Fraunhofer Institut Photonische Mikrosysteme

OLED-on-CMOS for Sensors and Microdisplays

Introduction

Highly efficient, low-voltage organic light emitting diodes (OLEDs) are well suitable for post-processing integration onto the top metal layer of CMOS devices. This has been proven for OLED microdisplays so far. Moreover, OLED-on-CMOS technology may also be excellently suitable for various optoelectronic sensor applications by combining highly efficient emitters, use of low cost materials and cost effective manufacturing together with silicon inherent photodetectors and CMOS circuitry.

The use of OLEDs on CMOS substrates requires a top emitting, low-voltage and highly efficient OLED structure. By reducing the operating voltage for the OLED below 5 V, the costs for the CMOS process can be reduced, because a process without high-voltage option can be used.

Integrating such OLEDs on a CMOS-substrate provides a preferable choice for silicon-based optical microsystems targeted towards optoelectronic sensor applications, such as integrated light barriers, optocouplers, fluorescence sensors, flow sensors or lab-on-chip devices.

Challenges

- CMOS-OLED interface (material, topology, surface characteristics)
- low-voltage operation (<15 V)
- high brightness (>100…1,000…10,000 cd/m²)
- power efficiency
- lifetime
- operating temperature
- electronics feature integration
- sensor co-integration

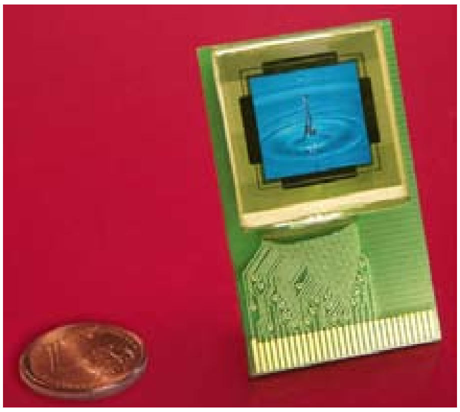

Fig. 1: Demonstrator of OLED microdisplay

Parameters and Specification

OLED Color	Operating Voltage @100 cd/m²	Operating Voltage @1000 cd/m²	Current Efficiency @100 cd/m²
red	2.4 V	3.1 V	14.1 cd/A
orange	2.5 V	3.2 V	11.6 cd/A
white	3.2 V	4.7 V	5.7 cd/A

Applications

- microdisplay (viewfinder, projection, HMD, optical inspection,…)
- bi-directional microdisplay (including optical feedback via internal CMOS sensor)
- light barriers
- opto-coupler
- optical sensors, e.g. chemical, medical (fluorescence, photoplethysmography,…)
- communication (chip-to-chip, board-to-board, chip-to board,…)

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Development offer

The OLED fabrication technology offers firstly the possibility to integrate highly efficient light source into silicon to establish a new class of organic based microsystems. The Fraunhofer IPMS offers developments in this novel application area. Including the IPMS driving circuits and integration technology the Fraunhofer IPMS is the only system supplier worldwide, who offers product developments starting with the system concept till fabrication in this novel technology.

- OLED-on-CMOS device integration
- R&D in OLED-based integrated optoelectronics
- electronics design (backplane, control, interface,…)
- system design
- product development and qualification
- small to medium volume fabrication

