Karlsruhe Institute of Technology

Perspectives of optical data transmission

Institute for Data Processing and Electronics

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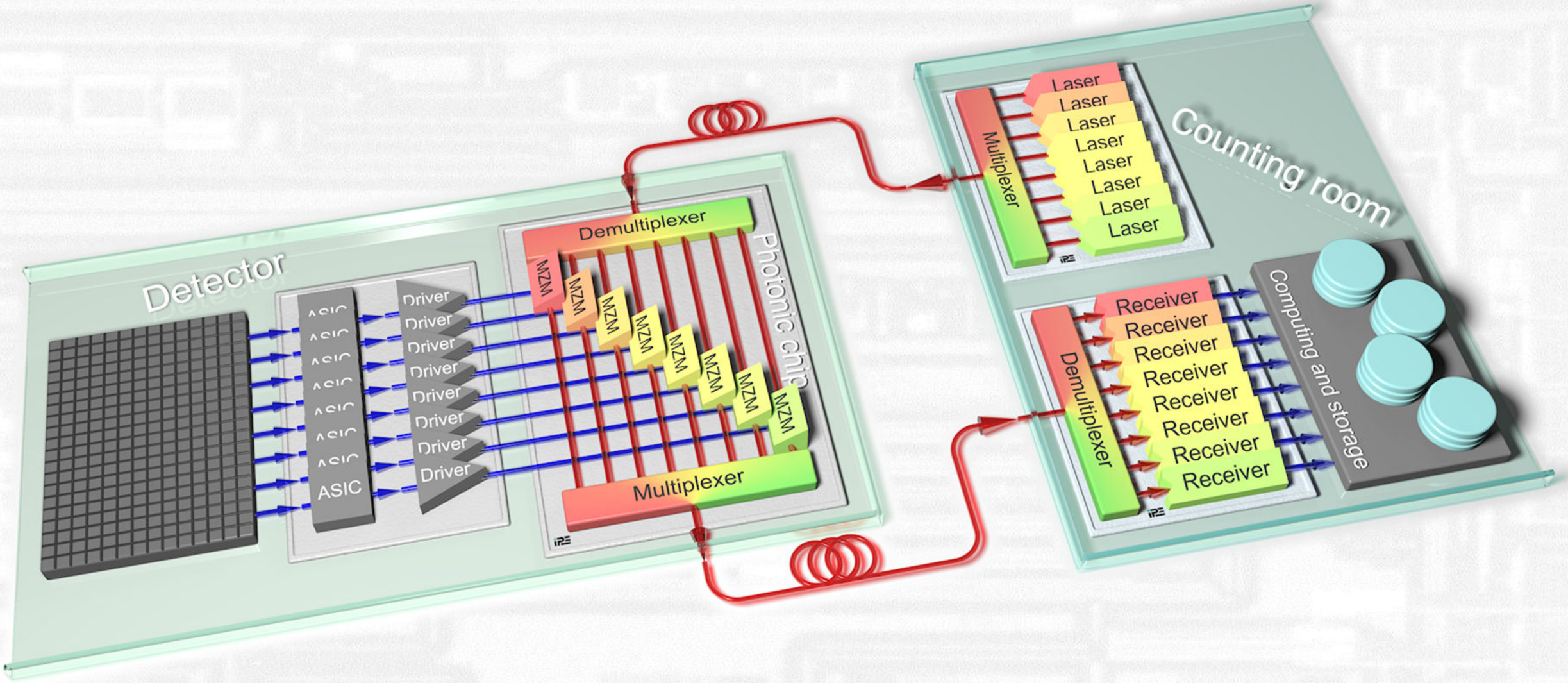
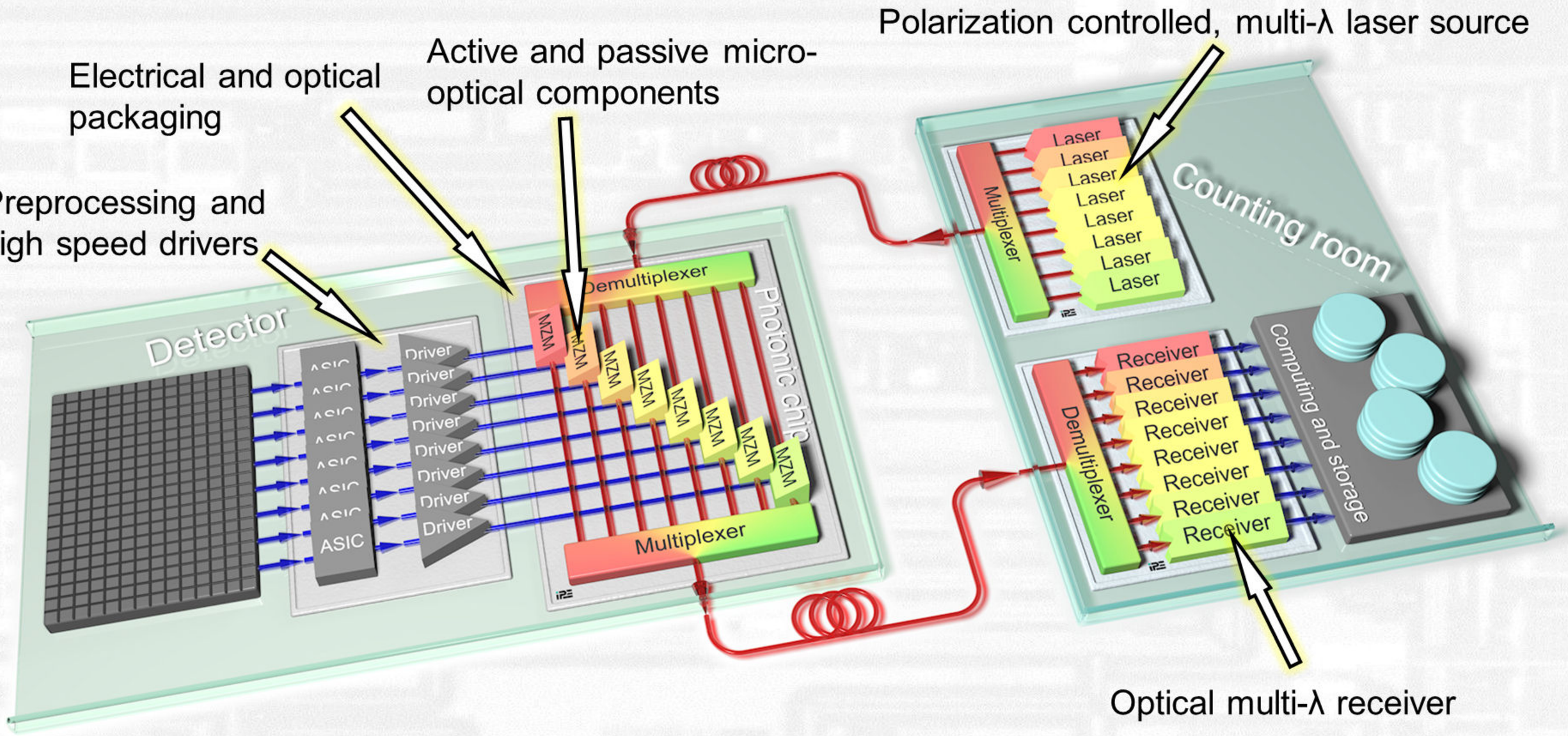
2017-02-01

