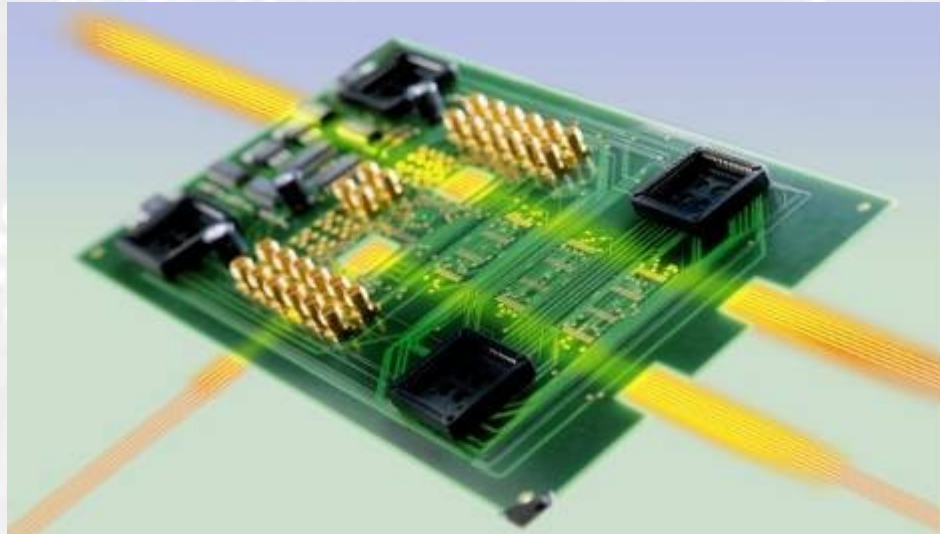


# **vario-optics ag**



## ***Planar Polymer Waveguides for Integrated Optical Packages***

# Agenda



- **Introduction vario-optics**
- **Technology**
- **Motivation**
- **Challenges**
- **Coupling strategies**
- **Samples**

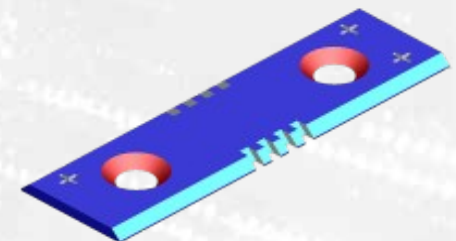
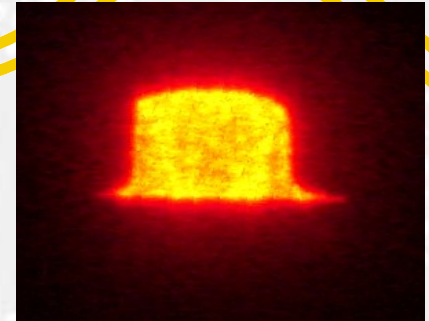
# **vario-optics ag**



- ***Spin-off from Varioprint***
- ***5 engineers with long term experience in planar polymer waveguide technology***
- ***Own clean room with necessary equipment***
- ***Financed privately***

# History

- 2002** • **Varioprint starts development of EOCB technology**
- 2004** • **Clean Room installation**
  - **Patent filed for light coupling concept**
- 2005** • **1st Electro- Optical Circuit Board (EOCB) demonstrated at the SMT in Nürnberg**
- 2006** • **Establishing EOCB fabrication processes**
  - **Successful development of two EOCB projects**
- 2007** • **Winner of the „Swiss Technology Award 2007“**
- 2008** • **Assembly of electro-optical components with conventional SMD insertion machines shown by FAPS Uni Nürnberg**
- 2009** • **Spin-off vario-optics ag**
- 2011** • **New LDI Machine and improved Layer Deposition**



# **vario-optics ag**

## **Business Concept**



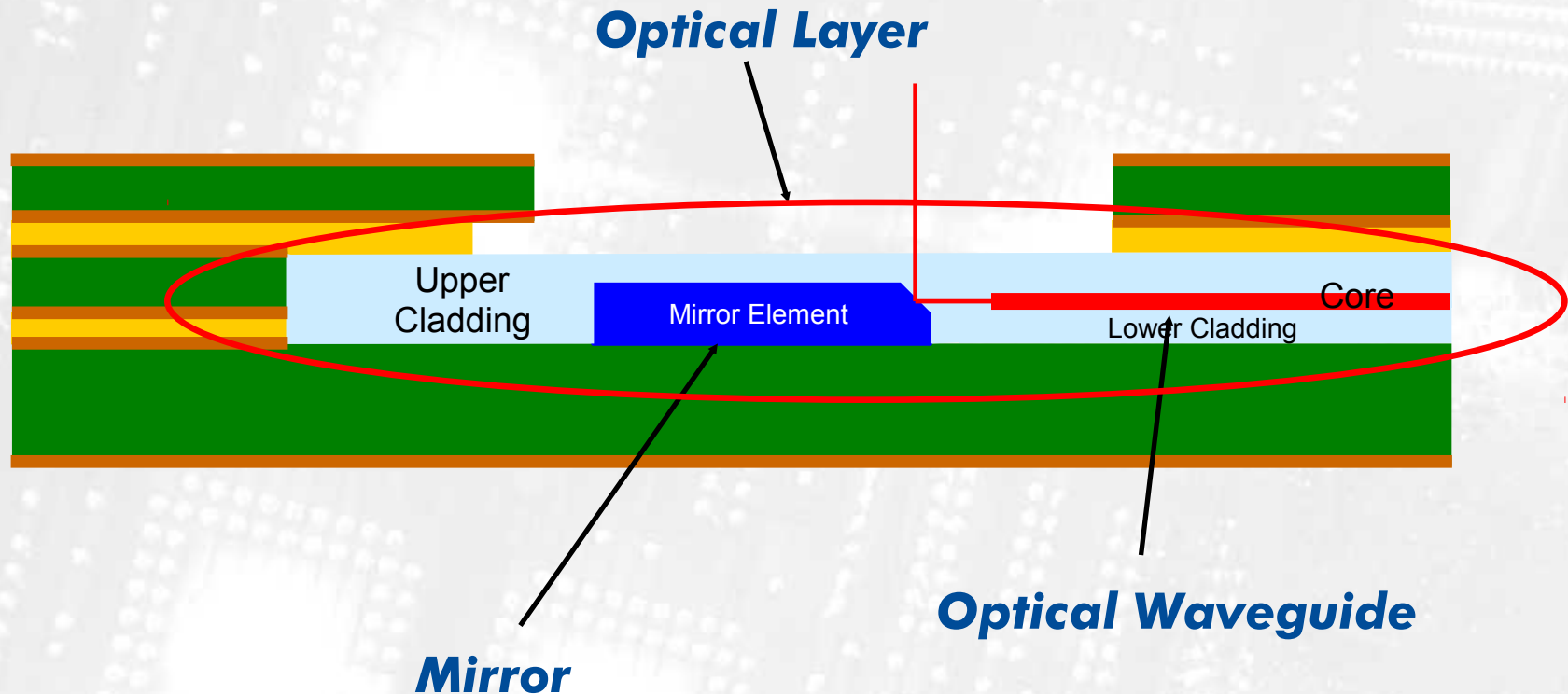
- **Development of production technologies for electro-optical printed circuit boards (EOCB) and optical solutions**
- **Manufacturing of electro-optical functional models, prototypes and small and medium series**
- **Providing engineering services to customers**