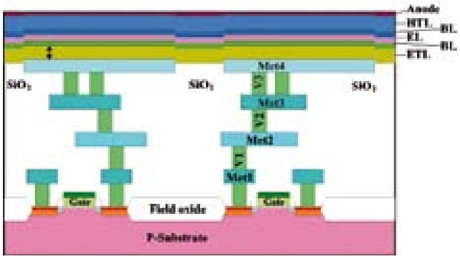

Fig. 2: OLED layer stack (nip-type) on CMOS

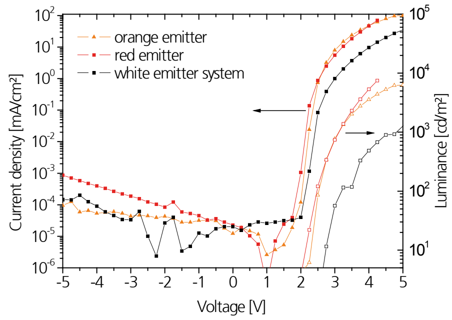

Fig. 3: Current-voltage characteristic

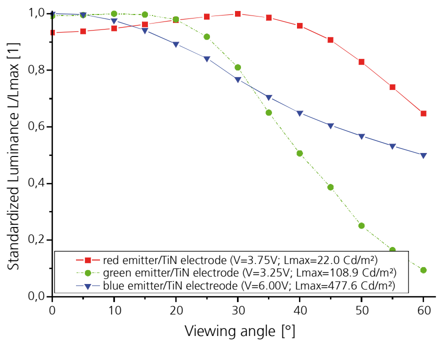

Fig. 4: Luminance angular characteristic

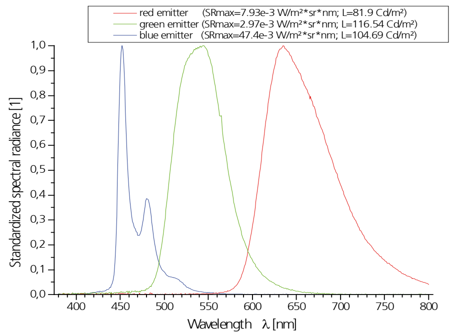

Fig. 5: Spectral characteristics

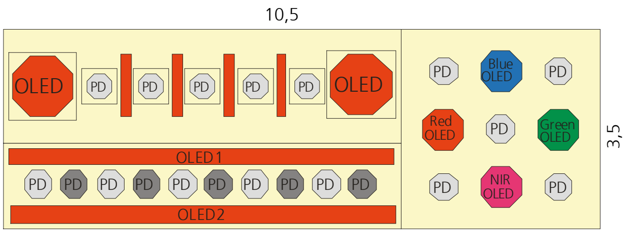

Fig. 6: Setup of OLED-on-CMOS sensor device

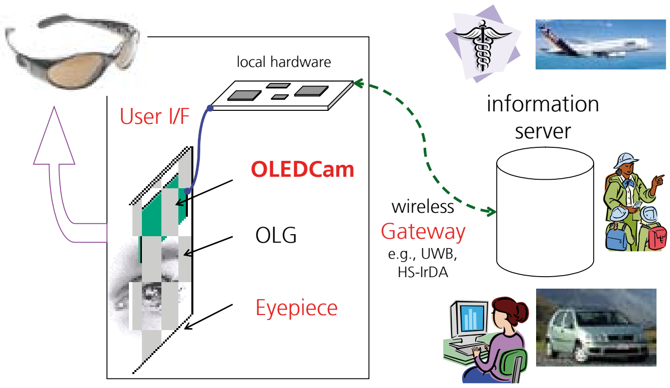

Fig. 7: Bidirectional microdisplay for see-through augmented reality

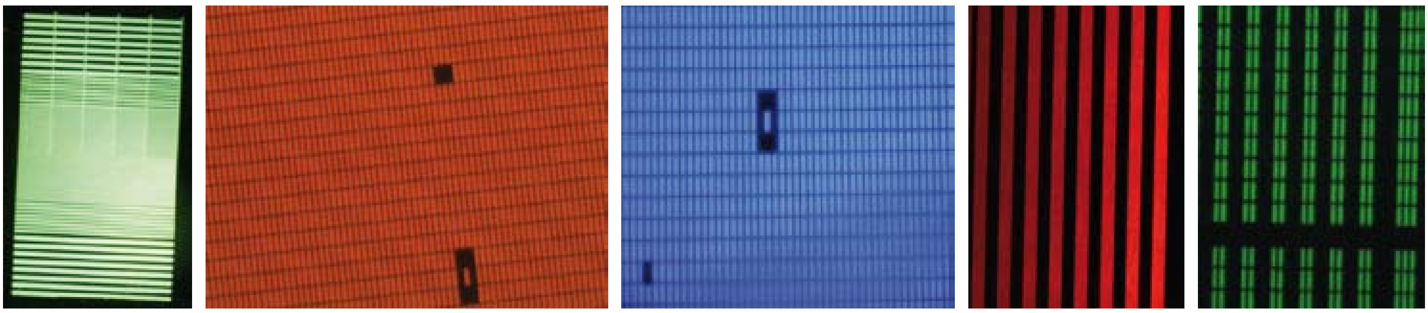

Fig. 8: OLED microdisplay test chips with varying OLED stacks/colors