Fraunhofer Institut Photonische Mikrosysteme

OLED backlight for auto-stereoscopic 3D displays

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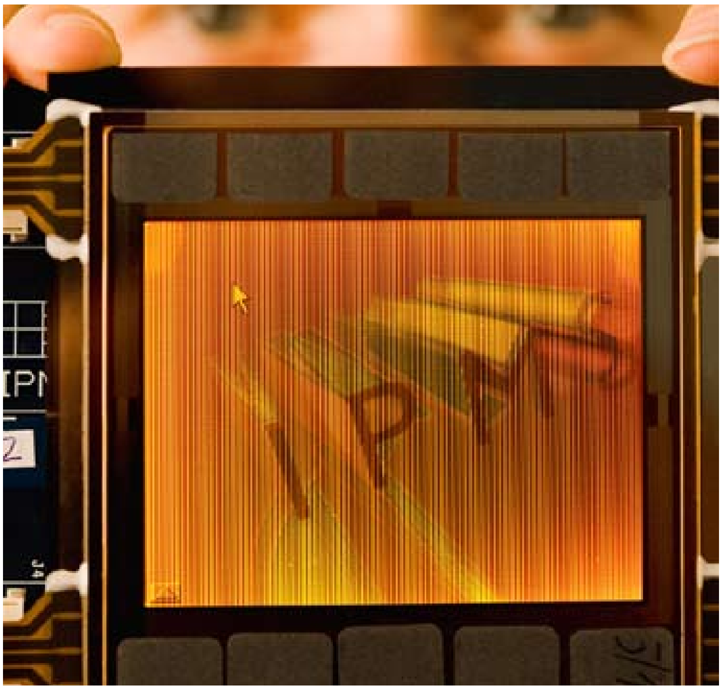
Introduction

The ability to fabricate large-area light emitting devices based on OLEDs can also be used for 3D displays. Typically, they consist of a conventional (unpatterned) flat panel display (FPD) backlight (e.g., CCFL/LED and light guide plate), a front modulator (e.g., Liquid Crystal, LC) and a parallax barrier or lenticular optics in front of the modulator. However, the visibility of the light guiding component is one of the major disadvantages of this approach. This problem can be addressed by designing a backlight which compromises the stereo separation functionality. In this case the backlight emission characteristics and therefore the illumination angle of the LC modulator have to be a function of the user position relative to the display. This can be achieved by using a patterned OLED backlight. It consists of thin, individually controllable OLED stripes that are associated to the columns of the images, respectively the LC modulator that generates the image. In addition to the patterned OLED backlight and the LC modulator a cylindrical micro lens array is an important element to realize the 3D effect of the display. The micro lens array has as many cylindrical optical elements as number of columns of the LC-modulator as well as the same pitch like the LC modulator. Therefore the described illumination principle is called "Single Pixel Illumination".

In principle, the OLED stripes are imaged into the pupil of the eyes, whereas the eyes are accommodated on the image generated by the LC-modulator. In order to realize the 3D effect two images corresponding to left and right eye have to be directed into their proper eye. A time-multiplex solution in which OLED areas behind one microlens are alternately switched on and off respectively keeps the full geometrical resolution of the modulator.



Backlight design

The results of the optics design in combination with the geometrical and optical parameters of the used modulators influence the design of the OLED backlight. Three OLED stripes per lens have to be used. This leads to a maximum stripe pitch of 35 µm. The ratio between bright and dark areas has to be 4 : 1 (i.e. 28 µm stripe width and 7 µm dark gap) and the total size of the bright area must be at least 71.52 x 53.64 mm.

Since the LC modulators have 320 columns, a total of 960 OLED stripes are necessary. They were split up into three groups. The light lines where assigned to a group due to their contribution to the designated eye-box / viewing-zone area that had to be illuminated. Because of the different light paths and hence different requirement a separate supply rail was assigned to each group. This minimizes the external connections to manageable amount, because the wiring could be incorporated in the backlight design itself.