# Targeted Markets

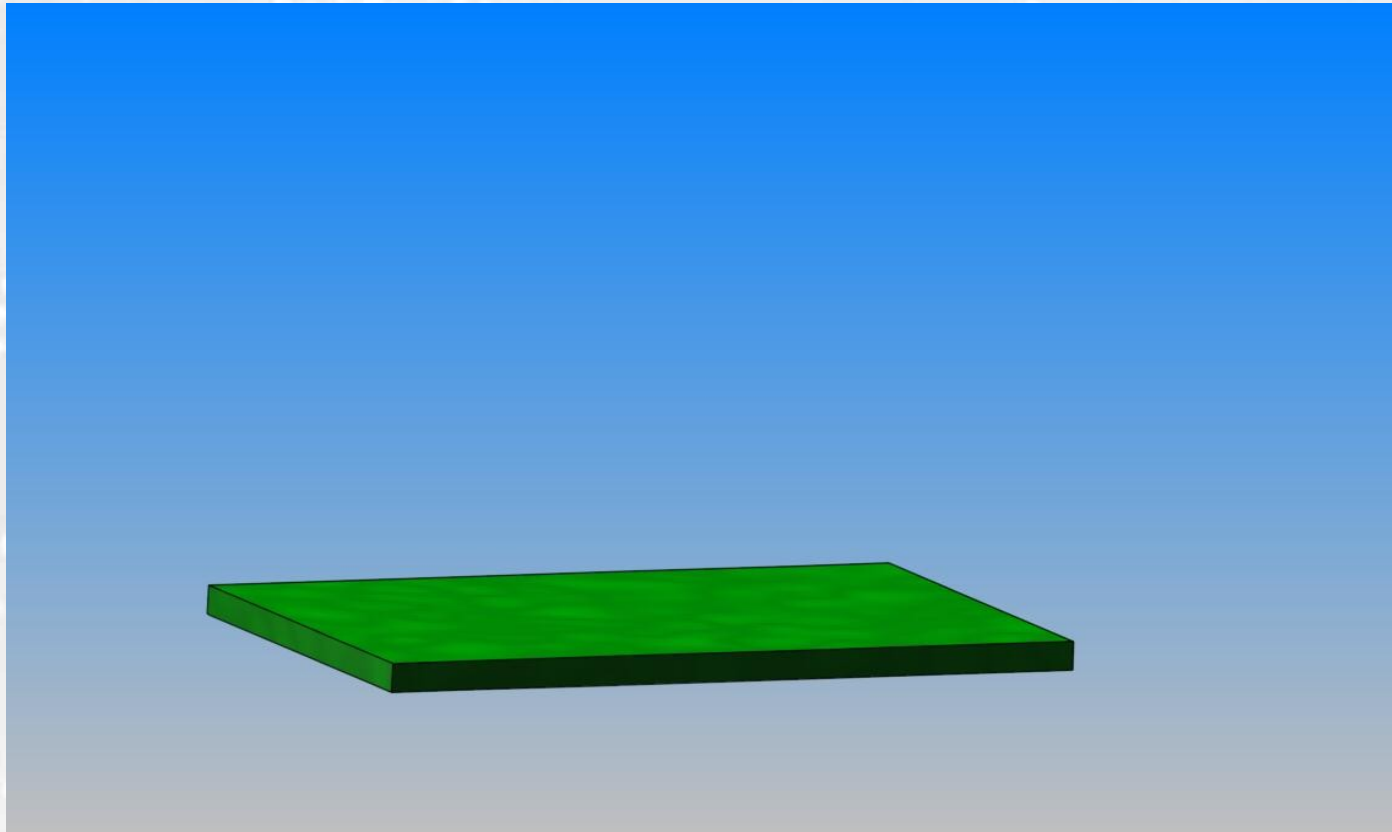


- **ICT:**
  - **Telecom – routers, switches**
  - **Datacom – switches, servers, storage devices**
  - **Super computing**
- **Sensors:**
  - **Optical sensors**
- **others**