Optical Data Transmission System

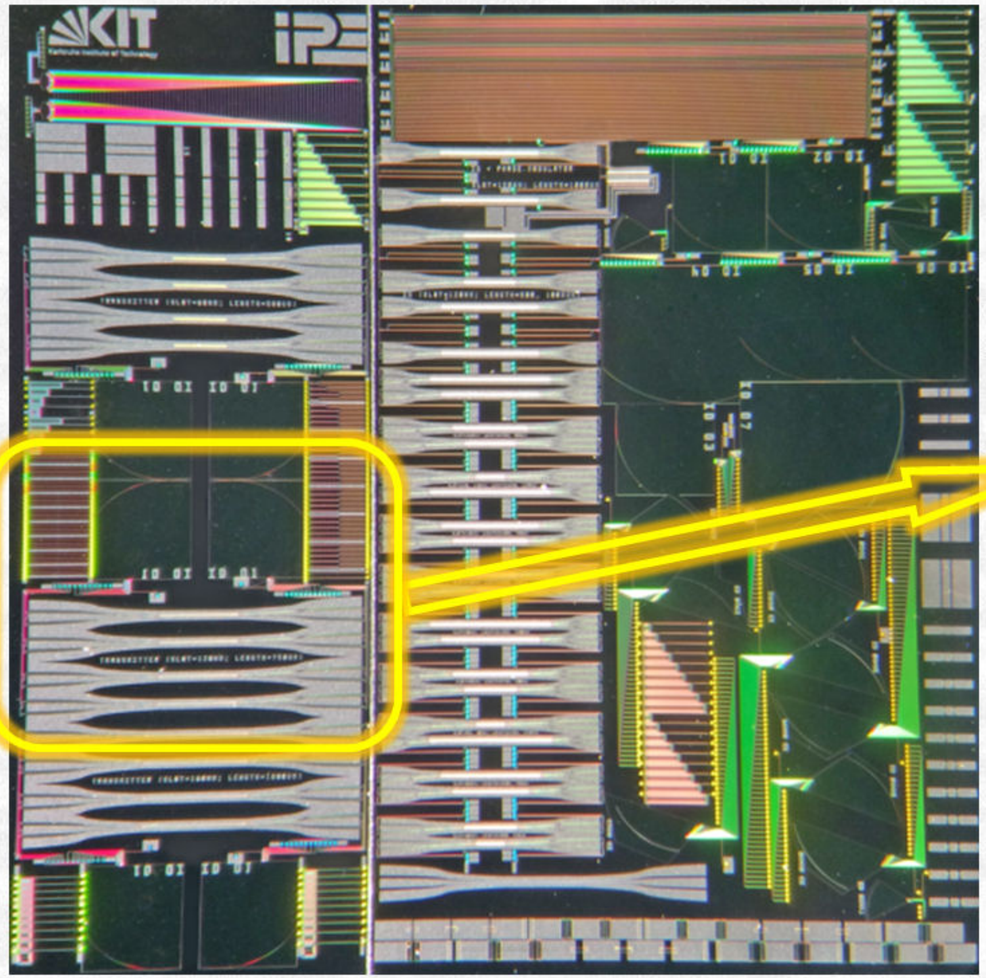


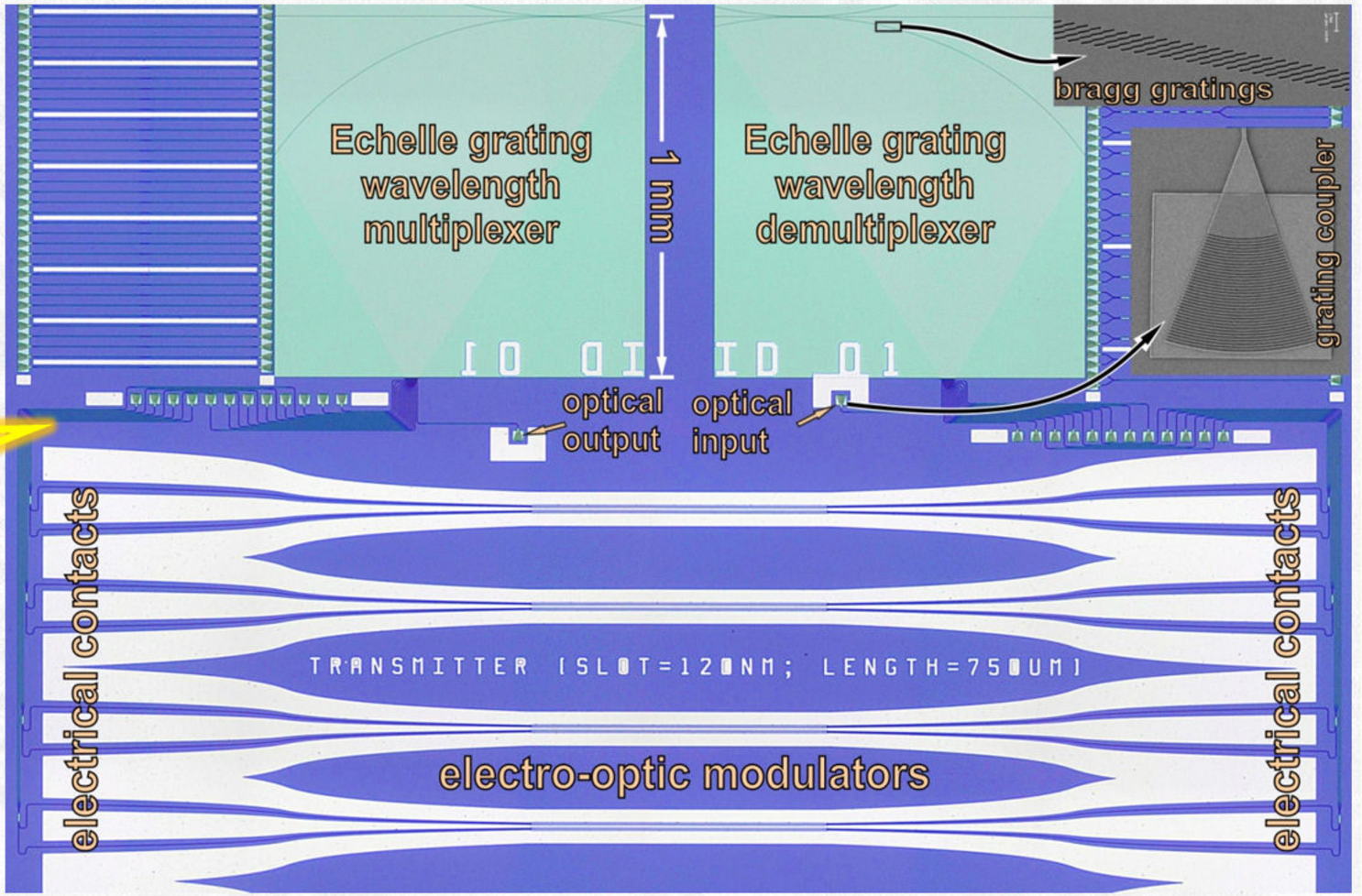
Optical Data Transmission System



Optical Data Transmission System

Our first photonic system chip:

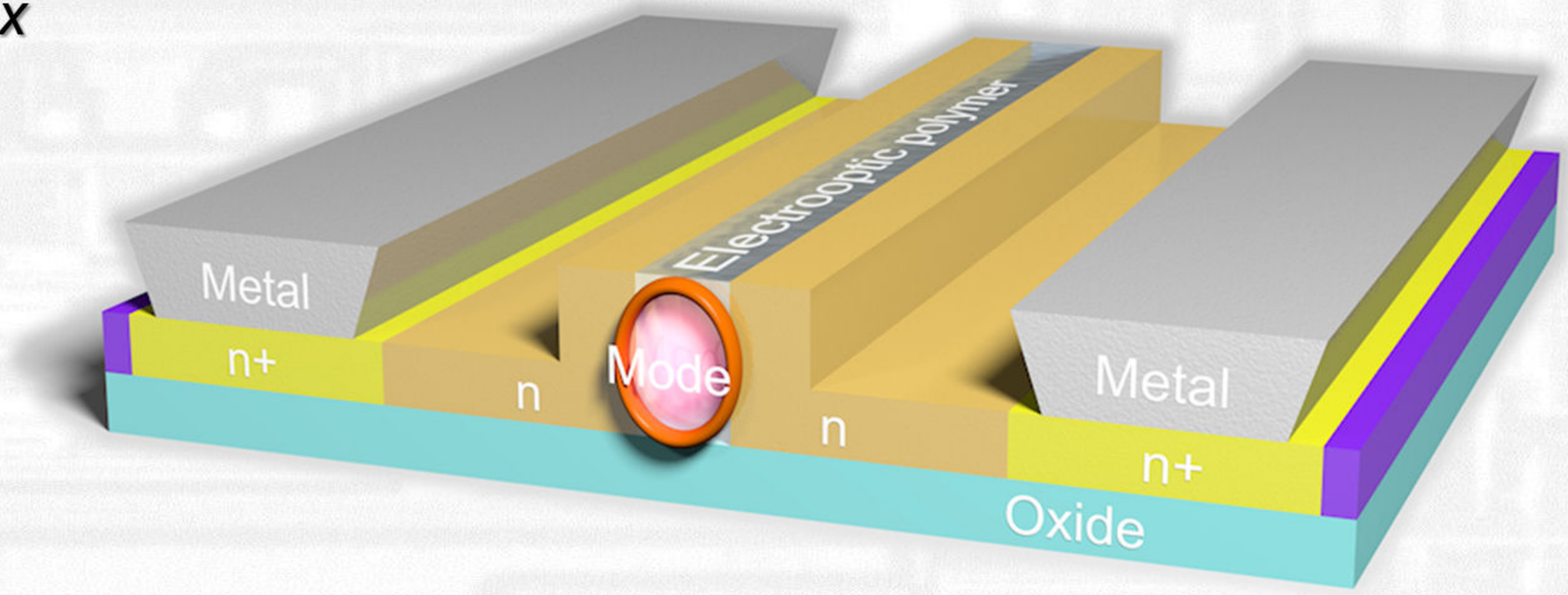




SOH-Modulators

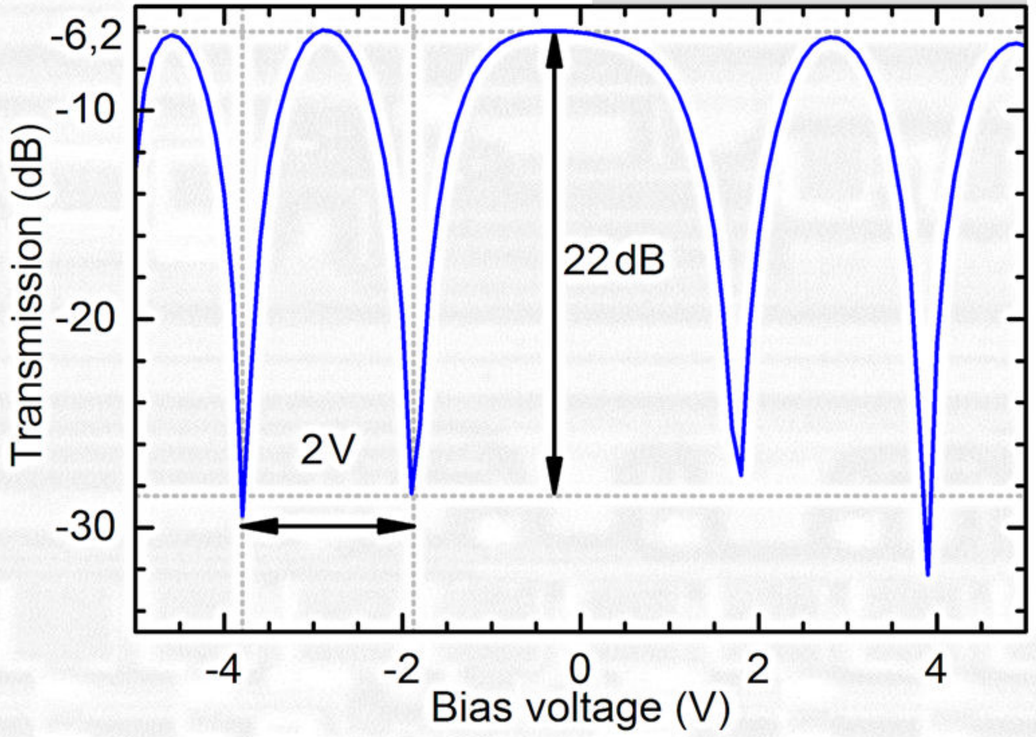
Silicon-organic hybrid (SOH) modulator:

