2x2 Electro-Optical Switch in a Thin-Film Lithium Niobate Foundry Process

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High-speed, small footprint photonic switches are crucial for data centers, telecommunications, and 5-6G due to increasing data traffic. Thin-film lithium niobate (TFLN) switches, leveraging lithium niobate's electro-optical properties, show promise for replacing slower and more lossy silicon switches currently in use. We present a 2×2 Mach-Zehnder interferometer TFLN switch, operating at 1550 nm, with an average rise time of 0.29 µs and an average fall time of 0.28 µs, demonstrating our foundry's capability for large-scale, fast TFLN switches.

Background

Thin-film lithium niobate (TFLN) possesses unique and valuable optical properties [1].

Property	Value
Refractive index	2.21 (o) (@ 1550 nm) 2.13 (e) (@ 1550nm)
Band-gap	4.9 eV
Transparency window	350 nm – 5550 nm
EO coefficient	r_{33} = 31 pm/V
$\chi^{(2)}$ nonlinearity	3 x 10^{-11} m/V
$\chi^{(3)}$ nonlinearity	1.6 x 10^{-21} $m^2 V^{-2}$

Table 1. Properties of TFLN.

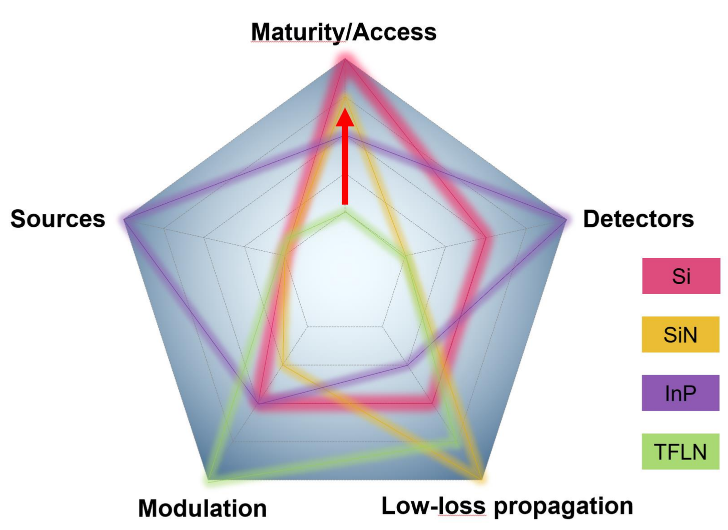

Fig. 1. Properties of various PIC platforms.

CSEM established an open PIC foundry based on the TFLN platform, supported by a thoroughly tested process design kit (PDK) library. The aim is to increase the maturity level of the platform for large-scale deployment.

