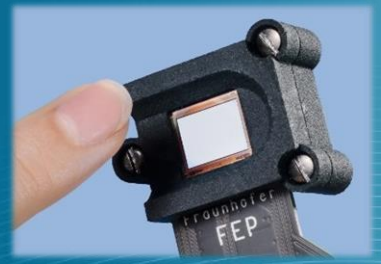
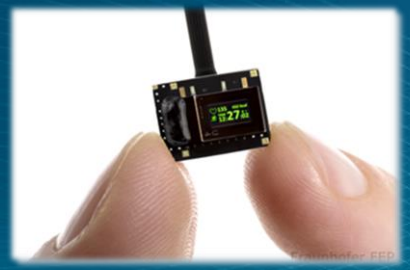
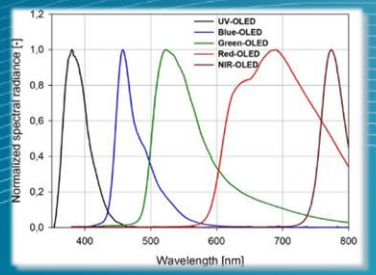






Fraunhofer
IPMS

Fraunhofer Institute for Photonic Microsystems IPMS

Bernd Richter, Philipp Wartenberg, Stephan Brenner, Johannes Zeltner, Christian Schmidt, Judith Baumgarten, Andreas Fritscher, Martin Rolle, Uwe Vogel
Fraunhofer IPMS, Dresden, Germany

A new semi-transparent OLED-on-Silicon microdisplay technology enabling new optical design opportunities for slim near-to-eye optics

Outline

Introduction Microdisplays @Fraunhofer IPMS

Motivation

Technology

- OLED-on-Silicon technology
- OLED-on-SOI transparency technology

Results

- Optical design aspects
- Waferlevel results
- NTE module

Conclusion

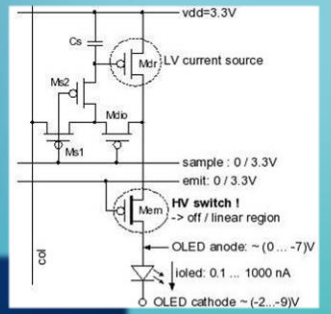
About

Dr. Uwe Vogel
Division Director Microdisplays & Sensors

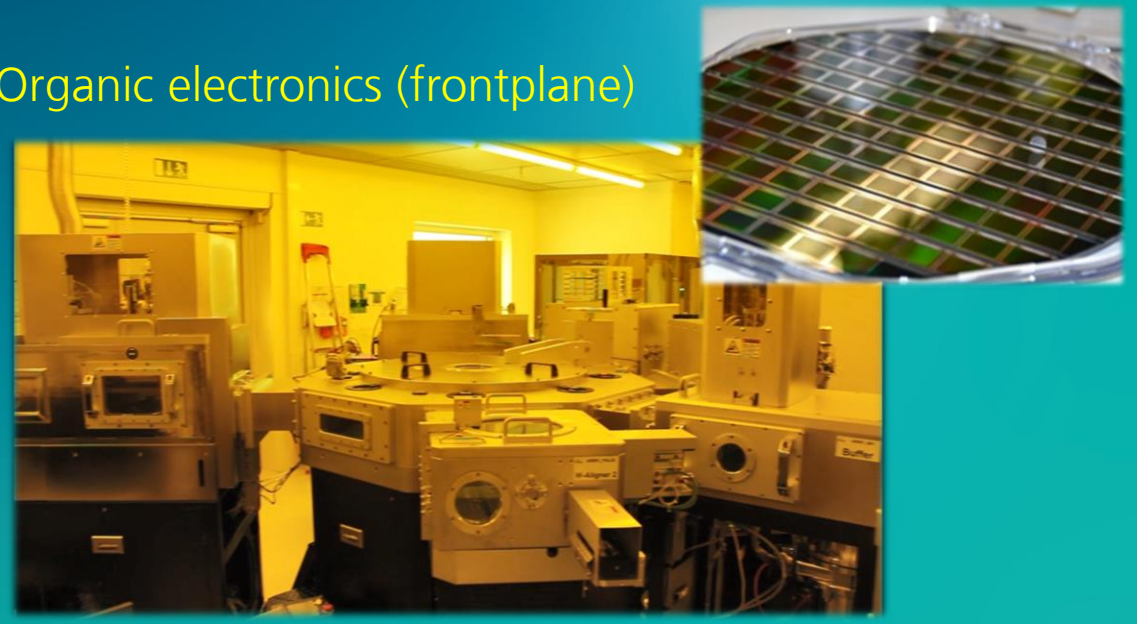
Location: Dresden/Germany („Silicon Saxony“)

Core competences

IC design (backplane)



Organic electronics (frontplane)

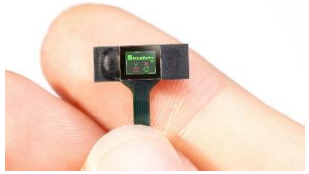


Where do we come from?

Our Background - Organic-on-Silicon

Sensor

Virtual-Reality



Augmented-Reality

Assisted-Reality/EVF

Fraunhofer IPMS

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Motivation – AR Glasses

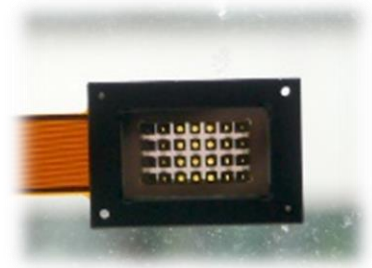
Key Targets for AR-Glasses

- Transparency, FOV, Slim Formfactor, Low Power

Various AR-Concepts has been presented over the last years

- **Combiner** based: Google Glass and similar
  - Beam splitter, bird bath, free-form prism…
  - **Optically efficient** but **not slim**
- **Waveguide** based: Magic Leap and similar
  - Waveguide requires high luminance – high power light engine
  - **Slim** but **not efficient**
- **Video see trough**: Apple Vision Pro
  - **Nether slim nor efficient**

- New Concept: **Semi-Transparent OLED-microdisplay**
  - **Optically efficient AND slim**