# Electro- Optical Circuit Board Technology Concept

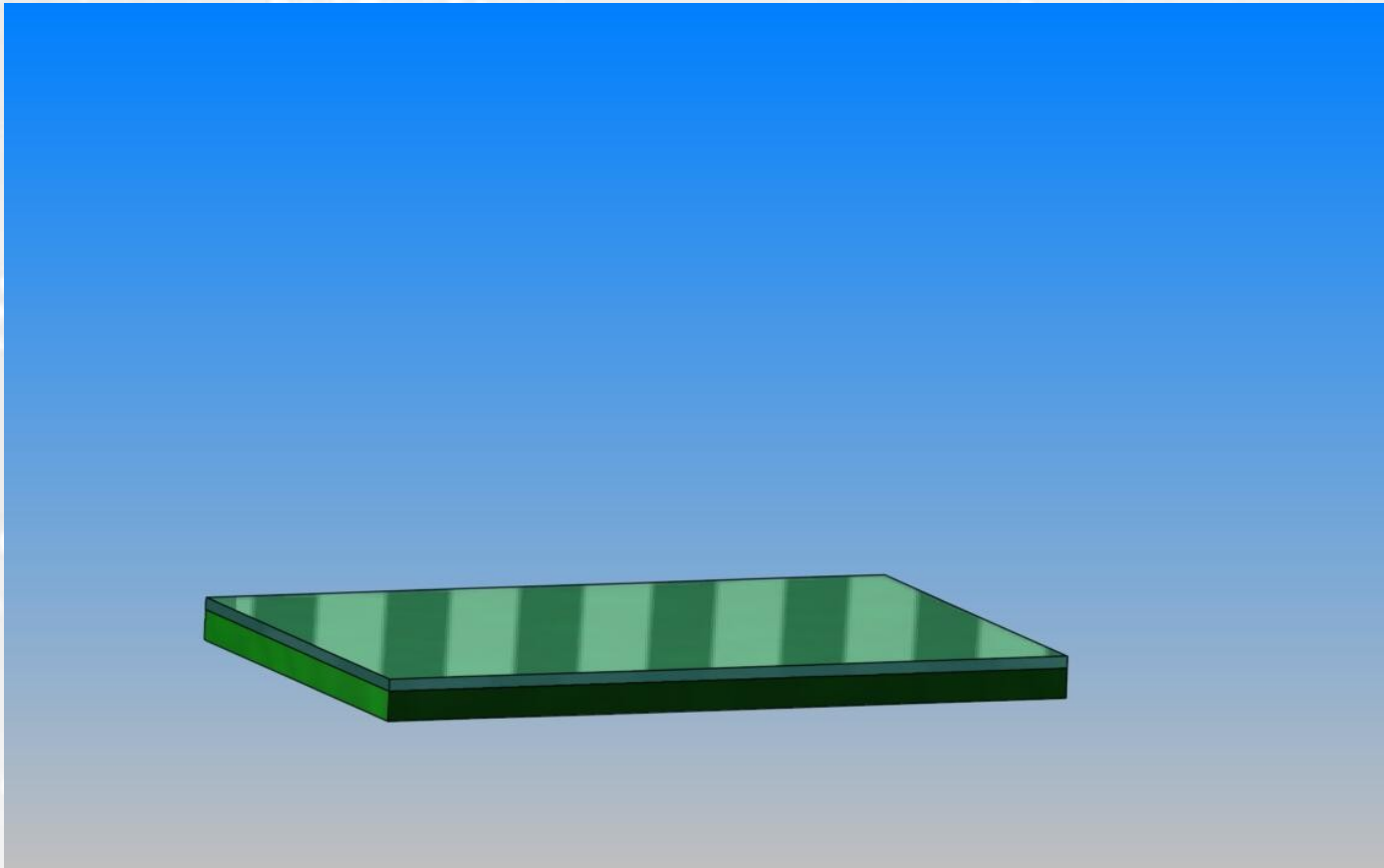


# ***Manufacturing Step 1: Substrate***

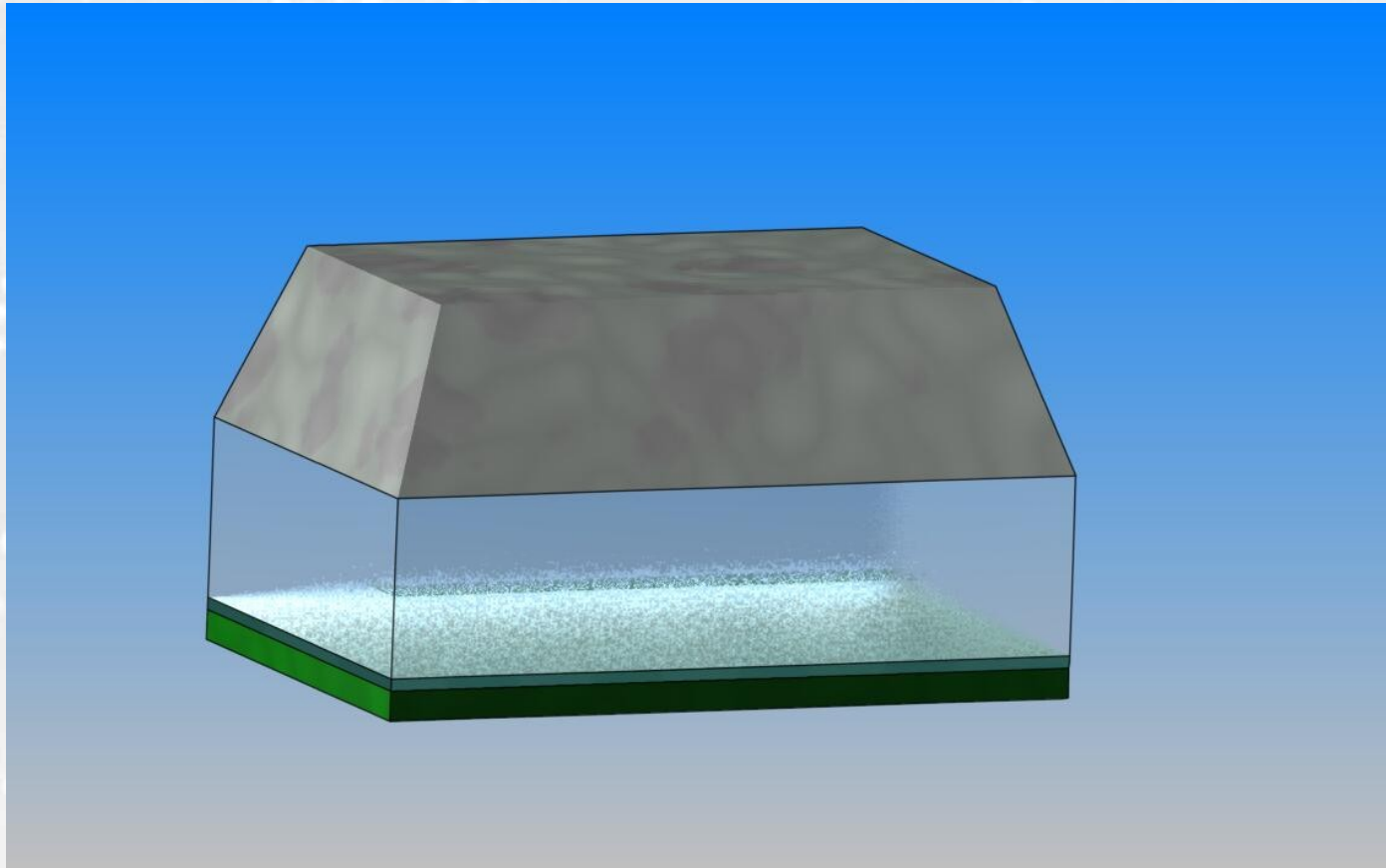




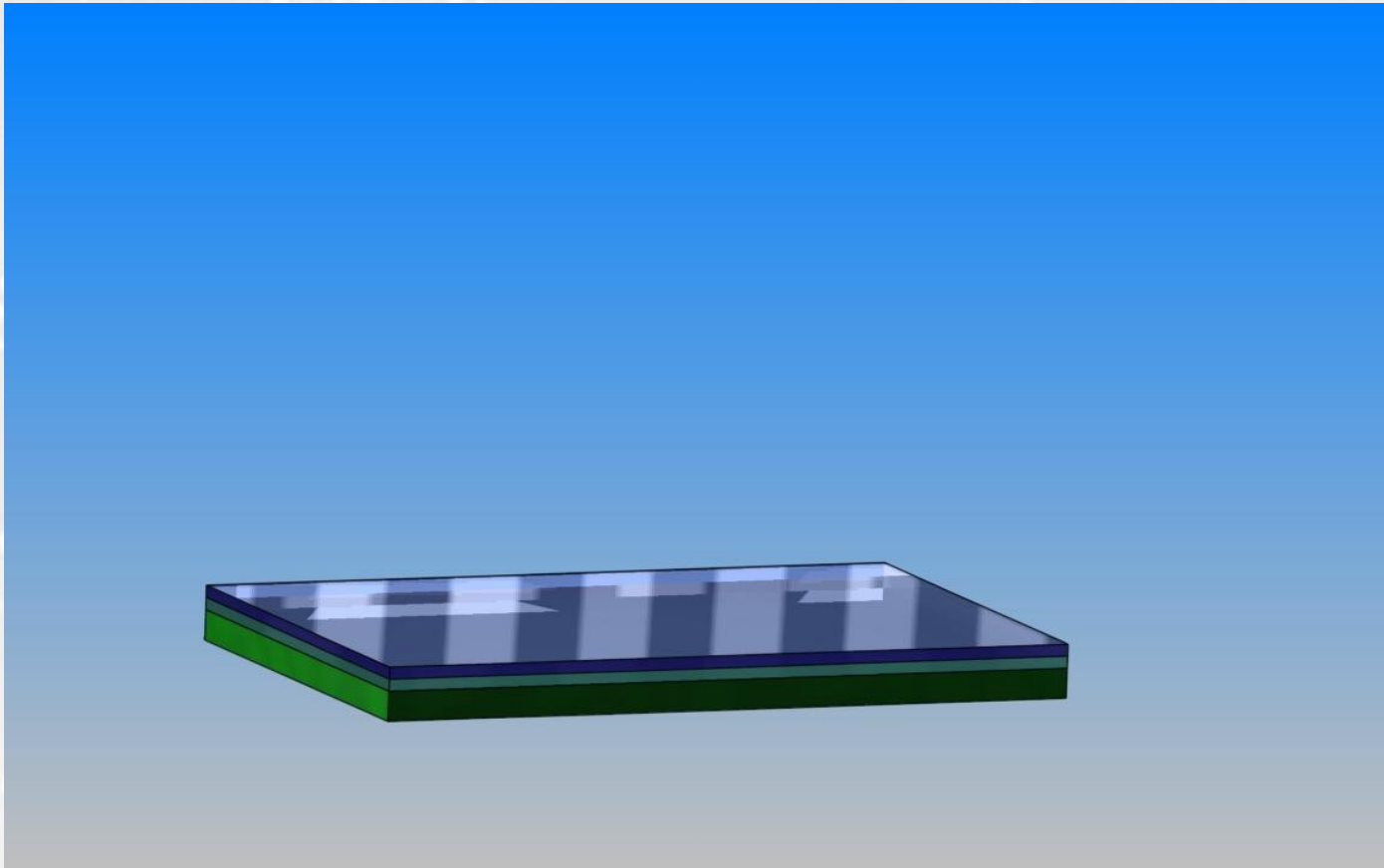
# ***Manufacturing Step 2: Doctor blading of lower cladding***



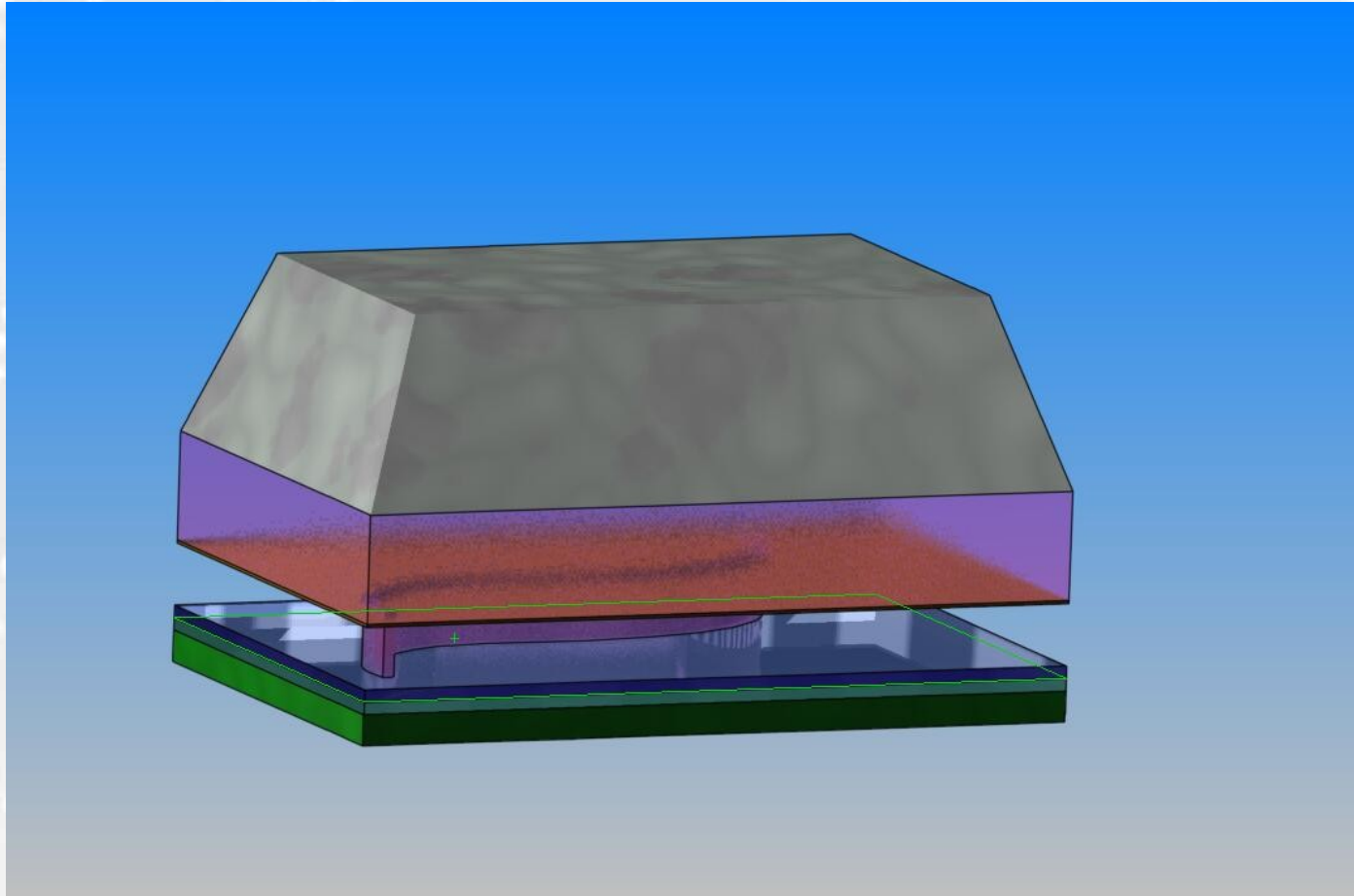
# ***Manufacturing Step 3: UV-curing of lower cladding***



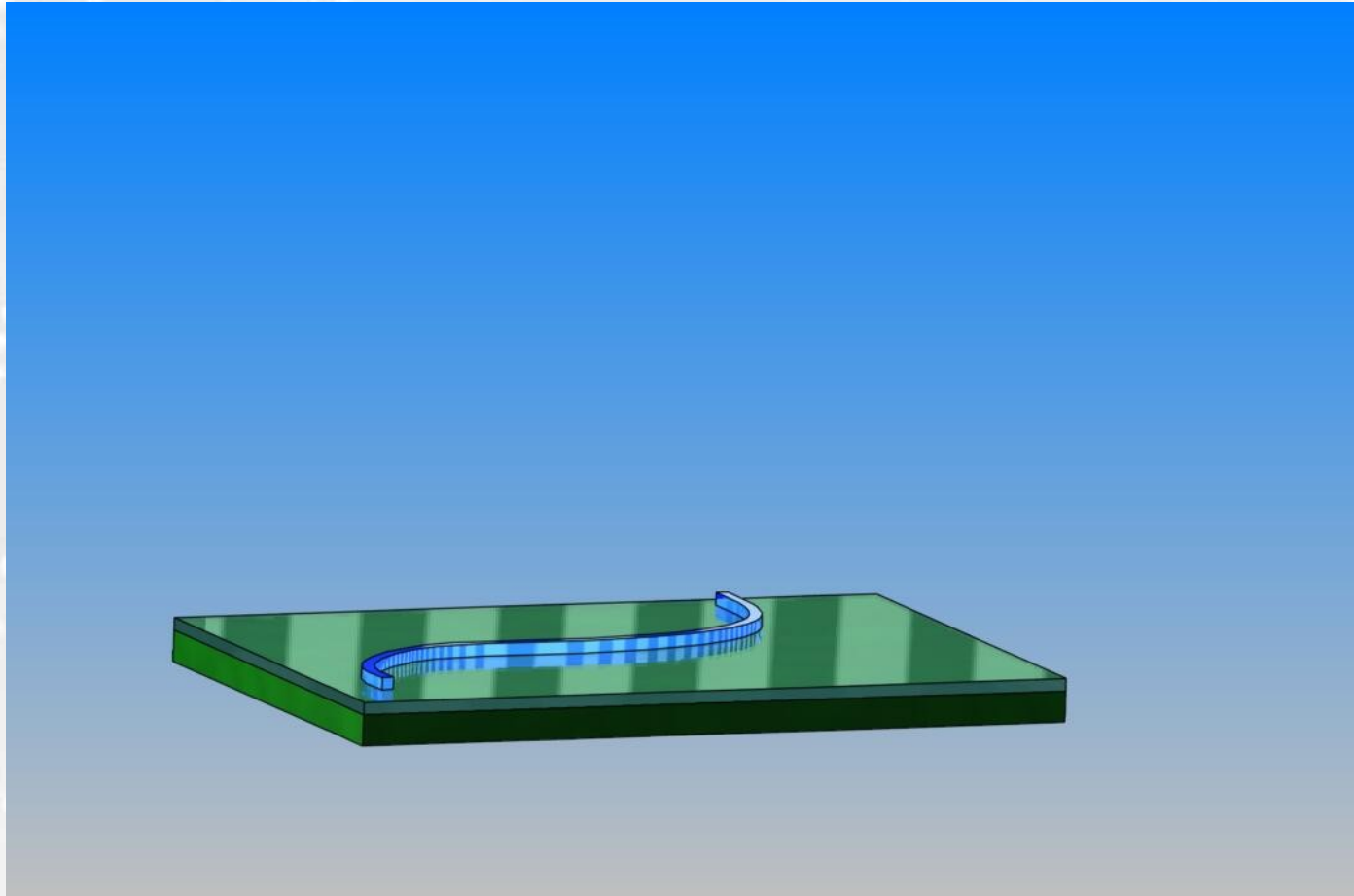
# ***Manufacturing Step 4: Doctor blading of core layer***