- *Passive silicon slot waveguide filled with electro-optic polymer*
- *Electric field in polymer changes refractive index*
- *Phase modulation*

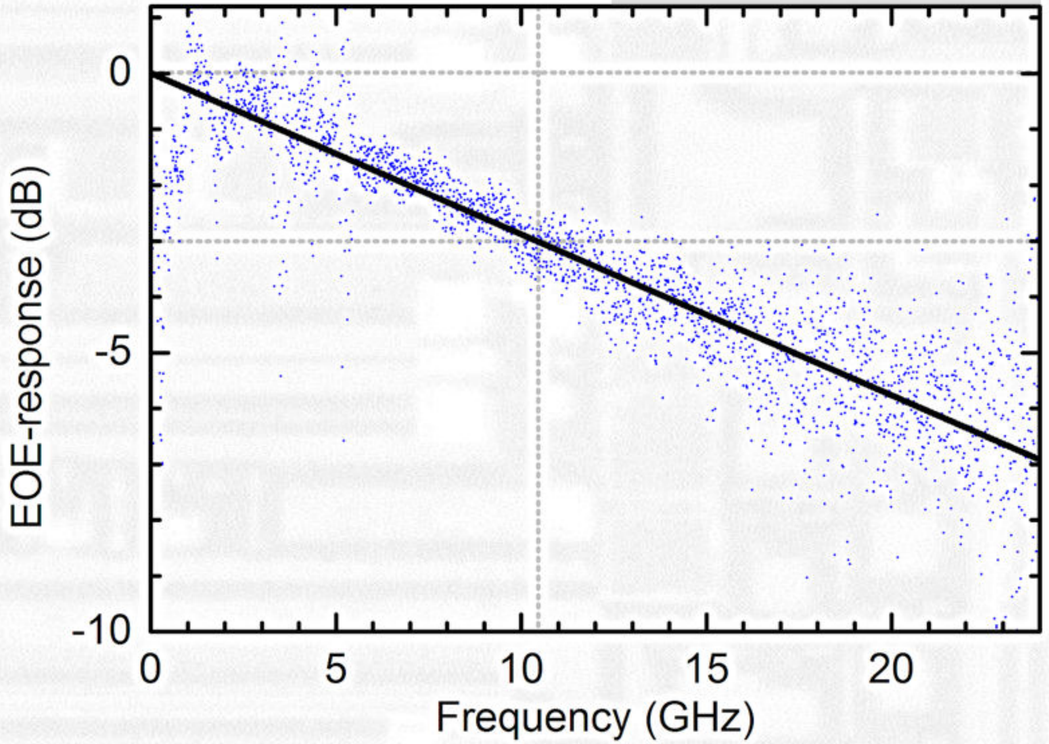


SOH-Modulators

DC characteristics



RF characteristics



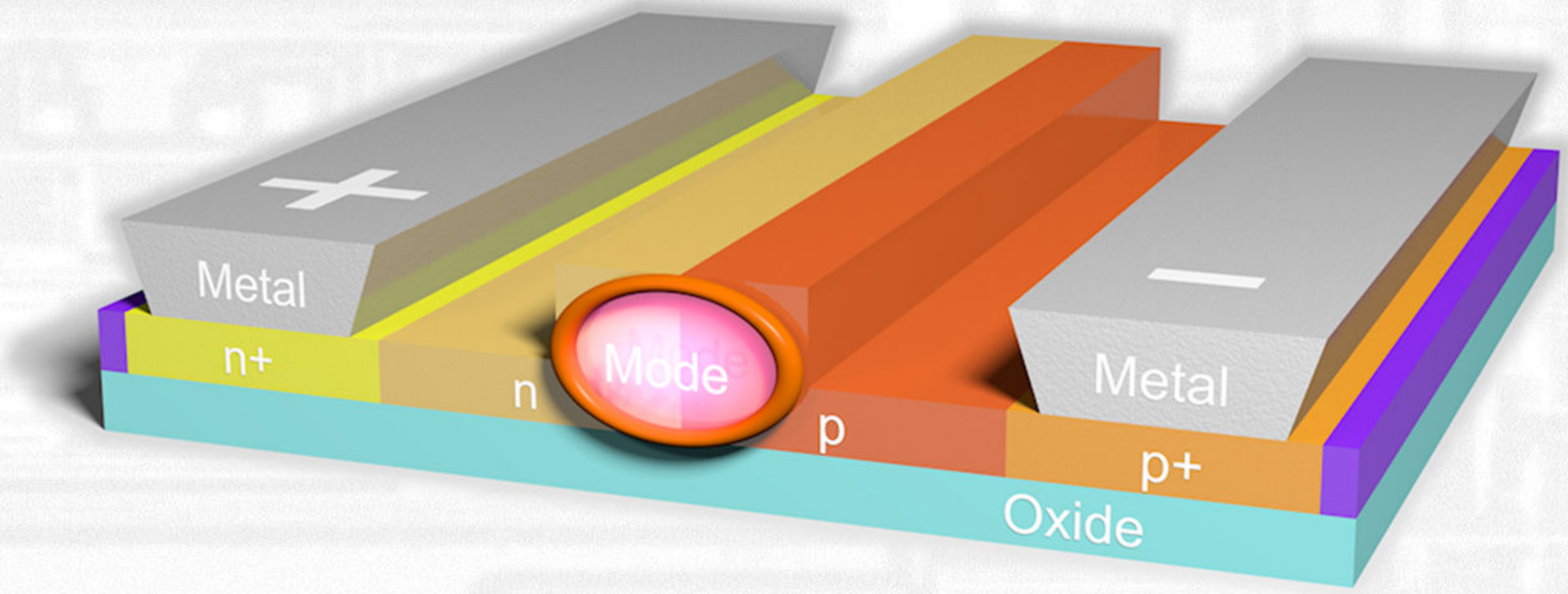
- *Good initial performance*
- *Strong degradation*
- *Low yield*

} *Unsuitable for demonstrator system ⇒ pn-modulators*

pn-Modulators

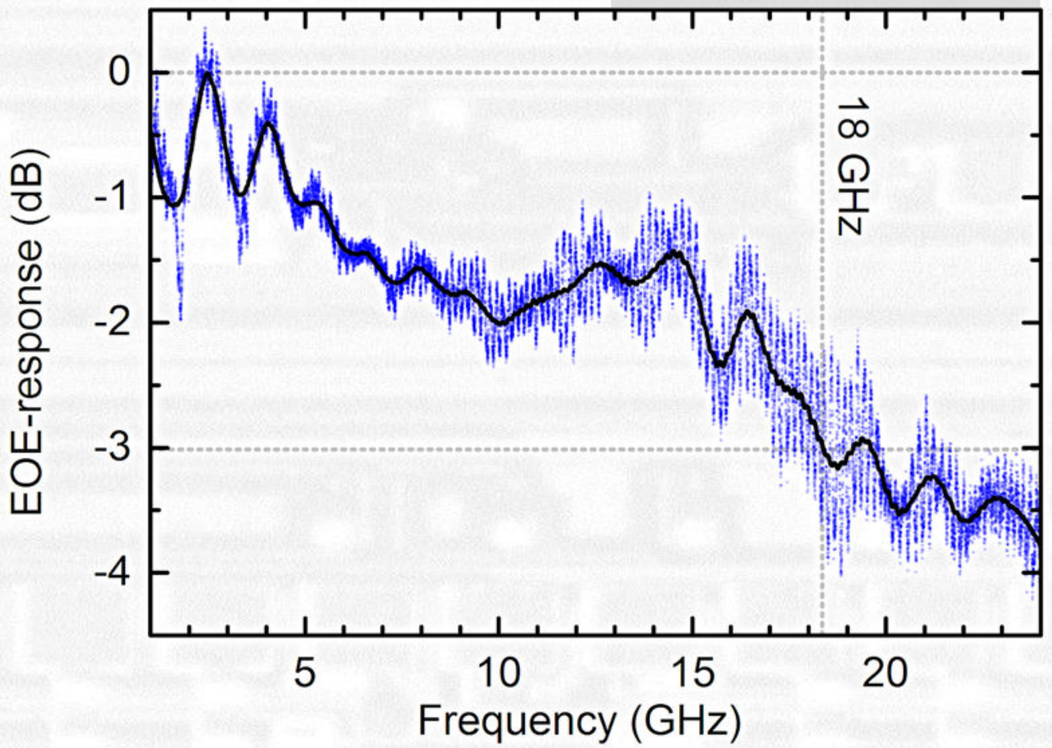
Depletion type pn-modulator:

- *pn-junction in optical waveguide*
- *Refractive index change by free carrier depletion in the waveguide*
- *Phase modulation*

