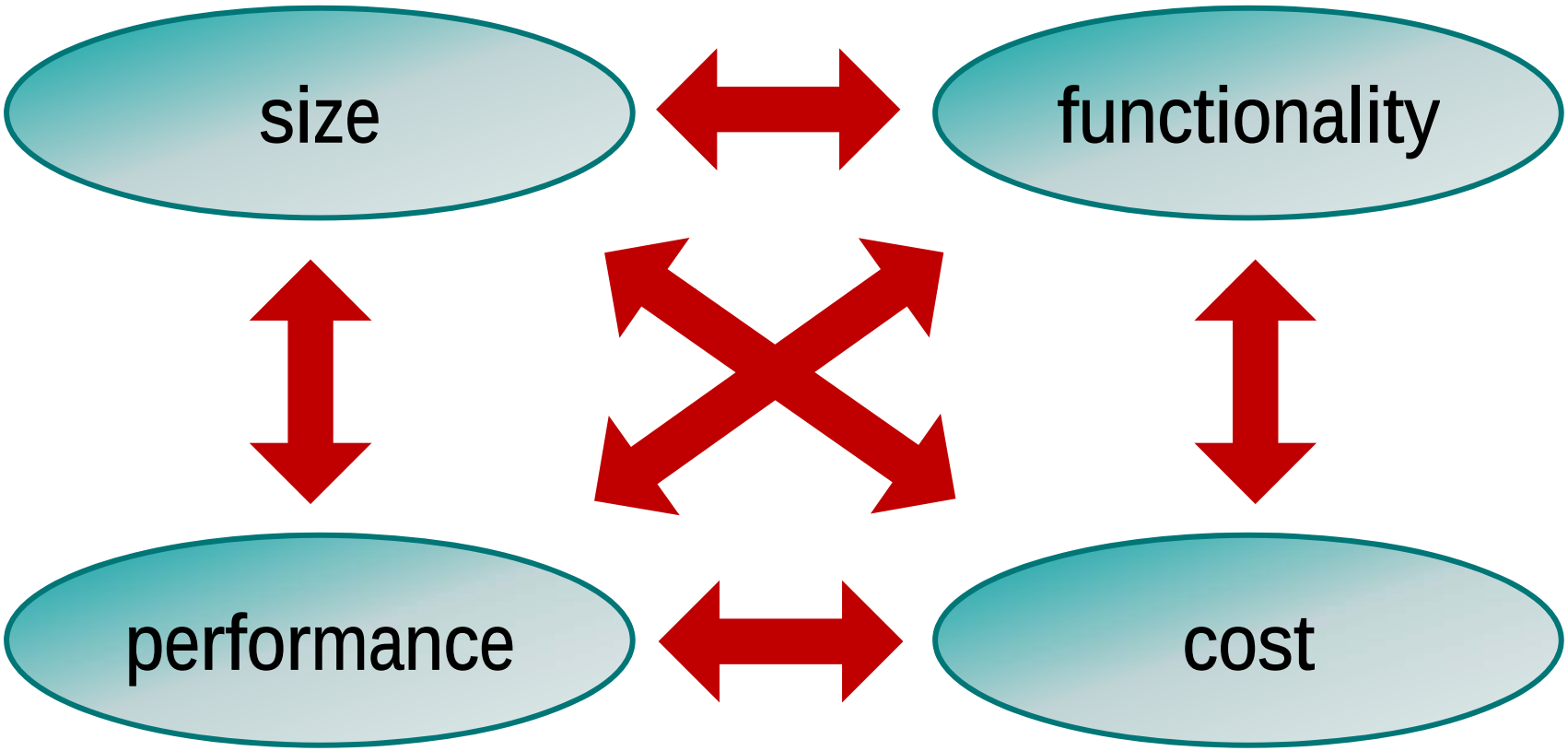
→ skew control makes use of fibers problematic

- Development of long-haul transceiver modules (300pin MSA)

