

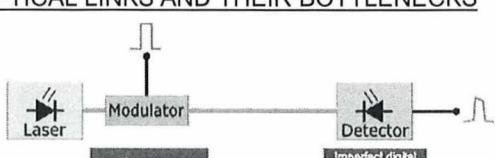


CHARACTERIZATION OF ELECTRO-OPTICALLY ACTIVE THIN FILMS FOR NEUROMORPHIC PHOTONIC CIRCUITS



Enas Lieveins, Ewout Picavet, Klaartje De Buysser, Dries Van Thourhout, Peter Bienstman and Jeroen Beekman

OPTICAL LINKS AND THEIR BOTTLENECKS



- New electro-optic materials
- Better material integration
- Optimized modulator design
- Better signal processing
- Low-power alternatives
- Optical signal processing

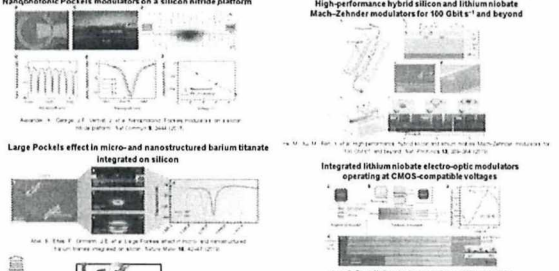


HIGH-SPEED MODULATOR TECHNOLOGIES

Nanophotonic Pockels modulators on a silicon nitride platform

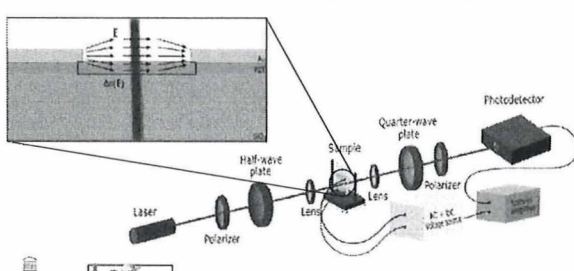


High-performance hybrid silicon and lithium niobate Mach-Zehnder modulators for 100 Gbit/s² and beyond

Large Pockels effect in micro- and nanostructured barium titanate integrated on silicon

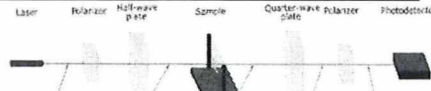
Integrated lithium niobate electro-optic modulators operating at CMOS-compatible voltages



CHARACTERIZATION OF EO THIN FILMS

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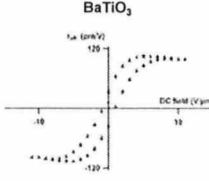


$$\Delta n(E) = n_x - n_y \approx \Delta n(0) - \frac{1}{2} n^3 (r_{33} - r_{13}) E = \Delta n(0) - \frac{1}{2} n^3 r_{eff} E$$

$$P_{out} = \left(\frac{1}{2} + \frac{\pi n^3 r_{eff} V_m d}{2 \lambda L} \right) P_{in} \Rightarrow r_{eff} = \frac{\lambda L}{n^3 \pi d} \frac{dV_{diode}^{base}}{dV_m}$$



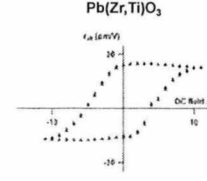
POCKELS COEFFICIENTS FOR PZT AND BTO

BaTiO₃





$r_{33} = -106.60 \text{ pm/V}$

Pb(Zr,Ti)O₃



$r_{33} = -24.10 \text{ pm/V}$

NEUROMORPHIC COMPUTING

von Neumann architecture

Neuromorphic architecture

Phoenergi M. et al. Training Passive Photonic Reservoirs With Integrated Optical Readout. 2020. 1543-1553 (2020)

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PHOTONIC NEUROMORPHIC COMPUTING

Photonic reservoirs with electrical readout

Photonic reservoirs with integrated optical readout

Phoenergi M. et al. Training Passive Photonic Reservoirs With Integrated Optical Readout. 2020. 1543-1553 (2020)

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EVERYTHING IS COMMUNICATING

Volume of data transmission in Europe (predicted by IHS Markit, 2016 to 2026 in Tbps/year)

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PROMISING RESULTS FROM SIMULATIONS

Readout trained using ridge regression

The next step is to turn simulation into experiment

Phoenergi M. et al. Training Passive Photonic Reservoirs With Integrated Optical Readout. 2020. 1543-1553 (2020)

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RESERVOIR COMPUTING

Recurrent neural network closely resembles brain

Framework of computation for recurrent neural networks

Training of network occurs at readout, so ideal for photonics

- Adapting makes of samenvoeging op slide 7&8

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Sensing, imaging and spectroscopy session

14:30 | Tutorial: Prof. Michel Voué (UMons)

What can we learn from imaging ellipsometry analysis of plasmonic nanocomposite materials?

15:10 | Invited: Prof. Francesca Ceschet (UNamur)

Vibrational nonlinear optical spectroscopy as innovative, label-free and highly sensitive bio-recognition solution

15:40 | Contributed talks

Margot Vandermotten (VUB) - *In-vitro DILI monitoring using Raman spectroscopy*

Aina Fitó Parera (UAntwerpen) - *Spectroscopic techniques to characterise encapsulated dye molecules inside single wall carbon nanotubes*

16:10 | Paper discussion - Indy Magnus (VUB)

L. Smeesters, I. Magnus, et al, "Potato quality assessment by monitoring the aspartamide precursors using reflection spectroscopy and machine learning", *Journal of Food Engineering* 311, 110599, 2021.

16:40 | Beer break & networking

Day #2 : Friday 24 September 2021

Optical fibers and integrated optics session

08:45 | Tutorial: Prof. Peter Bienstman (UGent - IMEC)

Photonic neuromorphic computing using silicon chips

09:25 | Invited: Dr. Agnieszka Gieraj (VUB)

Fabrication of microstructured polymer optical fibers

09:55 | Contributed talks

Enes Lievens (UGent) - *Characterization of electro-optically active thin films for photonic circuits*

Médéric Loyez (UMons) - *Cancer cells detection using optical fiber sensors*

10:25 | Paper discussion - Awanish Pandey (UGent - IMEC)

A. Pandey et al., "Nonreciprocal Light Propagation in a Cascaded All-Silicon Microring Modulator", *ACS Photonics* 8(7), 1997-2004, 2021

10:55 | e-coffee break "Coffee & Chocolate"

Optical design session

11:20 | Tutorial: Prof. Fabian Duerr (VUB)

"First time right" freeform optics design

12:00 | Invited: Dr. Lionel Clermont (ULiège)

