POLARITON TECHNOLOGIES

Plasmonics - a Powerful Platform for Next-Generation Integrated Circuits

Swissphotonics PIC webinar—23.05.2021

Claudia Hoessbacher

claudia@polariton.ch

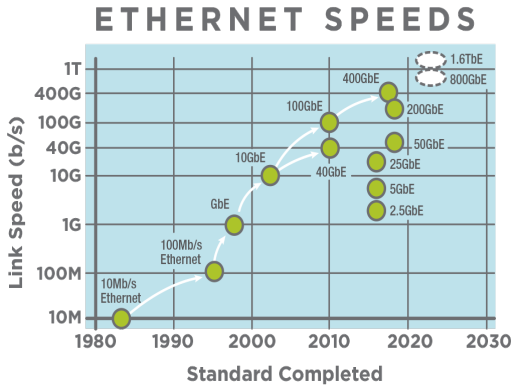
Outline

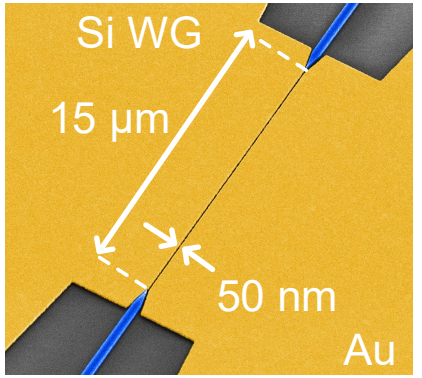
— Introduction - Towards Tbs with Plasmonics

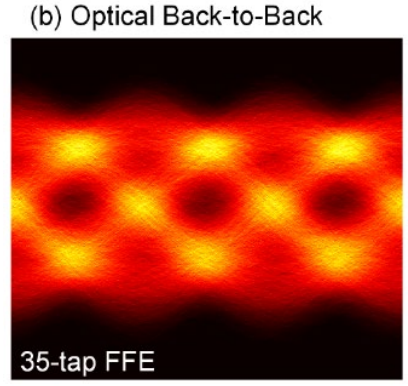
— Plasmonic Modulators – the POH Toolbox

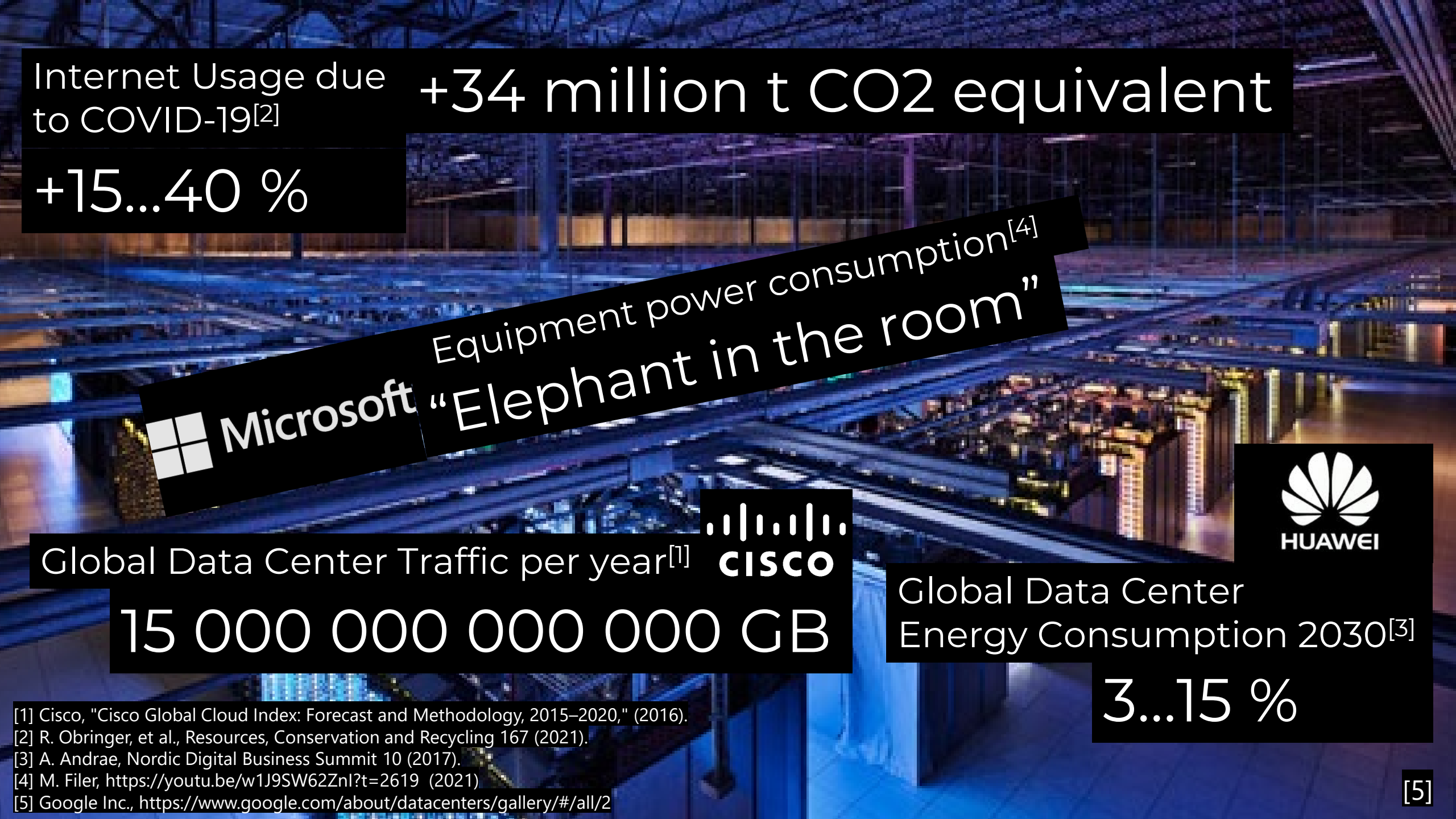
— Applications in Optical Communications

— Summary







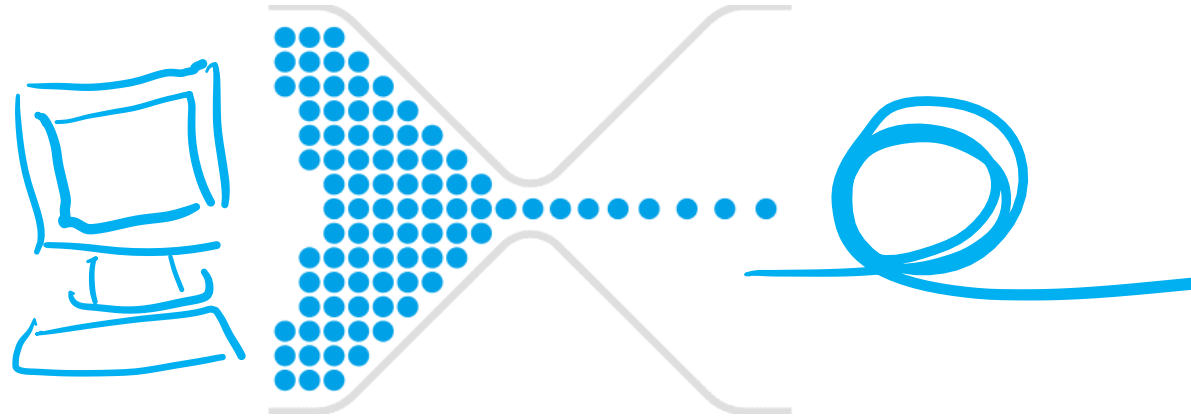


[1] Cisco, "Cisco Global Cloud Index: Forecast and Methodology, 2015–2020," (2016).
[2] R. Obringer, et al., Resources, Conservation and Recycling 167 (2021).
[3] A. Andrae, Nordic Digital Business Summit 10 (2017).
[4] M. Filer, https://youtu.be/w1J9SW62ZnI?t=2619 (2021)
[5] Google Inc., https://www.google.com/about/datacenters/gallery/#/all/2