→ miniaturisation becomes major issue

- Integration is required for <u>functionality</u>

Challenges for Integration



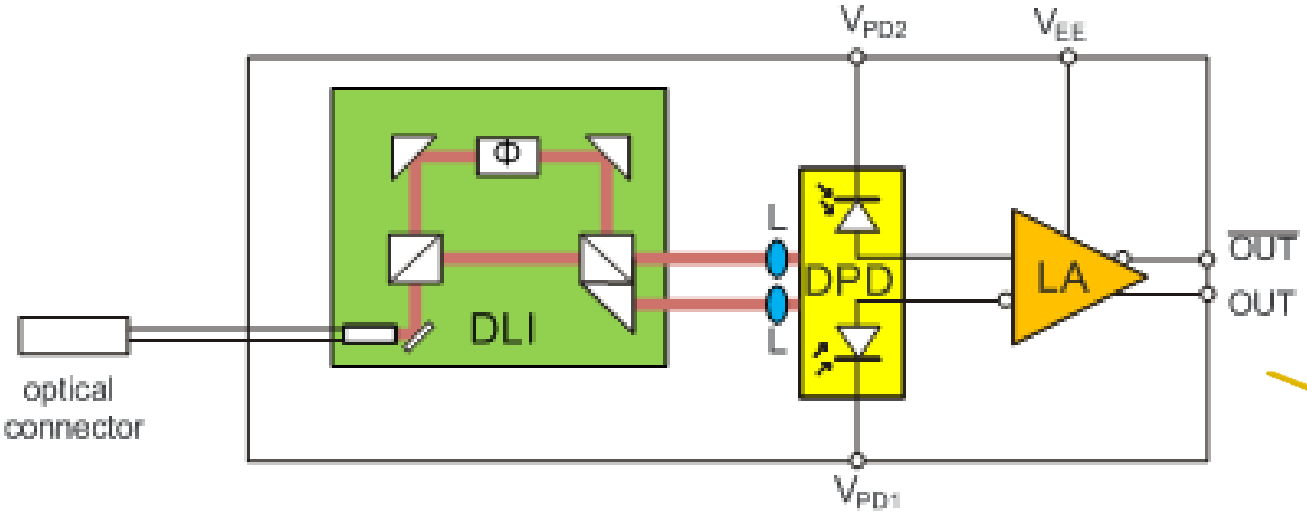
→ many options, but not so many solutions

Market Requirements

- **Sufficient Performance**
  - High speed
  - Good sensitivity
  - High functionality
- **High Reliability**
  - Long lifetime
  - Robustness
  - Zero failures
- **Low Cost**
  - High yield, limited complexity
  - Small chip size
  - Low power consumption

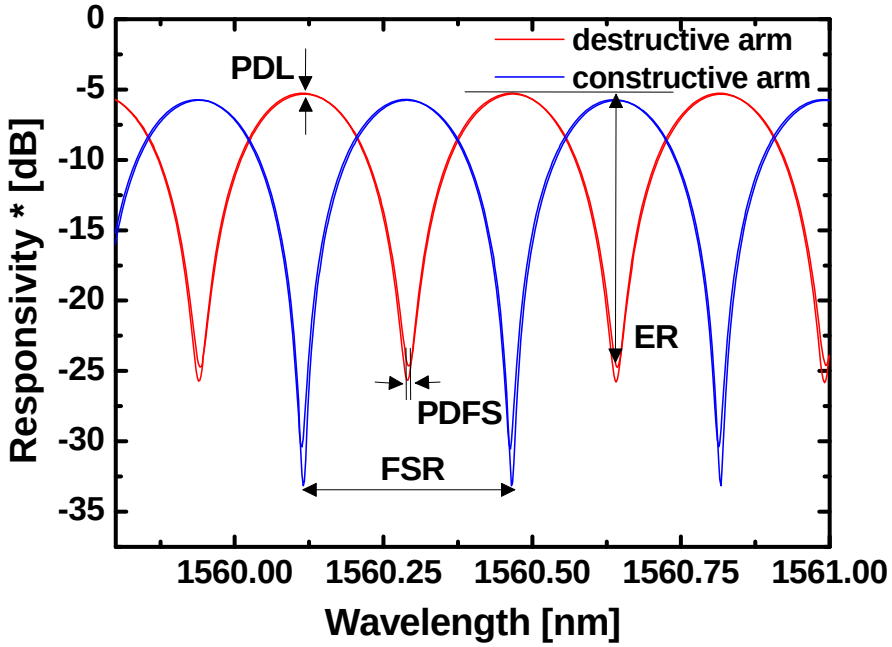
These are the goals of Photonic Integration

