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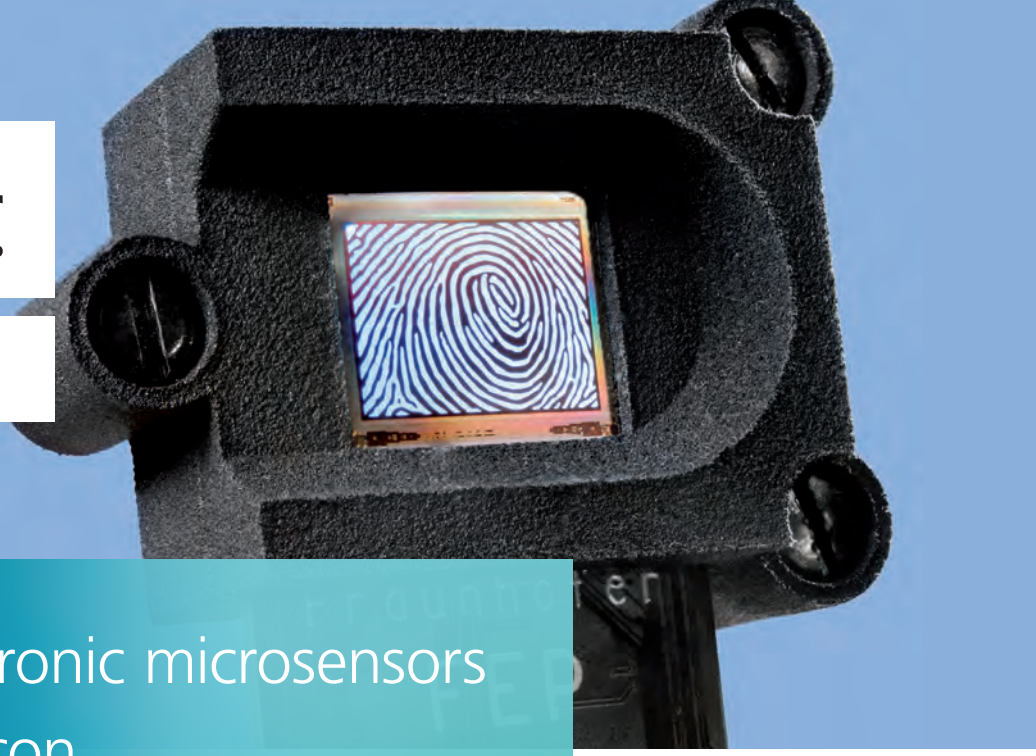


Smart optoelectronic microsensors by OLED-on-Silicon

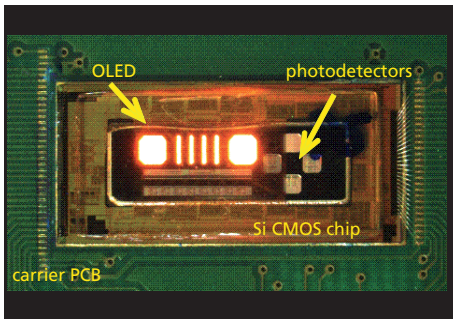
Optical fingerprint sensor based on a bidirectional microdisplay

Introduction

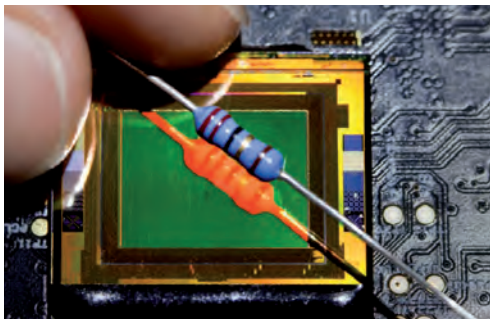
Since the emergence of silicon-based microelectronics, the combination of circuitry and embedded sensors, especially photodetectors has been evident (e. g. image sensor). However, there is a specific area that cannot be covered by this technology inherently due to the silicon bandgap – efficient photoemission. That application is so far reserved to the III-V semiconductor industry and prevents the monolithic integration of light-emitting optoelectronic devices into silicon processes which are common in microsystems manufacturing. Light-emitting components for optoelectronic sensors have to be added in a hybrid way, which increases cost and reduces reliability. Nowadays, organic-light emitting diodes (OLED) cross that barrier. The highly efficient OLED layers can be monolithically integrated on top of silicon CMOS backplanes (referred to as "OLED-on-Silicon").