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The Base Technology: OLED-on-Silicon

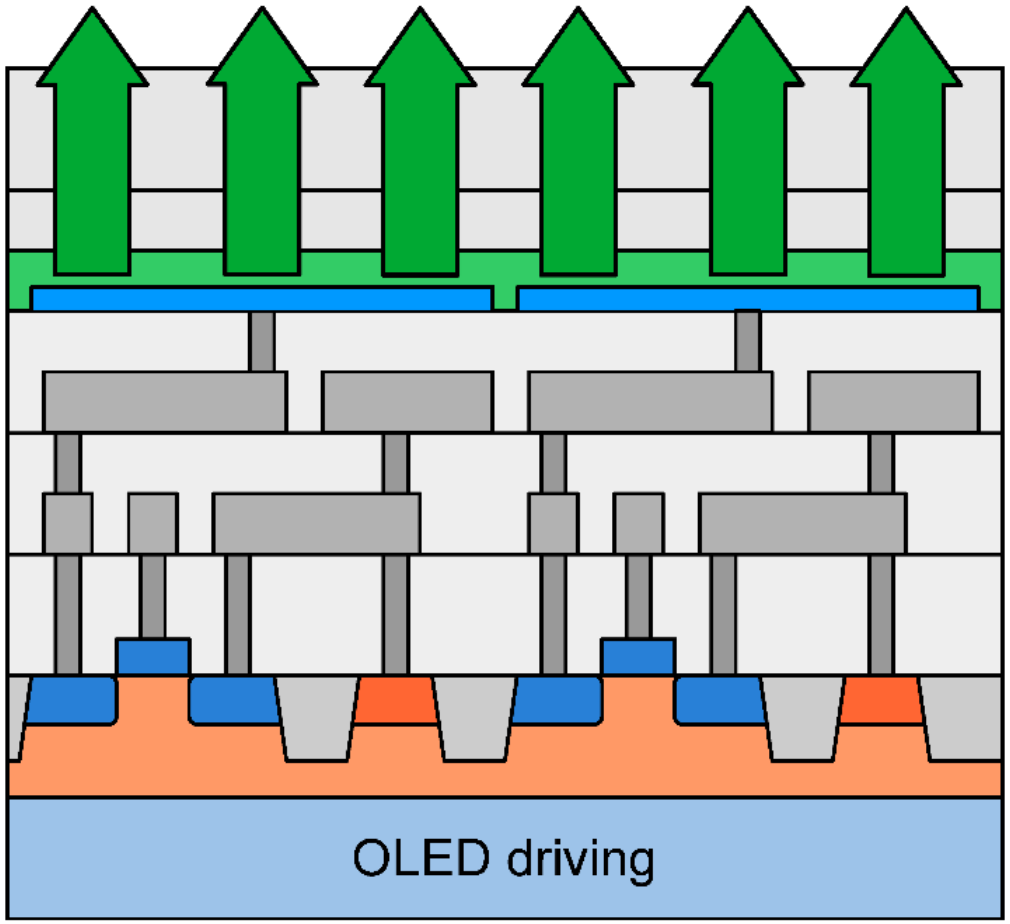
Organic-Frontplane

- Monolithic integration of organic stacks on silicon
- **OLED** for light emission

Silicon-Backplane

- State-of-the-art microelectronics
- Small pixel size typ. <10 µm
- High resolution, e.g. WUXGA (HD+)
- Integration of sensors, driving electronics, processing...

Simplified cross-section. Not to scale.



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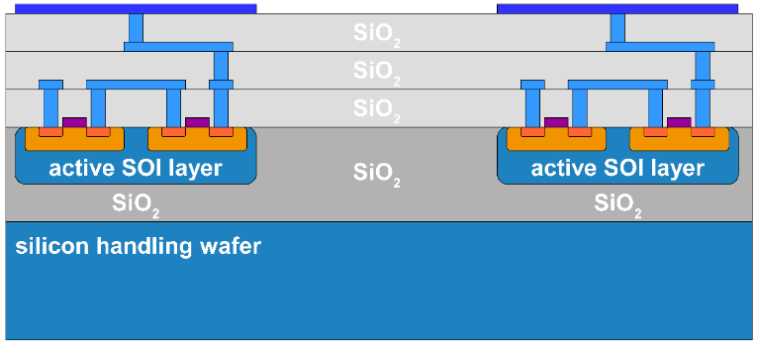
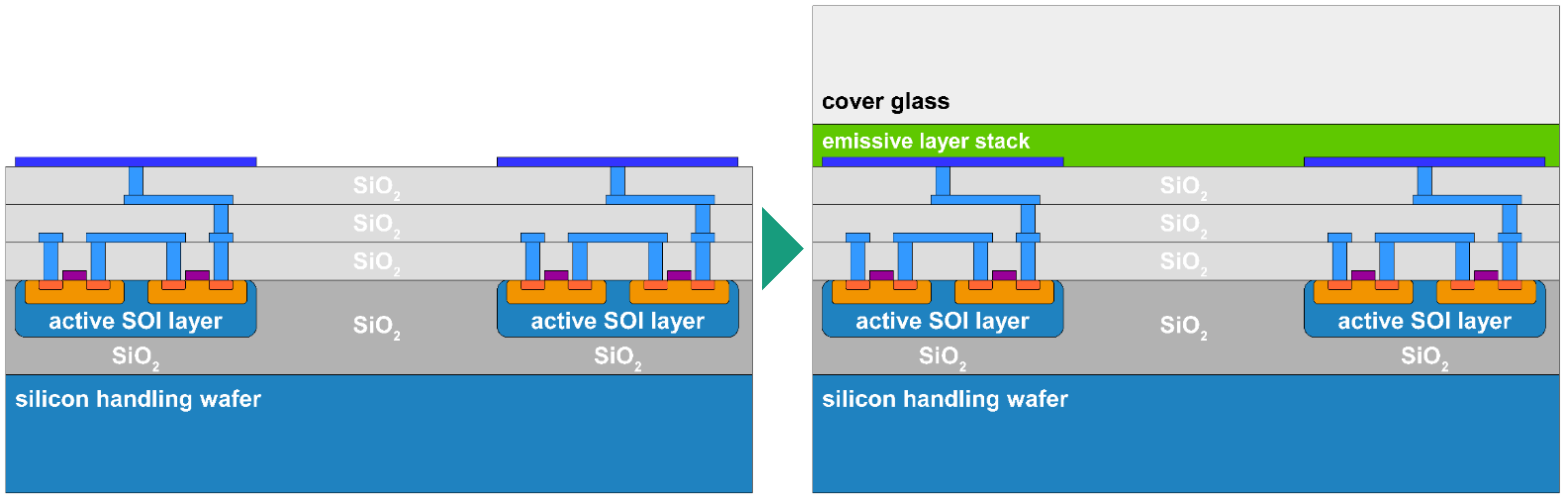
OLED-on-SOI Transparency Technology