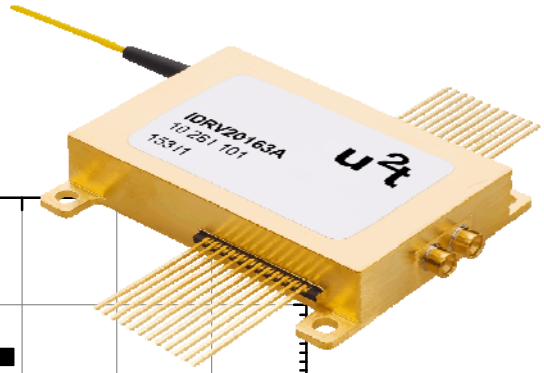
DPSK-Rx with Free-Space Optics

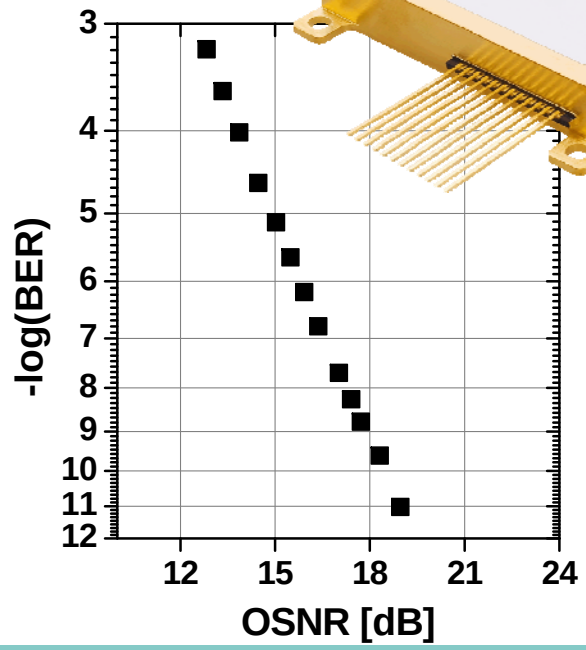


Responsivity [dB]
= 10*LOG (R [A/W] / 1A/W)