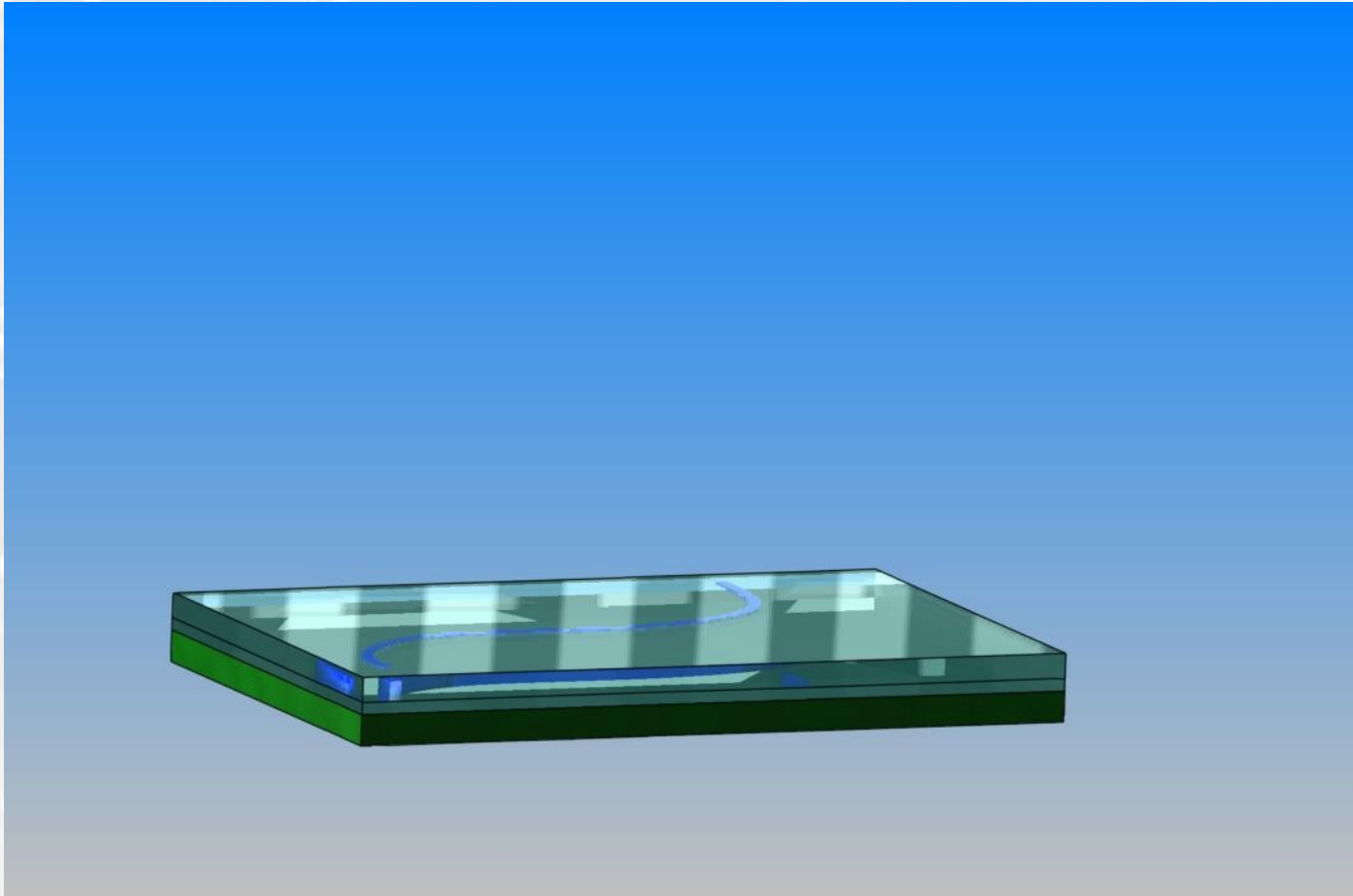
# **Manufacturing Step 5: Mask Exposing of core layer**



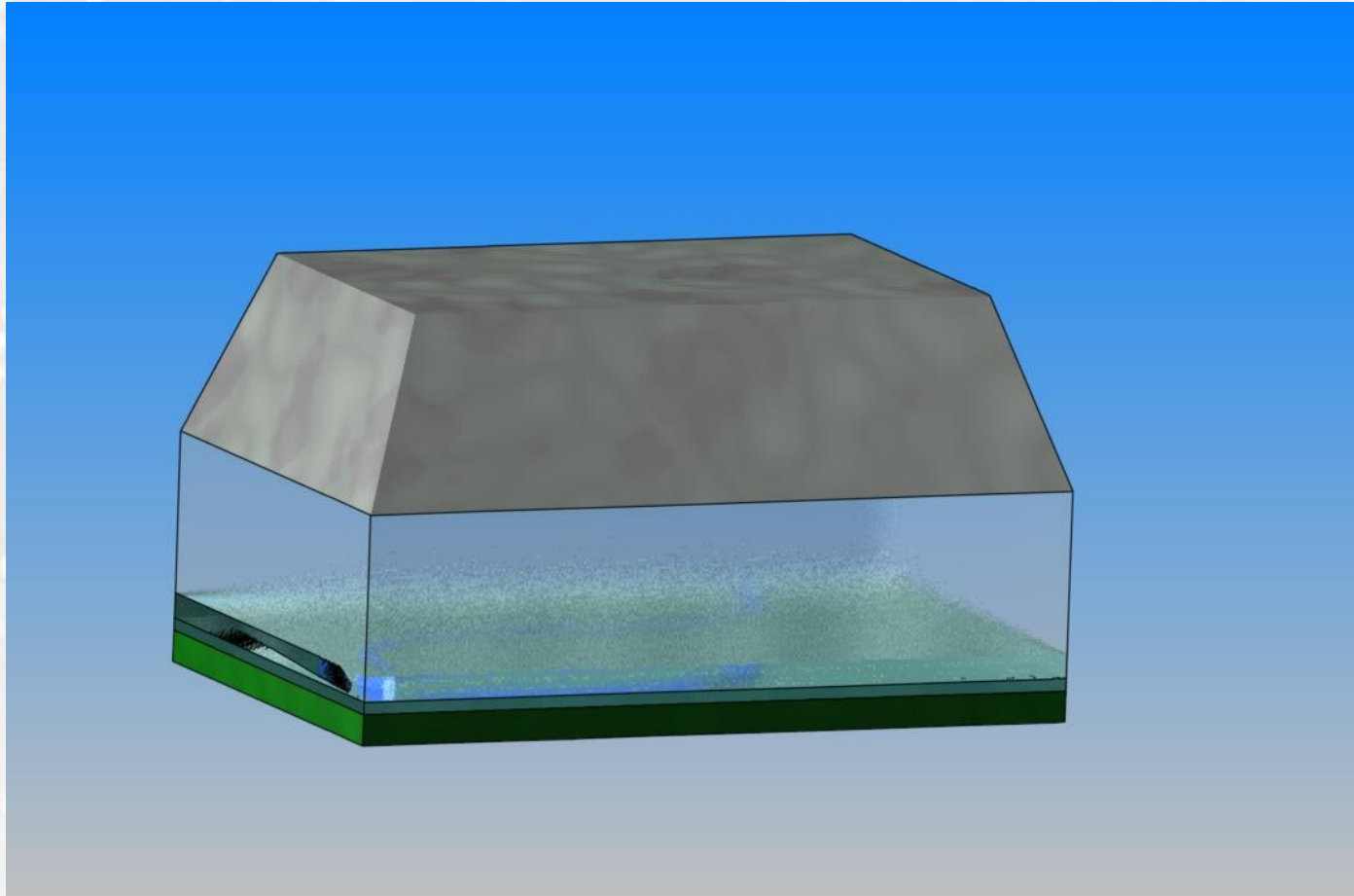
# ***Manufacturing Step 6: Development of core layer***