How to make silicon semi-transparent…



SOI-CMOS wafer

OLED-on-SOI Transparency Technology



SOI-CMOS wafer

SOI-CMOS wafer with OLED or other emissive frontplane

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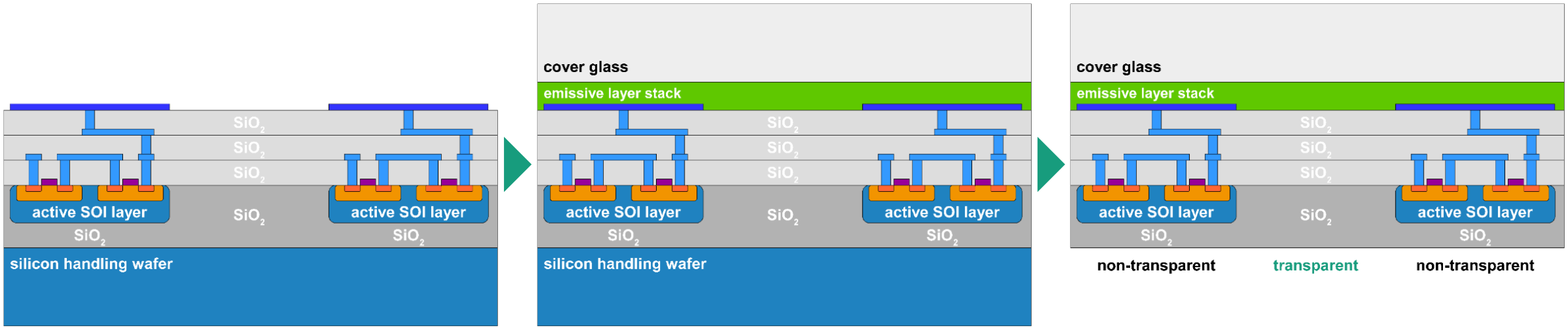
OLED-on-SOI Transparency Technology



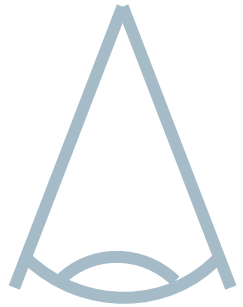
SOI-CMOS wafer

SOI-CMOS wafer with OLED or other emissive frontplane

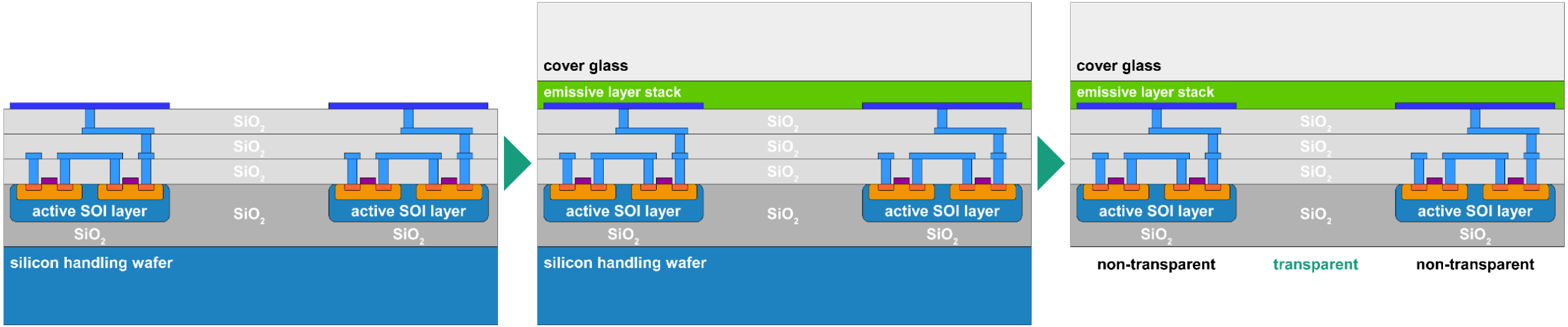
SOI-CMOS wafer with OLED and removed handling wafer realizing transparency

