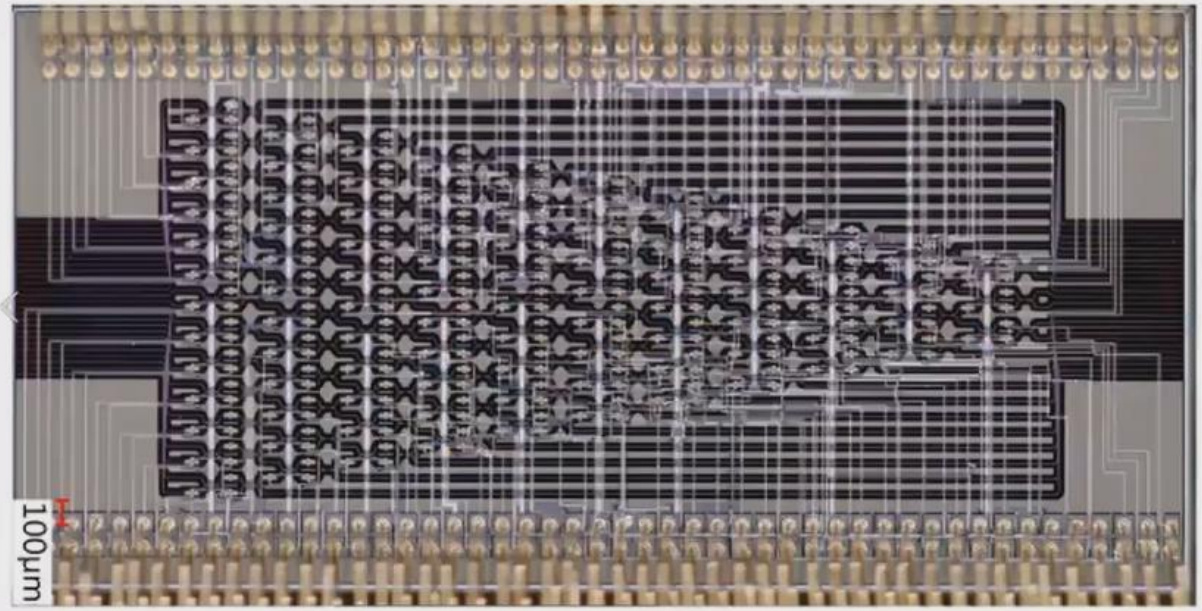
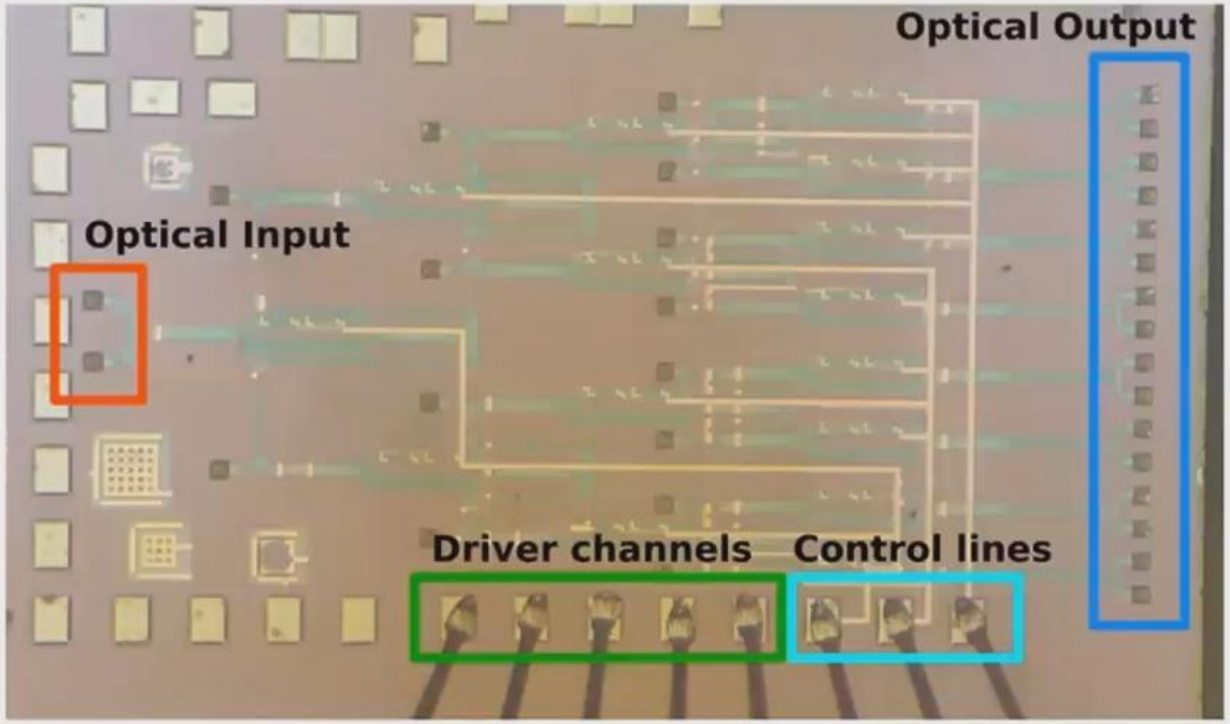
Photonic integrated circuits are getting more co and demanding