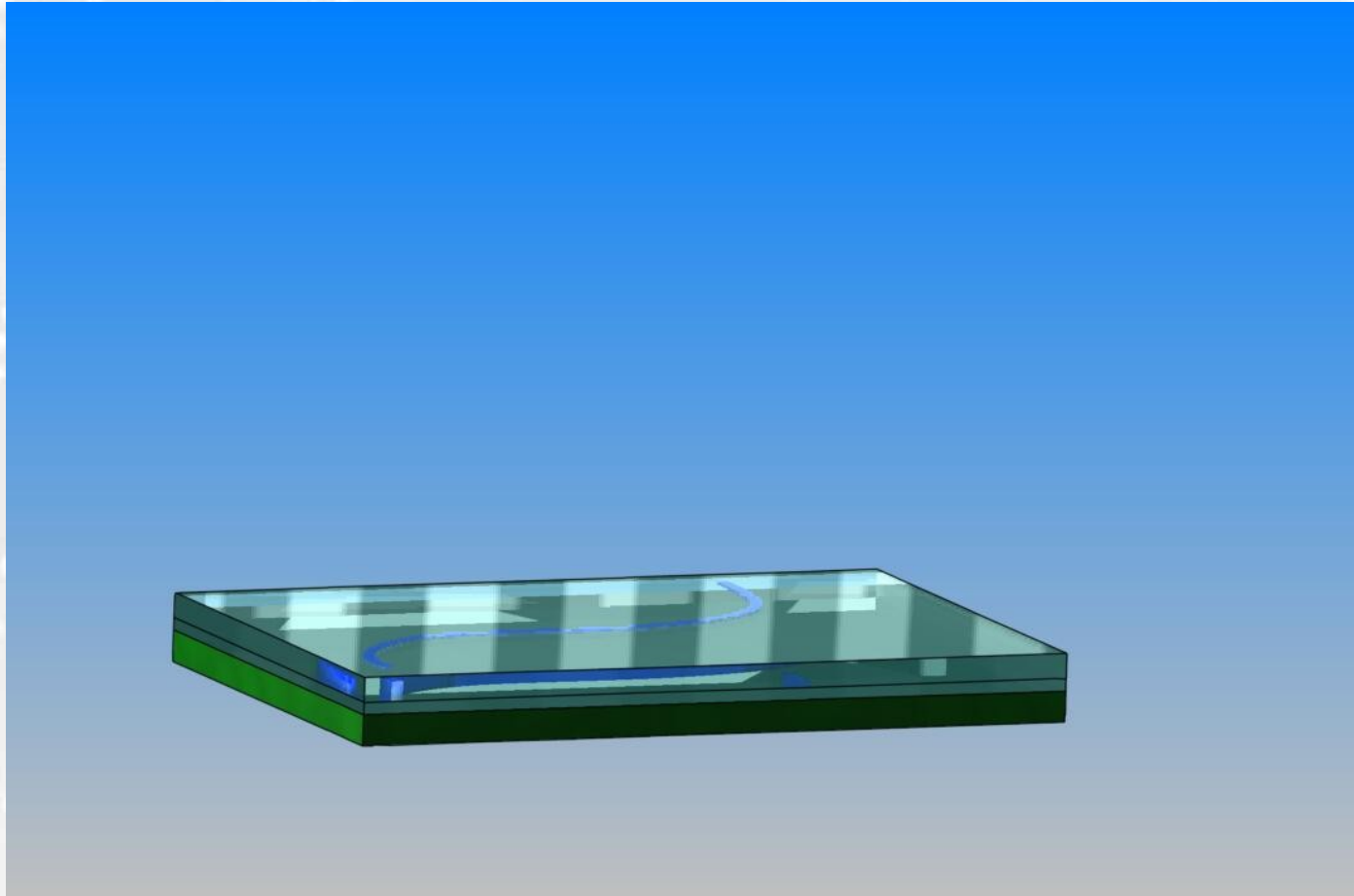
# ***Manufacturing Step 7: Doctor blading of upper cladding***



# **Manufacturing Step 8: UV-curing of upper cladding**

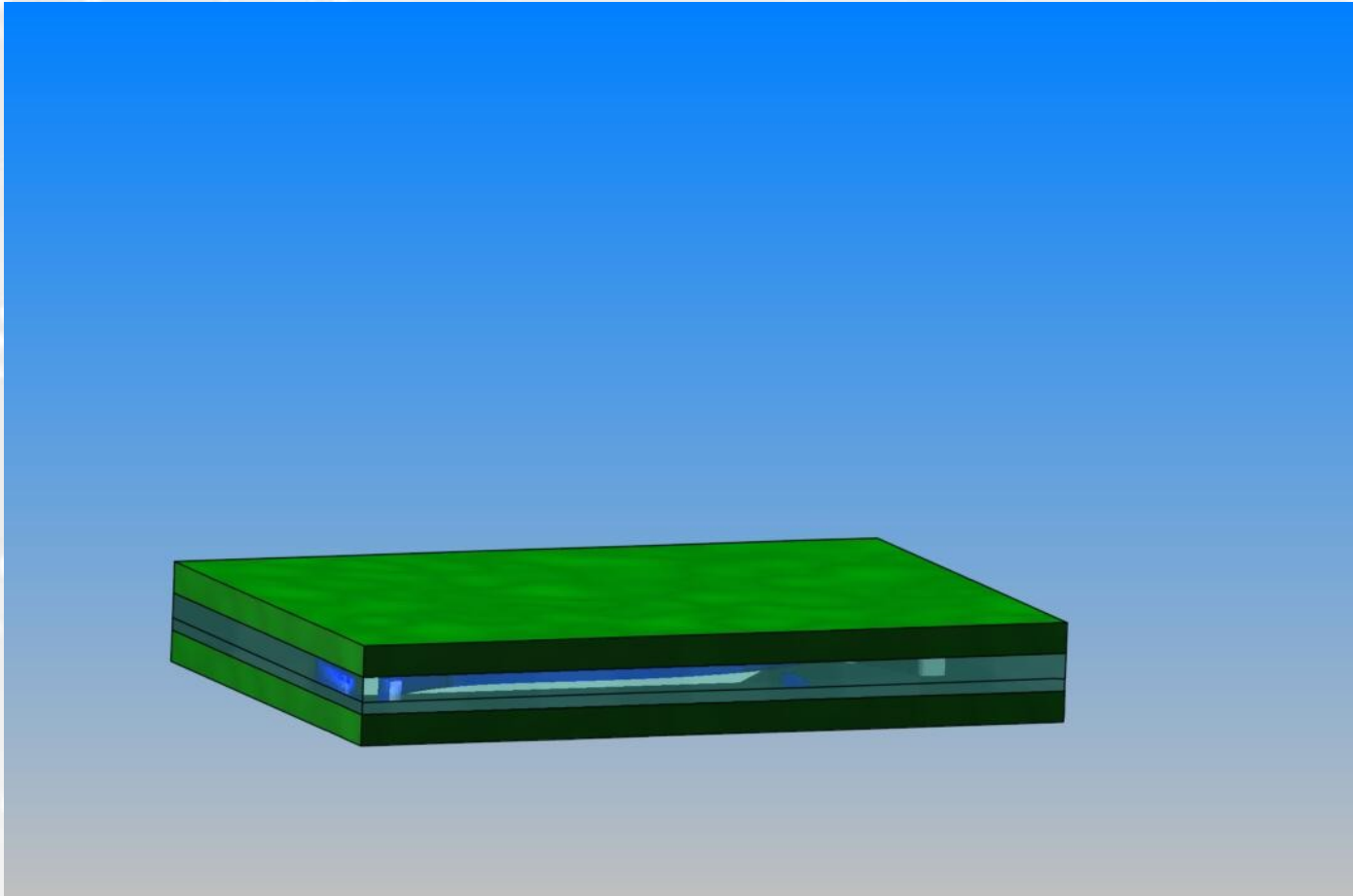


# ***Manufacturing Step 9: Cured upper cladding***



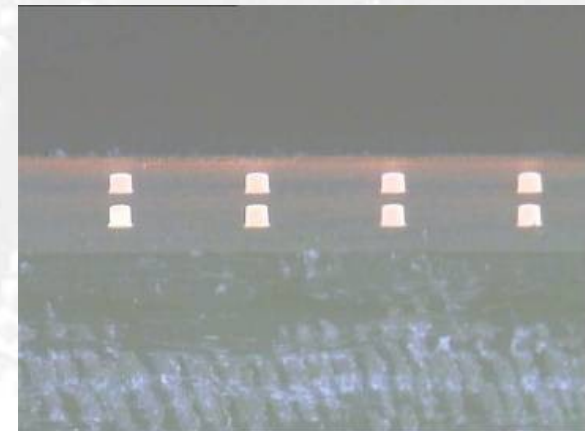
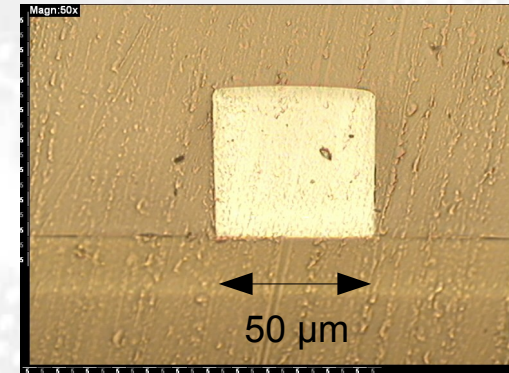


