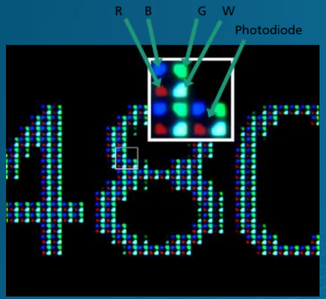

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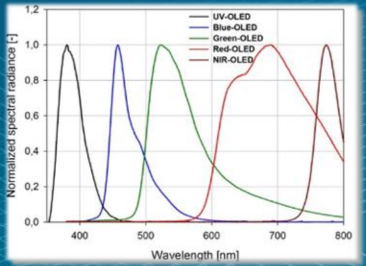
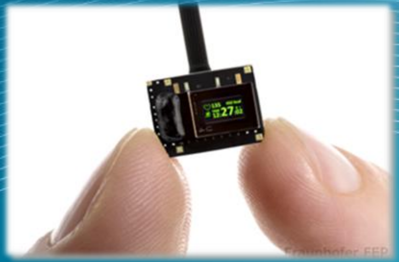
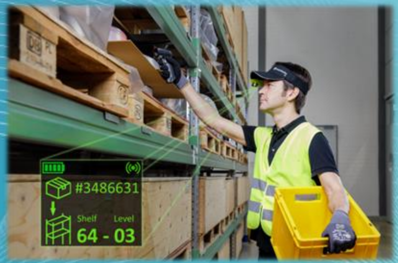




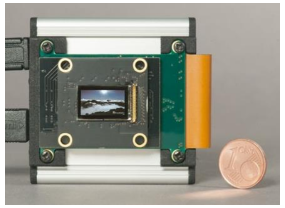


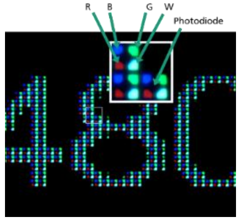
„O/LED-on-Silicon for Microdisplays and Embedded Sensing"

Dr. Uwe Vogel & colleagues

Fraunhofer Institute for Photonic Microsystems IPMS, Dresden, Germany

About



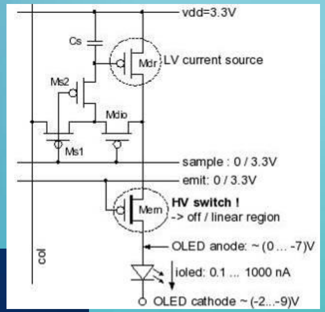




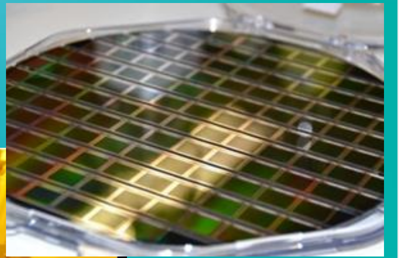

- Location: Dresden/Germany („Silicon Saxony")

Core competences

IC design (backplane, 8/12" foundries)



Emissive frontplane integration

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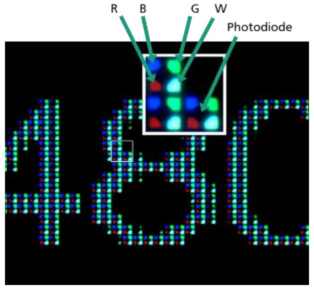
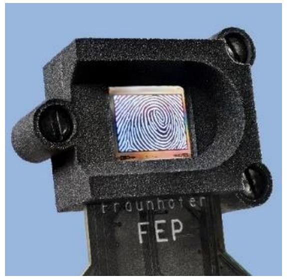
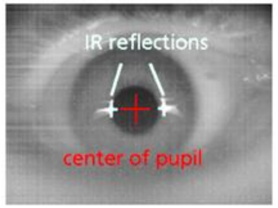
OLED-on-Silicon/CMOS: Features, devices and applications

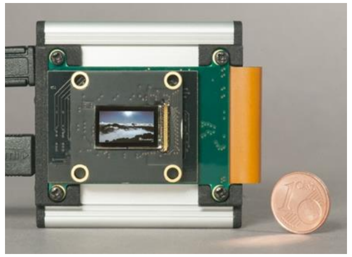
- Bi-directional
  - Display and image sensor in single chip
    - AR, VR, Eye-tracking
    - Optical fingerprint, Surface inspection, medical
- ultra-low power
  - Wearables, electronic viewfinder, assisted-reality
- Highest pixel density
  - Deep sub-micron CMOS
  - 10kdpi+ (2.5µm dot pitch)

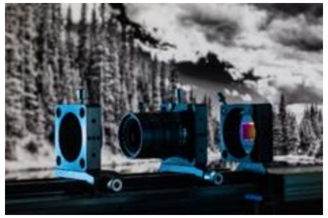
- large-area
  - very high-definition (>FHD)
  - VR, AR, micro-projection
- NIR imager
  - Organic photodiodes (OPD) on silicon CMOS
- embedded sensors
  - Gas or liquid process monitoring, e.g., O2, pH