Hariss et. al., Nature Photonics (2017)
Shen, Hariss et. al., Nature Photonics (2017)
Hariss et. al., Optica (2018)



A. Ribeiro et. al., IEEE J. Sel. Topics Quantum Electron. (2017)

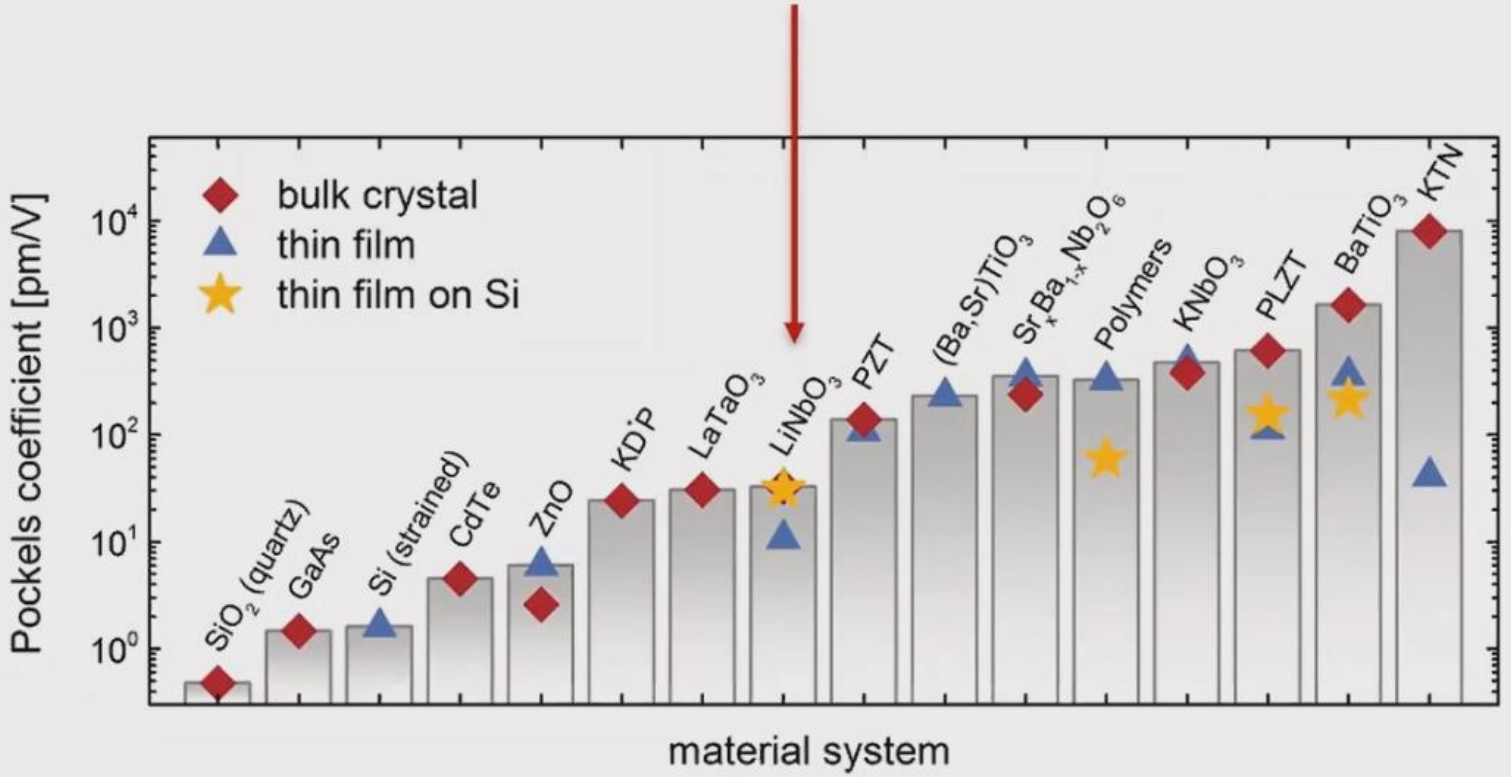
Lithium Niobate (LN) is an interesting candidate for hybrid integration

