Fountain (FE-FFS) Technology for Wide Viewing Angle LCD

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Keywords: Perforated electrode, fountain fringe fields, wide azimuthal viewing angle.

ABSTRACT

A new electrode structure for generating fringe field switching (FFS), which contains holes in the pixel electrode, is suggested. Such pixel perforated electrode (PE) with circular holes results in azimuthally degenerated switching of the liquid crystal molecules around the holes and thus enables the generation of images with 360° viewing angle and constant contrast.

1. INTRODUCTION

Liquid crystals (LCs) are materials with anisotropic physical properties, due to the anisotropic form of their molecules. For the majority of display applications of the LCs, wide viewing angle with constant contrast, is required. For achieving of such properties, however, a variety of combinations of different optical plates are used in the liquid crystal display (LCD) architecture for compensating the viewing angle dependence of the display. As a result, the complexity and the cost of the LCD increases.

We present here a typical case of a new FFS electrode structure, consisting of common electrode and pixel electrode with circular holes, as perforated electrode (PE), separated from each other by insulation layer. The PE is generating a Fountain like Fringe Fields around the holes. Such fields, however, are producing azimuthally degenerated switching of the liquid crystal molecules around the holes and thus images with azimuthal viewing angle of 360° with constant contrast are generated.

2. EXPERIMENT

To demonstrate our new Fountain Fringe Field Technology, we report below one typical example of this technology employed in a conventional nematic liquid crystal display architecture (LCD) using Electrically Controlled Birefringence (ECB) effect.

The experimental cell is of sandwich type, consisting of two parallel glass plates separated at predefined distance, usually several microns. On one of the substrates is deposited a layered electrode for generating fringe field, consisting of common ITO electrode, covered by insulation layer (SiO_x or Si_3N_4). On top of the insulating layer is deposited another ITO electrode (second (pixel) electrode), containing circular micron size holes, which are uniformly distributed over the whole pixel area (c.f.Fig.1). The inner surfaces of the cell substrates are covered

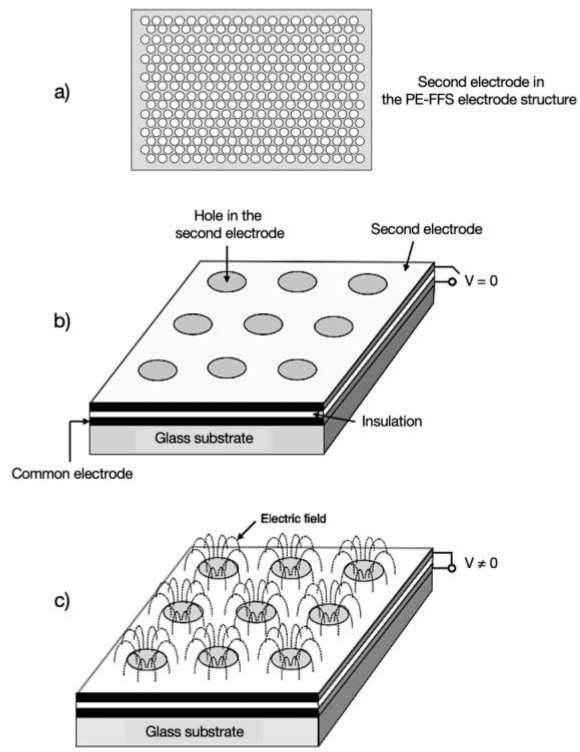

Fig.1. PE-FFS technology with circular holes. a) perforated second electrode. Cross-section of the PE structure in field-off b) and field-on state c).

with alignment layer (SE-1211, Nissan) promoting vertical alignment (VA) of the LC, filling the cell gap. The LC used in our experiments was ZLI 4792 ($\Delta\varepsilon>0$).

After filling with LC material, the cell was heated up to the isotropic state and then slowly was cooled down to room temperature. The quality of the VA was inspected in polarising microscope between crossed polarisers. In field-off state, the cell exhibited a perfect dark state, indicated thus a good quality VA over the entire cell area. The electric field generated by the PE-FFS electrode structure, having circular holes in the second electrode, has a fountain like form, which field lines direction around each hole are azimuthally degenerated, as shown in Fig.1c. The molecules of liquid crystal ZLI 4792, filling the cell gap, tend to orient along the field lines, due to the positive Δε of the LC material. Therefore, the molecules adopt azimuthally degenerate alignment around each hole of the PE-FFS electrode. The switching of the molecules of the nematic LC, having Δε>0 and field-off VA, is demonstrated by the computer simulations, shown in Fig.2. Such locally degenerate field-on alignment of the liquid crystal molecules around the holes results in isotropic in-plane optical properties of the cell and, hence, the generated images possess 360° azimuthally viewing angle and constant contrast.