Motivation

We need faster switches with lower power consumption

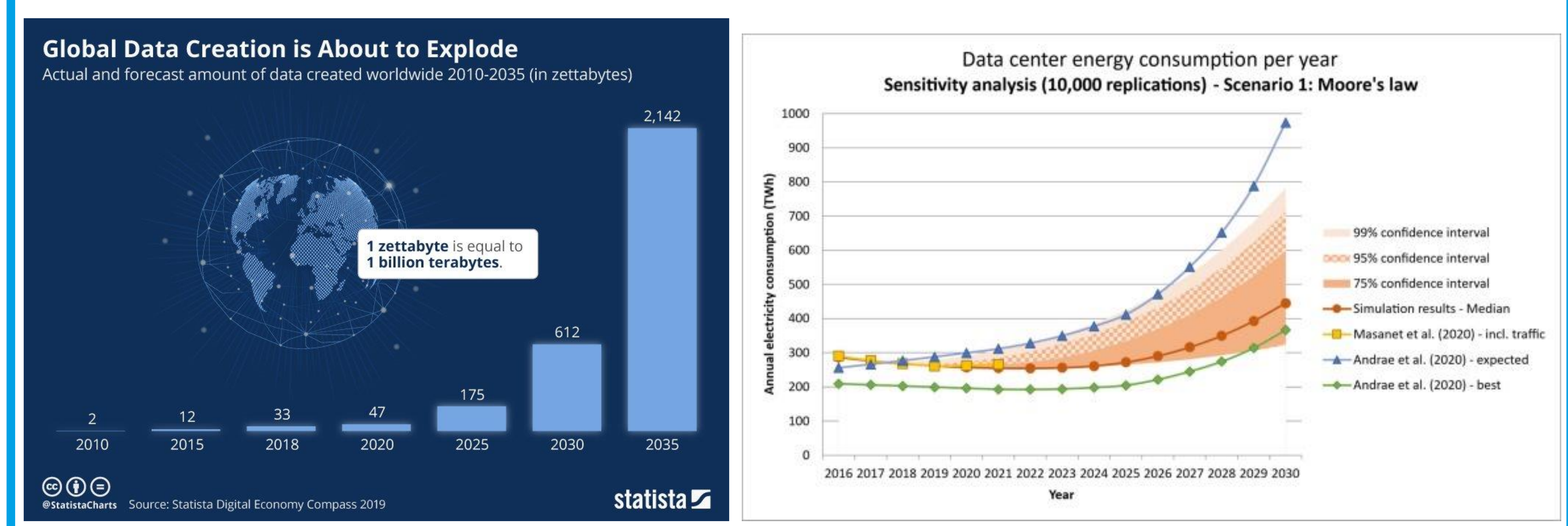

Fig. 2. Left: historical and foreseen amount of data annually created worldwide [2]. Right: historical and foreseen annual electricity consumption in data centers [3].

Results

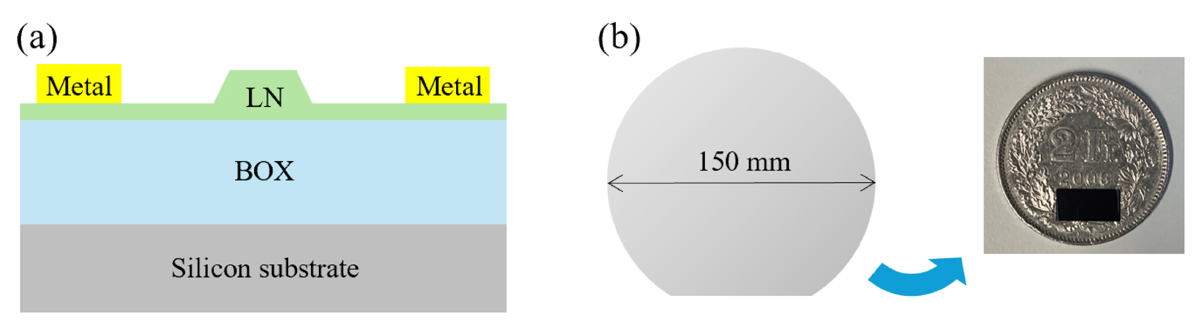

Fig. 3. (a) Schematic of the cross-section. (b) Picture of the chip fabricated in a 150 mm wafer.