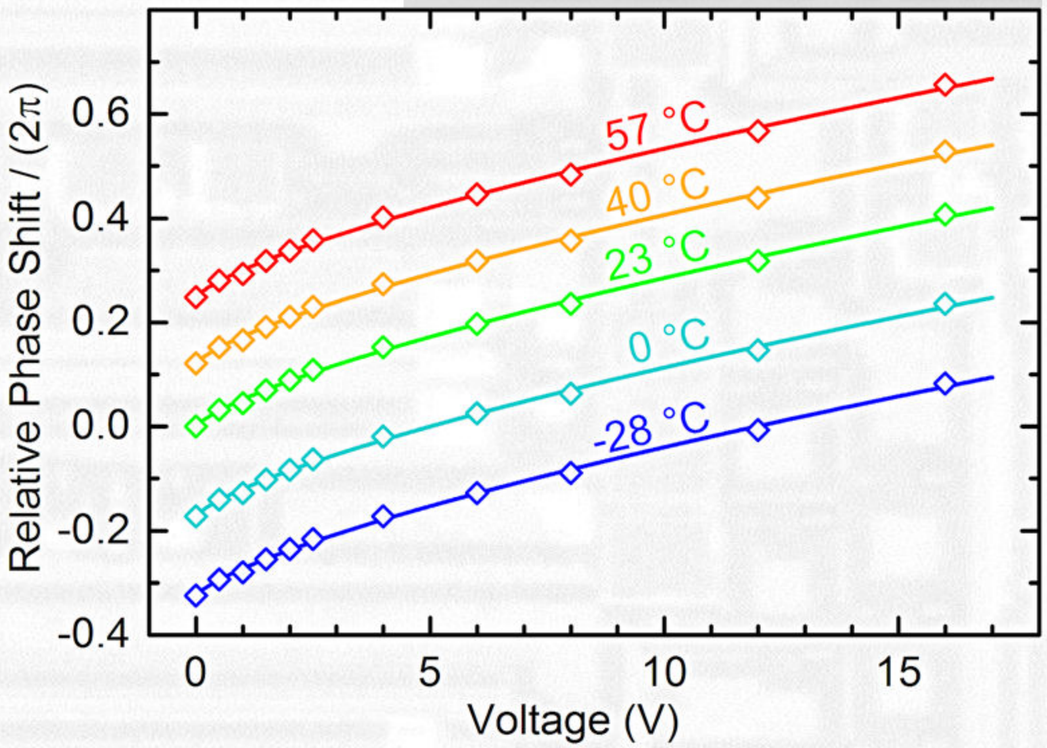


pn-Modulators

RF characteristics



Temperature characteristics



- *Good performance*
- *Long term stable*
- *Radiation hard*

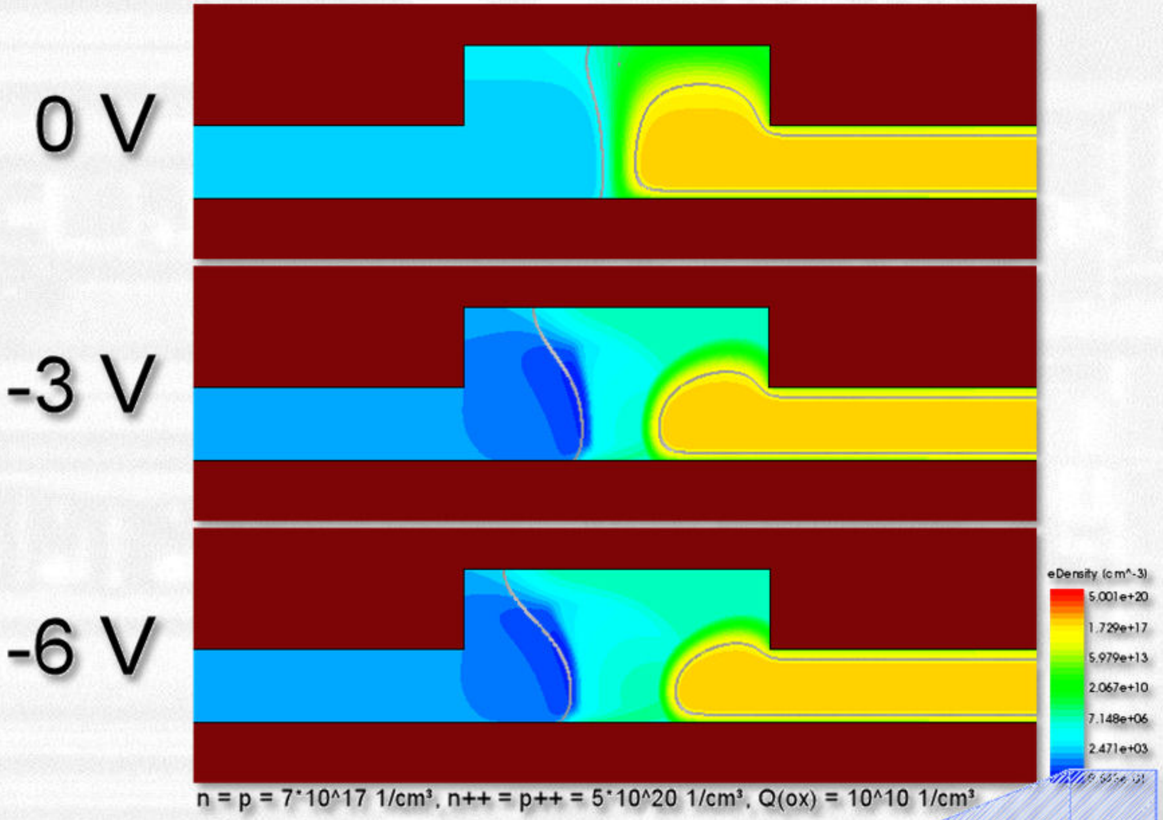
First choice for demonstrator system

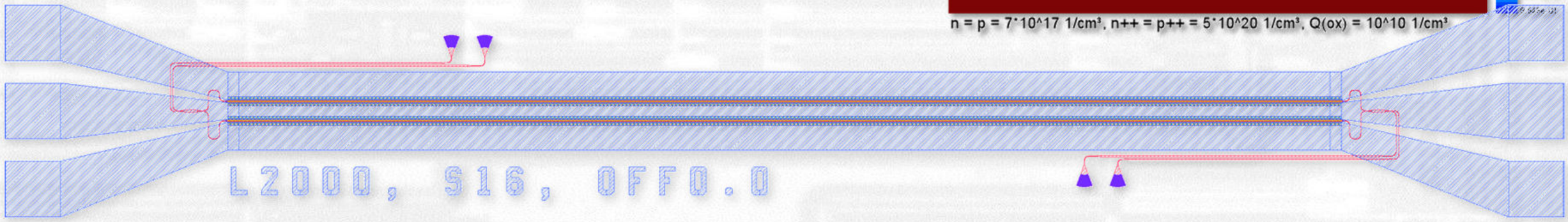
pn-Modulators

Former supplier of layouts out of business, copyright and licensing unclear

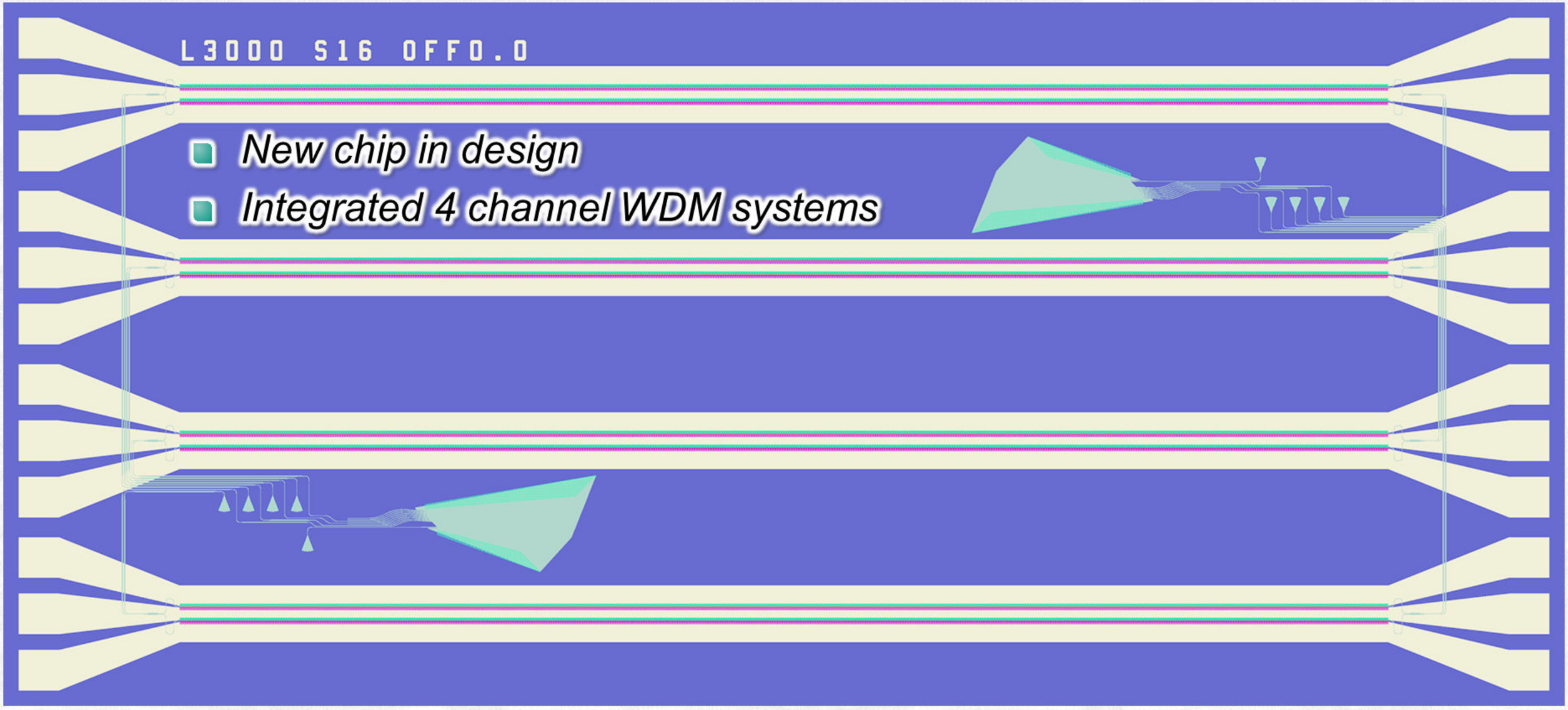
⇒ Own Mach-Zehnder-Interferometer modulators utilizing pn-phase-modulators