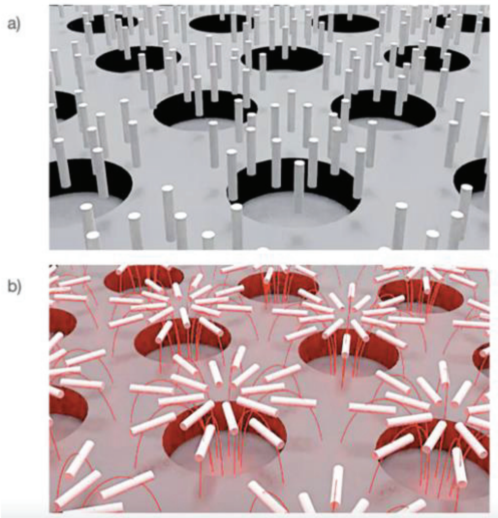

Fig.2 Computer simulations of the switching in LCD with VA in field-off state a), driven by the perforated electrode b).

Azimuthal viewing angle dependence of the generated image by the perforated electrode structure was check in single pixel cell filled with nematic liquid crystal with Δε>0 and VA in the field-off state. The switching of the liquid crystal in the cell is depicted Fig. 2, and in Fig.3 is shown the photographs of the cell taken at different position of the cell pixel between the crossed polarisers of polarizing microscope. The dark part of the photographs corresponds to the area outside of the pixel, in which the LC molecules have VA, whereas the bright area corresponds to the activated pixel area. As seen, the contrast between the field-off area outside the pixel (dark part) and field-on area of the pixel (bright part), remains constant during the rotation of the cell between the crossed polarisers. This observation indicates that the generated image by the LC cell, with field-off VA switched by the perforated electrode structure, exhibits wide azimuthal viewing angle with constant contrast.

3. CONCLUSIONS

To omit the azimuthal angular dependence of the viewing angle of the images, displayed by LCDs, is not a trivial task. There are a number of known methods, which partially but not completely suppress this dependence. In

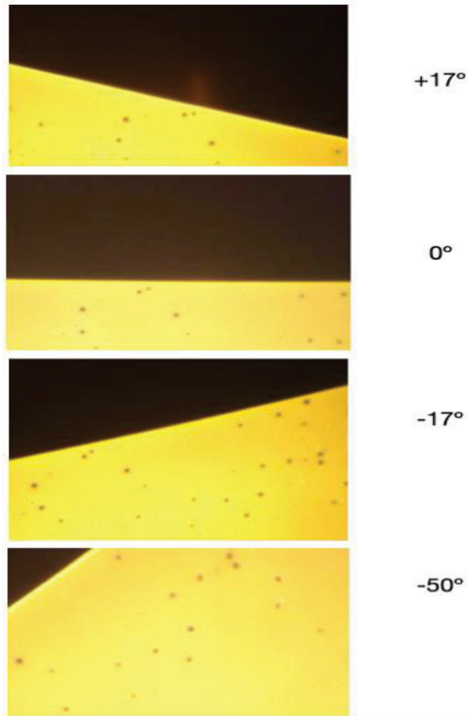

Fig.3 Photographs of a single pixel LC cell, inserted in microscope between crossed polarisers. The cell is switched by the perforated electrode structure. The images are taken at different angles of rotation of the cell pixel.

this work, we report one typical case of our novel technology, which we call PE-FFS. According to this technology, a layered electrode, consisting of common electrode and second perforated electrode with circular holes, separated from each other by insulation layer, is providing azimuthally degenerated fringe field around each hole in the second electrode. Because of the similarity, the fringe field around the circular holes also calls Fountain Field and has no any preferred direction, hence being with azimuthally degenerated (isotropic in-plane) distribution. Following the in-plane distribution of the applied electric field, the LC molecules adopt also such isotropic in-plane distribution during the switching process, and, thus, the generated images appear with the same in-plane isotropic optical characteristics, i.e. they exhibit wide azimuthal viewing angle of 360° with constant contrast. The novel PE-FFS Technology (or Fountain Field Technology) is also appropriate for applications in other Display modes than in ECB mode as well as for non-Display applications.

REFERENCES

[1] Pochi Yeh and Claire Gu, "Optics of Liquid Crystal Displays", Second Edition 2010, John Wiley & Sons, Inc.