Fraunhofer IPMS

OLED-on-SOI Transparency Technology



Orientation in near to eye optics



SOI-CMOS wafer

SOI-CMOS wafer with OLED or other emissive frontplane

SOI-CMOS wafer with OLED and removed handling wafer realizing transparency

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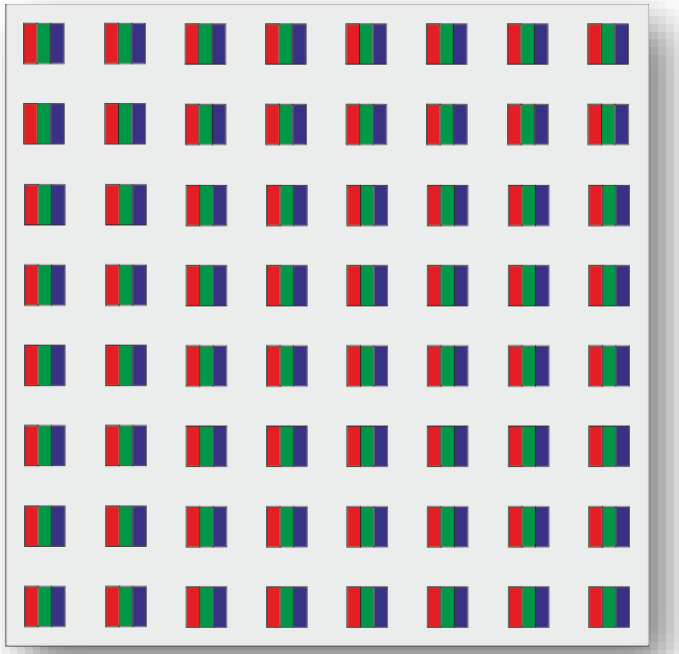
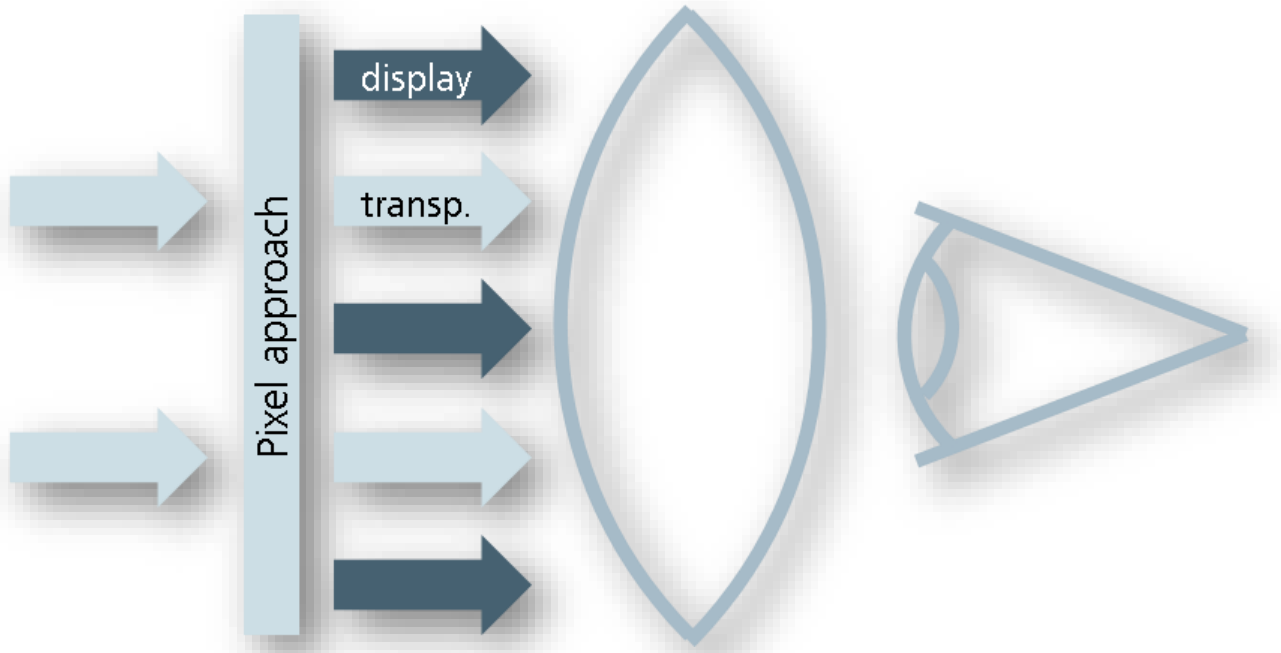
Example Optical Setup – Pixel approach





Sparse pixels

- Transparent areas in each pixel

Optics

- Typically common magnification optics for display and transparent optical path

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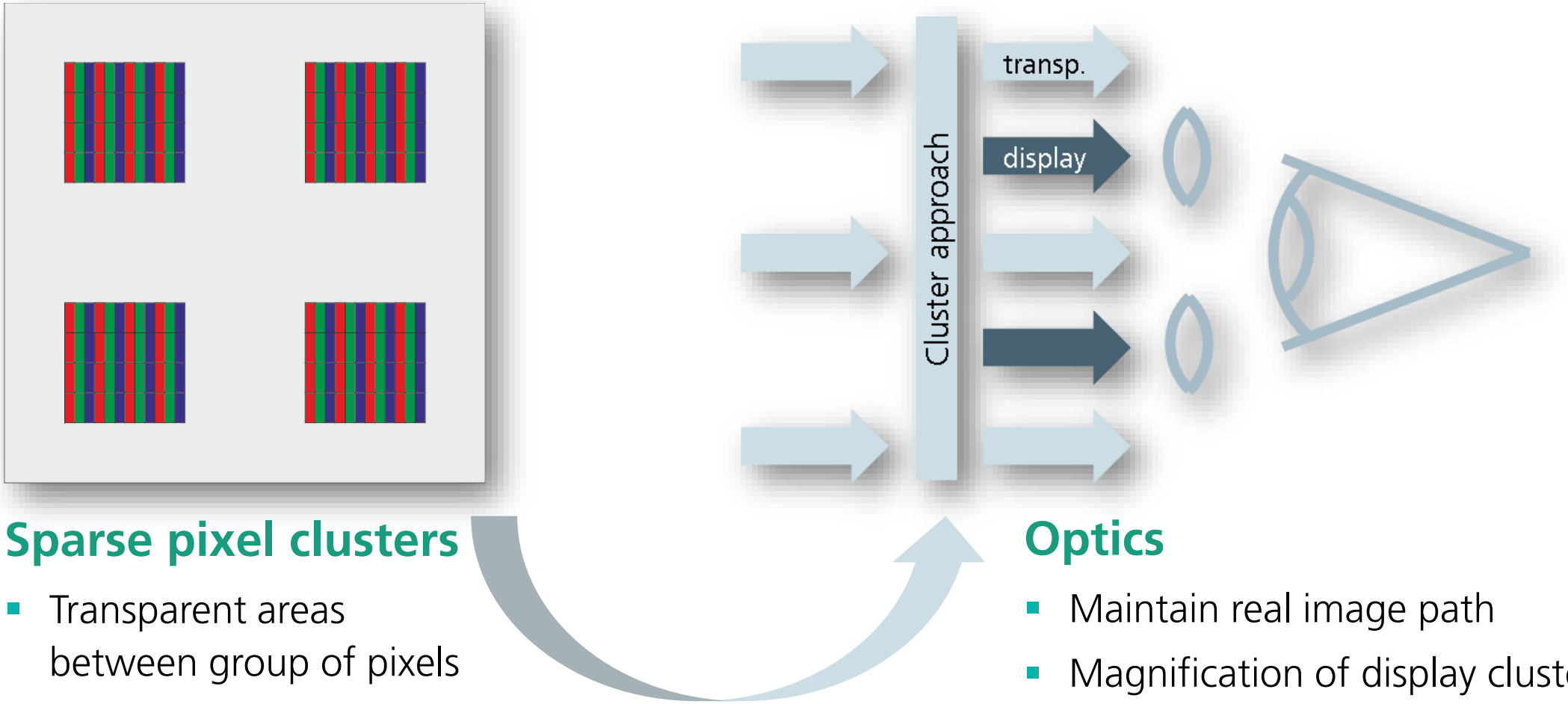
Example Optical Setup – Cluster approach



