Planar Polymer Waveguides for Medical Applications
Agenda

- vario-optics ag
- Planar polymer waveguides and their integration
- Coupling schemes
- EOCB's for medical sensors
- EOCB's for high speed data transfer
- Conclusions
vario-optics ag
Heiden, Switzerland

- Spin off from Varioprint AG
- Own clean room with necessary equipment
- Financed privately
- Independent from Varioprint
History

2002  Varioprint starts development of EOCB technology

2004  Cleanroom installation
       1st patent filed

2005  1st electro-optical circuit board demonstrated at
       SMT in Nürnberg

2006  Establishing regular EOCB fabrication runs
       Successful completion of 2 EOCB-projects

2007  Winner of “Swiss Technology Award 2007”

2008  Assembly of electro-optical components with
       conventional SMD insertion machines

2009  Spin-off vario-optics ag

2011  New LDI- and layer deposition machine
       installed
Electro-Optical Circuit Board
Layer Build-up

Electrical layers

Mirror

Waveguide
Manufacturing:
Substrate
Manufacturing:
Deposition of Lower Cladding
Manufacturing: UV-Curing
Manufacturing:
Deposition of Core Layer
Manufacturing:
Mask- or LDI- Structuring
Manufacturing: Development of Core Layer
Manufacturing: Deposition of Upper Cladding
Manufacturing: UV-Curing
Manufacturing:
Lamination
Waveguide Properties

- **Substrates:** rigid, flex, up to 305 x 460 mm²
- **Dimensions:** 30 x 30 μm² – xxx x 500 μm²
- **Pitch:** min. 60 μm (aspect ratio: 1:1)
- **Optical attenuation:** < 0.05 dB/cm @ 850nm
- **Numerical Aperture:** 0.33 (Θ/2 = 19.2°)
Additional Degree of Freedom in Design

Splitter / Combiner

Crossings

Taper / Lense Structures

High density interconnects
**Butt-Coupling**

- **Direct, horizontal coupling** (LED's, Laser/Photodiodes, Fibers)
- **High coupling efficiency**
- **No further optics required**
- **Passive assembly**

![Diagram of Butt-Coupling setup]

- LED
- Waveguide carrier (FR4)
- Optical Casting
- PCB with electronic components
- Upper cladding layer
- Core layer
- Lower cladding layer
Coupling Element

- Optical attenuation: 1.2 dB
- Pitch: 500 μm
- Pick & Place tolerance: ± 100 μm (3 dB loss)
- Layer thickness variation: up to 1 mm
Electro-Optical Circuit Boards for Medical Applications

- **Sensors**
  - Light sources
  - Light absorbance
  - Evanescence field
  - Index change
  - Bending
  - ...

- **High speed data transfer**
  - High speed imaging
  - Bio-chemical simulations (Supercomputing)
  - ...


EOCB's for Sensors

- Better optical performance for splitters/combiners compared to fiber-based systems
- High reproducibility
- Complex planar optical systems
- Highly integrated electronics and optics
- Automated, passive assembly
Highly Integrated, 4-Wavelengths-Laser-Source

- Highly integrated, fits into a cigarette box
- Competes with free-space and fiber based optics
- 4 laser sources of different wavelengths coupled into one glass fiber
- Splitter for reference channel
Optical PH-Electrode

- Highly integrated electro-optical sensor for PH-detection (spectral absorption)
- Complex planar optical structure
- Optical layer thickness: 500 µm
Blood-Coagulation Sensor

- Puck – electromagnetically moved
- Light barrier to monitor movement
- Highly integrated electro-optical sensor
Evanescence Field / Index Change

- Cladding layers can be structured as well
- Detection of the presence of material
Optical vs. Electrical High Speed Signal Transmission

- Higher bandwidth density
- Lower cost at high datarates
- Reduced complexity

- Significant reduction of power losses (up to 75%)
- No electro-magnetic radiation
- Galvanic separation
Optical Flex Supporting High Data Rates

- 1 x 48 inputs, 4 x 12 outputs
- > 480 Gbit/s
- Passively assembled MT-ferrules
- Realized by panel-size (305 x 460 mm$^2$)
Optical Backplane

- **Rigid-flex board (260 x 360 mm²)**
  - 192 waveguides on backplane (2 Tbit/s)
  - 192 waveguides on linecard
- **Finisars optical Engine**
  - 2 x 12 x 10 Gbit/s, passively cooled
- **Huber + Suhners optical backplane connector**

Live demo – data rate of 10Gbit/s

Backplane (4 Linecards)
Conclusions

- Electro-optical circuit board technology is used within more and more applications
- Data- and telecom applications can profit from reduced costs and power consumptions at higher data rates
- Better optical performance and reduced costs for complex optical systems for sensor application
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The future is bright!