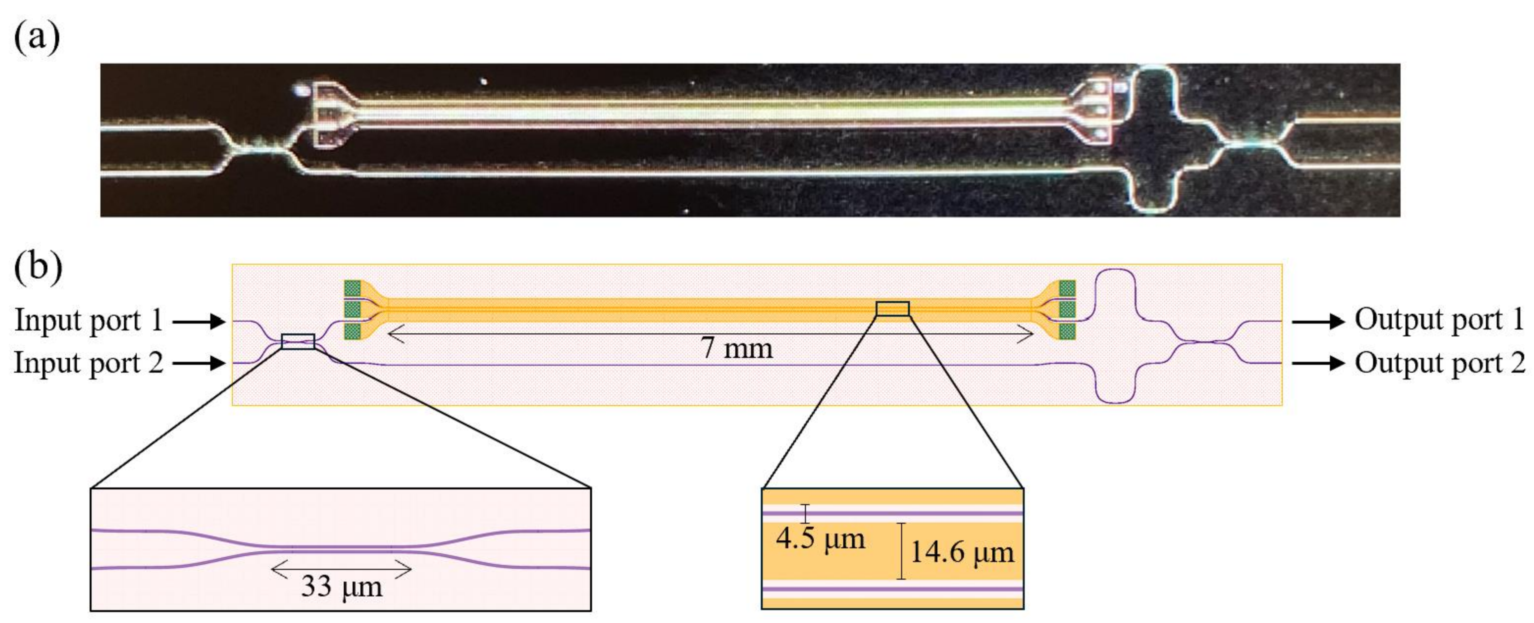

Fig. 4. (a) Optical microscope image and (b) schematics of the 2x2 Mach-Zender interferometer switch.

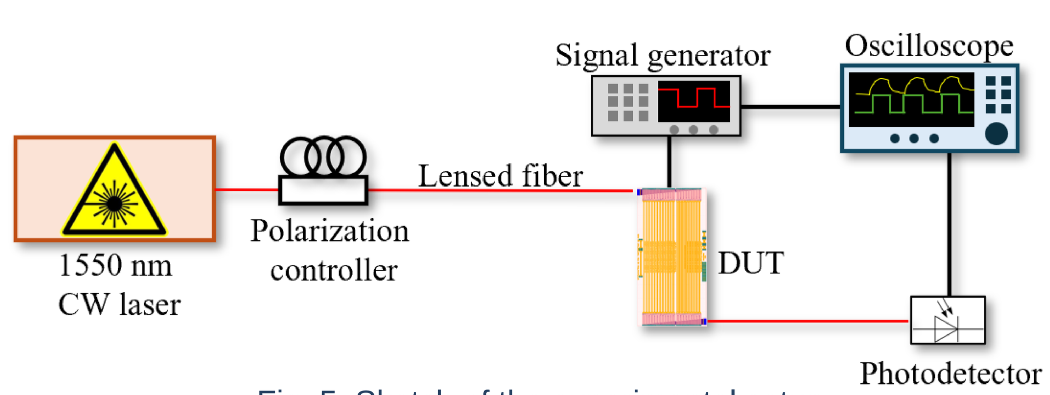

Fig. 5. Sketch of the experimental setup.

- Mach-Zender interferometer switch manufactured in a TFLN PICs foundry following design rules and operating in the telecom C-band
- Avg. 10-90% rise time: 0.29 µs
- Avg. 90-10% fall time: 0.28 µs