[5]

Key Issue – Electrical ↔ Optical

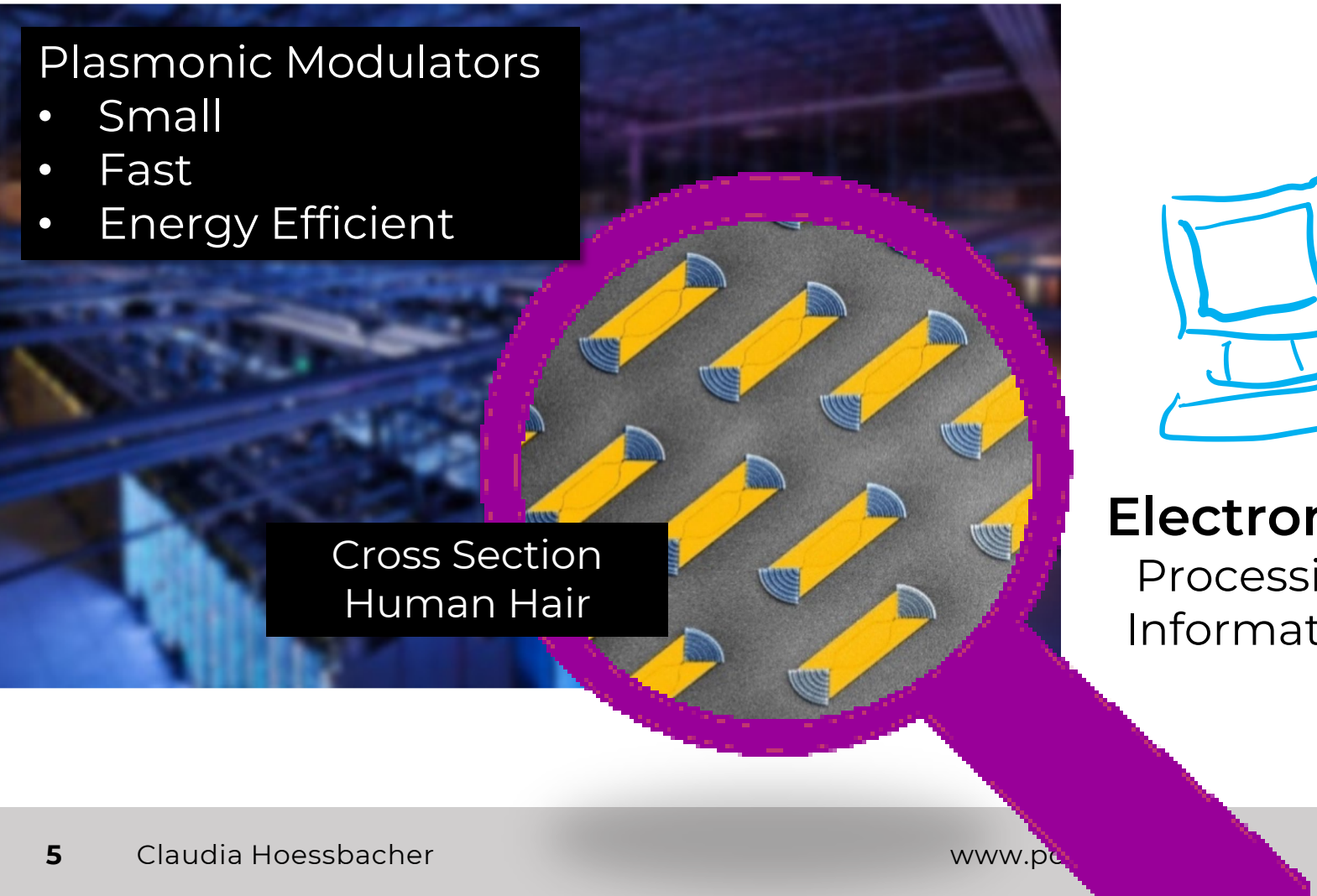
Electro-Optic (EO) Conversion

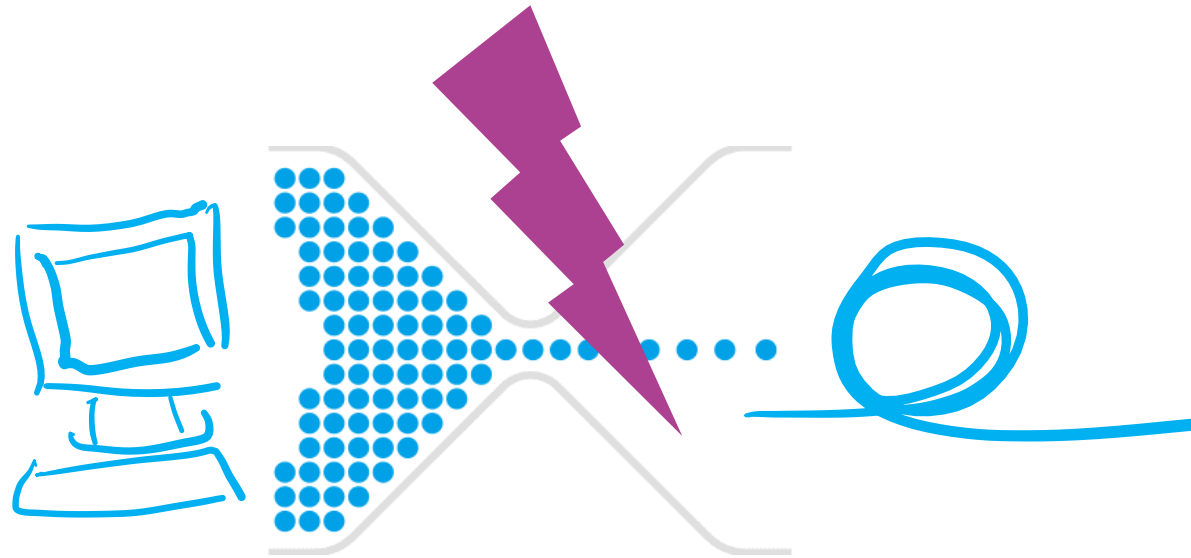


Electronics
Processing Information

Photonics
Transporting Information

Breaking The Bottleneck!