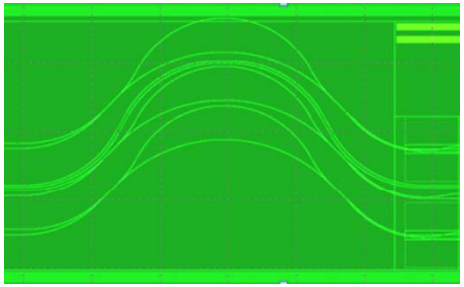
* -5dB equals 0.32 A/W



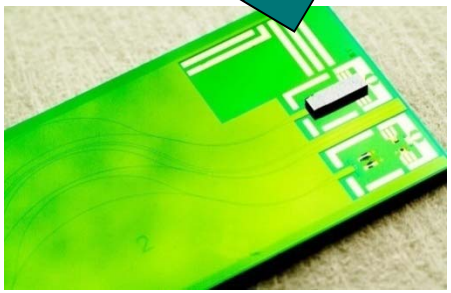




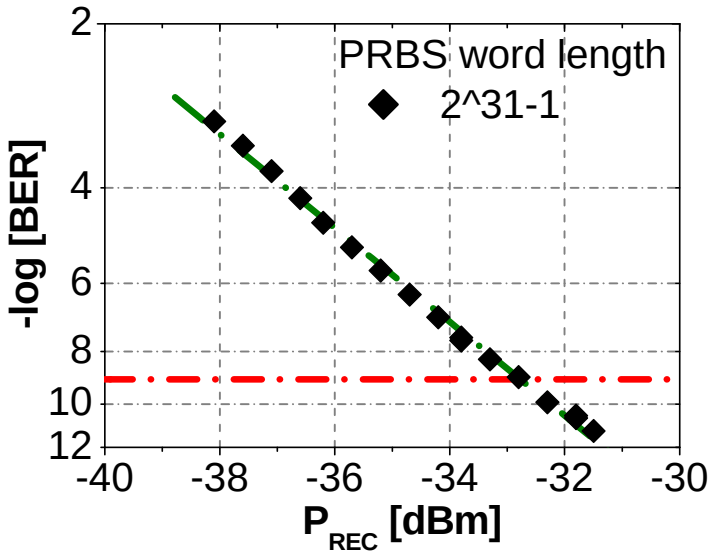
Hybrid Integrated DPSK Receiver

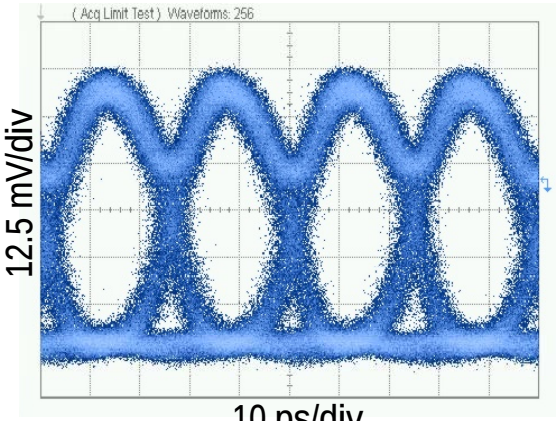


flip-chip BPD



SOI – DLI and integration platform





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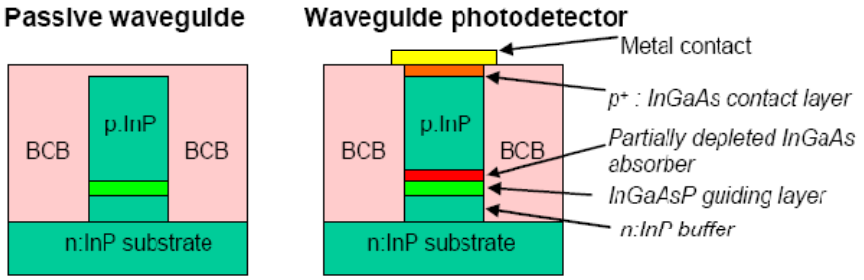
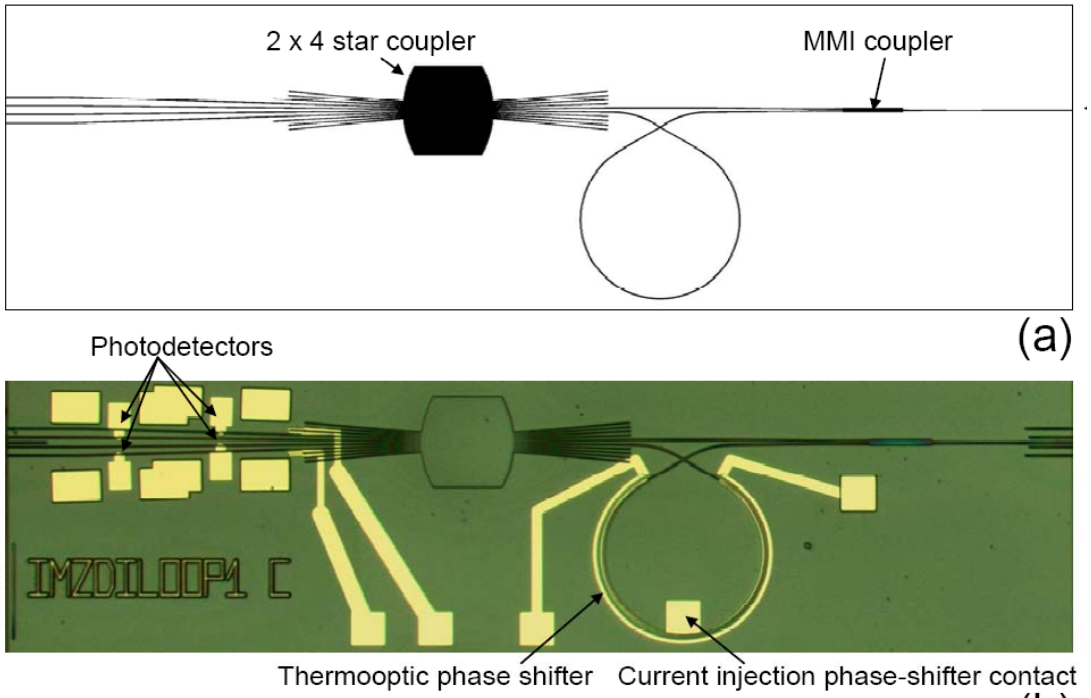
Monolithic InP DQPSK 53.5-Gb/s receiver

