BACKPLANES FOR DISPLAYS AND SENSORS, EVALUATION KITS
Augmented reality (AR) and virtual reality (VR) applications are increasingly affecting everyday work and private life. The number of available data glasses is rapidly growing and the state of the required technologies allows compact and powerful as well as convenient data glasses.

Their key components are the integrated displays. Therefore energy efficient OLED microdisplays represent ideal candidates. They offer very high pixel densities, extremely high contrast ratios of more than 100,000 : 1 and allow simplified optical concepts without any backlight because of their self-emissive characteristics.

Fraunhofer FEP has a long lasting experience in the development and manufacturing of OLED microdisplays. This covers all steps from the first idea to the design of the silicon backplane, the design of the organic device and the related processes and technologies to the manufacturing from single prototypes up to small series.

Motivation

Fraunhofer FEP is specialized in the development of OLED microdisplays for AR and VR glasses as well as for the use in sensor applications. The concept and the parameters of the display like resolution, pixel size and embedded functions can be varied in a wide range appropriate to the project specifications or customers needs. The spectrum ranges from ultra-low-power displays for small and lightweight data glasses over high resolution HD displays for VR headsets and viewfinders up to bidirectional displays with embedded image sensor functionality.

The latter in combination with an appropriate optics enables the realization of smart data glasses with eye-control. Furthermore bidirectional displays can be used in optical fingerprint sensors or other optical measurement methods.

Technology

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OLED microdisplays are based on the monolithic integration of organic light-emitting diodes on silicon chips for the driving of the individual pixels. Beyond that the silicon chips respectively these wafers can be used to drive or to read-out alternative active layers. Examples are display technologies based on quantum dots (QDs) or micro LED.

The silicon backplanes that where developed for OLED microdisplays provide the basis for the evaluation of such technologies and can be utilized for further developments.
Evaluation Kits as Development Tools

Fraunhofer FEP offers a selection of evaluation kits for a straightforward transfer of the microdisplays into customer-specific applications.

Ultra-low-power OLED microdisplays

Ultra-low-power displays are best suited to show simple graphic information. They have a limited resolution but require only a small fraction of the typical power consumption. This is achieved through an innovative approach in the design of the display backplane and enables longer battery run times with even small and lightweight systems. The displays are driven by a SPI interface, are monochrome green with high luminance $>1000 \text{ cd/m}^2$ and require only 1 mW in typical operation.

The following display options are available:

**UUGL1120**: 0.19” diagonal, 304 × 256 pixels, 12 μm pixel pitch, 4 Bit grayscale

**UUGL1220**: 0.16” diagonal, 304 × 128 pixels, 12 μm pixel pitch, 4 Bit grayscale

**UUGL1320**: 0.15” diagonal, 720 × 256 pixels, 5 μm pixel pitch, 1 Bit grayscale

Each display is available in two different evaluation kits: In the lab evaluation kit the display is driven by a microcontroller evaluation board via a breakout board. This allows an easy access to all signals. In the HMD evaluation kit the driving is realized by a miniaturized electronics with battery and Bluetooth connectivity in a compact assembly. This can be directly used for the evaluation in specific use cases. Both kits include a simple optics and a graphical user interface for the control.

Bidirectional OLED microdisplays

Bidirectional microdisplays combine the functionality of a display and an image sensor. On a single chip images can be displayed and acquired simultaneously. This could be achieved by adding a sensor pixel to each RGBW pixel. Typical applications are smart data glasses with eye-tracking or optical sensors (e.g., optical finger printing).

The evaluation kit consists of one high-resolution SVGA microdisplay (800 × 600 pixels) with an integrated SVGA image sensor, 16 μm pixel pitch and 0.63” screen diagonal. The related control electronics offers a simple connection of the display via HDMI, the read out of the image sensor is realized via USB 3.0. A graphical user interface for Windows is provided for an easy configuration of the display. Following options are available:

**EBCW1020**: full color display with 24 Bit color depth, image sensor with 8 Bit grayscale

**EBGL1020**: monochrome green display with 8 Bit color depth, image sensor with 8 Bit grayscale
High-resolution WUXGA OLED microdisplays

These microdisplays with a display diagonal of 1’’ are particularly suitable for VR applications. They offer an excellent resolution of 1920 × 1200 pixels with a pixel pitch of 11 µm (2300 ppi) and enable high frame rates up to 120 Hz. The display mode can be varied from hold-type to impulse-type. The latter allows the elimination of motion artefacts and flicker with a special rolling emission mode. The WUXGA display achieves a superior image quality with a very high contrast ratio of >100000:1 at extraordinary low power consumption.

The evaluation kit includes one WUXGA display with control electronics. It can be controlled via HDMI, and is powered via USB. The following options are available:

**JUCW1010:**
full color display with 24 Bit color depth

**JUGL1010:**
monochrome green display with 8 Bit color depth

Sensors

Optical sensors use active layers, which are read out electronically. Therefore organic photodiodes present a novel and interesting alternative as they could be integrated monolithically on wafer level on top of high-performance CMOS circuitries. The advantage in comparison to established technologies is the possibility to adapt the spectral behavior according to the application. Perspectively also wave lengths outside the visible range could be detected without the use of expensive III-V semiconductors. The active layers could be processed by deposition within high vacuum, by liquid processes or by hybrid approaches.

Fraunhofer FEP offers a development platform with different substrates, wafer layouts and processes for the development and evaluation of such layers and layer systems. An evaluation kit is available consisting of an SVGA image sensor, which uses an organic photodiode for detection. Read out is realized by a simple electronics over USB:

**ESML1011:**
0.63’’ monochrome SVGA image sensor, 8 Bit grayscale, 16 µm pixel pitch
Silicon Backplanes for Customized and Alternative Applications

The backplanes of the displays can also be used for alternative technologies beside OLED. Those range from Quantum Dots (QDs), Liquid-crystal-on-Silicon (LCOS) over micro-LEDs up to read out options of sensitive layers.

Apart from the mentioned fields of application further branches like medical- or biotechnology (e.g. optical sensors for fluorescence-based monitoring of pH, O₂, saturation, temperature in fermentation processes) and opto-genetics (e.g. by combining microscopic excitation light sources with embedded photodetectors) could be explored. The availability of the circuits and suitable control electronics reduces the NRE costs costs for experiments and enables a near-term evaluation at the same time.

Fraunhofer FEP is available and pleased to support customer-specific developments.

Please do not hesitate to contact us!

Our Offer

- Evaluation kits for microdisplays and sensors
- Silicon CMOS backplanes for customer-specific applications, e.g. for microdisplays and sensors
- Application-specific development and evaluation of OLED- and sensor layers
- Application studies
- Manufacturing of samples up to small series production
- Technology consulting and -transfer

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