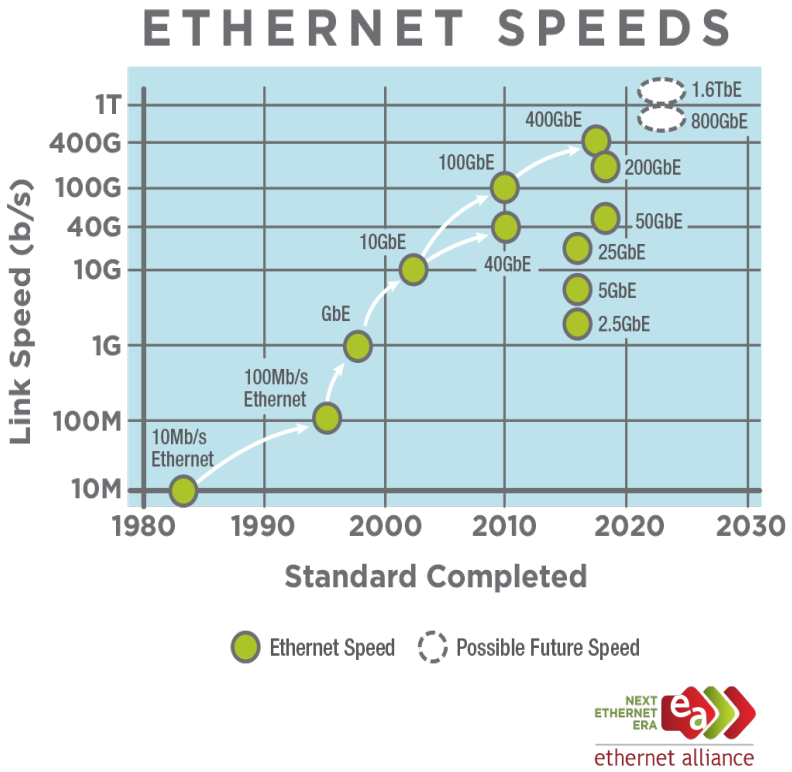


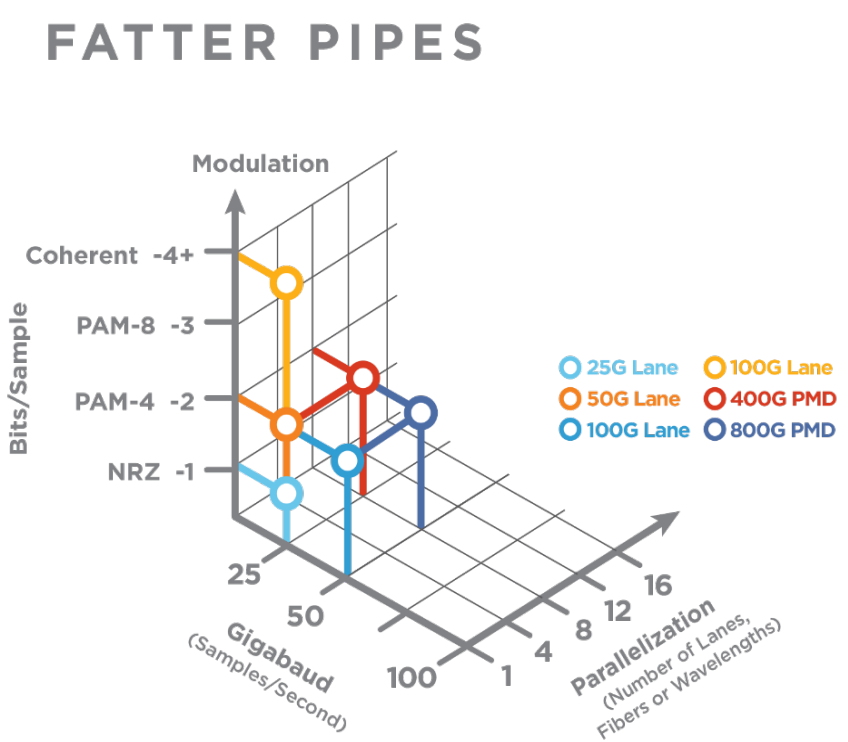


Electronics
Processing
Information

Photonics
Transporting
Information

Towards Tbs



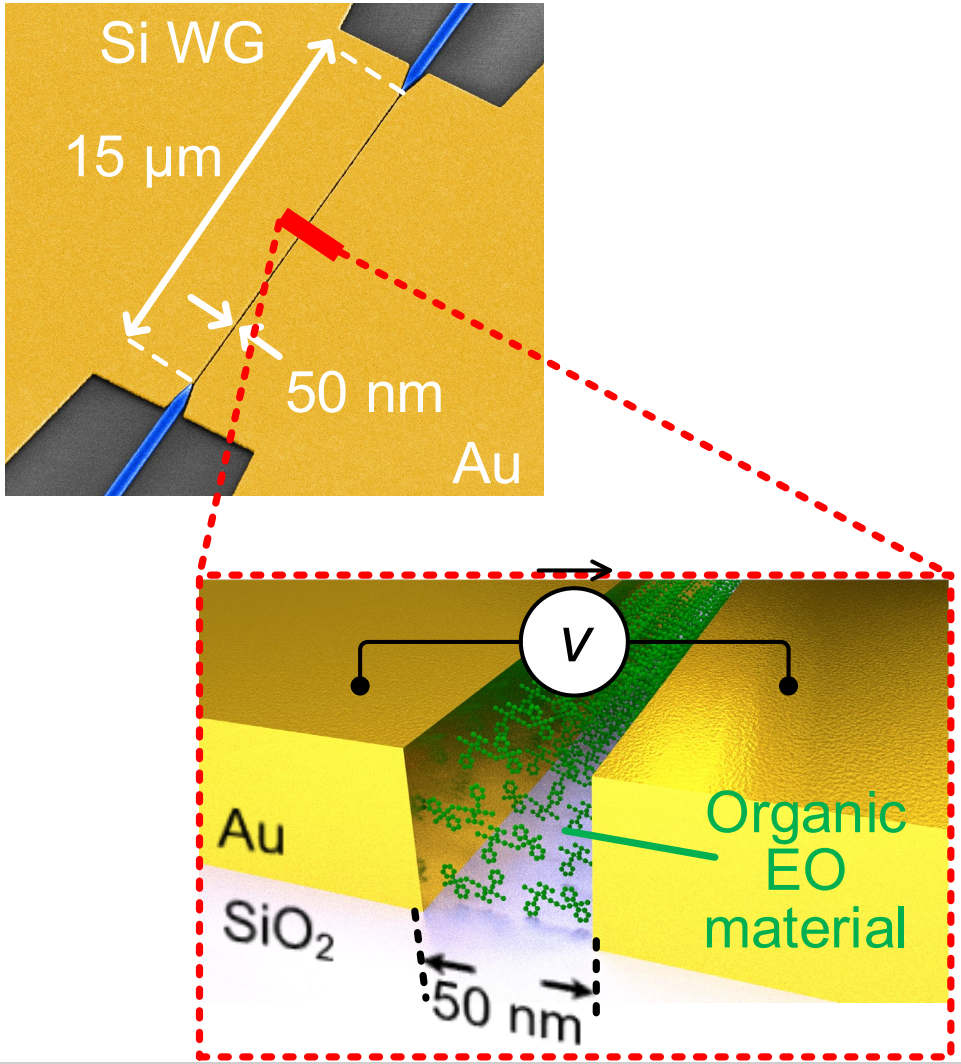


➔ High symbol rates of >100 GBd
➔ Compact integration and parallelism
➔ Low power consumption

