

Display device with dummy electrodes.

The invention relates to a display device comprising an electro-optical medium between two supporting plates provided with electrodes which define pixels at overlap locations. The invention particularly relates to such a display device in which the electrodes on at least one supporting plate extend on the supporting plate beyond the area of the pixels where they are provided with drive elements.

The electro-optical medium is, for example a liquid crystal material, particularly a (super)twisted nematic liquid crystal material.

Such display devices are used in alphanumerical displays for measuring instruments, dashboards etc., but also, for example in computer monitor screens.

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Display devices of the type described above are generally known. A problem which may occur particularly, but not exclusively in supertwisted nematic liquid crystal display devices is the phenomenon of discoloration because the distance between the two supporting plates is not the same throughout; notably this distance differs at the location of (between) two pixel-defining electrodes from that at the location of (between) an electrode and a supporting plate not provided with an electrode. Since the color difference increases at larger thicknesses of the electrodes, this problem frequently occurs in display devices in which the electrodes on at least one supporting plate extend on the supporting plate beyond the area of the pixels where they are provided with drive elements, because the electrode tracks should have a minimum thickness to ensure a good contact for connecting these drive elements, for example via chip-on-glass (COG) techniques. Moreover, a certain thickness is advantageous because there will be less voltage drop across the electrode and a more uniform display is obtained. The minimum thickness for this purpose is approximately 100 nm.

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It is, inter alia an object of the present invention to mitigate the above-mentioned problem as much as possible.

To this end a display device according to the invention is characterized in

that extra electrodes having substantially the same thickness as the pixel-defining electrodes are provided between the pixel-defining electrodes on at least a first supporting plate, and in that the display device comprises means for supplying the extra electrodes with a voltage during operation.

5 By providing extra electrodes between the pixel-defining electrodes, it is achieved that differences in the thickness of the liquid crystal layer and hence discolorations are reduced considerably. Since the extra electrodes can be provided with a voltage, it can be prevented that pixels are provided with the wrong picture contents due to electric crosstalk via the extra electrodes.

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A device according to the invention in which the electrodes on at least the first supporting plate extend on the supporting plate beyond the area of the pixels where they are provided with drive elements is characterized in that extra electrodes having substantially
15 the same thickness as the pixel-defining electrodes are provided between the pixel-defining electrodes on at least the first supporting plate, and in that the display device comprises means for supplying the extra electrodes with a voltage during operation. The extra electrodes have a thickness of at least 100 nm in this case.

Applying a voltage to the extra electrodes is not always readily possible,
20 for example because the number of external connections is to be limited as much as possible. In that case, a display device according to the invention is characterized in that extra electrodes having substantially the same thickness as the pixel-defining electrodes are provided between the pixel-defining electrodes on a first supporting plate, the extra electrodes being mainly present at locations which, viewed transversely to the display device,
25 are present between pixel-defining electrodes on the other supporting plate. This limits crosstalk.

It is to be noted that the provision of extra (dummy) electrodes to inhibit discoloration is known per se from JP-A 3-290621, but here the electrodes are not provided with an electric voltage (they are electrically insulated), while there is neither any question of
30 a given pattern to prevent crosstalk.

The electrodes and the extra electrodes are preferably made of the same material, for example indium tin oxide. An additional advantage is the antireflective effect of such electrodes.

Although the measures for reducing discoloration and crosstalk consist of

providing extra electrodes on the first substrate, these measures can also be extended to the second substrate.

A further embodiment of the display device, in which the extra electrodes can be provided with a fixed voltage, is therefore characterized in that extra electrodes
5 having substantially the same thickness as the pixel-defining electrodes are provided between the pixel-defining electrodes on the other supporting plate, and in that the display device comprises means for supplying the extra electrodes on the other supporting plate with a voltage during operation. A further embodiment of the display device, in which the extra electrodes are provided with a pattern, is then characterized in that extra electrodes having
10 substantially the same thickness as the pixel-defining electrodes are provided between the pixel-defining electrodes on the other supporting plate, the extra electrodes being mainly present at locations which, viewed transversely to the display device, are present between pixel-defining electrodes on the first supporting plate.

Also the area outside the actual image plane is preferably provided with
15 extra electrodes so as to obtain a minimal thickness variation throughout the surface.