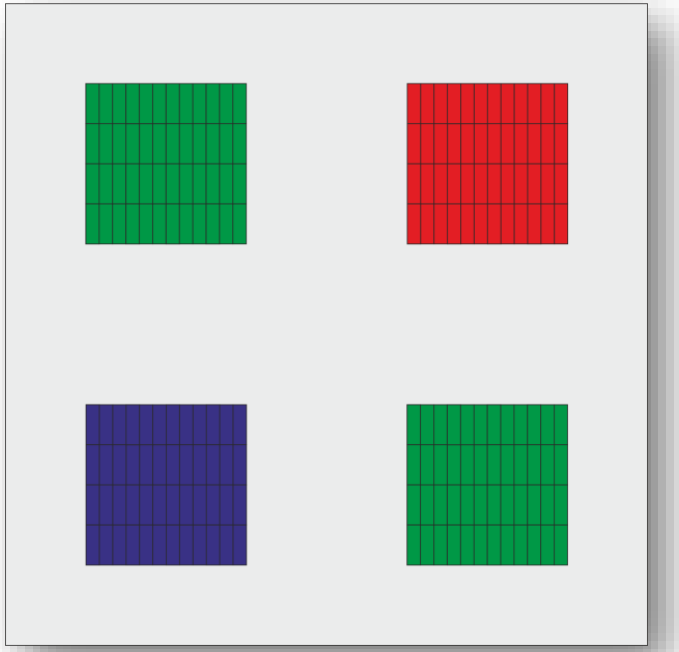
Sparse pixel clusters

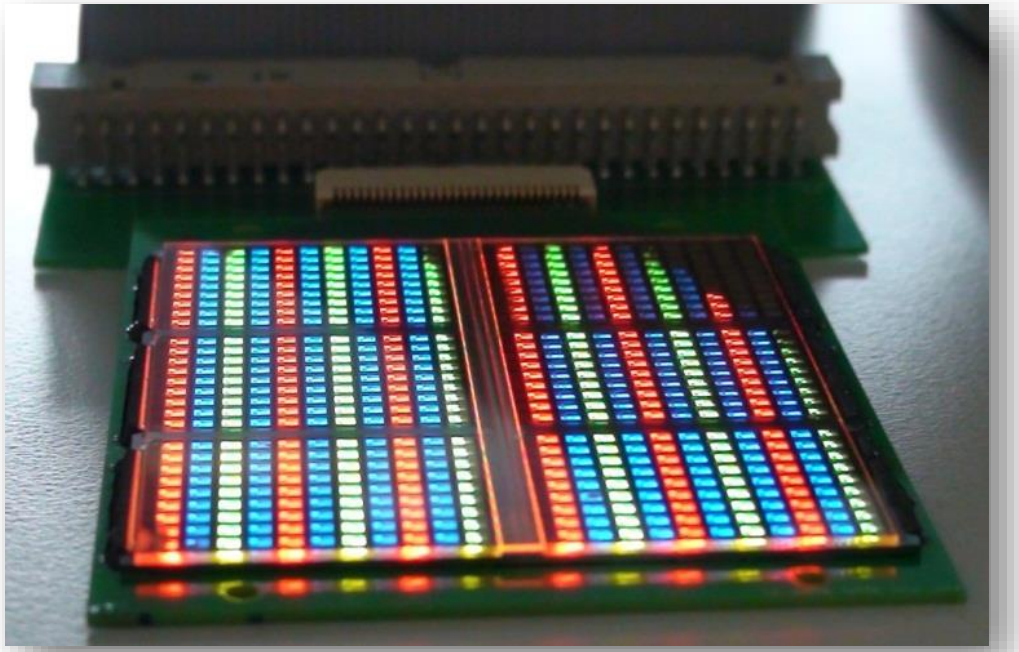
- Transparent areas between group of pixels

Optics

- Maintain real image path
- Magnification of display clusters

Example Optical Setup – Cluster approach





OLED, non-transparent integration example of colored clusters by Fraunhofer for projector applications more than 10 years ago

