OLED-on-CMOS based single chip microdisplay and image sensor device

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ABSTRACT

After first reports of the principle of a single chip mircodisplay and camera device, this paper presents the first characterization results of a chip with active matrix camera. Operation will be explained by block-schematic. A second part shows the characterization results of the camera and the display.

1. INTRODUCTION

To minimize augmented reality systems, for example head-mounted-displays and sensor applications, single chips with enhanced functions are needed. In this article, we describe the design conception, the challenges and the solution to design a single chip microdisplay and embedded image sensor/camera device. In a second part the characterization results of the intergrated display and camera will be presented.

2. Design conception

Figure 1.1 shows the block-schematic of the single chip microdisplay and camera device. The main component is the nested active-matrix of 320 x 240 OLED-pixel and 160 x 120 photodiodes. The integrated display has an external digital data-interface with 8-bit parallel data and synchronizations signals. The vsync sets the flag for a new display image, due the row addressing unit jumps to the first row. With the first valid hsync-signal, the external data for one row is shifted by the column addressing unit into the display column puffer. During the shift procedure, the data converter changes the digital signal to an analogue one. In the next stage, the stored data for one row is driven by the column driver to the activated first row. The next hsync-signal activates the second display row for data-in. This procedure is repeated until the end of frame is reached. The integrated camera component is driven by the display pixel-clock; this one could be divided to reduce the power consumption. The first phase of the camera readout procedure is the integration cycle. This integration is started by resetting all camera rows through the camera logic. After a programmable integration time, the camera logic starts the storage of the sampled camera image in all pixel cells. The camera readout procedure is similar to the display but the direction of data changed. To compensate the variations of the pixel-cell-transistor threshold voltage, the component correlated double sampling provides the corrected signal. The unit column addressing shifts the stored corrected analogue signals to the camera amplifier. The amplified signal is then converted to a digital on. In the changed direction, the output camera interface is also a digital one. The camera control generates the synchronization signals.

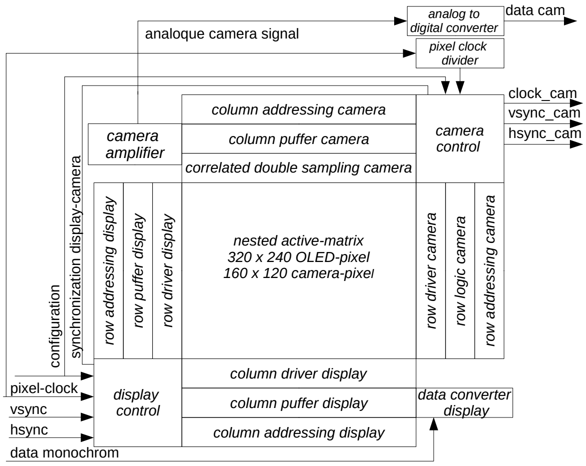

Fig. 1.1 block-schematic

3. Operation Challenges

The main challenge to secure a reliable operation of the single chip microdisplay and camera device is the optical crosstalk between the photo emitters and photo detectors. Investigations show a linear relation between the OLED luminance and the photocurrent. To avoid this crosstalk, the display and the camera must operate in a sequential scheme. This means that the camera operates only in the OLED off-mode.

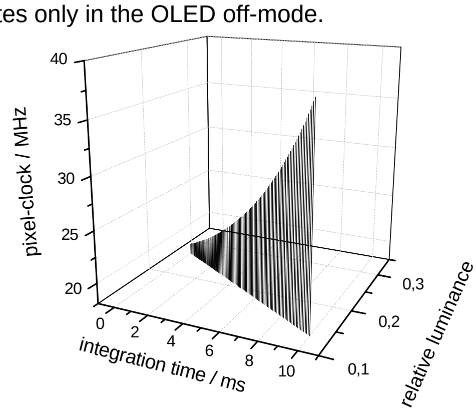

Fig. 1.2 Dependencies of pixel-clock

Figure 1.2 illustrates the relations between the camera integration time and the resulting pixel-clock and the relative luminance. As can be seen, at the integration time of 8 ms the OLED luminance is reduced to 15 %. In consequence the OLED pixel must provide a 85 % higher luminance to secure the reliable display and camera operation.