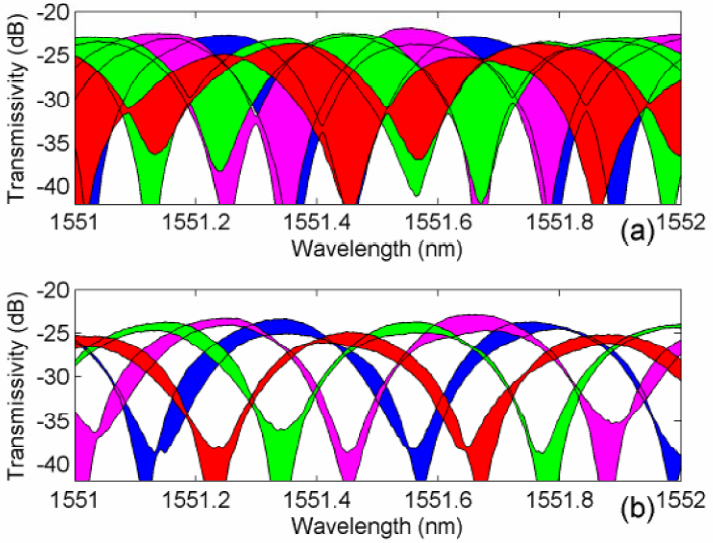


Monolithic integration on InP

→ small size



polarization dependent frequency shift compensated by current-controlled phase shifter



C. R. Doerr et al., PDP ECOC 2007, Berlin, Germany

Bell Laboratories, Alcatel-Lucent, Holmdel, NJ, USA

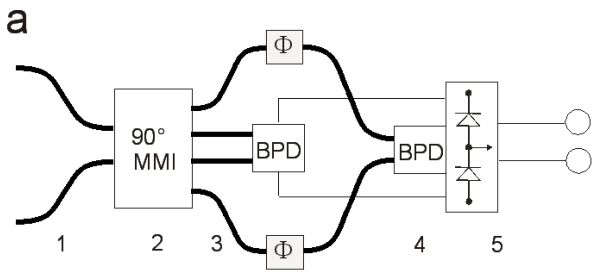
u²t photonics

more results: ECOC2009, Poster P3.20, Wednesday

Coherent Detection of a 50 Gb/s QPSK Signal Using an InP 90°Hybrid Monolithically Integrated with Balanced Photodetectors

R. Ludwig(1), A. Matiss(2), H.-G. Bach(1), L. Molle(1), C.C. Leonhardt(2), R. Kunkel(1), D. Schmidt(1)

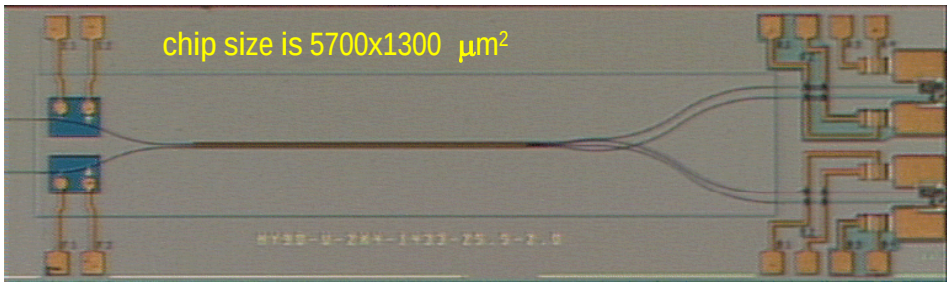
FhG-Heinrich-Hertz-Institut, u²t Photonics AG