To this end, a further embodiment of the display device according to the invention is characterized in that the extra electrodes on at least one of the supporting plates extend substantially throughout the supporting plate across parts of the supporting plate surface exposed by the pixel-defining electrodes and the supply electrodes connected thereto.
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These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

In the drawings:

25 Fig. 1 is a diagrammatic plan view of a part of a display device according to the invention,

Fig. 2 is a diagrammatic cross-sectional view taken on the line II-II in Fig. 1,

Fig. 3 is a diagrammatic cross-sectional view taken on the line III-III in
30 Fig. 1,

Fig. 4 shows diagrammatically a part of Fig. 1, while

Fig. 5 is a diagrammatic plan view of a part of a further display device according to the invention, and

Fig. 6 is a diagrammatic plan view of a part of another display device

according to the invention.

The Figures are diagrammatic and not to scale: corresponding parts are usually denoted by the same reference numerals.

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Figs. 1, 2 and 3 are diagrammatic plan views and cross-sections taken on the lines II-II and III-III in Fig. 1 of a part of a liquid crystal display device comprising a liquid crystal cell 1 with a twisted nematic liquid crystal material 2, in this example a supertwisted nematic liquid crystal material which is present between two substrates 3, 4 of, for example glass provided with electrodes 5, 6 which are transparent in this example and are made of, for example indium tin oxide (ITO). The device further comprises orientation layers 7, 8 which orient the liquid crystal material on the inner walls of the substrates in such a way in this example that the cell has a twist angle of, for example 240° . If necessary, the device further comprises one or two polarizers (not shown) and the conventional insulating layers between ITO and glass and/or between ITO and orientation layers. In this case, the liquid crystal material has a positive optical anisotropy and a positive dielectric anisotropy.

The display device further comprises (see Fig. 2) one or more drive elements 10, in this example integrated circuits (ICs) which are connected to the electrodes 5 by means of chip-on-glass technology, for example by means of thermocompression or soldering in such a way that the bumps 11 establish a satisfactorily conducting contact with these conducting electrodes 5. Similarly as shown for the conductors 5, the conductors 6 on the substrate 4 may be connected to the electrodes 6 by means of a chip-on-glass technology.

To obtain a satisfactory electric contact via the bump 11, this electrode should have a thickness of at least 100 nm. Moreover, at such a thickness, the resistance of the ITO electrodes has a small influence on the display effect. This means that the thickness of the liquid layer at an original distance of the supporting plates of, for example $6\text{ }\mu\text{m}$ has a thickness of approximately $5.8\text{ }\mu\text{m}$ at the location of the pixels, and at locations where picture electrodes are arranged opposite a supporting plate it may have a thickness of approximately $5.9\text{ }\mu\text{m}$ and the original thickness of approximately $6\text{ }\mu\text{m}$ at locations where no picture electrodes are present. This variation leads to color differences which can be partly compensated by providing extra electrodes 15, 16 having substantially the same thickness as the electrodes 5, 6 between the electrodes 5, 6 so that the variation of thickness of the liquid crystal layer 2 is reduced. For process-technological reasons, the extra electrodes 15, 16 are preferably made of the same material as the electrodes 5, 6.

However, it appears in practice that such a solution is not sufficient, which will be further explained with reference to Fig. 4. This Figure shows the situation in which an extra electrode 16 is located opposite two electrodes 5^a, 5^b with liquid crystal material in between, as is shown in Figs. 1, 2. The overlapping parts of the extra electrode 16 and the electrodes 5^a, 5^b are assumed to have surfaces A₁ and A₂. If the electrodes 5^a, 5^b are driven by, for example voltages +V_d and -V_d, respectively (which voltages are customary in datagraphic display devices), the opposite (floating) extra electrode 16 acquires a voltage of $V = ((A_1 - A_2) / (A_1 + A_2)) \cdot V_d$ due to capacitive crosstalk. The voltage differences between the extra electrode 16 and the electrodes 5^a, 5^b will then be $V_1 = -$
2(A₂/(A₁ + A₂)).V_d and $V_2 = 2(A_1 / (A_1 + A_2)) \cdot V_d$, respectively. If these voltages exceed the threshold voltage of the liquid crystal material, unwanted information will be visible. According to the invention, this can be prevented by suppressing said capacitive crosstalk. To this end, the extra electrodes 15, 16 are connected to ground (Figs. 1, 2) via connections 15', 16' shown diagrammatically, or to a fixed voltage source 12 (Fig. 3) in the
embodiments of Figs. 1, 2 and 3. To ensure the operation of such an extra electrode as satisfactorily as possible, the distance between the electrodes and the extra electrodes is chosen to be as small as possible, for example at most 100 μm and preferably at most 50 μm. At smaller distances, the risk of short-circuit increases due to process tolerances.