The wiring consists of 3 metal layers (see fig. 3): firstly, a thick low-resistance layer for the supply rails, secondly, an intermetal via layer to interconnect layer 1 and 3, and thirdly, a thin anode metal layer. The first and second layers are only used outside the active area to achieve a low resistance supply. These are relatively thick metal layers to ensure a good electrical supply to the active area. The third metal layer is a special metal which matches the requirements for conducting the OLED stack (e.g. low roughness, work function).

System integration

Based on the new OLED backlight for autostereoscopic displays, a demonstrator that shows the capabilities of the approach has been developed. Its system architecture is shown in fig. 2. A controller generates the two images for the left and right and is responsible for both driving the OLED stripes and addressing the LC modulator. The controller is based on a commercially available PDA platform running Windows CE 5.0 operating system. Custom electronic has been added to the PDA module for connection of the patterned OLED backlight. Global lighting parameters can be controlled by a special, custom Windows CE application. The auto-stereoscopic 3D display is connected to the backlight driving unit and the display interface of the controller board and mounted on top.

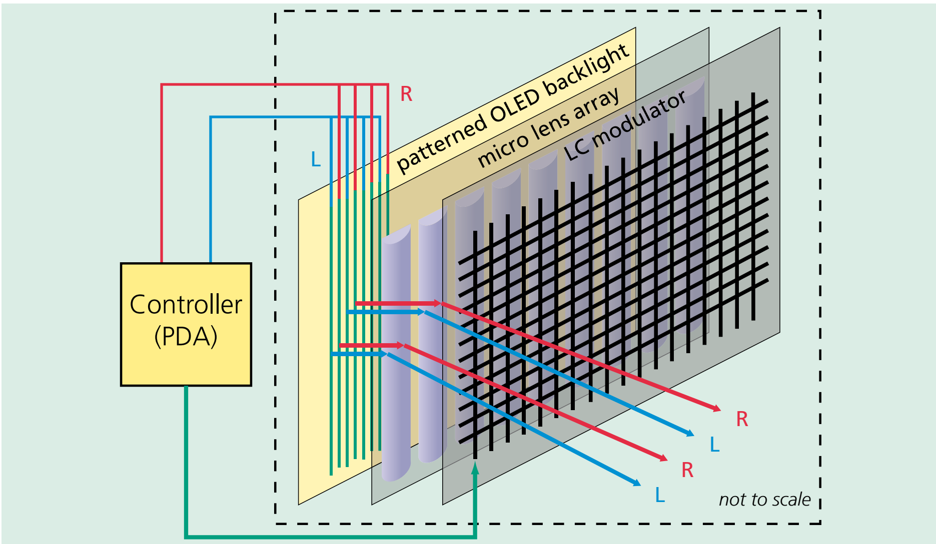


Fig. 2: Functional schematic of OLED backlight control for auto-stereoscopic display

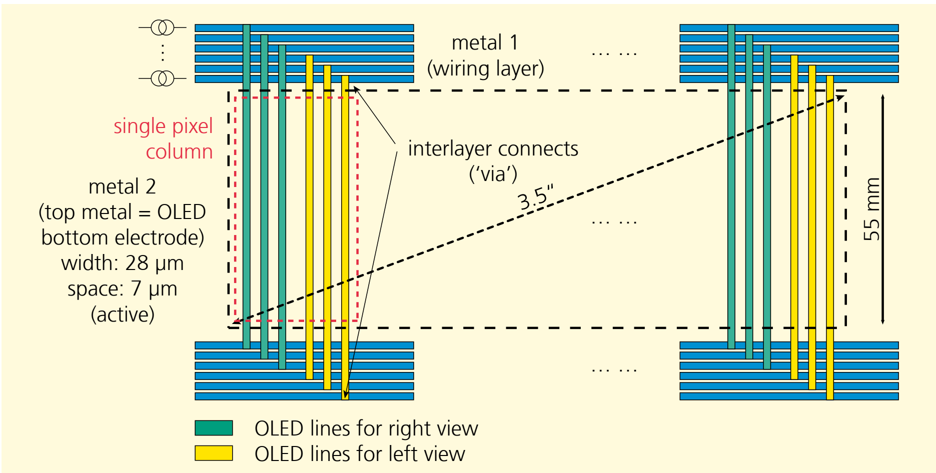


Fig. 3: Setup of wiring and metal electrodes for OLED backlight