Pockels coefficient

$\chi^{(2)}$ coefficient

$\chi^{(3)}$ coefficient

Low loss



https://www.zurich.ibm.com/st/photonics/materials.html

Modulators are still under development

Broadband

Fast

High Extinction Ratio

Low insertion Loss

Pure phase/amplitude modulation

Modulators are still under development

M. Zha
C. War
C. War

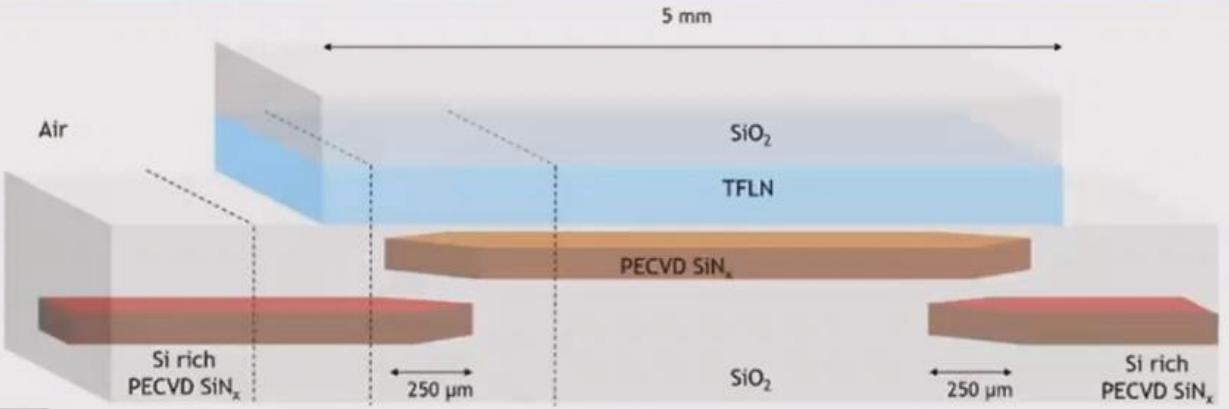