If it is not possible to connect extra electrodes due to, for example layout-technical problems or for other reasons, the capacitive coupling may also be interrupted by not providing an extra electrode on the opposite supporting plate at the location of the electrode overlaps. The extra electrodes 15, 16 then acquire a pattern as is shown by way of example in Fig. 5.

The invention is of course not limited to the examples shown, but said measures (connecting the extra electrodes to ground or to a fixed voltage, providing the extra electrodes in a pattern so that overlap is avoided) are also applicable to other display devices, for example for less thick tracks 5, 6 if no COG techniques are used or for twisted nematic liquid layers having a smaller twist angle. In both cases, the risk of incorrect information due to crosstalk and influencing of the picture contents (discoloration) is reduced. The invention is also applicable to other electro-optical media in which the layer thickness plays a role because of optical properties. The extra electrodes 16 on the second substrate may also be present opposite parts of the pixel-defining electrodes 5 which are outside the actual image plane as is shown in Fig. 6 by the electrode 26 (shown in broken lines) for a configuration of pixel-defining electrodes 5 on a first substrate between which extra electrodes 15 and 15'

(outside the actual image plane) are present, while extra electrodes (dummy electrodes) 26 are present on the second substrate opposite the connection electrodes 5' located on the first substrate.

- 5 In summary, the invention provides a display device comprising an electro-optical medium, for example an LCD of the (super)twisted nematic type, in which the capacitive influence on the switching behaviour of extra (dummy) electrodes employed to neutralize the difference in electro-optical behaviour (discoloration) is compensated by giving the extra electrodes a fixed voltage or by providing a pattern of the dummy electrodes on the other substrate particularly on non-overlapping parts of the picture electrodes.

Claims:

1. A display device comprising an electro-optical medium between two supporting plates provided with electrodes which define pixels at overlap locations, characterized in that extra electrodes having substantially the same thickness as the pixel-defining electrodes are provided between the pixel-defining electrodes on at least a first supporting plate, and in that the display device comprises means for supplying the extra electrodes with a voltage during operation.
2. A display device comprising an electro-optical medium between two supporting plates provided with electrodes which define pixels at overlap locations, in which the electrodes on at least a first supporting plate extend on the supporting plate beyond the area of the pixels where they are provided with drive elements, characterized in that extra electrodes having substantially the same thickness as the pixel-defining electrodes are provided between the pixel-defining electrodes on at least the first supporting plate, and in that the display device comprises means for supplying the extra electrodes with a voltage during operation.
3. A display device as claimed in Claim 1, or 2, characterized in that extra electrodes having substantially the same thickness as the pixel-defining electrodes are provided between the pixel-defining electrodes on the other supporting plate, and in that the display device comprises means for supplying the extra electrodes on the other supporting plate with a voltage during operation.
4. A display device comprising an electro-optical medium between two supporting plates provided with electrodes which define pixels at overlap locations, characterized in that extra electrodes having substantially the same thickness as the pixel-defining electrodes are provided between the pixel-defining electrodes on a first supporting plate, the extra electrodes being mainly present at locations which, viewed transversely to the display device, are present between pixel-defining electrodes on the other supporting plate.
5. A display device comprising an electro-optical medium between two supporting plates provided with electrodes which define pixels at overlap locations, in which the electrodes on at least a first supporting plate extend on the supporting plate beyond the area of the pixels where they are provided with drive elements, characterized in that extra





electrodes having substantially the same thickness as the pixel-defining electrodes are provided between the pixel-defining electrodes on at least the first supporting plate, the extra electrodes being mainly present at locations which, viewed transversely to the display device, are present between pixel-defining electrodes on the other supporting plate.

- 5 6. A display device as claimed in Claim 4 or 5, characterized in that extra electrodes having substantially the same thickness as the pixel-defining electrodes are provided between the pixel-defining electrodes on the other supporting plate, the extra electrodes being mainly present at locations which, viewed transversely to the display device, are present between pixel-defining electrodes on the first supporting plate.
- 10 7. A display device as claimed in any one of the preceding Claims, characterized in that the extra electrodes on at least one of the supporting plates extend substantially throughout the supporting plate across parts of the supporting plate surface exposed by the pixel-defining electrodes and supply electrodes connected thereto.
8. A display device as claimed in any one of the preceding Claims,
15 characterized in that the extra electrodes on at least one of the supporting plates extend opposite supply electrodes connected to pixel-defining electrodes provided on the other supporting plate.
9. A display device as claimed in any one of the preceding Claims, characterized in that the extra electrodes have a thickness of at least 100 nm.
- 20 10. A display device as claimed in any one of the preceding Claims, characterized in that the extra electrodes and the pixel-defining electrodes are made of the same material.