Plasmonic Modulators –

the POH toolbox

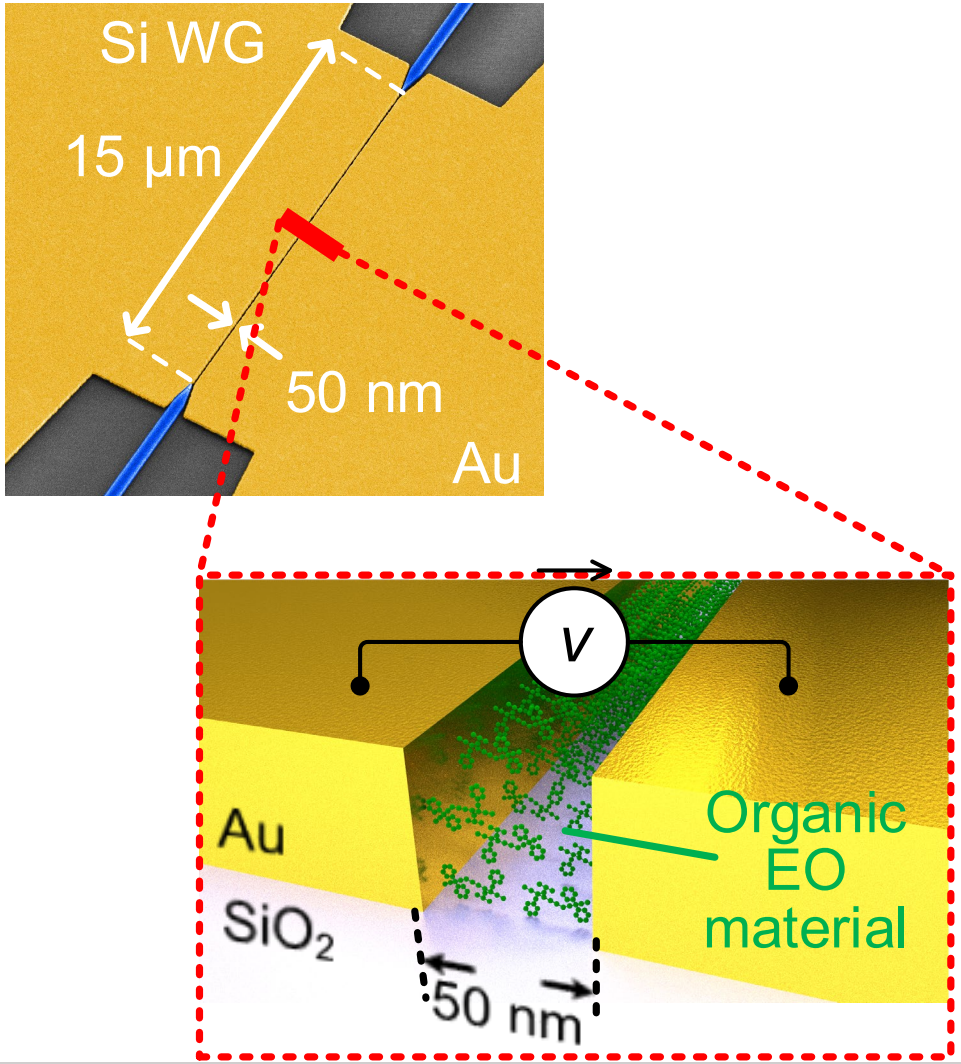
Plasmonic-Organic Hybrid Modulator



Plasmonic Phase Modulator

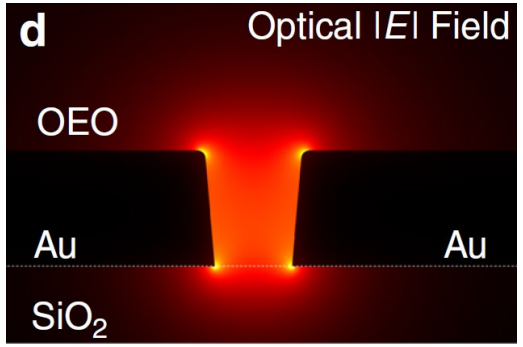
- The basic building block
- Surface plasmon polariton propagates along slot waveguide filled with nonlinear material
- Voltage drop across nonlinear material
  → Phase shift (Pockels effect)

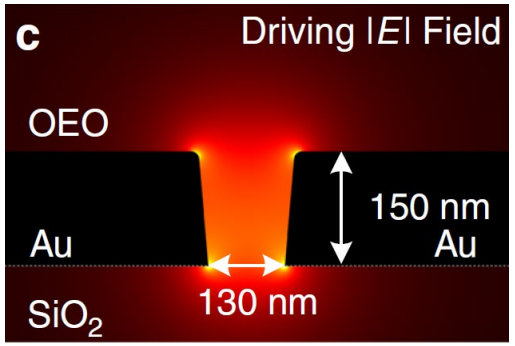
Plasmonic-Organic Hybrid Modulator



Plasmonic Phase Modulator

- Strong field confinement and good overlap of optical and driving field
  → High efficiency
- Metals of waveguide act as their own electrode → Small RC-constant
  → High speed

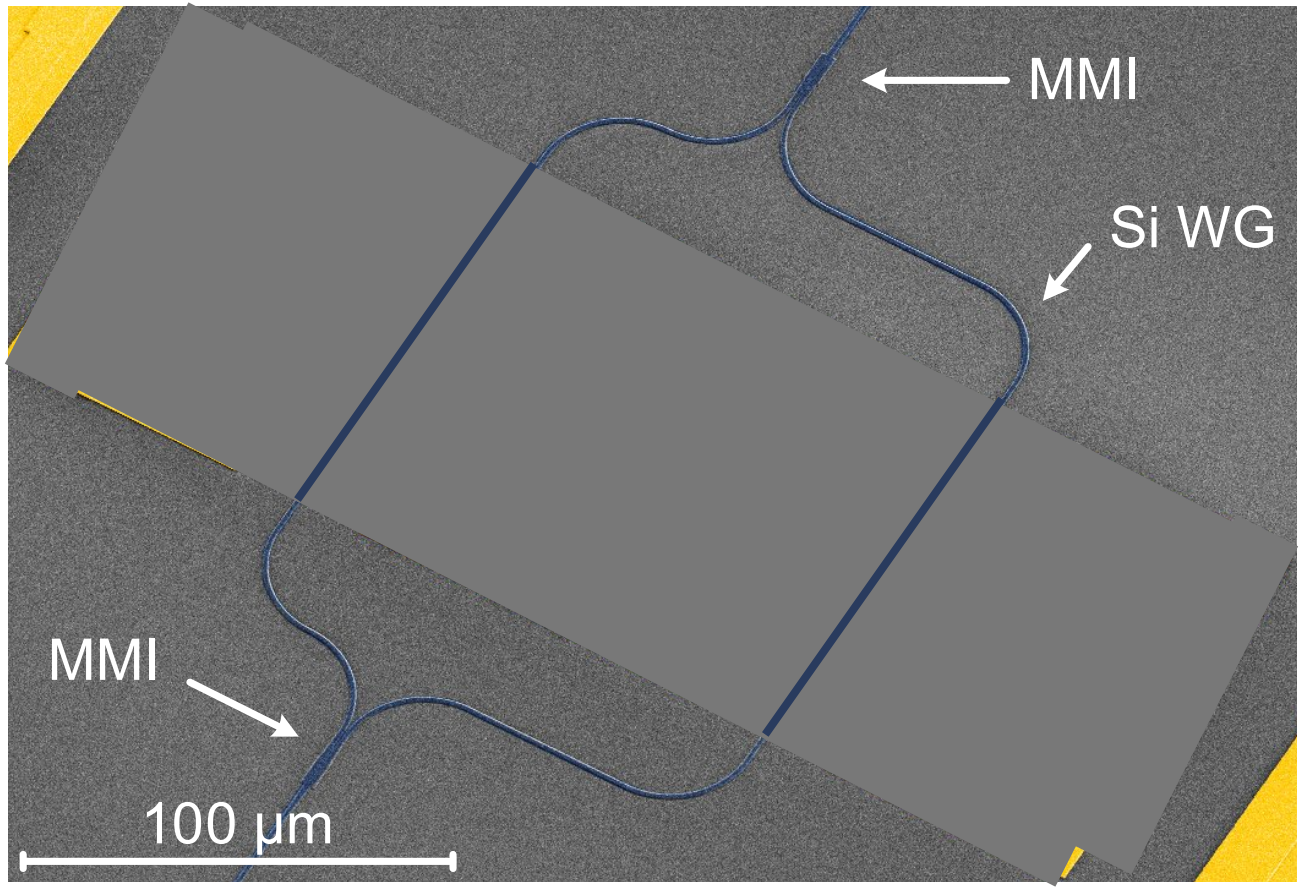




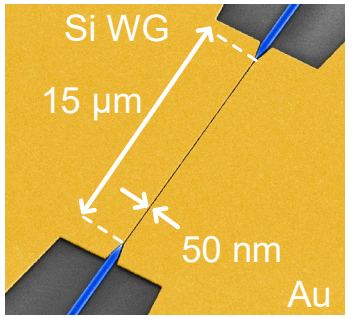
W. Heni, et al *Nature Communications, vol. 10, no. 1, p. 1694, 2019/04/12 2019.*