Broadband

Fast

High Extinction Ratio

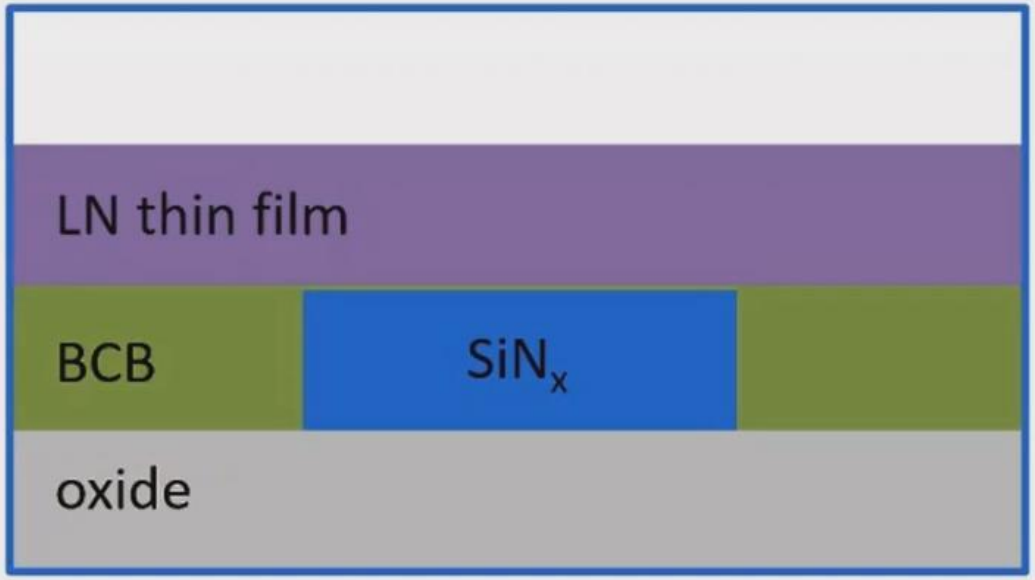
Low insertion Loss

Pure phase/amplitude modulation

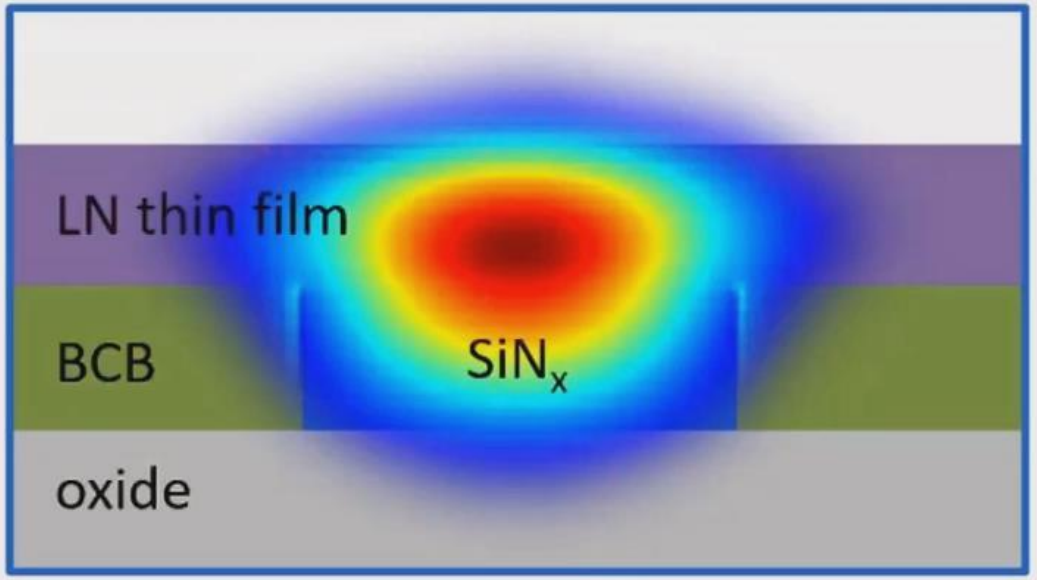


N. Boyton et. al., Opt. Express (2020)

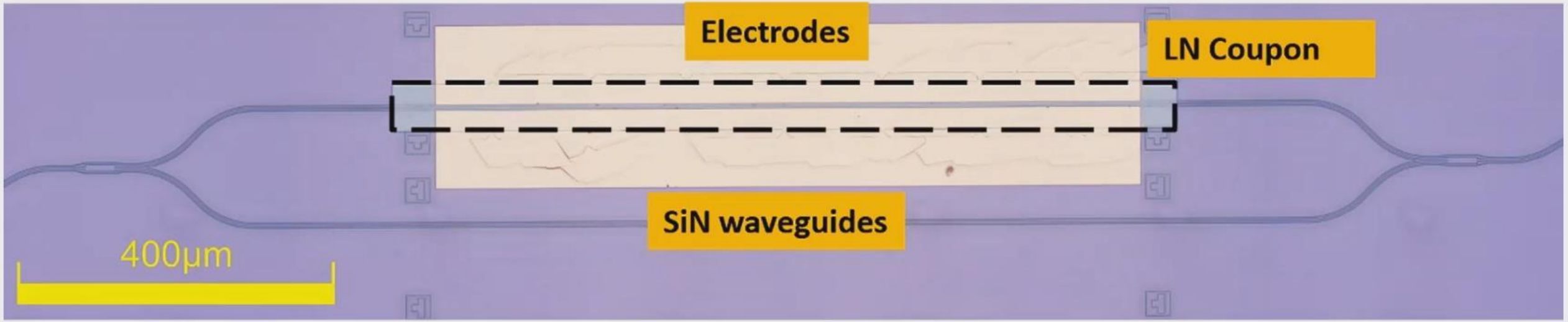
Micro-transfer printing of thin film LN enabl properties on the Si_3N_4 platform