# ***Manufacturing Step 10: Lamination of upper substrate***

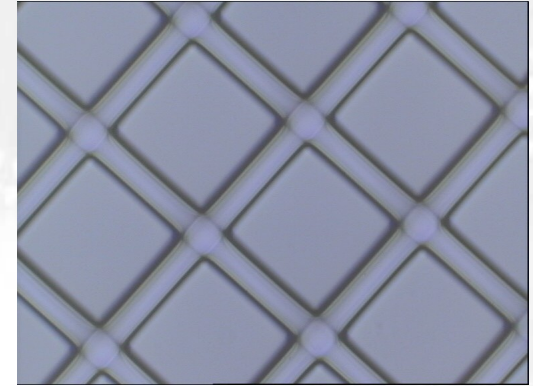
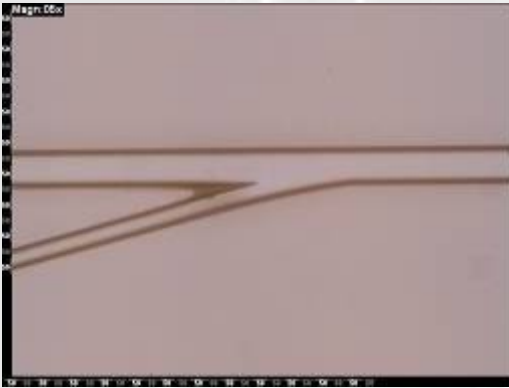


# Waveguide Properties

- **Dimension:**  $30 \times 30 \mu\text{m}^2 - xxx \times 500 \mu\text{m}^2$
- **Pitch**  $\text{min. } 60 \mu\text{m}$
- **Optical attenuation:**  $< 0.05 \text{ dB/cm @ } 850 \text{ nm}$
- **Aspect ratio:**  $1:1$
- **Numerical Aperture:**  $\sim 0.33$  ( $\theta/2 = 19.3^\circ$ )
- **Waveguide Material:** Polymer



# Motivation



- **Photolithographic process allows the implementation of virtually any optical system**
- **High integration of optics and electronic can be reached**
- **Cost effective, reproducible**
- **Compatible with PCB-manufacturing technologies**

# Challenges in panel-based production

## Waveguides:

- **Dimensions:  $< 50 \mu\text{m}$**
- **Tolerances  $< 2 \mu\text{m}$**
- **Wall roughness  $< 50 \text{nm}$**
- **Clean conditions**

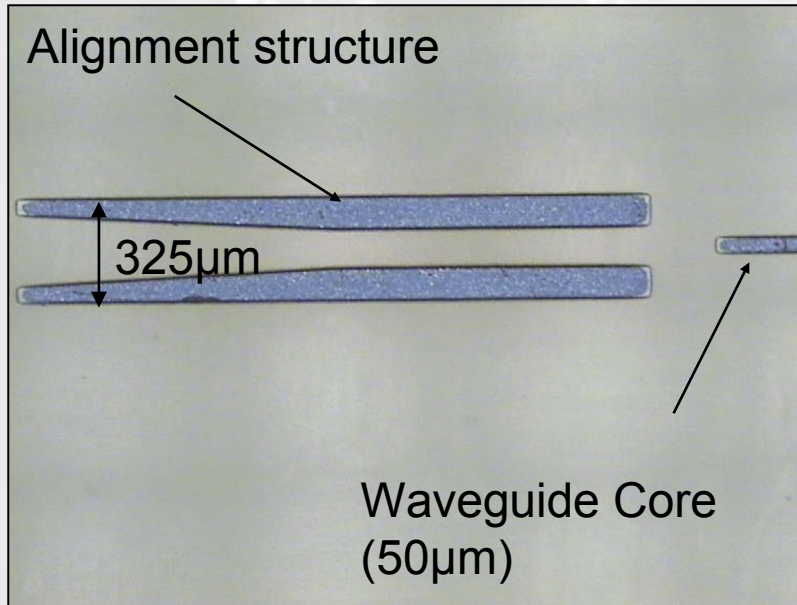


## Substrates

- **Dimensions:  $530 \times 610 \text{mm}^2$**
- **Tolerances:  $> 100 \mu\text{m}$**
- **Very bumpy  $> 5 \mu\text{m}$**
- **Dirty and acid environments**
- **High mechanical stress, temperatures, pressure**