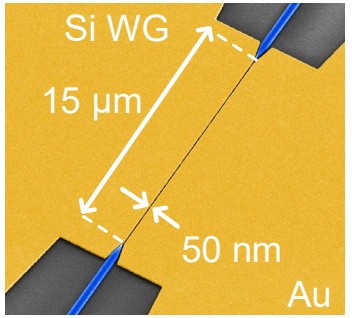
The POH Toolbox

Mach-Zehnder Interferometer



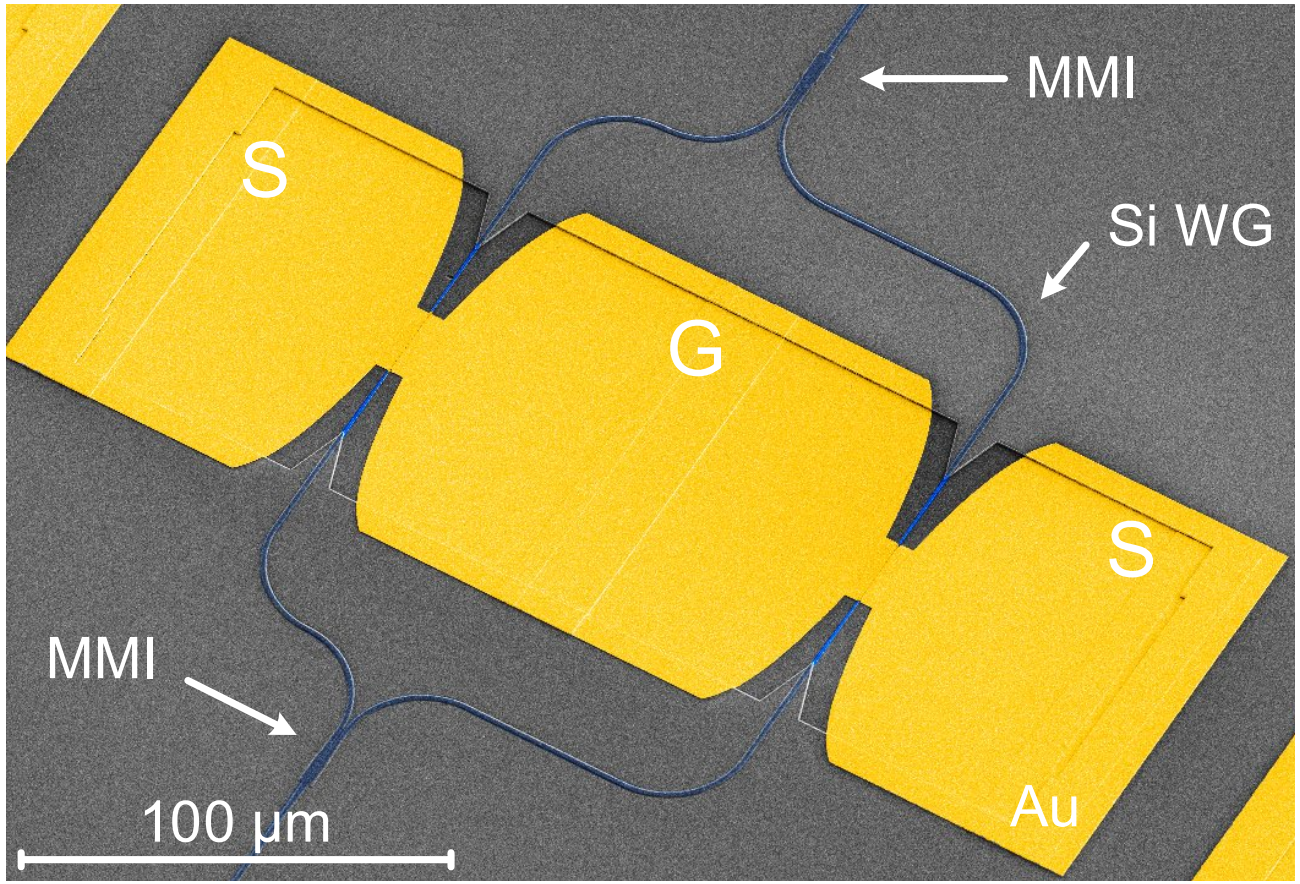
Phase Modulators



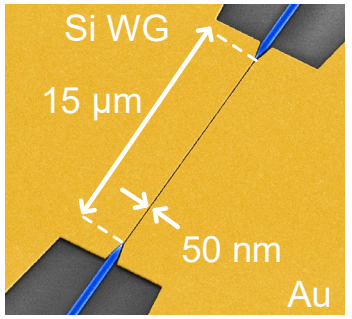


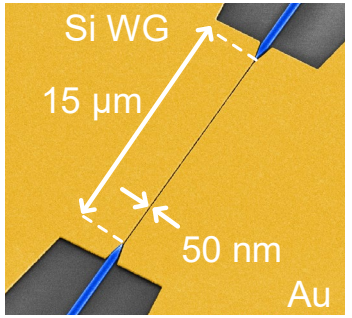
The POH Toolbox

Mach-Zehnder Modulator (MZM)