Fiber taper

Connecting waveguides including fine tuning Φ

Electrical termination



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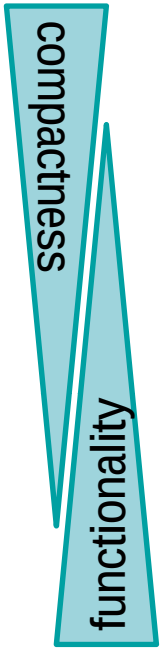
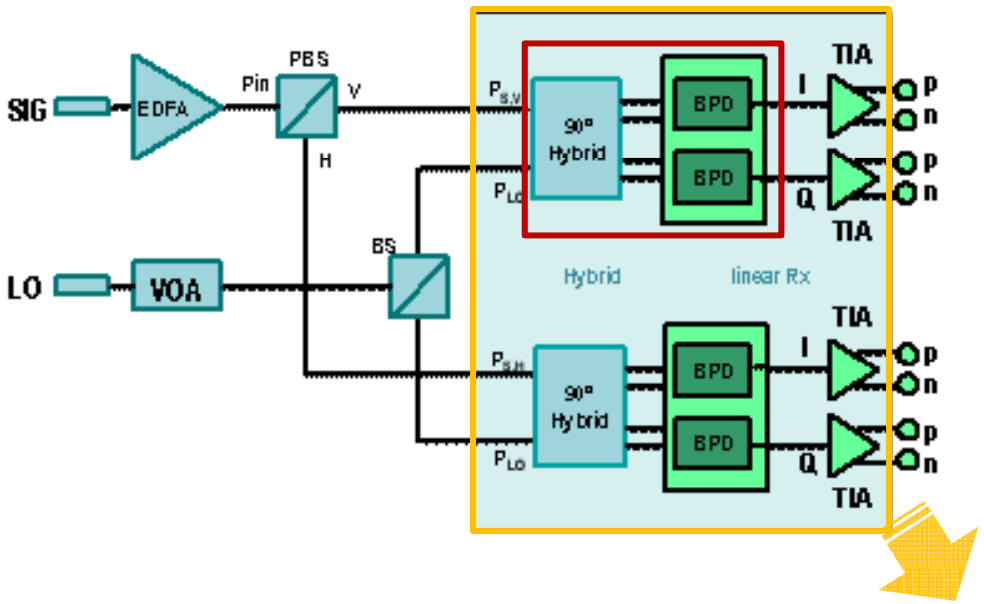
90° hybrid receiver comprising a 2x4 MMI with tapered input waveguides and two pairs of balanced detectors

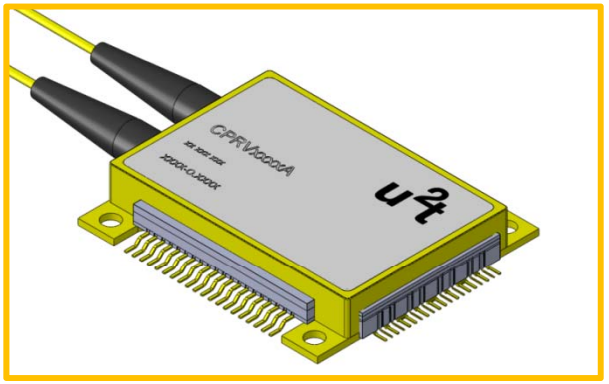
Integrated 100 Gbit/s Coherent Rx





- 90°-hybrid with balanced photodiodes on InP
- Dual-polarization linear coherent receiver

Compact Coherent Receiver (CCRx) MSA
Picometrix, u²t Photonics



Integration Options

- Free-space optics and direct coupling to optical devices
- Planar optics (SiO_2, SOI, Polymers), hybrid integration
- Integration on GaAs
- Monolithic integration on InP

figures of merit:

chip size, chips/wafer
wafer size, cost/wafer
yield (process maturity)

→ figures will change with time

AND with investment !
(When will we have 6-inch InP wafers?)
Who pays for the component level innovation?

The Future Might Look Easy

One material system might suite all

- Everything on Si
- Everything on InP
- Everything on whatever…

→ standardisation

→ large volumes

→ low cost

→ very few suppliers

BUT: I don't believe it !!

My Crystal Ball

- Transmission capacity increase by
  complex multilevel modulation formats
  at 40..56 Gbaud at most (DP-QPSK, X-QAM, OFDM, …)
- Components will have to modulate and detect
  all optical signal properties of the photons:
  intensity, phase, polarisation, wavelength
- One transmitter and receiver architecture each could fit all applications, but:
  performance will still depend on application
  (cost, reach, density, …)
- Different requirements of different markets will lead to a
  variety of solutions and technologies

Thank you
for your kind attention!

Questions?

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