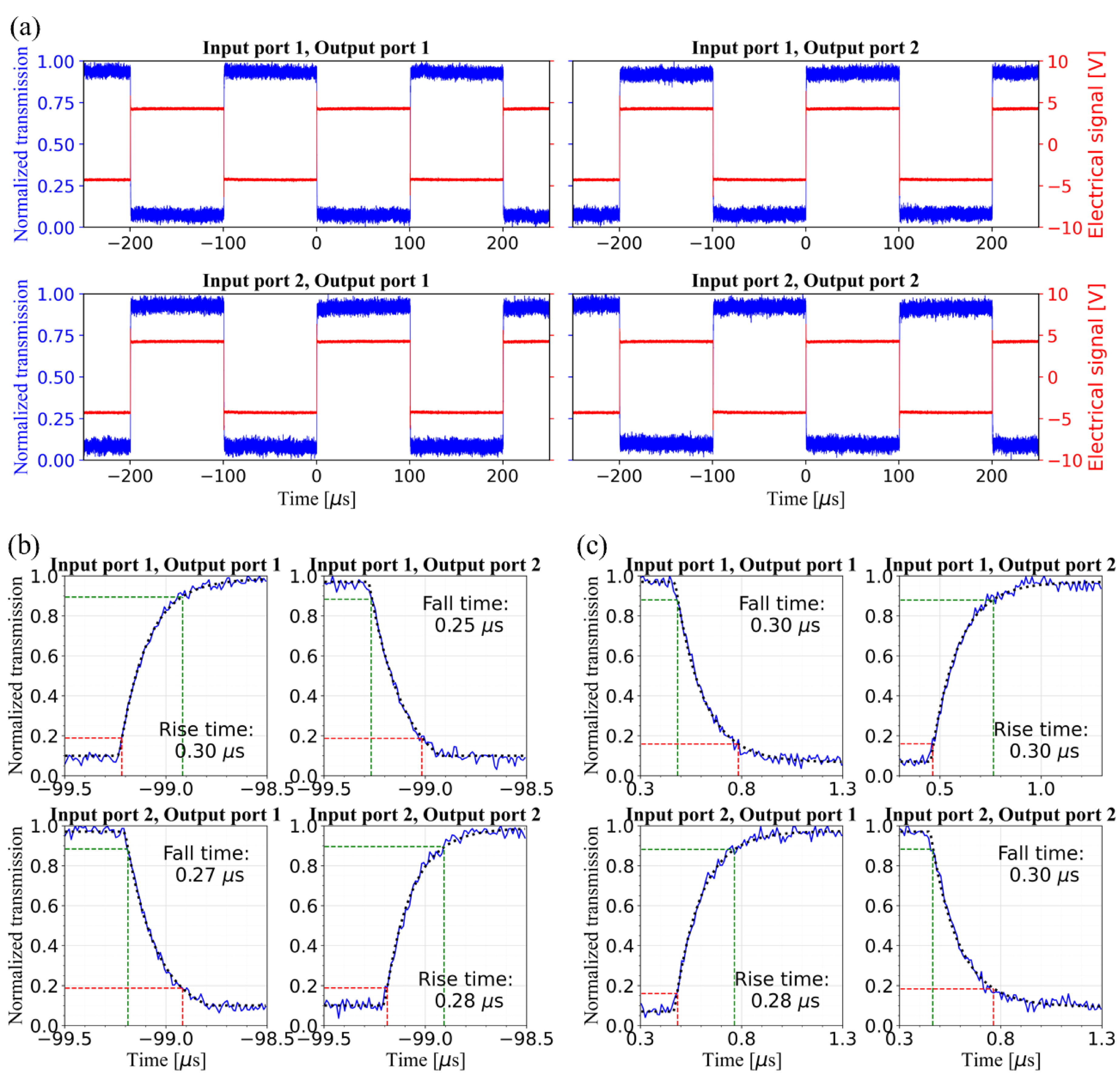

Fig. 6. (a) Measured response of the switch to a square function. (b) Close-up view in correspondence of rise and fall switches for different input and output ports. The solid blue curved are the measured responses, the dotted black curves are exponential fits of the responses, the green and red lines are the 90% and 10% levels of the on and off states, respectively.

Conclusion and outlook

- The success of this device serves as a validation of our standard fabrication process, with potential of large-scale deployment of optical switches based on TFLN PICs technology
- Although not exploited here, our platform includes two metal layers that greatly facilitate the design of intricate PIC components within the TFLN PIC platform

References

[1] D. Zhu et al., Adv. Opt. Photon. 13(2), 242-352 (2021).

[2] Statistica Digital Economy Compass (2019).

[3] M. Koot and F. Wijnhoven, Appl. Energy 291, 116798 (2021).

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Contact us

Our foundry