- *Geometry design*
- *Electrical and optical simulation*





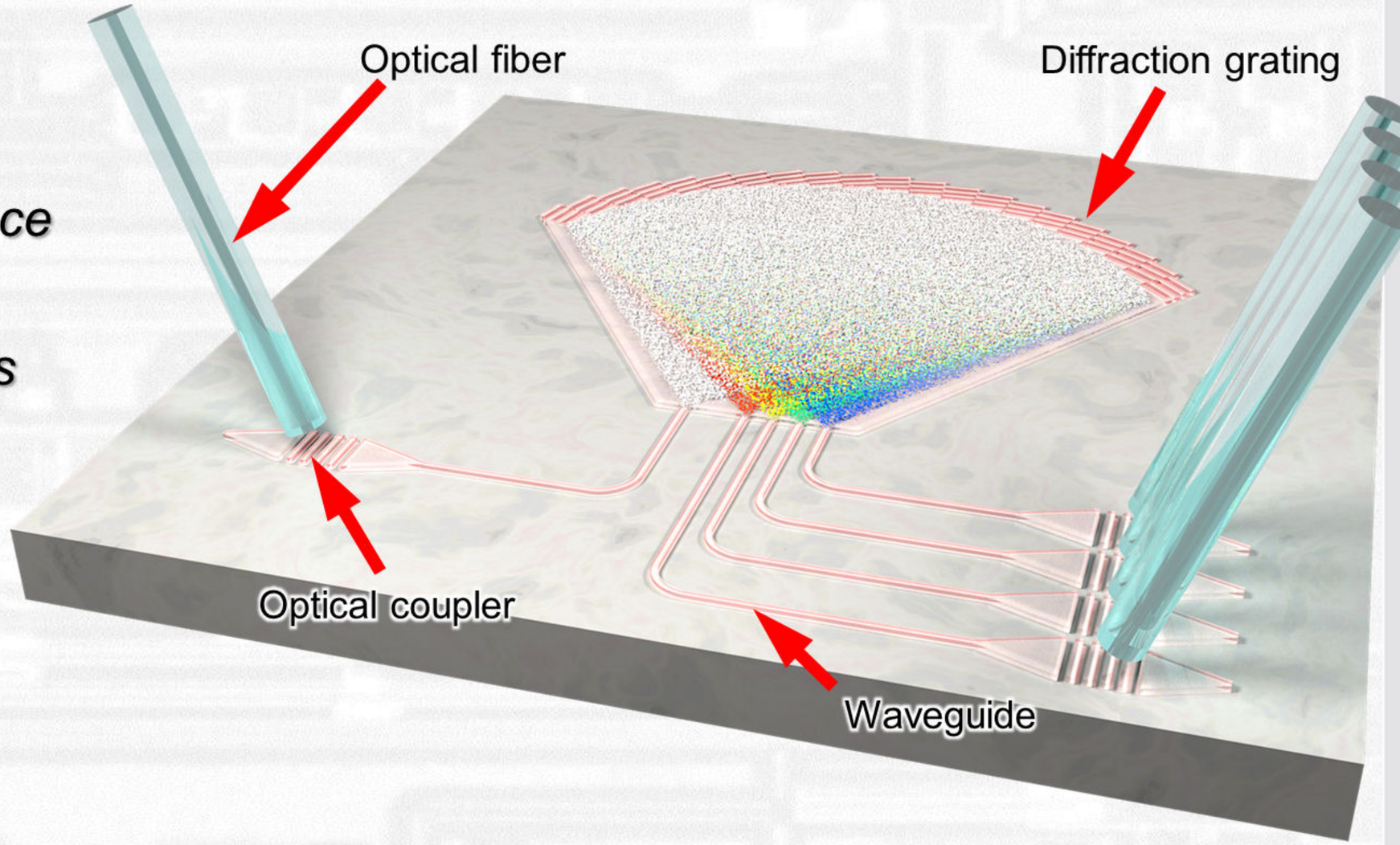
pn-Modulators



Wavelength Division Multiplexers

Planar Concave Gratings (PCG): Echelle gratings

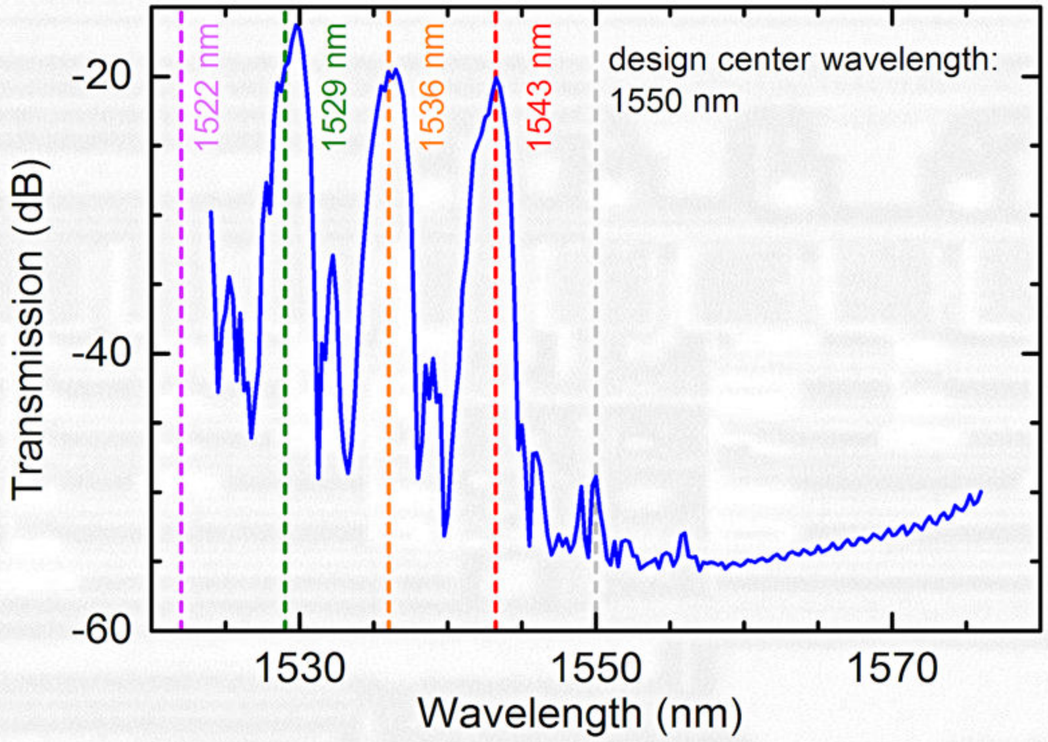
- *Multi-λ input signal diverges in 2D-free-space region*
- *Concave grating reflects and focuses optical radiation depending on wavelength*

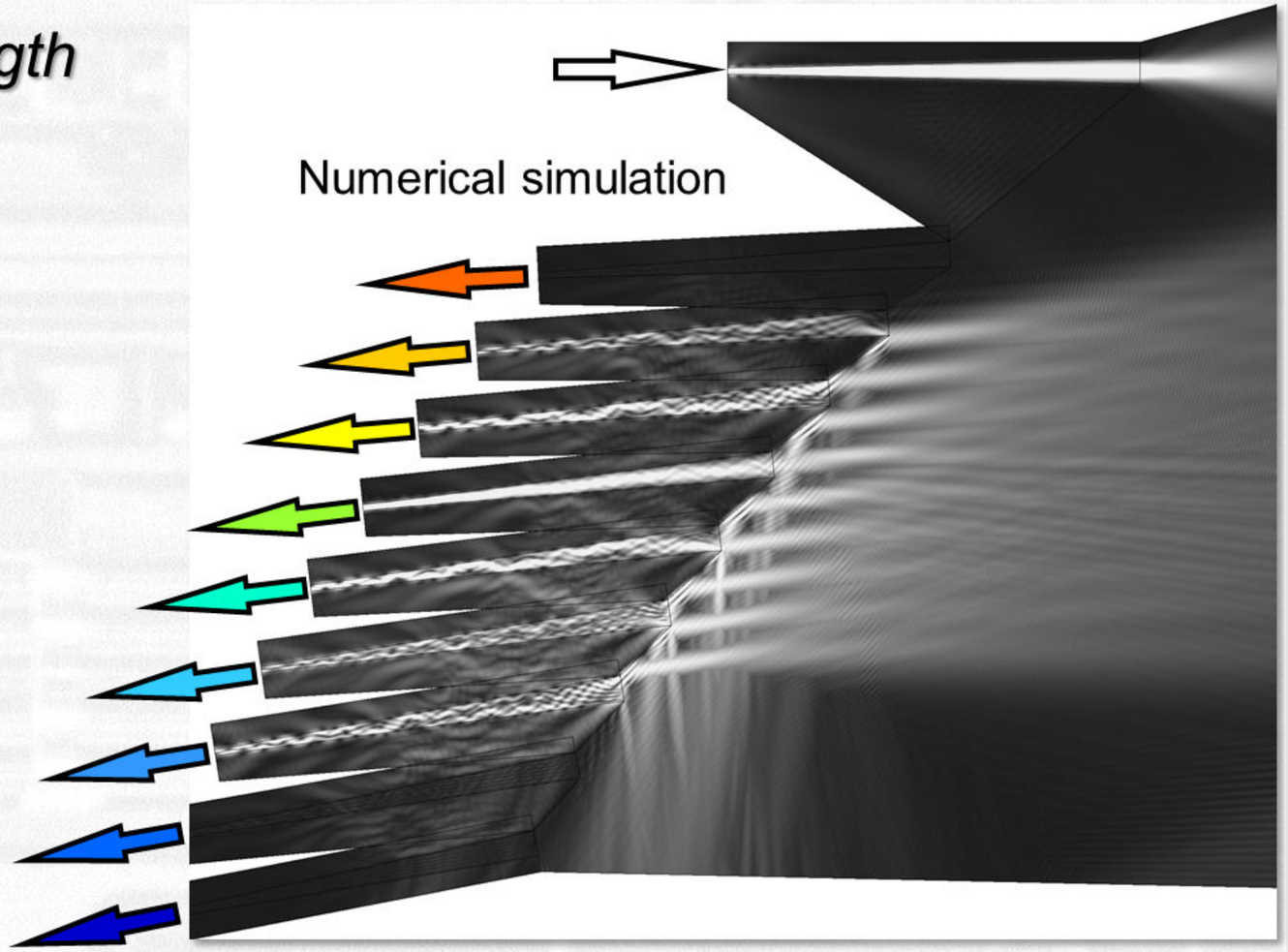


Wavelength Division Multiplexers

Before fixing:

- *Channel spacing and center wavelength incorrect*

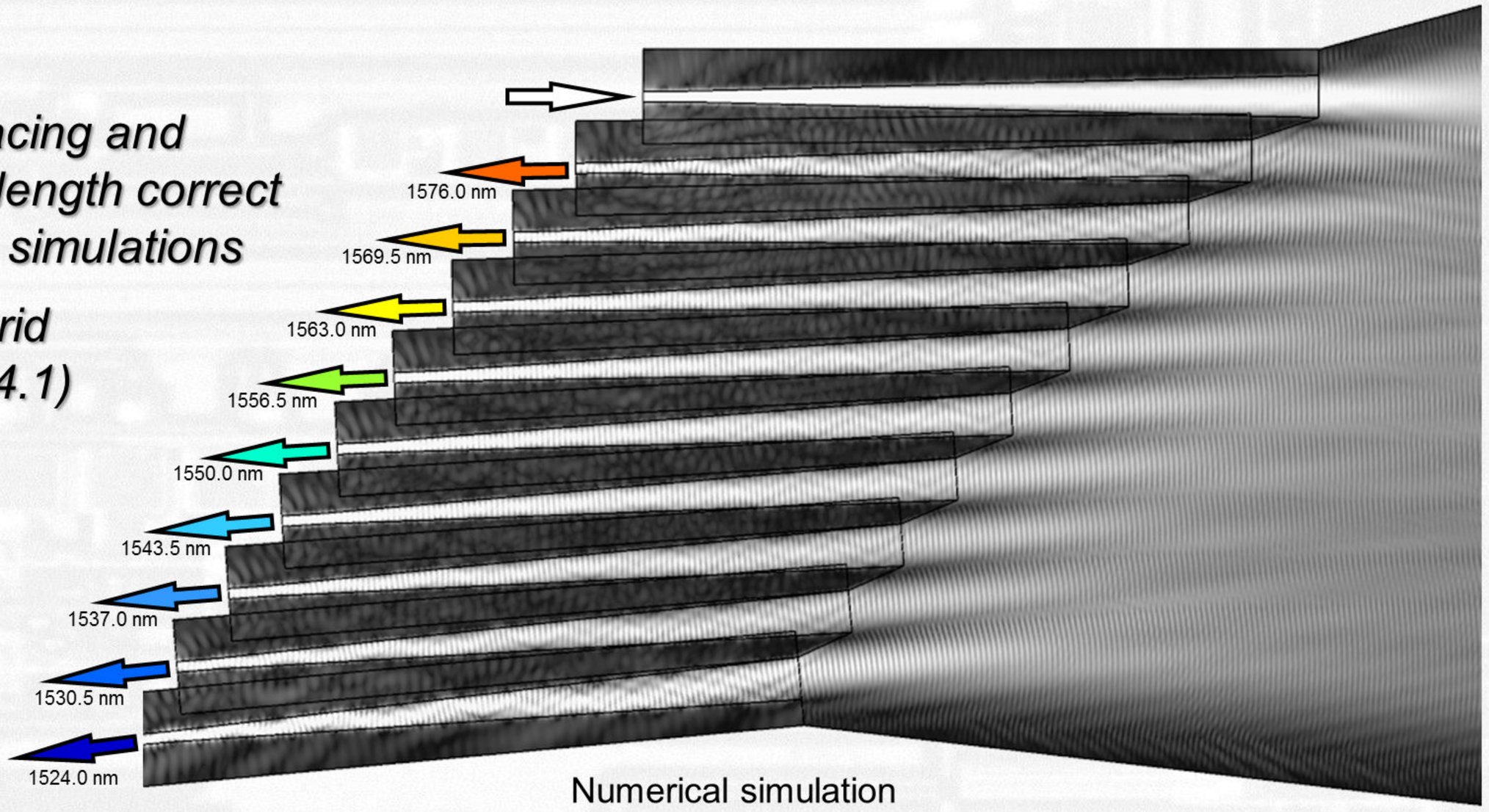




Wavelength Division Multiplexers

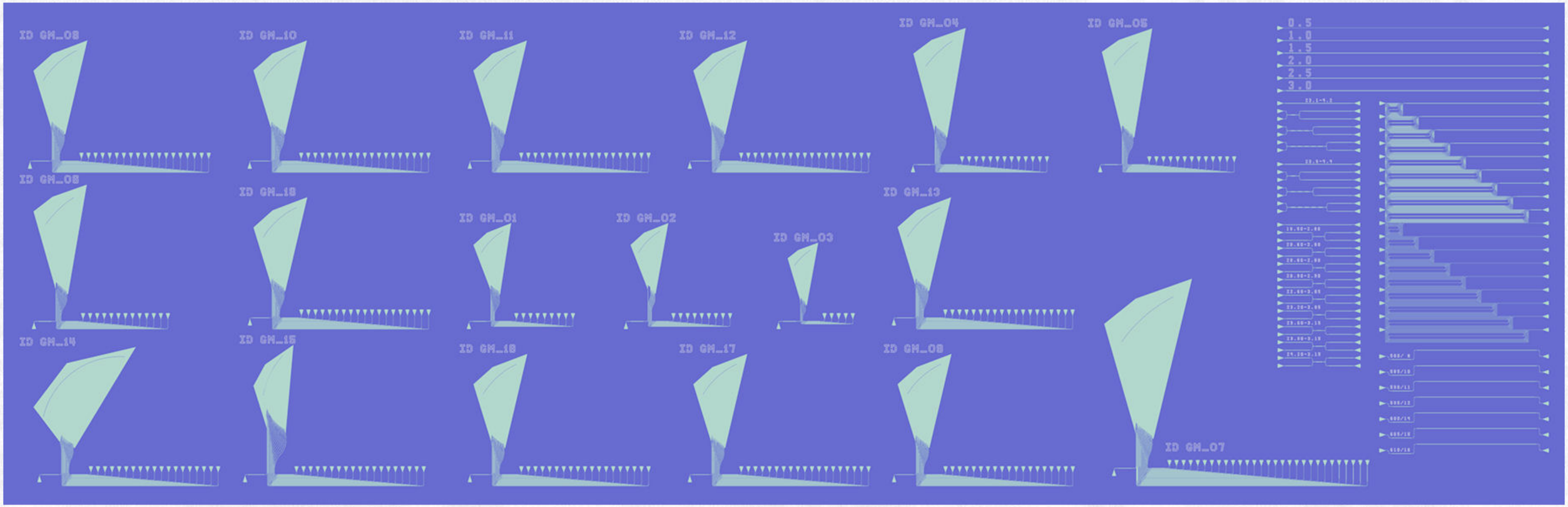
After fixing:

- *Channel spacing and center wavelength correct in numerical simulations*
- *Fitting ITU grid (ITU-T G.694.1)*



Wavelength Division Multiplexers

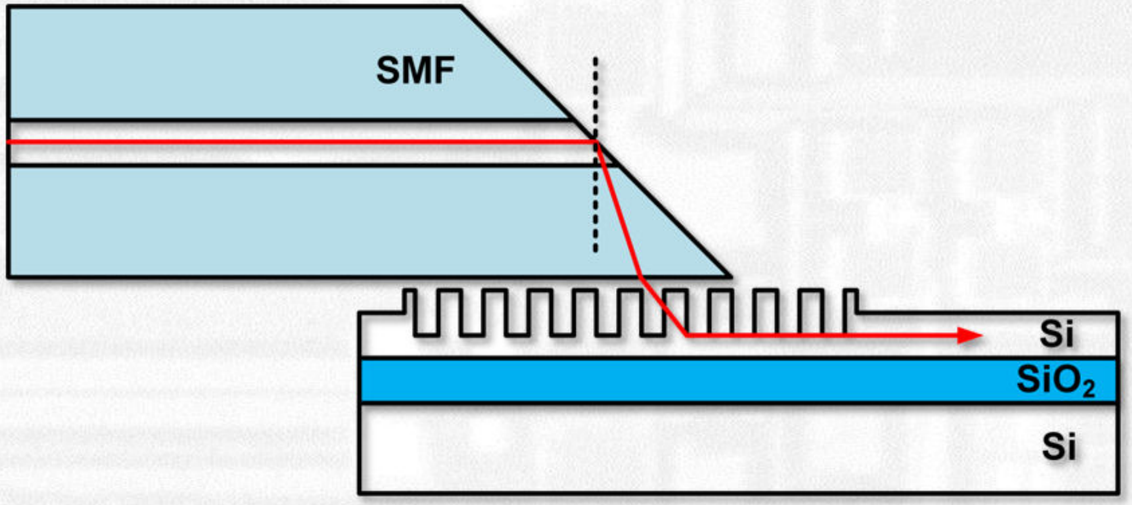
- *New test chip designed and submitted*
- *18 Echelle gratings, all suitable for full numerical investigation*