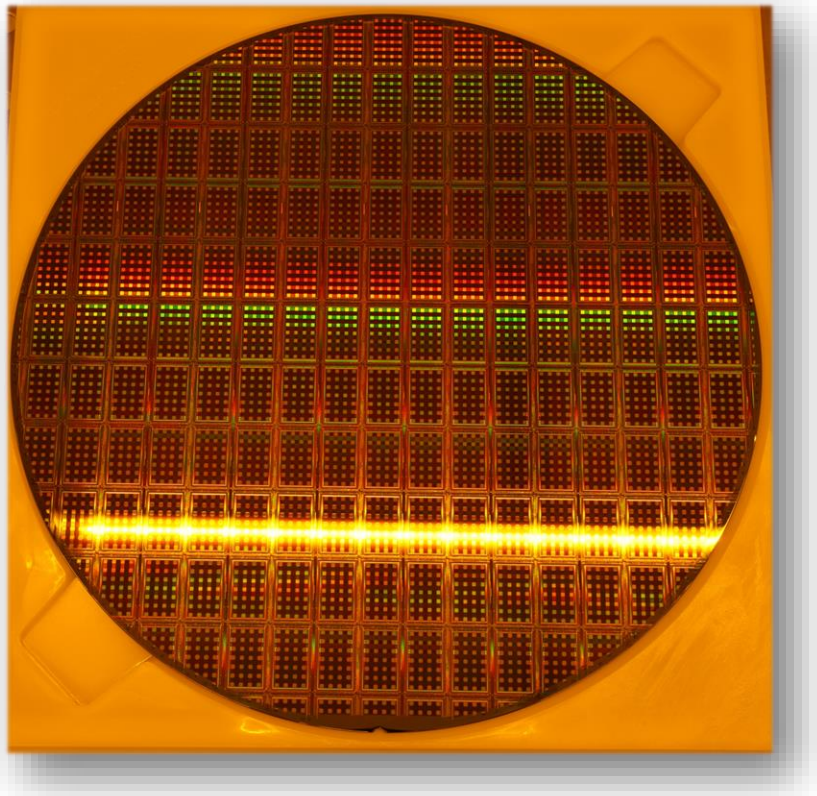
Sparse pixel clusters

- Monochrome emitters for higher power efficiency

Optics

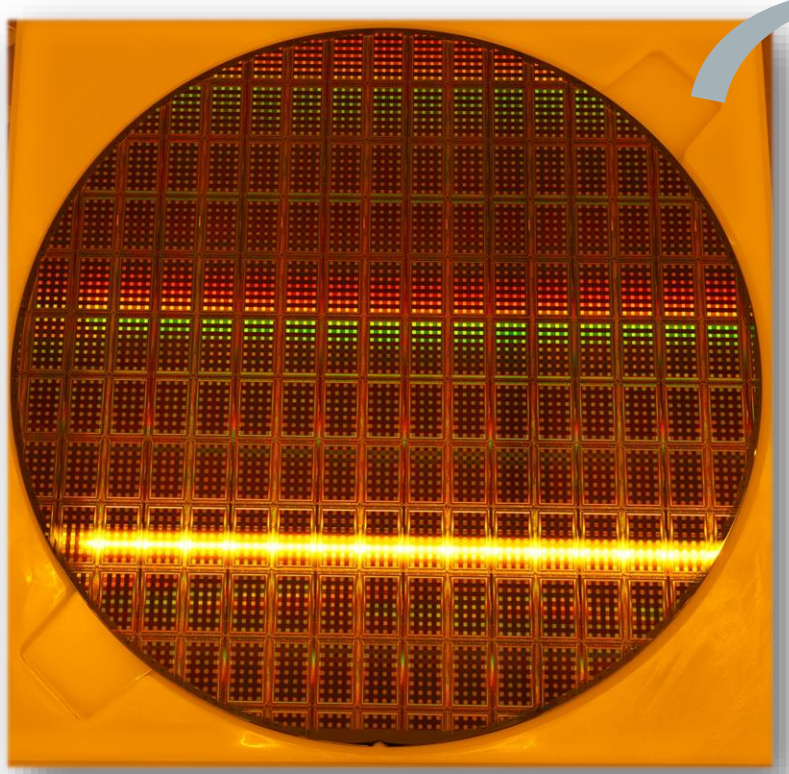
- Combines colors of different clusters
- Good for OLED and uLED integration as color pattern is relaxed