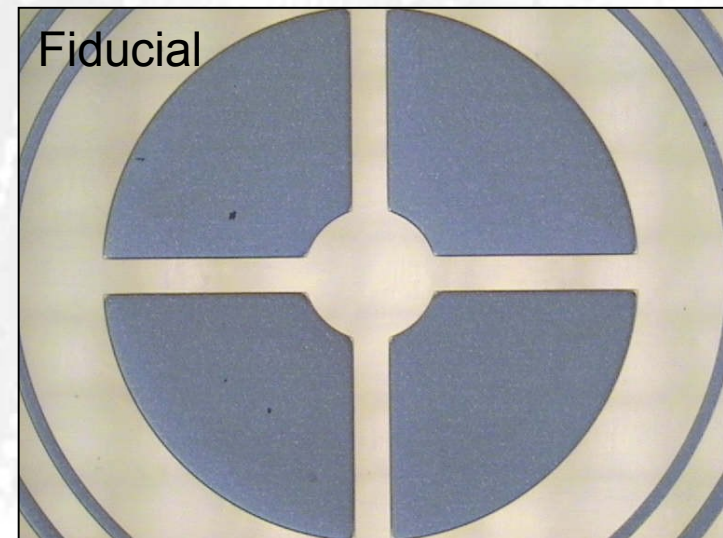


# Precise Copper Structures

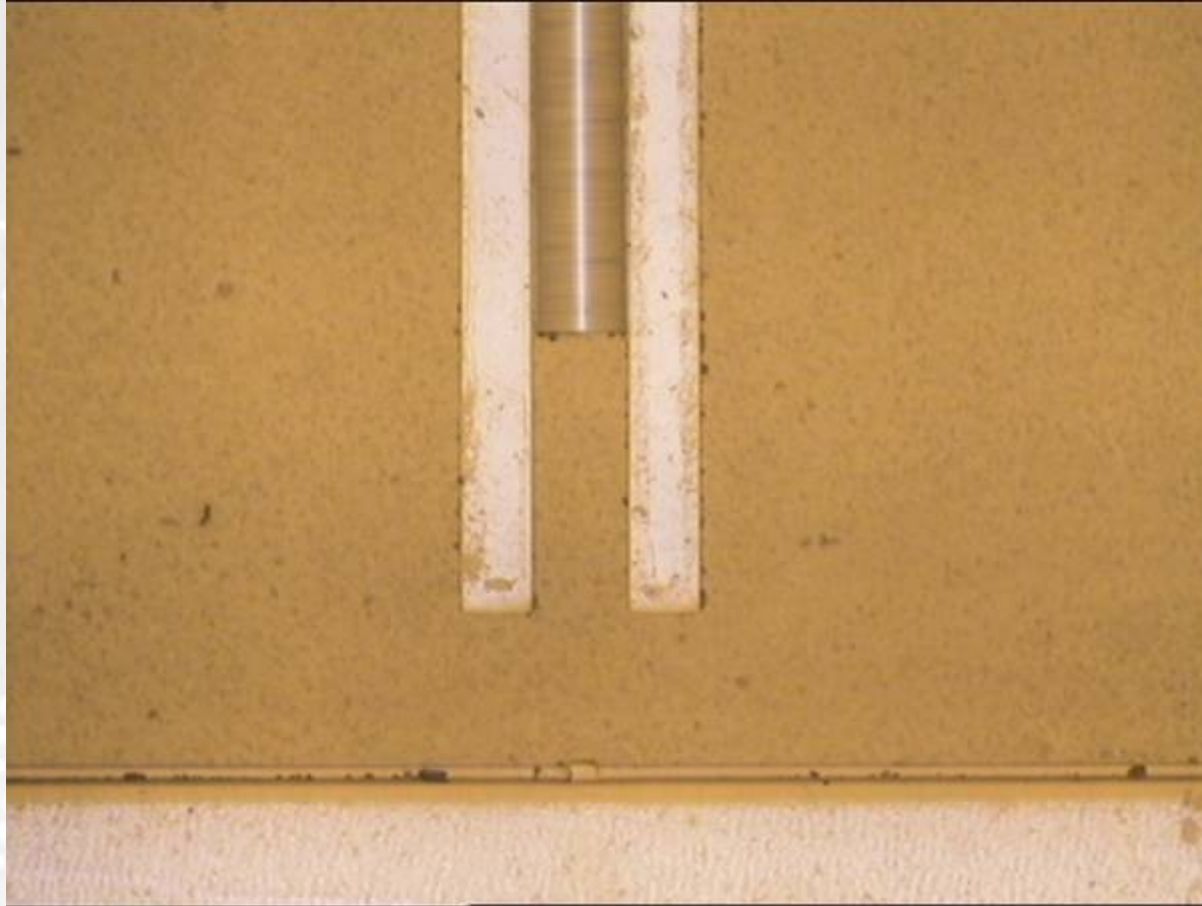


- **Copper structures for alignment of glass fibers**

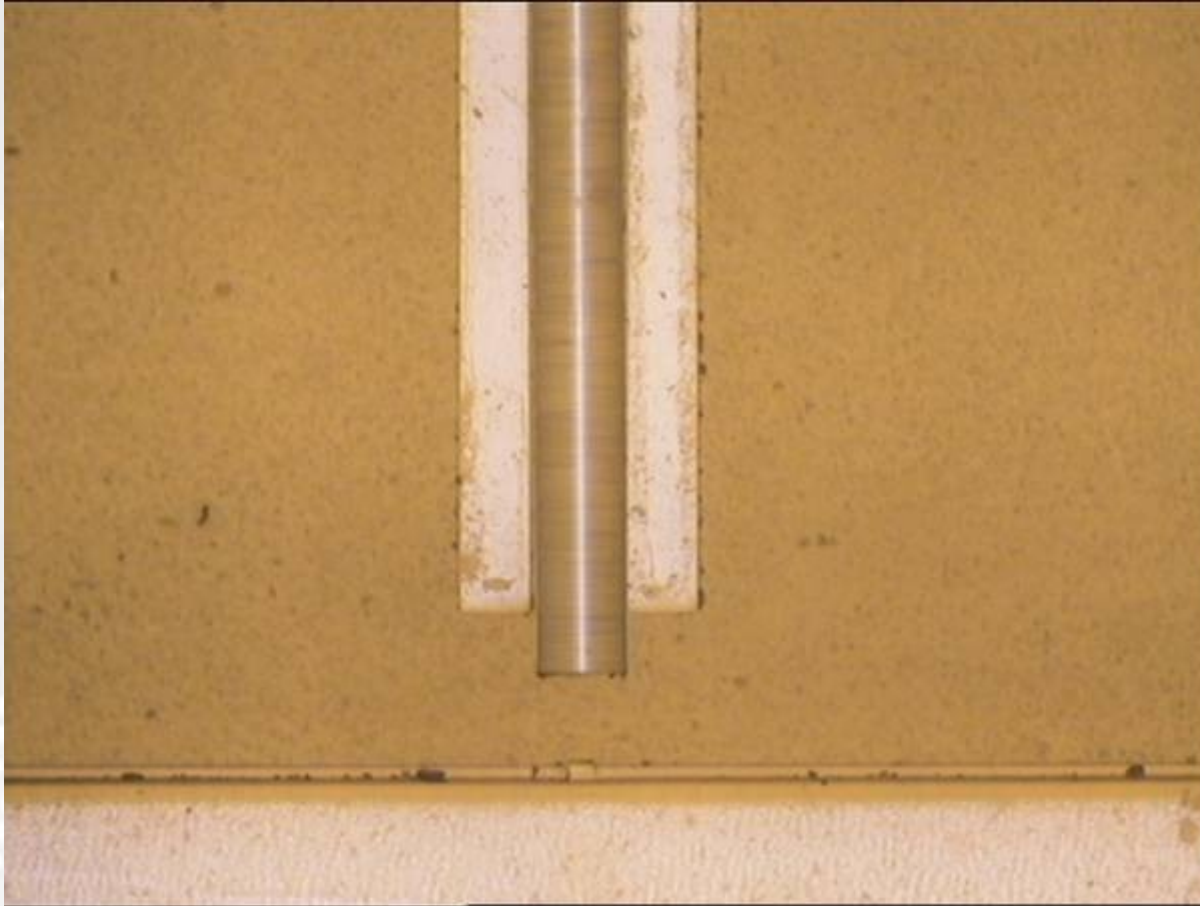
- **Precise aligned copper fiducials**



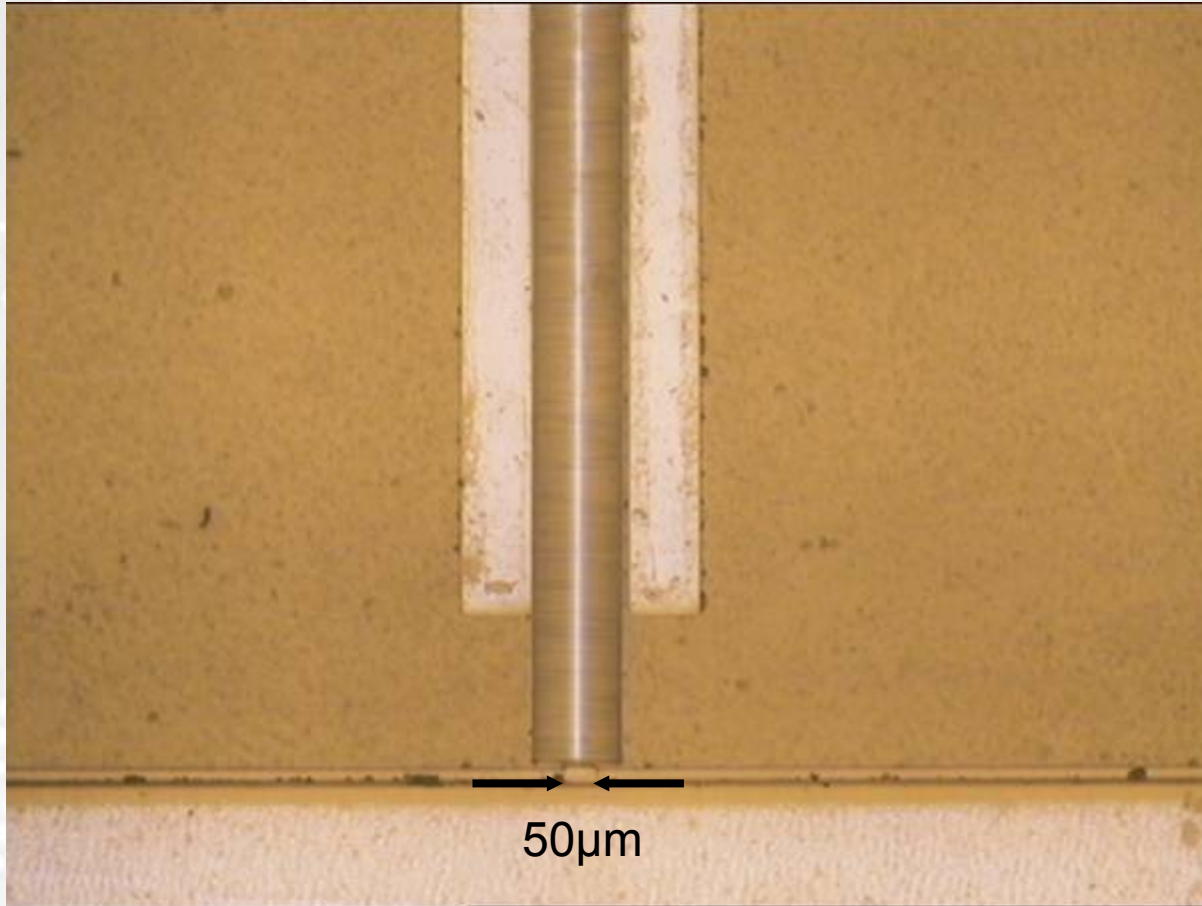
# Passive Assembly of Glass Fibers



# Passive Assembly of Glass Fibers



# Passive Assembly of Glass Fibers

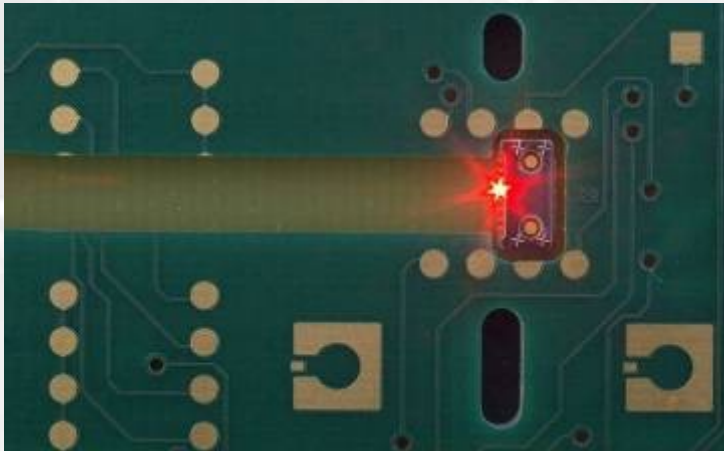




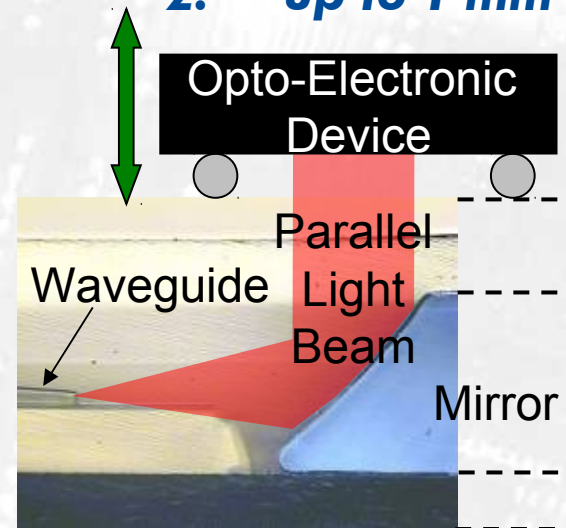
# Coupling Element



- **Optical attenuation 90° reflection:** **1.2 dB**
- **Micro mirror pitch:** **500 μm**
- **Pick'n'Place precision coupling element:** **x, y: ± 100 μm**
- **Pick'n'Place precision transmitter / receiver:** **x, y: ± 100 μm (3 dB loss)**
- **Layer thickness variation** **z: up to 1 mm**



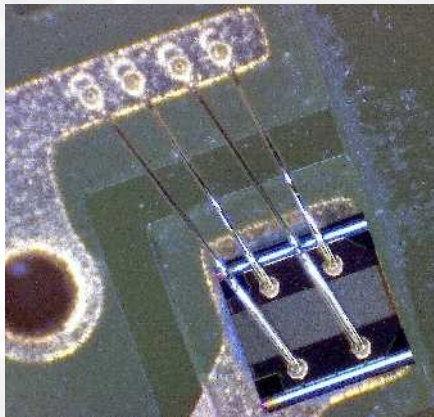
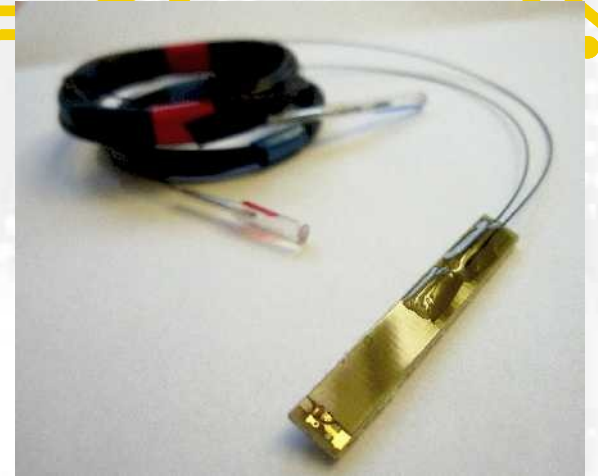
**Vertical coupling of light beam**