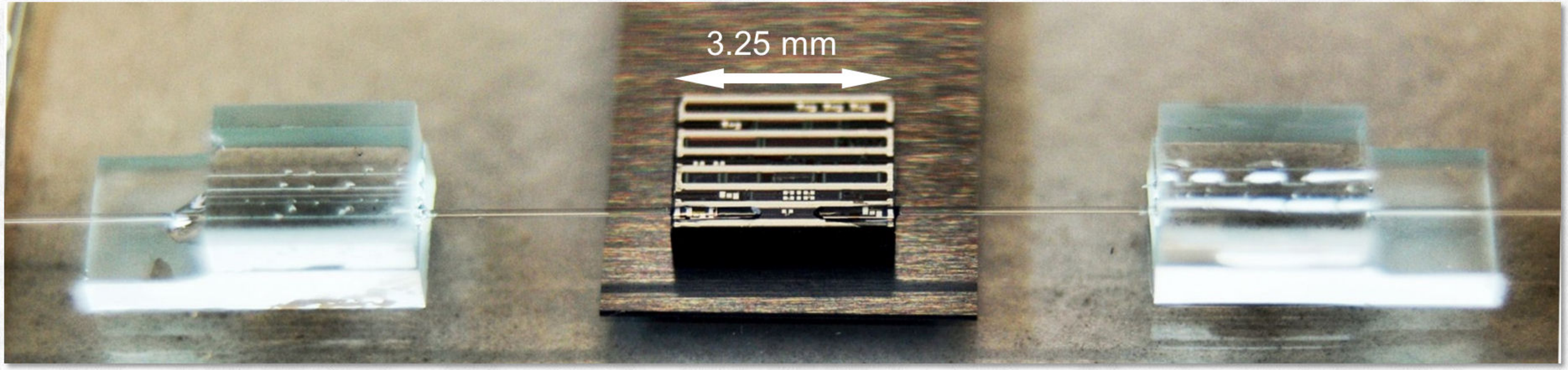


Fiber-Chip-Coupling

Angle-polished fibers

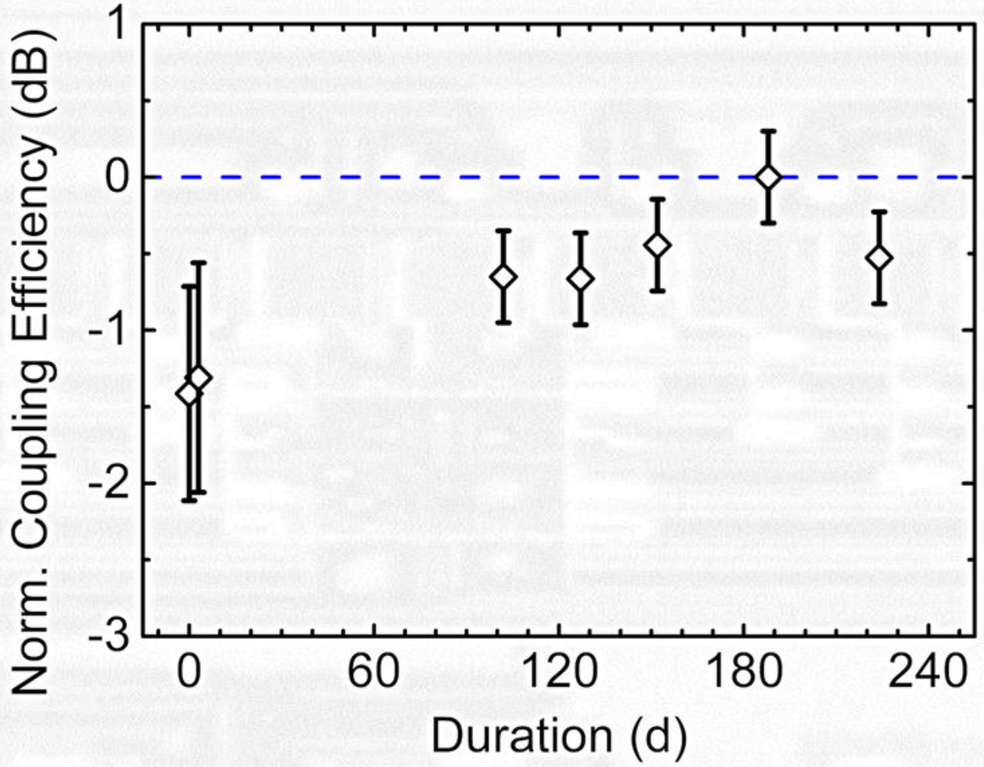
- *Surface coupling with planar alignment*
- *Polishing of fiber facet*
- *Total internal reflection*

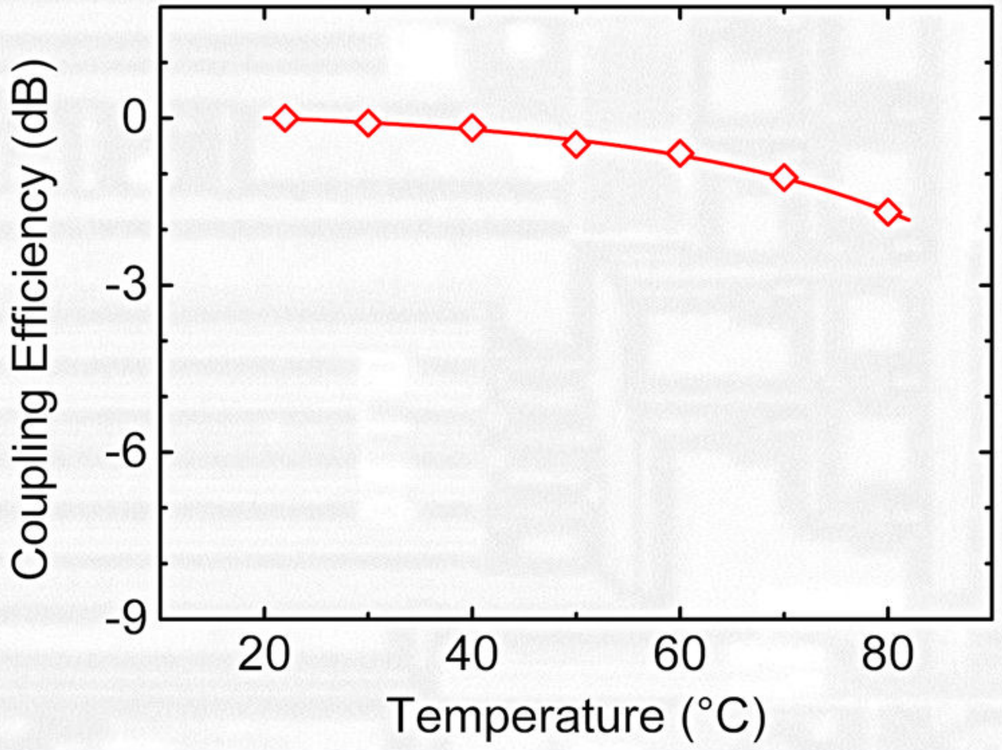




Fiber-Chip-Coupling

- *Substantial reduction of spatial requirements over former setup*
- *No power penalty*
- *Very good long term stability*



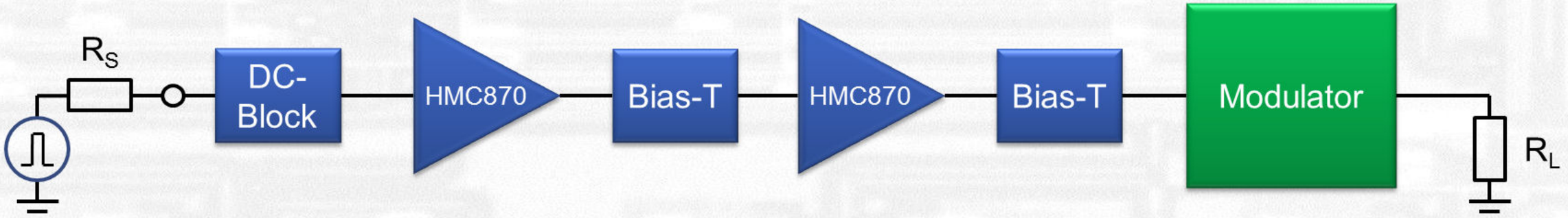


Modulator Drivers

Short term solution:

- Commercial HMC870 modulator drivers
- Aims: modulate MZM with V_{π}, measure response and BER

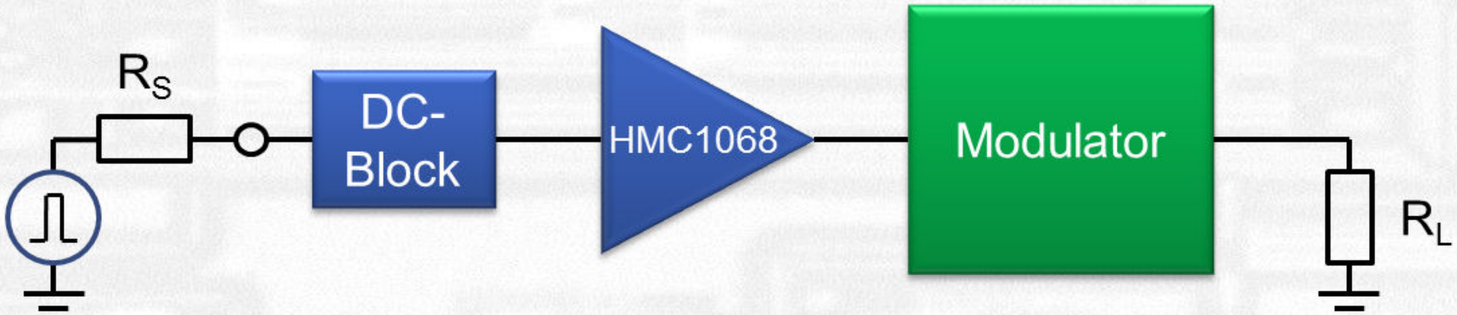
- HMC870
  - Housed 10 Gb/s NRZ single ended driver
  - 8 V_{PP} output swing @ 1.2 V_{PP} input swing → first stage serves as predriver
  - Total DC power consumption: 1.25 W
  - Efficiency @ maximum output voltage swing: 12.8 %