Micro-transfer printing of thin film LN enabl properties on the Si_3N_4 platform



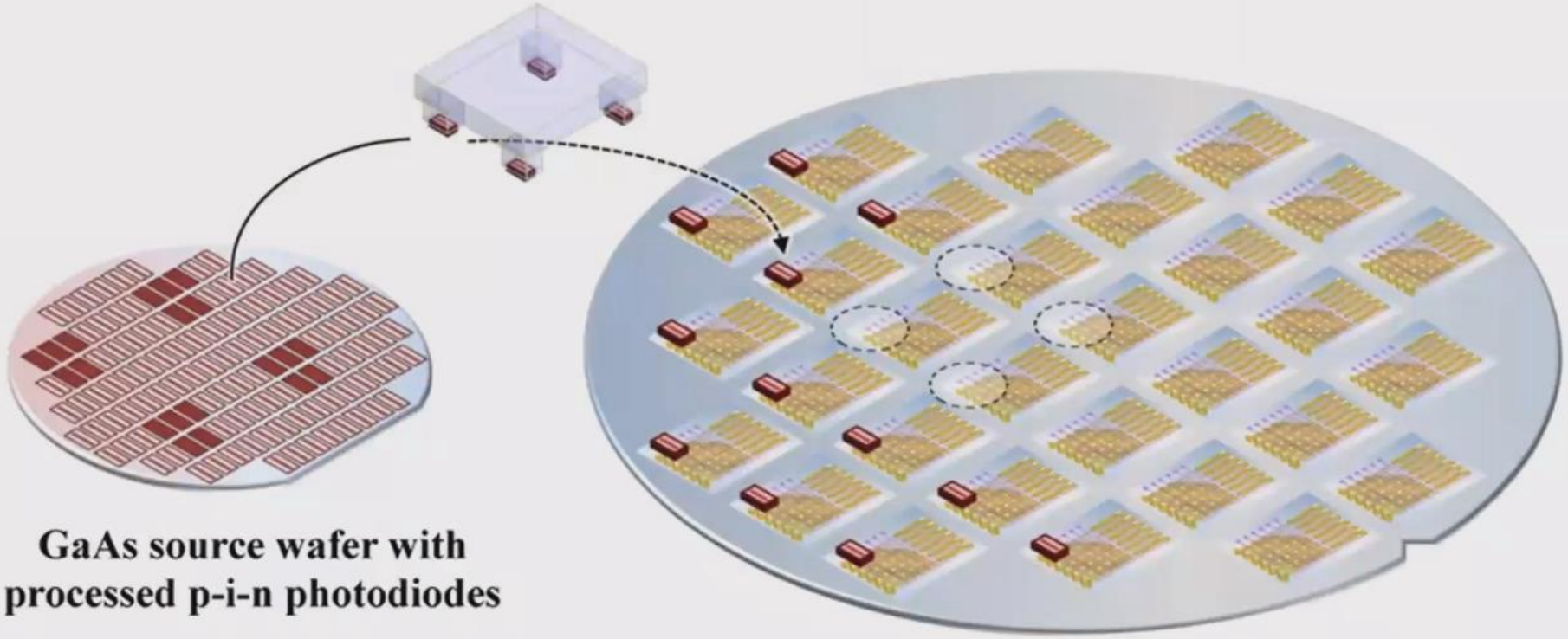
Proof of concept: electro-optical (EO) modulato demonstration



Micro-transfer printing allows for the hybrid integration of micrometer sized devices or thin films

J. Zhang et. al., APL Photonics (2019)
G. Roelkens et. al., IEEE Opt. Int. Conf. (2018)

simultaneous transfer of multiple devices using an elastomer stamp



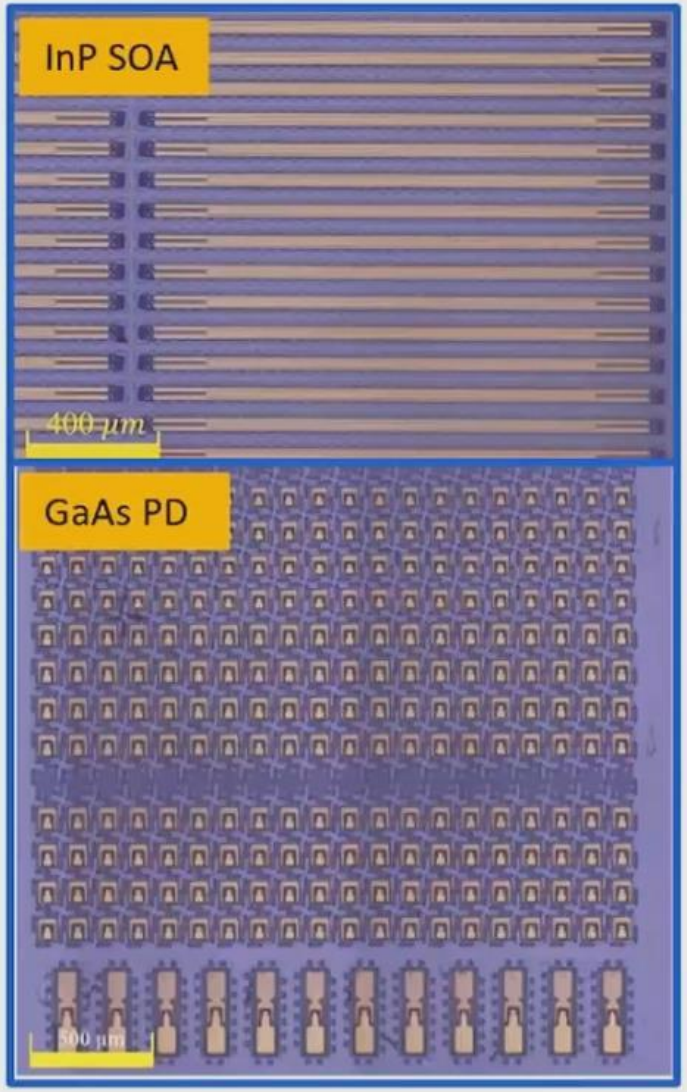
GaAs source wafer with processed p-i-n photodiodes