The so formed optoelectronic devices can be designed as highly-integrated micro-scale optical illumination components and detection units on a smart single chip (adding on-chip signal processing capabilities). These can be realized by single elements (e. g., OLED-photodiode combination), in segments, or as arrays.

OLED-on-Silicon sensor test chip



Feedback demonstrator



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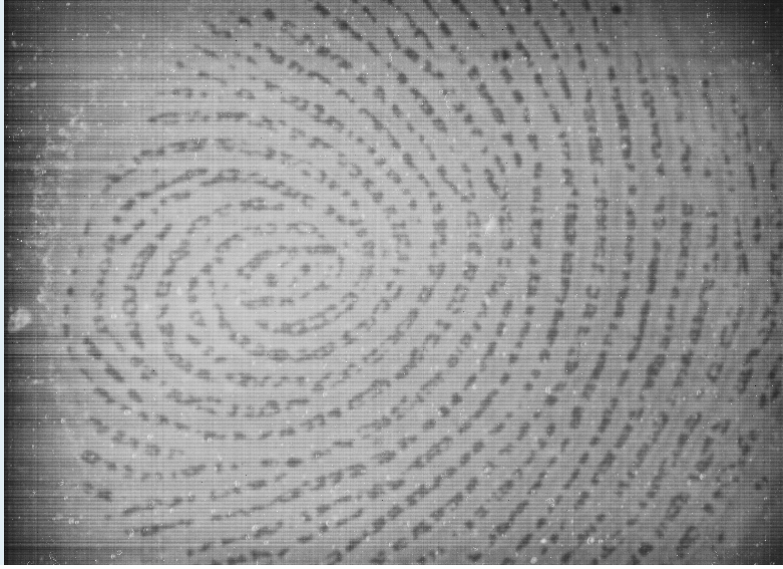
Fingerprint application



Sample of detected fingerprint

Perspective

Based on OLED-on-Silicon a novel opto-electronic device generation with the following benefits is foreseen:

- Monolithic OLED integration
- Real solid state device (no moving parts, no fluids, ...)
- Reduced number of system components, lower size, weight and costs of the system
- Highly-precise optical adjustment of the OLED emitter with respect to the integrated photodiodes
- Arbitrary shaped and patterned OLED-on-Silicon light sources allow
- new approaches for dimensional sensors
- Wafer-level integration of beam-steering micro-optics

Further exploitation opportunities of OLED-on-Silicon opto sensor technology beyond the scope of this project can be expected, e. g., single-chip reflection light barriers, optical sensors requiring embedded illumination (slope sensors, stray light sensors, wave front sensors, single-chip optical heads for 3D shape detection by patterned illumination, …), lab-on-chip modules with embedded microfluidics, excitation and sensors, optical finger-print sensors, chip-to-chip communication and OLED-based print-heads. That shows the broad market potential of this new technology and devices in several areas beside biomedicine and biotechnology (including pharmacy), such as mechanical engineering, telecommunication, or automotive.

Achievements

- Bidirectional devices
- Brightness: > 1000 cd/m²
- OLED emitter in RGB / NIR / UV
- Customer specific display and camera resolution, e. g., QVGA, XGA, ...
- Active matrix diagonal size typically < 1,0″

Applications

Finger print sensor

- OLED for controlled finger illumination
- Photodiodes detect papillary lines as well as sweat pores with high resolution
- Microdisplay can still work as imaging device for notification, branding, ...

Particle flow sensor

- OLED stripes for fluid illumination and photodiodes for detection
- Light reflection depending on local fluid velocity and particle density
- Analyzing photocurrents and correlation functions, the fluid particle velocity can be calculated

Optical inspection

- Patterned illumination and detection of pattern distortion
- Dimensional optical measuring of surface topology

Opto-coupler

- OLED as embedded light source for integrated opto-couplers (e. g., in drivers, controllers,…)
- Biosensors
- OLED for fluorescence excitation
- Photodiodes for detection

Development offer

- OLED-on-Silicon device integration
- R&D in OLED-based integrated optoelectronics
- Electronics design (backplane (integrated circuitry / ASIC), control, interface, …)
- System design (sensor electronics, packaging, module)
- Product development and qualification
- Pilot production (small to medium volume fabrication)

References

- Zoom: BMBF /16SV2283
- ISEMO: BMBF /D 16SV3682