**Cross section of EO-CB**

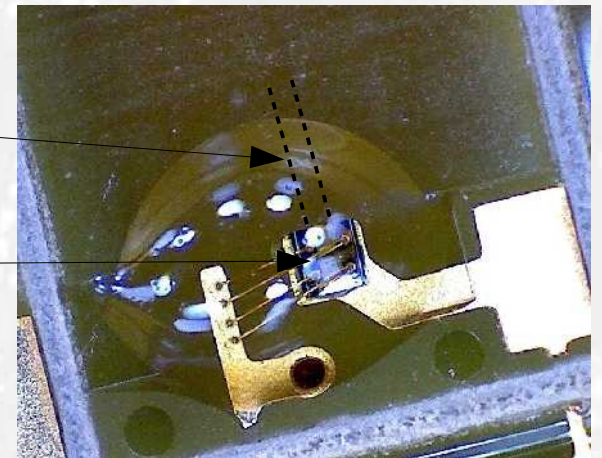
# Directly attached laser diode for sensor application

- **Directly attached laser diode for butt-coupling**
- **Splitter- and taper structures**
- **Passively attached glass fibers**



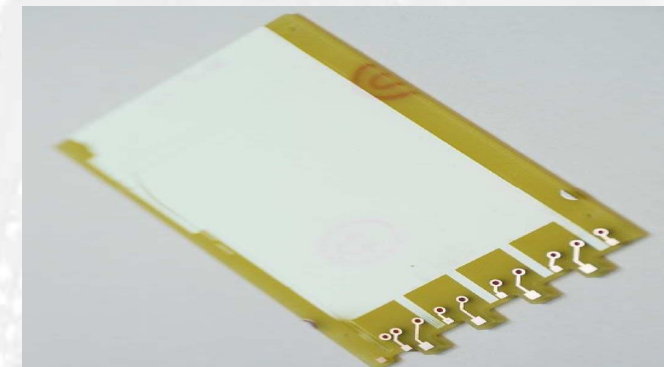
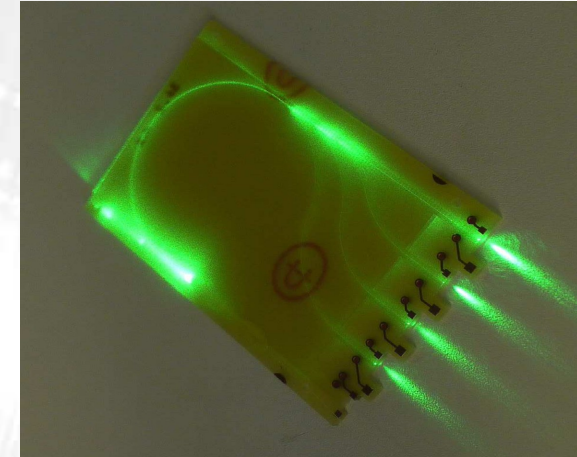
Waveguide

Laserdiode

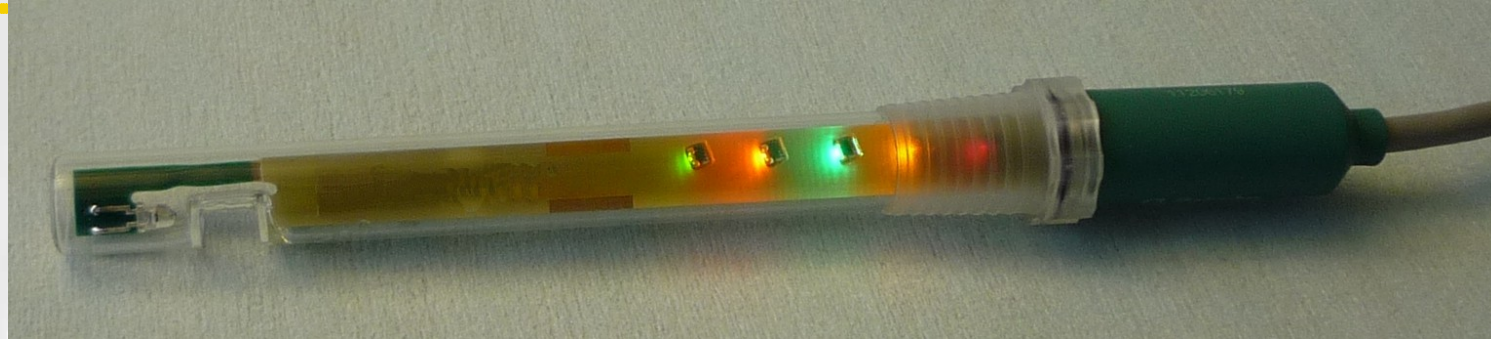


# ***Laser Source for Medical Application***

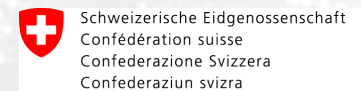
- ***Highly integrated, fits into a cigarette box***
- ***Competes with free-space optics and fiber-coupler/splitter***
- ***4 laser sources of different wavelength coupled into one glass fibre***
- ***Splitter for reference channel***
- ***Currently in clinical test***



# Optical PH-Electrode



- **Highly integrated electro-optical sensor for color detection**
- **Complex planar optical structure**
- **Optical layer thickness  $500\mu\text{m}$**



# Optical Backplane

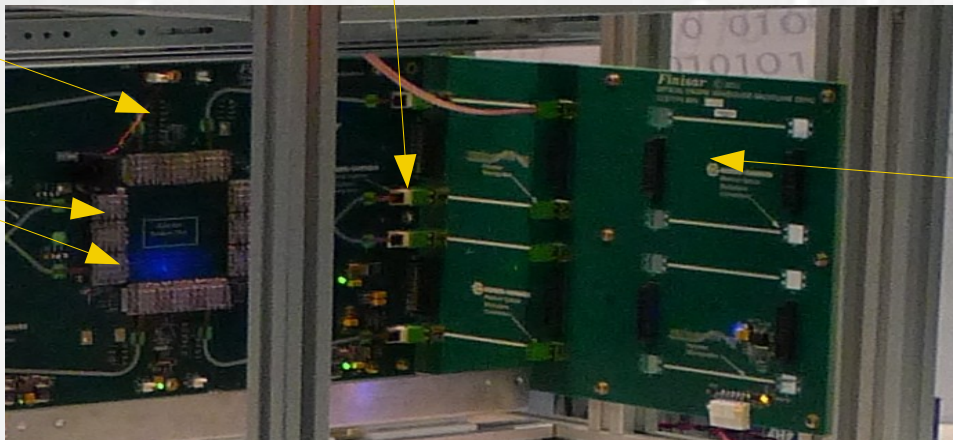
- **Rigid-flex boards (260 x 360 mm<sup>2</sup>)**
  - **192 waveguides on backplane (2 Tbit/s!)**
  - **192 waveguides on linecard**
- **Finisar's Optical Engine (2 x 12 x 10 Gbit/s, passively cooled)**
- **Huber + Suhner's optical backplane connector**



Backplane Stecker

Line-card

Optical Engines



Live demo – data rate of 10Gbit/s

Backplane (4 Linecards)

# Summary

- **Polymer waveguides do not reach the optical losses as glass based systems**

**But!:**

- **Any planar optical system can be realized**
- **Reproducible and cost-efficient manufacturing**
- **Very high integration density**
- **Direct attach of electro-optical components possible**
- **Passive assembly of optical components**

# Contact



**Dr. Felix Betschon**  
**CEO**

**vario-optics ag**

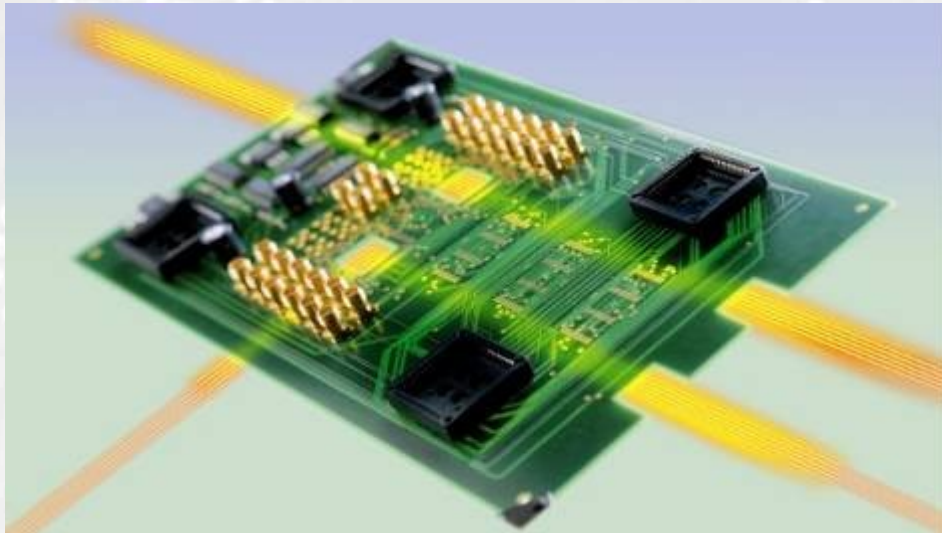
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# **vario-optics ag**



***The future is bright!***