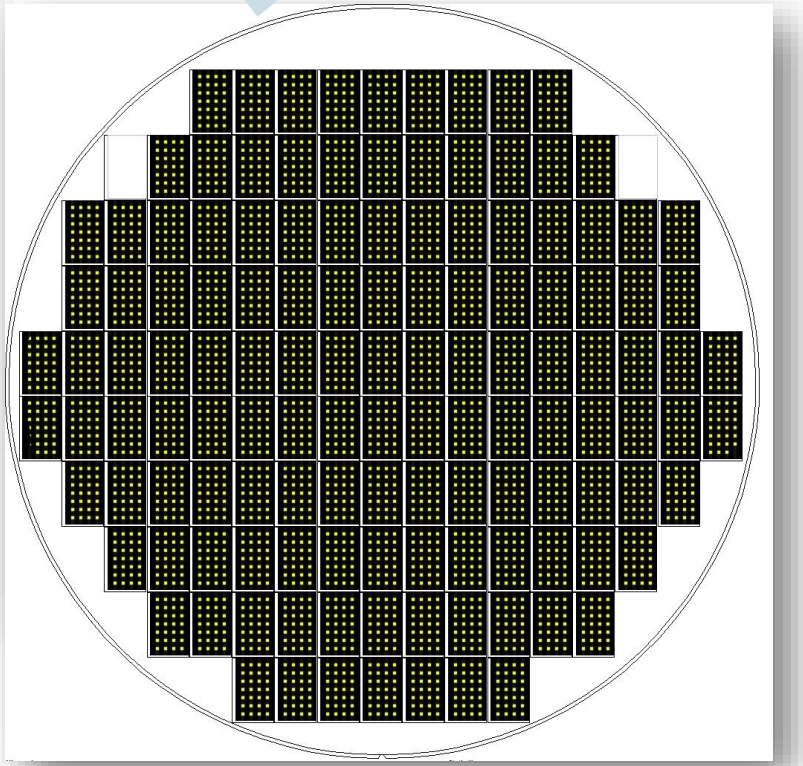
Results Waferlevel Integration



Results Waferlevel Integration

OLED integration

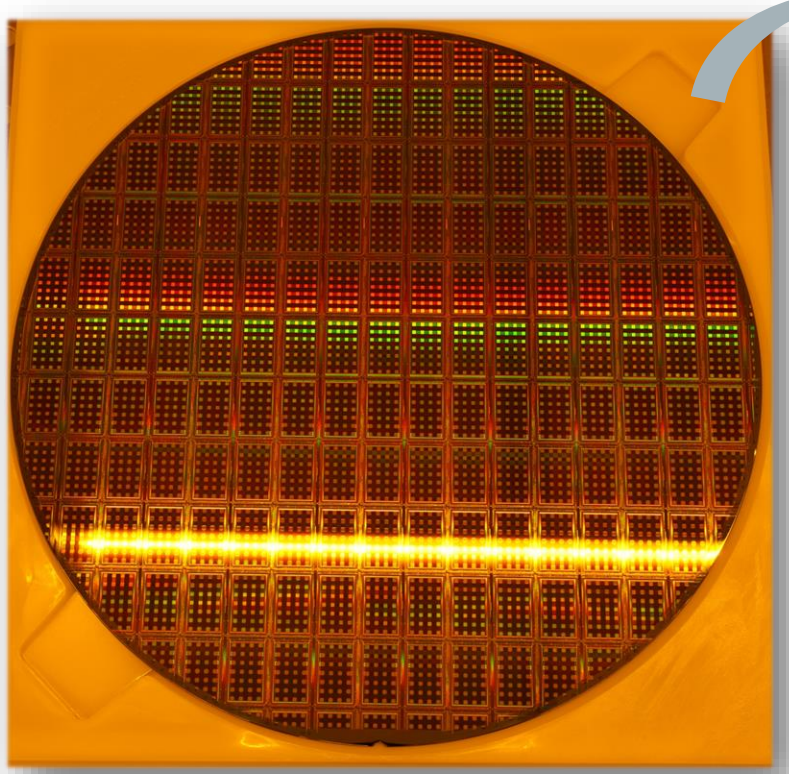


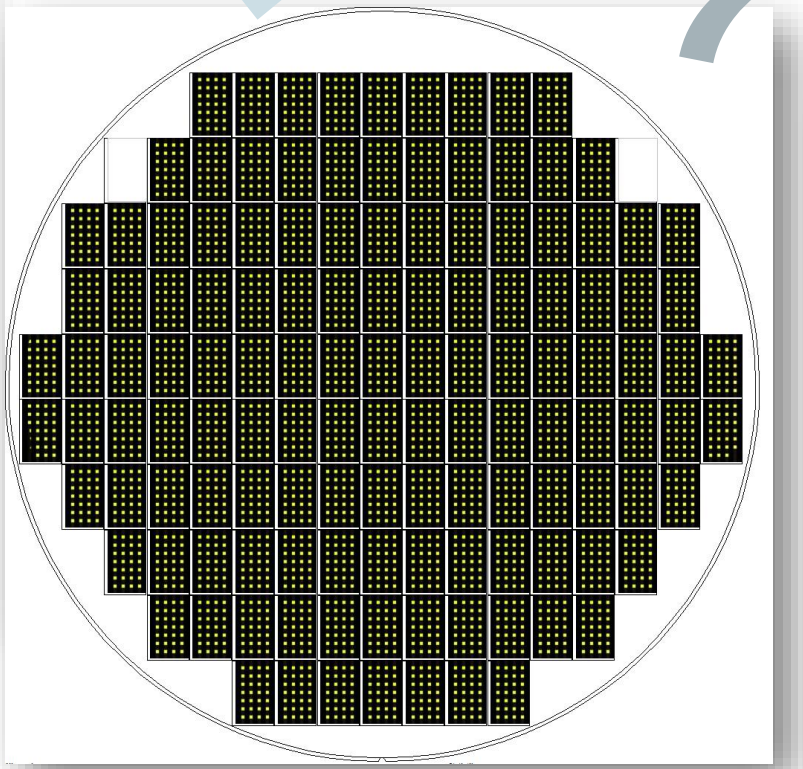


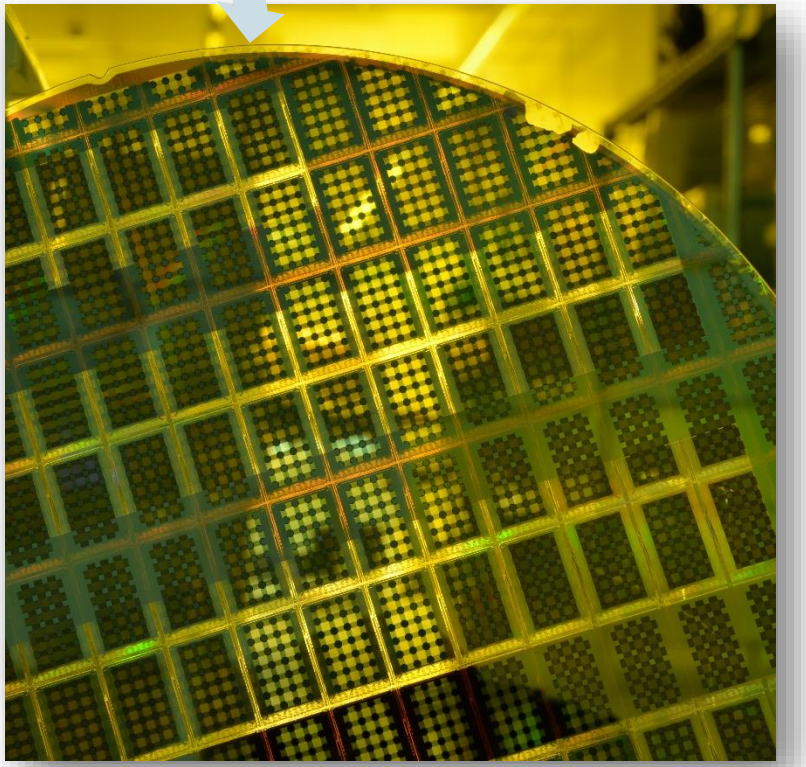
Results Waferlevel Integration

OLED integration

Transparency process

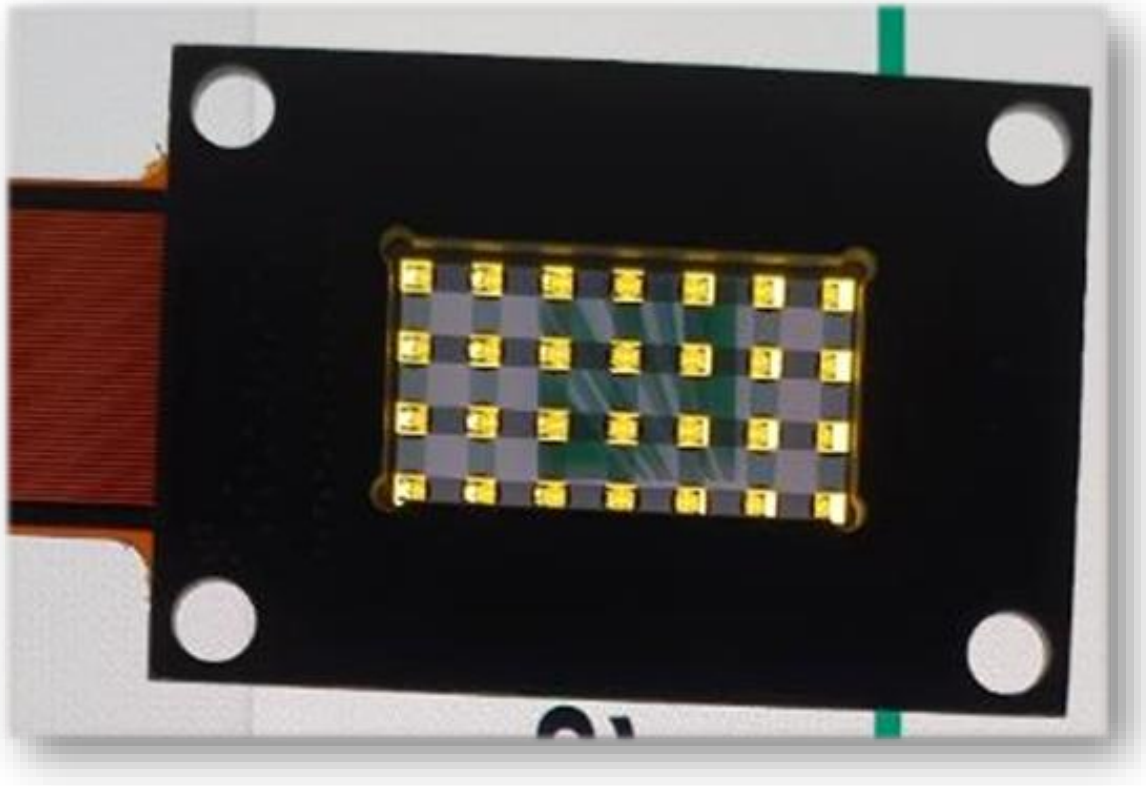






Initial Samples – Without Optics

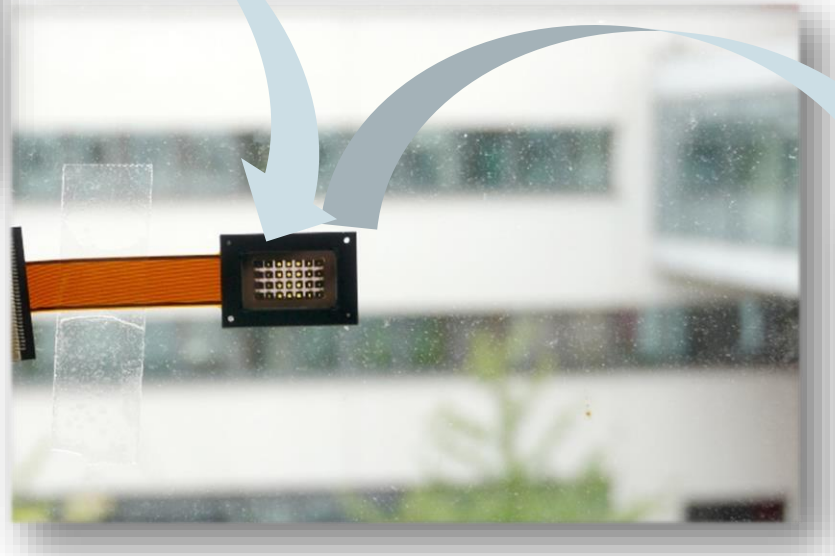
Parameter	Value
No. of clusters	7 x 4
Cluster resolution	128 x 128 x RGBW
Cluster pitch	2240 um
Cluster size	896 um x 896 um
Sub-pixel size	3.5 um
OLED type	Common cathode
Total active area	14.3 mm x 7.6 mm



Initial Technology Demonstrator With Optics

Microoptics supported by Fraunhofer IOF

- Initial integration with monochrome amber white OLED stack for **luminance up to 35knits**