target SiN_x wafer

Micro-transfer printing can co-integrate different materials back-end process

- High-volume manufacturing
- Efficient material use
- Dense co-integration

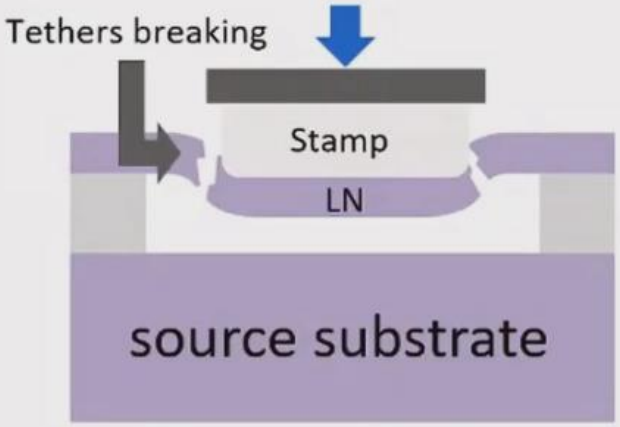
- Alignment accuracy dependent on equipment



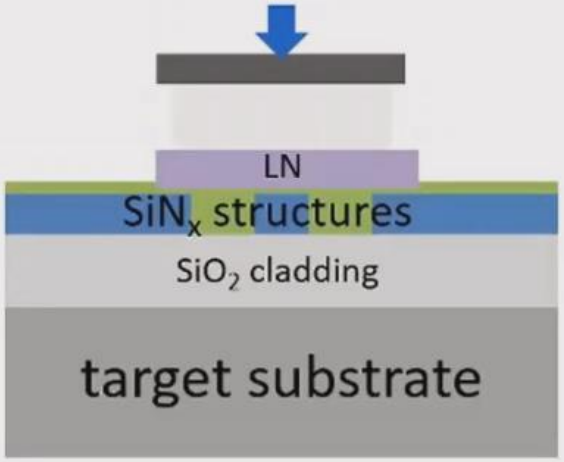
B. Haq et. al., Optics Express (2020)

J. Goyvaerts et. al., Optics Express (2020)

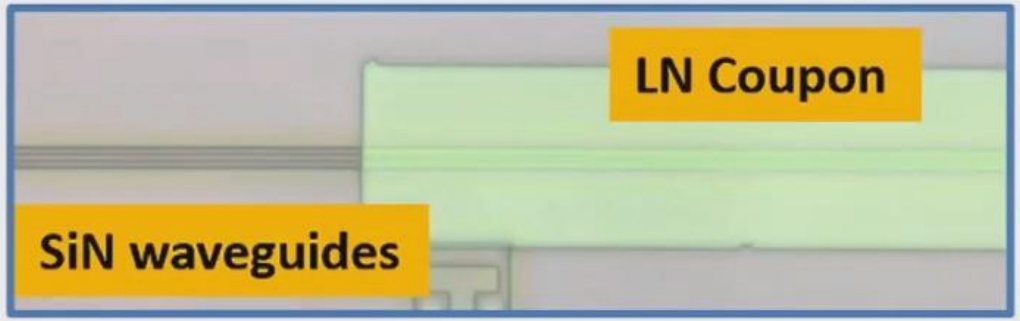
The source and target sample are fabricated using st photolithographic processes and brought together