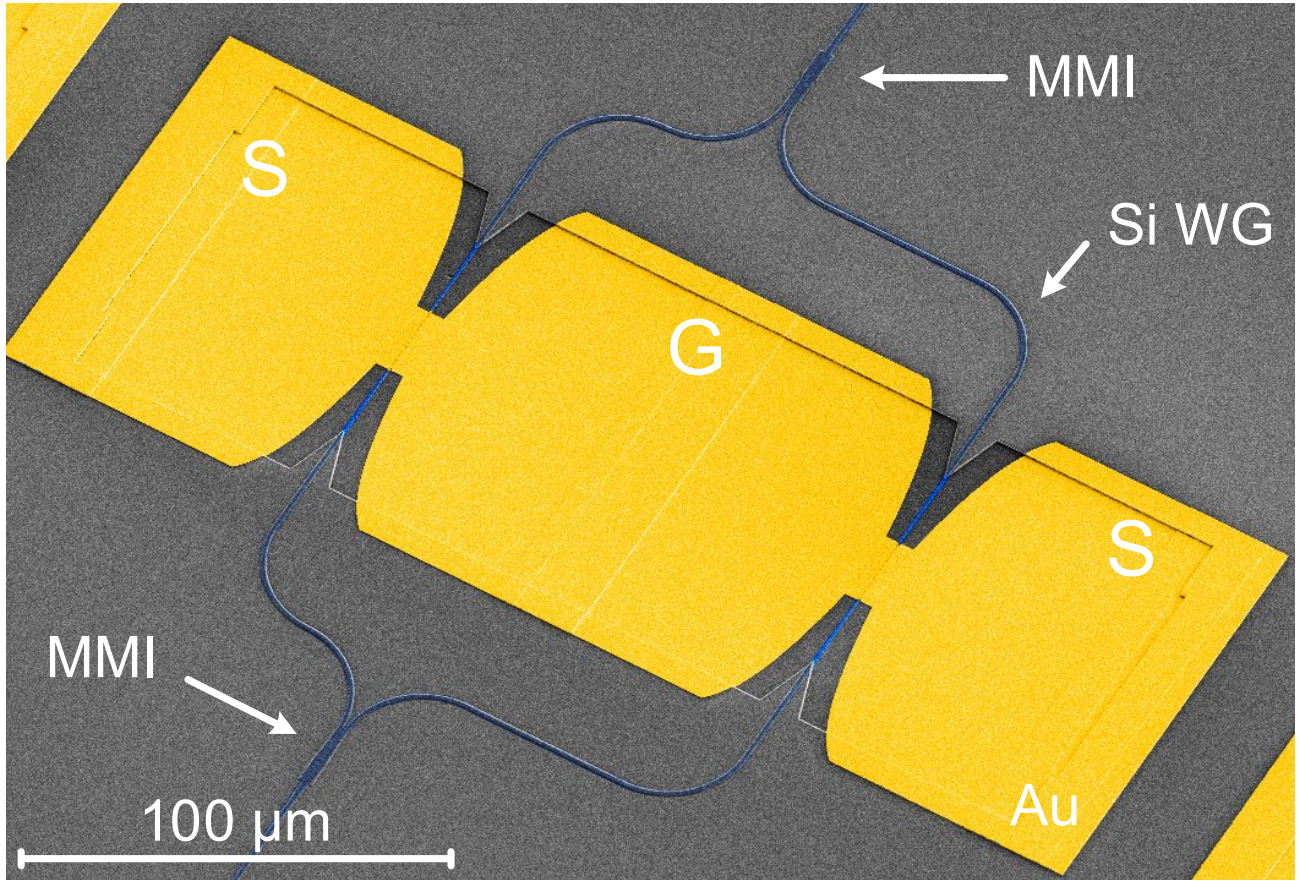
Phase Modulators



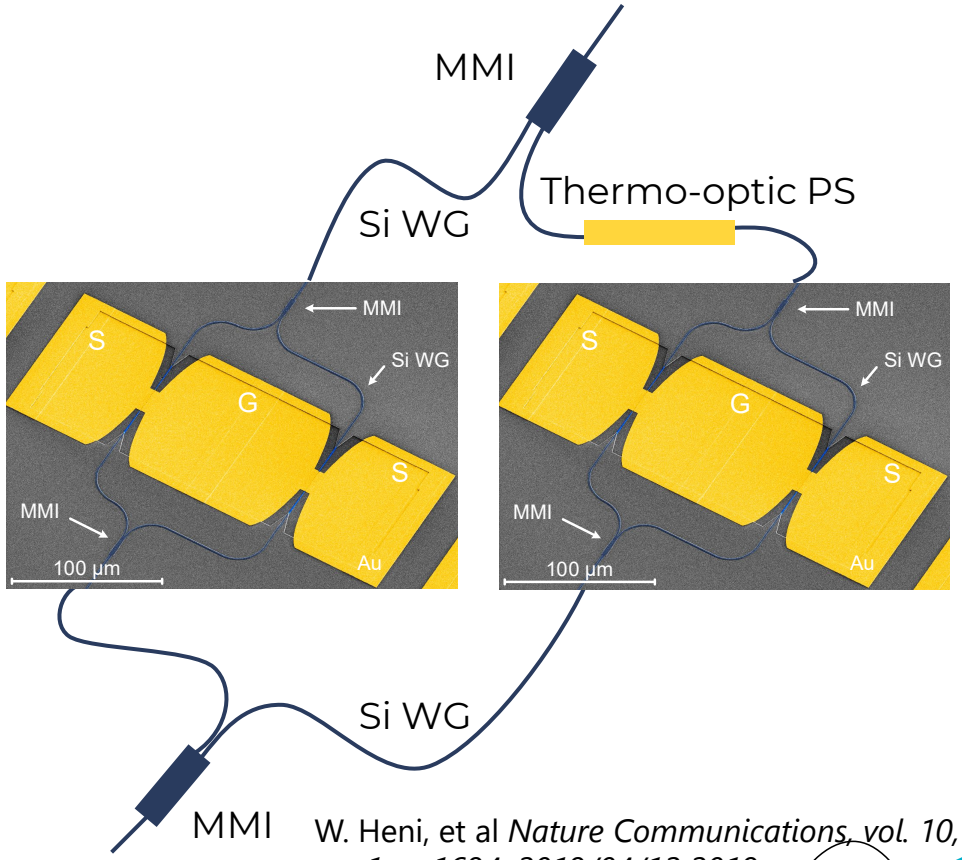


The POH Toolbox

Mach-Zehnder Modulator (MZM)