- Initial **transparency** of demo 22%, improved process **in lab already showed > 50% for cluster utilization of 25%** (thus providing a theoretical fill-factor based limit of 75%)



Initial AR demo with optics

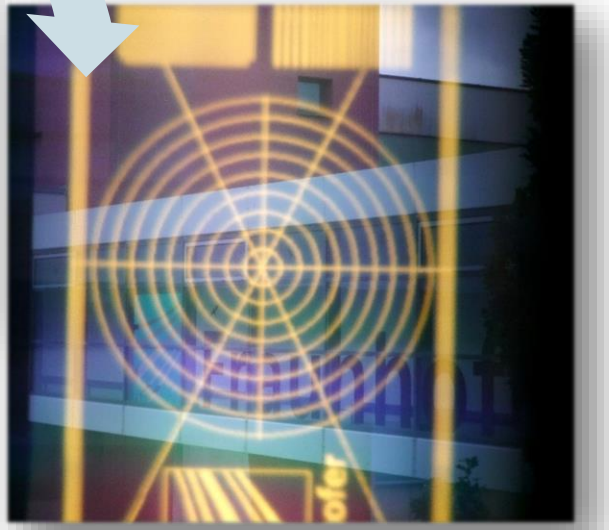


Image taken trough optics

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Technical summary

- New technology **OLED-on-SOI transparency** expands the toolbox for optical designers
- Promising **technology to solve the AR power challenge**
- Based on **production proven OLED-on-Silicon** technology – but also capable for uLED in the future
- Based on standard **wafer level** process steps
- Enables **new optical approaches** for higher optical efficiency

IPMS Microdisplay R&D Portfolio

- Customized microdisplay developments
- Customized photonics components
- Adapted spectral emission characteristics

Thank you!

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