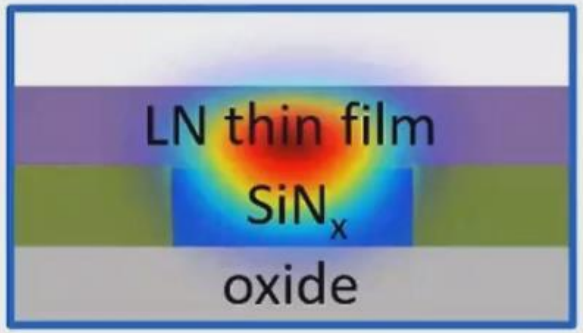
Pick the coupon from source

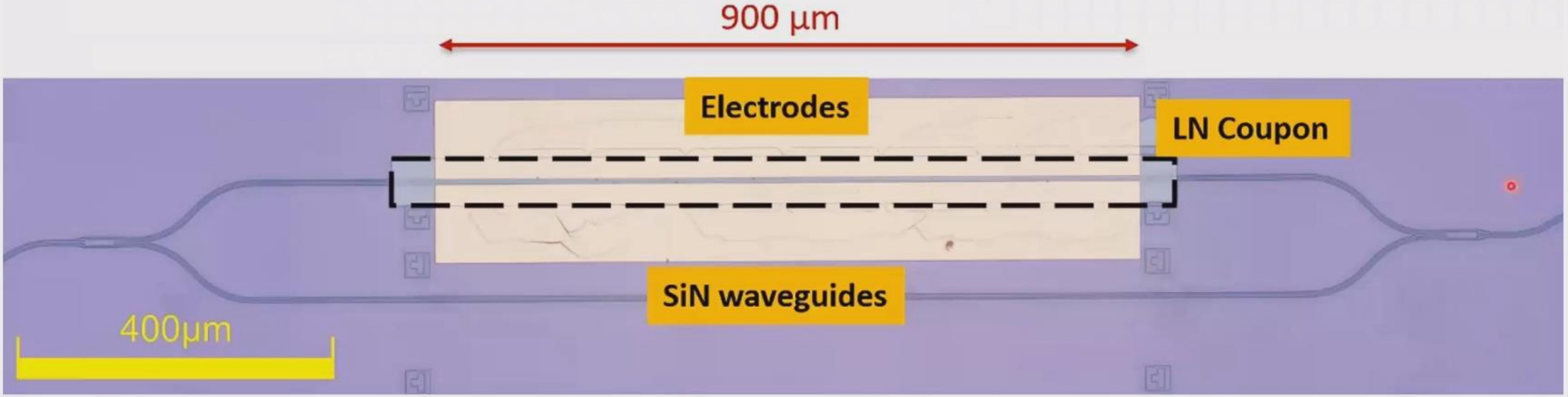


Print the coupon on target



To test the properties simple MZI circuits were fabrica measured



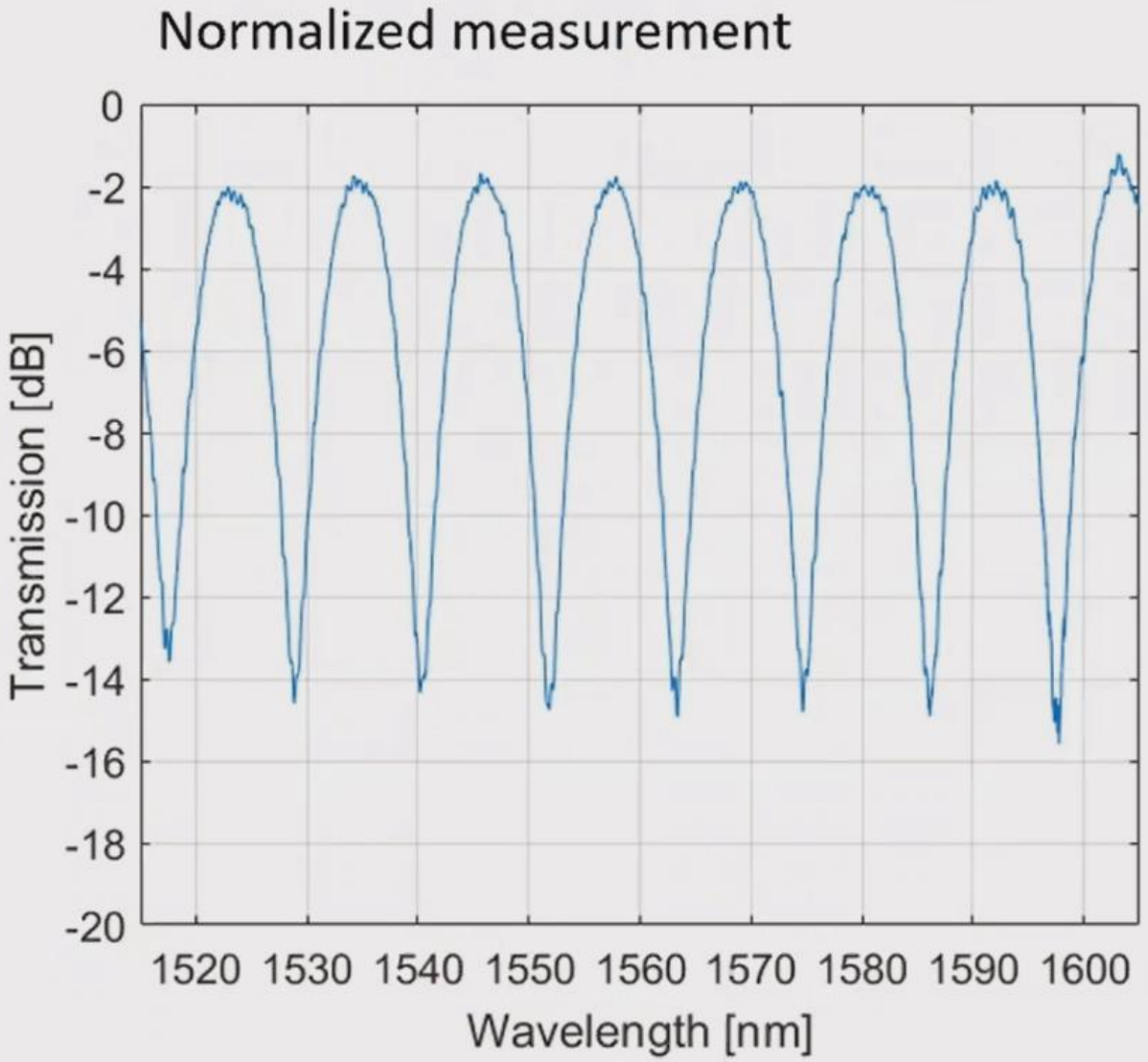


From the extinction ratio the loss can be calculated

measured extinction ratio: 12 dB

equivalent loss: 4 dB/coupon