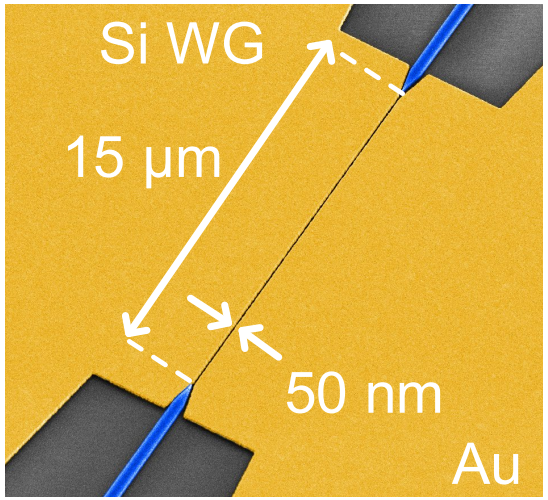


IQ-MZM



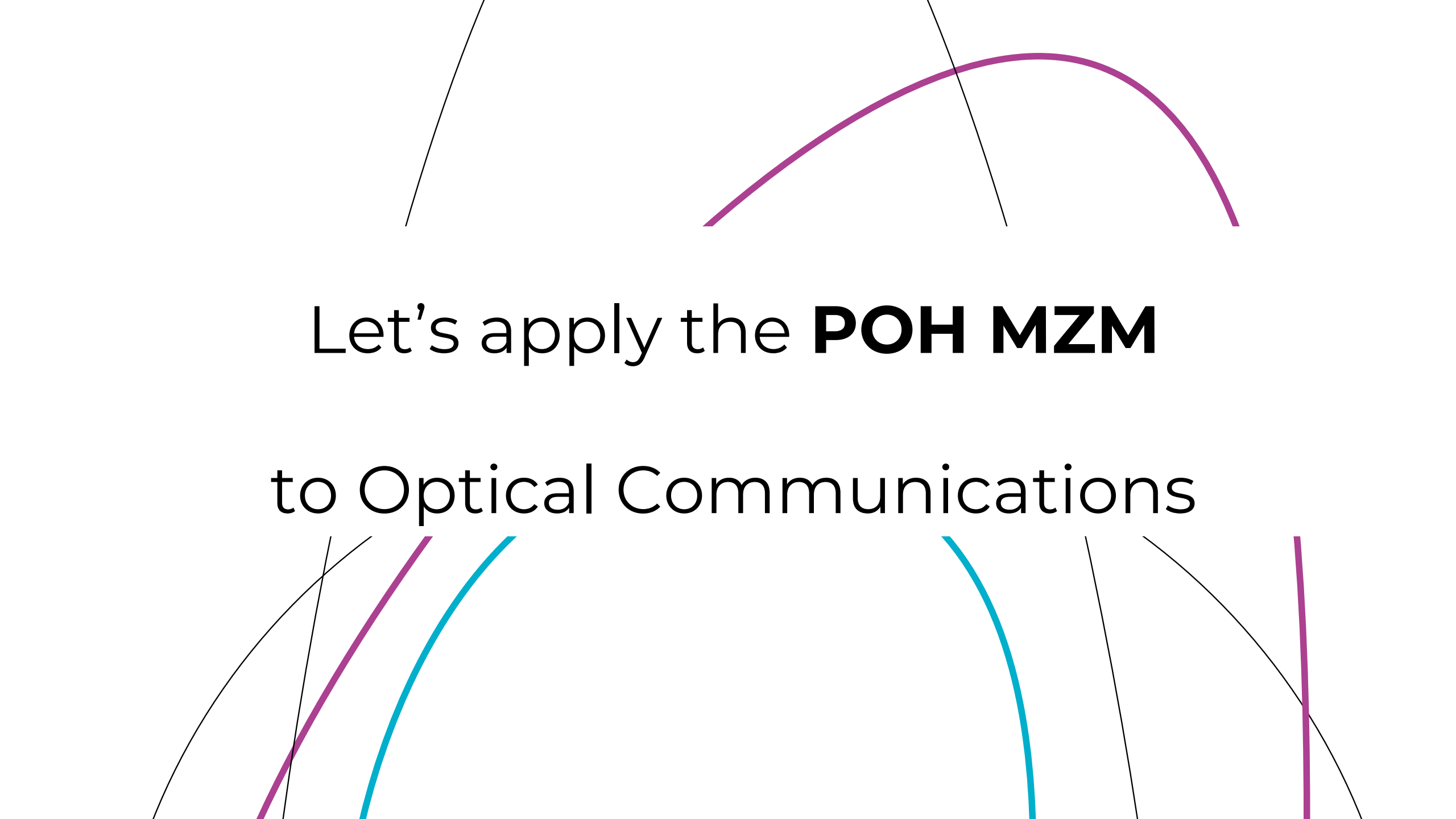
W. Heni, et al *Nature Communications, vol. 10, no. 1, p. 1694, 2019/04/12 2019.*

What About the Challenges?

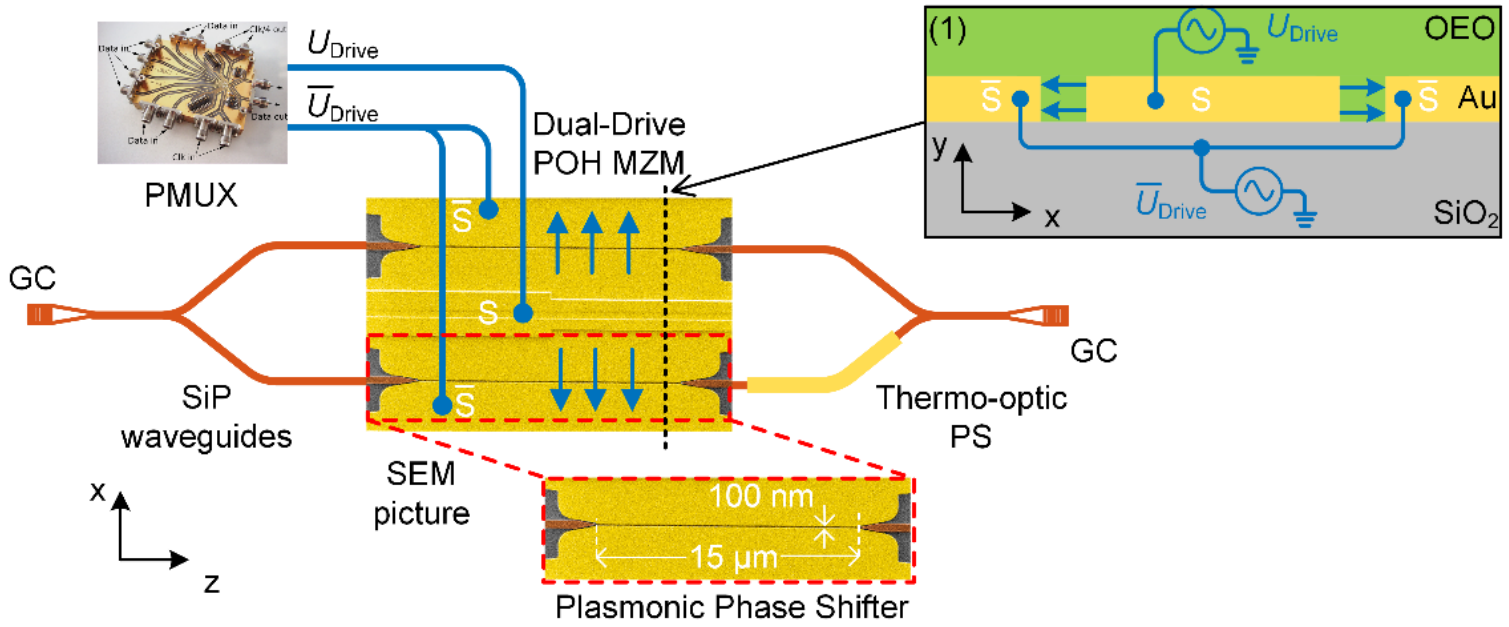


- Plasmonic MIM waveguide losses: 0.5 dB/µm
- Small length
  → on-chip losses: 8 dB[1]
- Different design:
  - Rings[2]: 2.5 dB
  - Race track[3]: <5dB
- Trade-off between losses and drive voltage
  → Dual-drive scheme

[1] C. Hoessbacher, et al., Opt. Express 25, 1762-1768 (2017).
[2] C. Haffner, et al., Nature 556, 483-486 (2018).
[3] A. Messner, et al., in *ECOC'20, Tu1B-6(2020)*.