Modulator Drivers

Mid term solution:

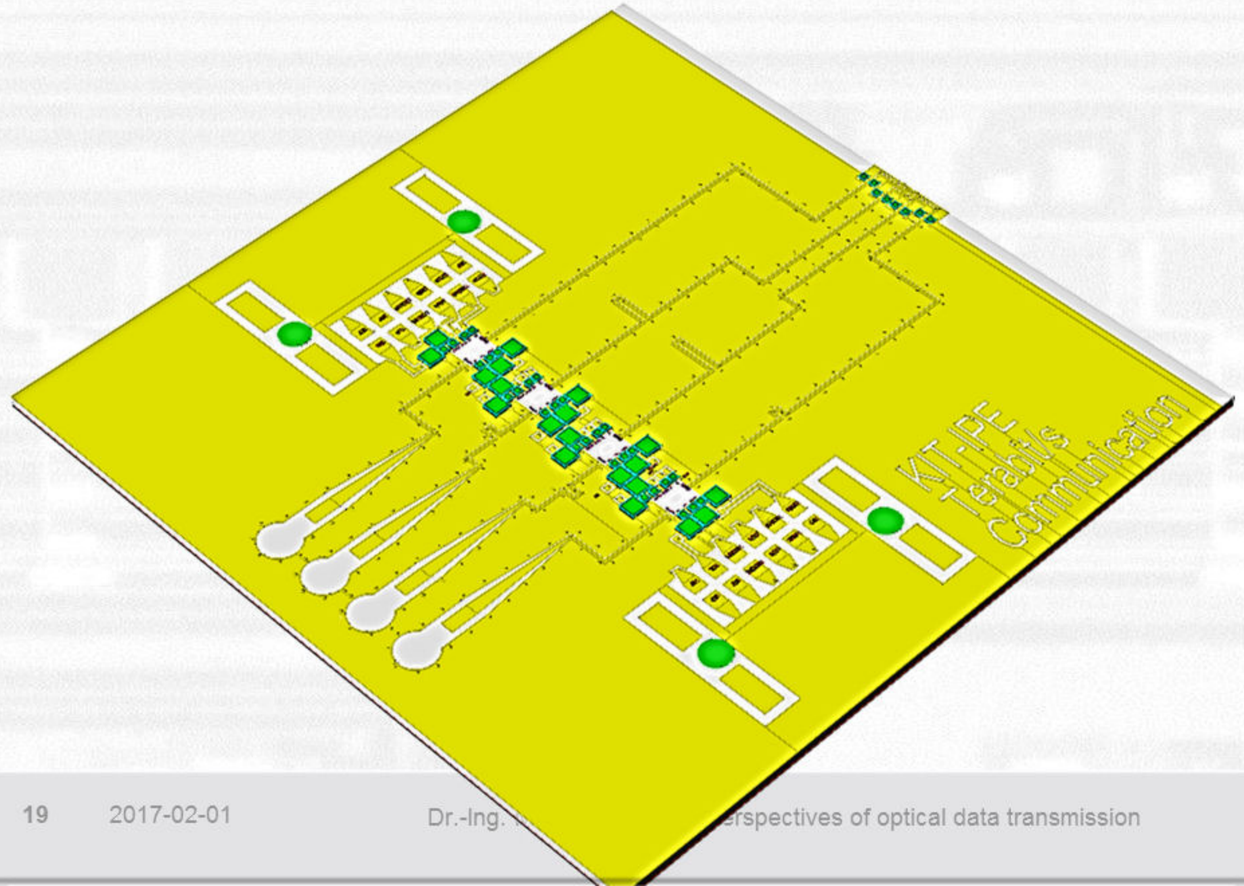
- Commercial HMC1068 modulator driver
- Aims: modulate MZM below V_π
  Test for SNR ≥ 17 dB @ electrical output of receiver (required for OOK to achieve BER of 10^{-12})
- HMC1068
  - Bare die 32 Gb/s NRZ single ended driver, TWDA configuration
  - 3 V_{PP} output swing @ 0.5 V_{PP} input swing
  - Lowest available DC power consumption for given output swing
  - Total DC power consumption: 0.45 W
  - Efficiency @ maximum output voltage swing: 5 %

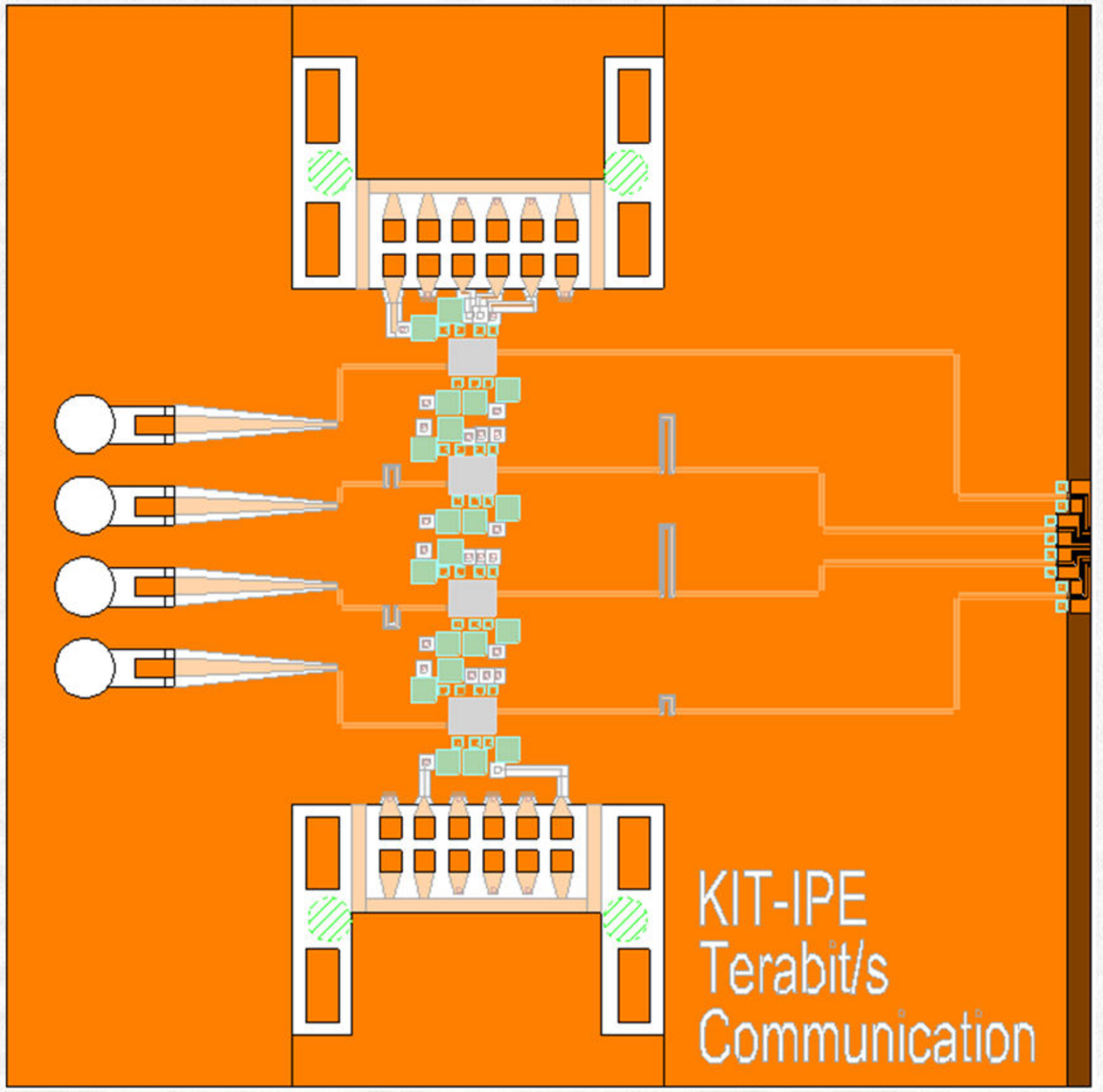


Modulator Drivers

Mid term solution:

- Design and layout of driver fan-out board to be build on ceramic board
- Production started January 2017





Modulator Drivers

Long term solution:

- Use of custom build driver circuits
- Aims:
  - Modulate MZM with voltage swing of approx. 5 V_{PP}
  - Test circuitry with discrete components for 10 Gb/s
  - SNR value for OOK to achieve BER of 10^{-12}

Main goal: substantial increase of efficiency

- Concept
  - establish push/pull configuration inside MZM
  - exploit power amplifier design concepts
  - combine small signal broadband amplifier concepts
- Future MMIC design:
  - Breakdown voltage doubler techniques?
  - Bandwidth enhancement methods?
  - Constant group delay methods?

Conclusion

- *Fiber-chip-coupling works*
- *Wavelength division multiplexers under test*
- *pn-modulators in development*
- *Driver electronics in development*

- *We already learned a lot*
- *Still many construction sites*


Thank you!
Questions
Q&A
Why Answers
How much Who
Where
When
What
How
Who
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KIT