4. Characterization

4.1 Display

Figure 4.1 shows the measured display transfer characteristic between the digital gray levels and the resulting relative luminance.

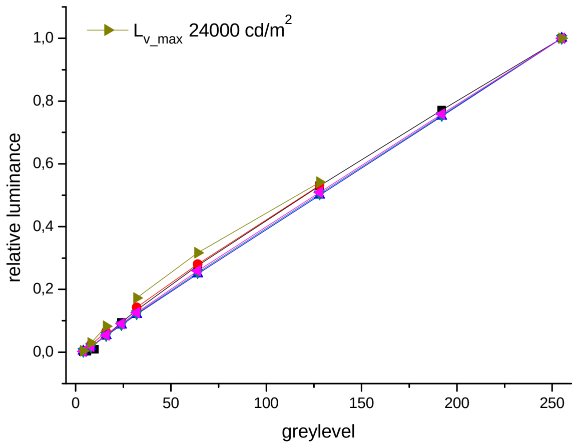

Fig. 4.1 Relative luminance vs. grey-level

As can be seen in Fig. 4.1, the integrated display can support a linear curve up to a luminance of 24000 cd/m^2.

4.1 Camera

Figure 4.2 shows the measured mean grey-level and the variance as a function of collected photons in the camera pixel cell. Above the minimum and below the saturation region, the curve shows a linear characteristic. The variance increases with higher rates of collected photons.

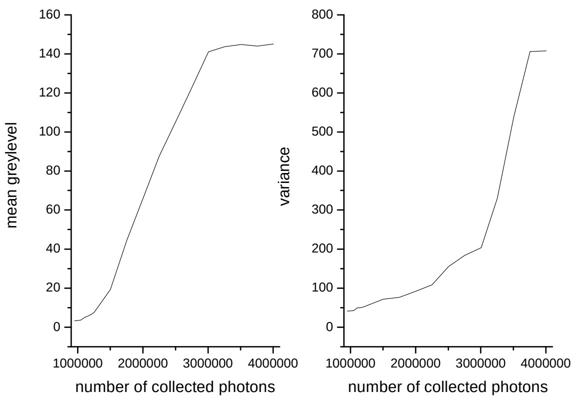

Fig. 4.2 Camera transfer characteristic

Figure 4.3 shows the realized prototype chip in a sequential operation without any optics. The chip runs in a feedback mode, i.e., the captured camera image is directly shown on the embedded microdisplay.

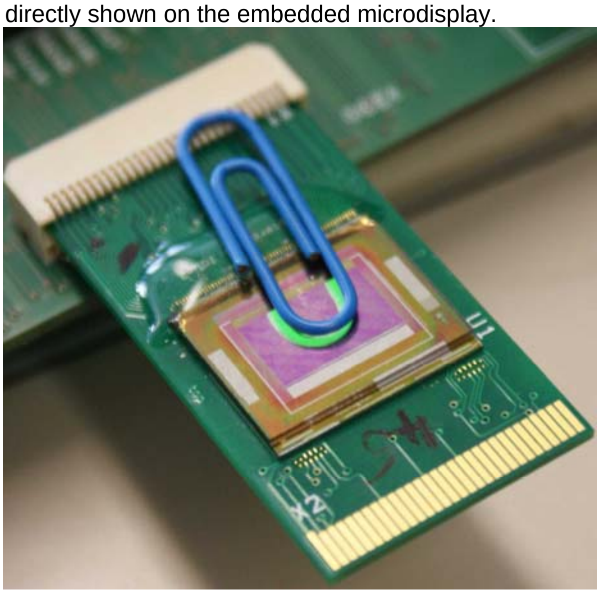

Fig. 4.3 Camera in feedback mode

5. Conclusion

In this paper the block-schematic of a new single chip microdisplay and image sensor/camera device was presented. A second part explained the challenges and design considerations for such device. A final Figure shows the image quality of captured objects.