simulated loss: 2 dB/facet

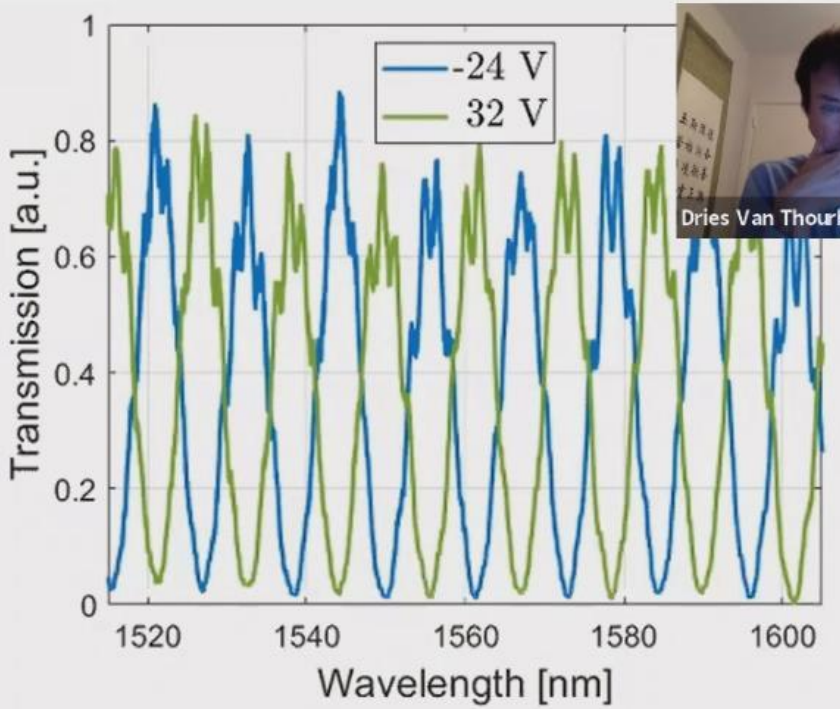


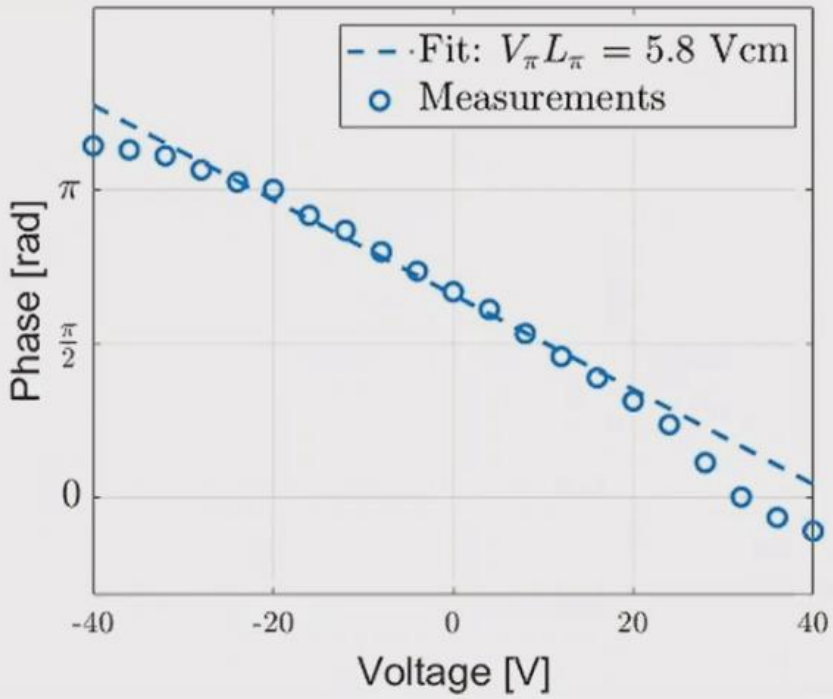
The EO response is close to the simulations

fitted $V_\pi L_\pi$ = 5.8 Vcm

simulated $V_\pi L_\pi$ = 6.0 Vcm

insertion loss: ~7 dB





Further development of the micro-transfer printing pro required

Fast modulator

Lower loss by making taper structures