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  - Gas or liquid process monitoring, e.g., O2, pH
- ***Production- and Field-proven***

Tilsberk dvision head-up display

Digades GmbH, Zittau

ActiveLook smart glasses (Image: ActiveLook)

Example customer products

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Microdisplays & Sensors

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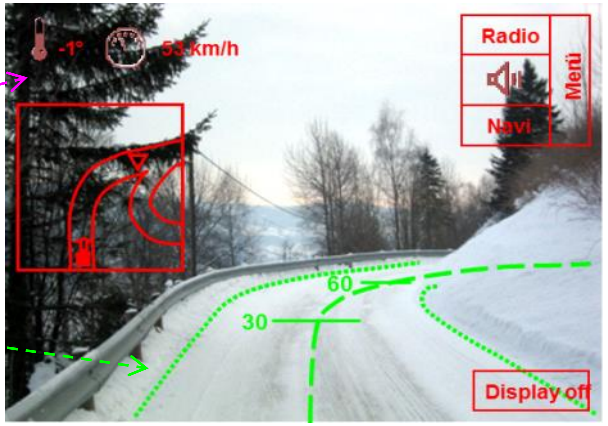
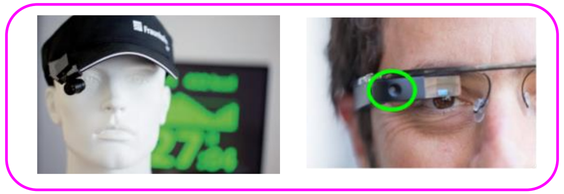
„Smart Eyewear“ (+ head-up Displays)

- AR vs. VR
  - VR: Immerses viewer into 3D environment
    - sense of being in another space
  - AR: Supplement or modify direct view of real world
    - overlay computer-generated graphics/video (or/and other information) in
      - semantic context – “assisted AR”
      - semantic and spatial context – ‘true’ AR



- Near-to-eye Displays
  - Head-mounted
    - Fully-immersive (or Video-see-through) -> virtual-reality (VR), mixed-reality (MR)
    - Optical see-through -> augmented-reality (AR) (also head-up displays/HUD)
    - Look-around (context-aware information display, AR)

	Fully immersive	Optical see-through	Look-around	Head-up (automotive, avionic)
Resolution	>FHD (1080p)	>HD (720p)	QVGA..HD	>F/HD
Luminance	<200cd/m^2	>5000cd/m^2	100..10.000cd/m^2	>10..1.000kcd/m^2
Power consumption	<500mW	<100mW	<10mW	>1W
Frame rate	>90Hz	>60Hz	≥0	>90Hz
Latency	<10ms	<10ms	<10ms	<10ms



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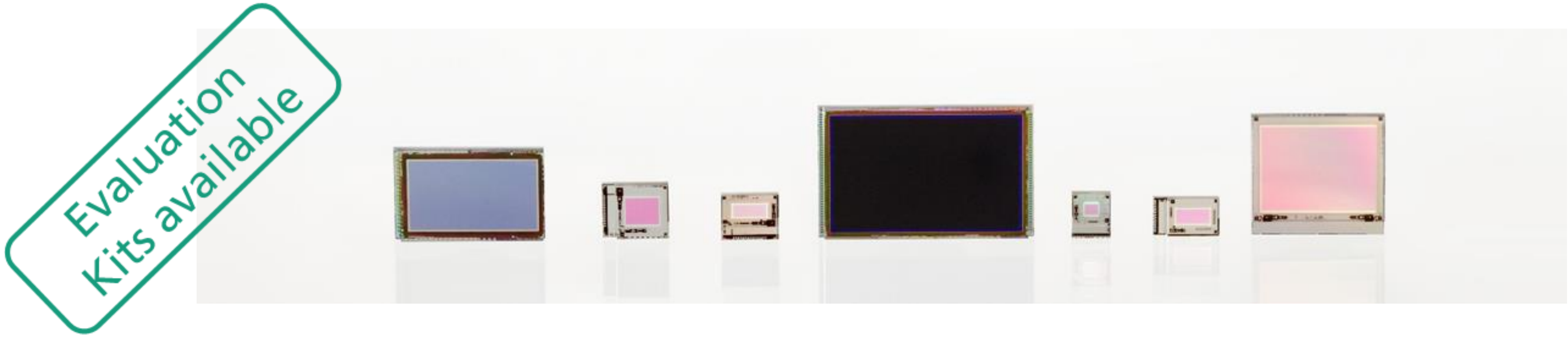
Characteristics of O/LED microdisplay backplane designs (selection)