Let’s apply the **POH MZM**
to Optical Communications

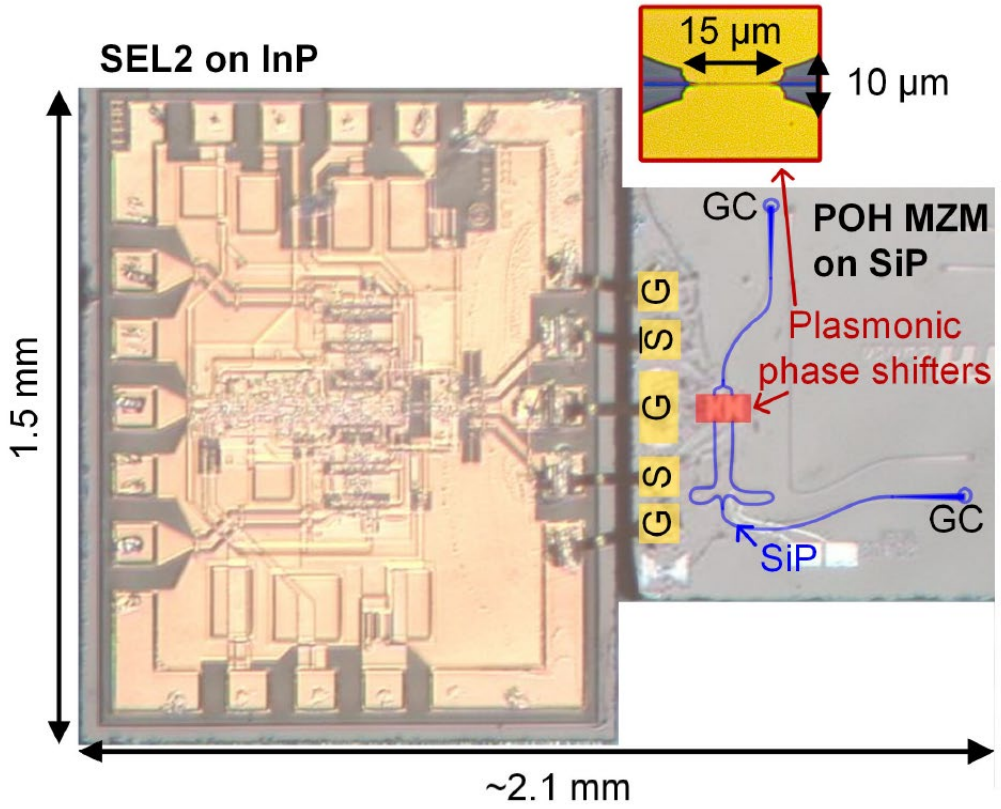
Dual-Drive POH MZM

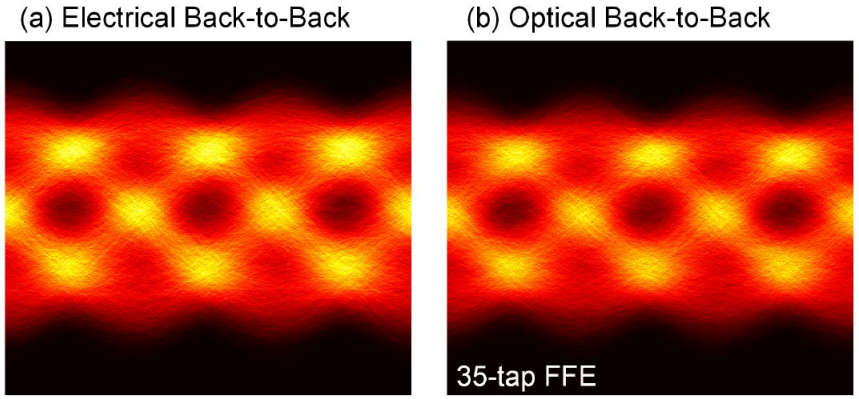


- No travelling wave elecrodes
  → Apply differential voltage drop over each phase shifter
  → 2x voltage drop
- No 50 Ω termination
  → Lumped capacitance
  → 2x voltage drop

B. Baeuerle, et al. Optics Express 27(12): 16823-16832 (2019).

222 GBd Demonstration

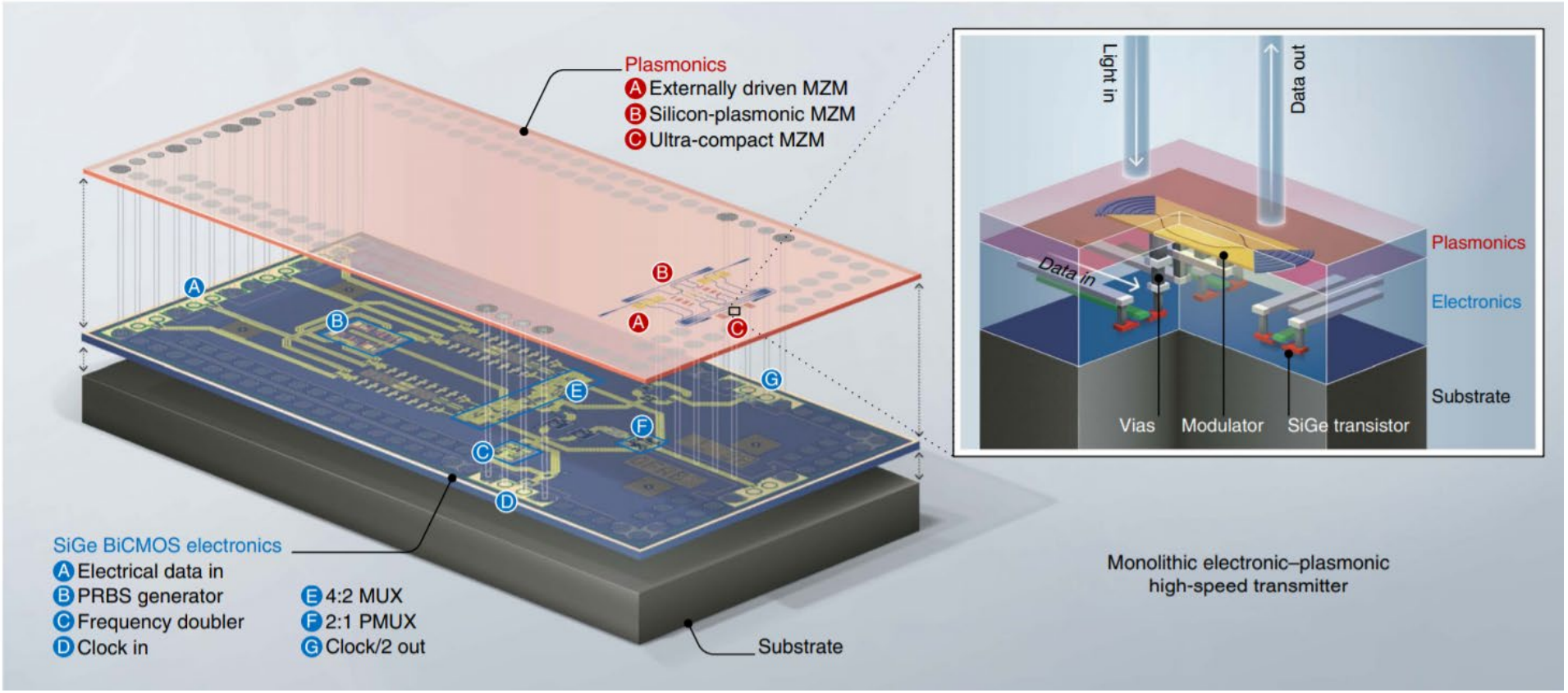




- 222 GBd NRZ data modulation
- Transmission over 120m
- No EO bandwidth limitation

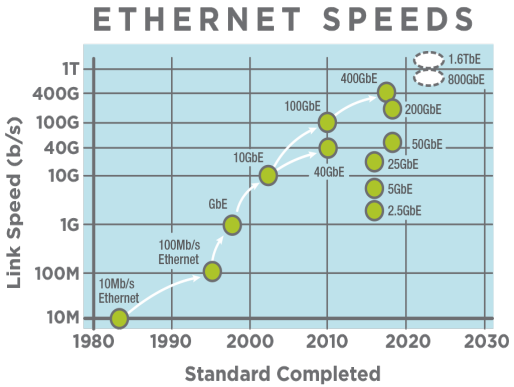
W. Heni, et al.. J. Lightwave Technol. (2020).

Monolithic Integration



U. Koch, et al., Nature Electronics 3, 338-345 (2020).

Summary



- Introduction - Towards Tbs with Plasmonics
- Plasmonic Modulators – the POH Toolbox
  - Phase modulator is basic building block
  - From MZM to IQ modulator
- Applications in Optical Communications
  - High speed (222 GBd)
  - Simple modulation format → reduce power hungry DSP
  - Compact integration with platform of your choice