	Ultra-low power			Bidirectional	AR	VR
	UUGL1120	**UUGL1220**	**UUGL1320**	**EBCW1020**	**HUCW1010**	**JUCW1010**
resolution	304x256	304x128	720x256	800x600	1280x720	1920x1200
dot/pixel pitch	12µm	12µm	5µm	8/16 µm	5.5/11µm	5.5/11µm
color	mono	mono	mono	RGBW	RGBW	RGBW
max. current per pixel	~2µA/pixel (~1,3A/cm^2)	~2µA/pixel (~1,3A/cm^2)	~900nA/pixel (~3,6A/cm^2)	~1µA/pixel (~1,56A/cm^2)	~2.8µA/pixel (~2,3A/cm^2)	~2.8µA/pixel (~2,3A/cm^2)
screen diagonal	0.19"	0.16"	0.15"	0.63"	0.64"	1.0"
data Interface	SPI	SPI	SPI	parallel	parallel	parallel
configuration interface	SPI	SPI	SPI	I2C	I2C	I2C
typ. power consumption	1-3mW	1-3mW	1-3mW	200mW@ 60Hz	100mW@ 60Hz	140mW@ 60Hz

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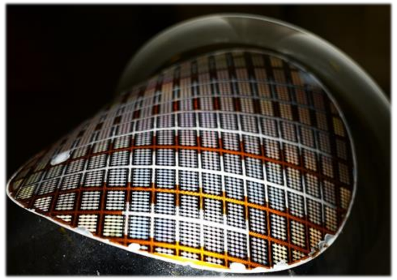
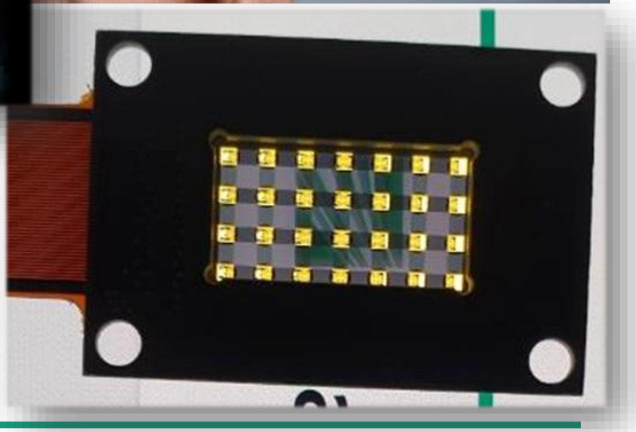
Outlook: O/LED-on-Silicon/microdisplays features and applications

- high-brightness
  - see-through near-to-eye @ sun light condition
  - embedded projection, optogenetics (brain/nerve interfaces)
- high-resolution
  - Pixel densities >10kppi
    - Light-field and holographic displays
    - smaller chip size, lower cost
- (embedded) sensing
  - Single-chip image converter
  - Quantum sensors (very-low magnetic fields)
- (embedded) computing/connectivity
  - Edge Vision + Edge AI
  - Deep sub-micron CMOS process backplanes on 300mm (LVDS, MIPI, Bluetooth)
- extended spectral emission and detection range
  - UV, IR; α, β, γ; µLED
- New form factors, e.g., *transparent & curved microelectronics*
    - e.g., smart contact lens display
- Manufacturing processes: yield, production costs





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Promise/expectations of µLED vs. µOLED

- Technical/performance
  - Higher luminance
  - Larger ambient/operating temperature range (>>85°C)
  - Narrower bandwidth (higher spectral purity)
  - (Short) Coherence
  - Faster switching (e.g., communication, higher frame rate)
  - Longer lifetime (reliability) (IF very high-brightness!)
    - No image sticking
    - mainly for sensors/communication, no real advantage in imaging
  - Wider wavelength range (IR, UV)
  - Tightened emission angle (NTE optics aperture)
  - Higher pixel-density (???)
  - Better current/power efficiency (???)
    - Currently < OLED@small pixels -> Low-power (???)
  - Cheaper (???)

	µOLED	µLED
Maturity	high	Low yet
Image quality	high	Tbc: pixel-to-pixel uniformity, color
Power efficiency	high	< OLED@small pixels
Brightness	Mono: High Color: Medium	**Mono: Very high** Color: Tbc
Cost	moderate	> OLED

- Economic
  - Serve applications not reachable so far, e.g., automotive and aviation HUD, LIDAR, holograhic displays, safety/security,…
  - Some years of public and industrial R&D funding in technology, devices, applications likely (before maturity)
  - Regional, national, EU value chain/sovereignty feasible (process technology closer to established microelectronics)

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Thanks for your attention!

- **Public funding references:**
  - SMWA/SAB „BACKPLANE“ (100392259)
  - SMEKUL/LfULG „ZierSens“
  - Else Kröner-Fresenius Zentrum für Digitale Gesundheit „CRT“
  - DFG EXC 2050/1 „CeTI“ (390696704)
  - BMBF RUBIN „EdgeVision“ (03RU2U061C)
  - Fraunhofer MAVO „HOT“ (840092), PREPARE BIOSYNTH
  - EU „Inno4Cov“ (101016203)

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