

DISPLAY DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to a display device such as a liquid crystal display (LCD).

A LCD normally comprises a pair of substrates with one or more electrodes on each substrate. An
5 alignment layer overlies each electrode, and a polarizing layer is usually disposed on the outside of each of the substrates. Further, for a color LCD, a color filter overlies one substrate enclosed in an encapsulating layer lying between the electrode and the
10 substrate. A liquid crystal material (LCM) is disposed between the alignment layers. The alignment layers align the LCM to a selected "tilt angle", which is the angle between the longitudinal axis of a liquid crystal molecule and the plane of the alignment layer. The
15 alignment layers cannot require a cure temperature that is so high that damage to the drive electronics and the color filter can result. While low curing temperature alignment materials exist, they also have a low tilt angle. A low value for the tilt angle can result in
20 ambiguities in the way the LCM aligns with the layer and a long response time. By "ambiguities" is meant that different portions of the LCM within an LCD align with different optical rotations. Further, some alignment materials allow ionic migration from the
25 substrate into the LCM.

A display device comprises a display device comprising: first and second opposing substrates having first and second electrodes, respectively thereon; a color filter between the second substrate and the second
30 electrode; and first and second alignment layers overlying the first and second electrodes, respectively, the second alignment layer having a lower cure temperature than that of the first alignment layer.

An embodiment of the device comprises parts,
35 i.e. the color filter and possibly also electronics etc., which are to be present with the second alignment layer during curing but which can only withstand a limited temperature.

The second alignment layer then has a cure temperature below the withstand temperature of such a part or parts, the part or parts being provided on the side of the device with the low cure temperature alignment layer. In
5 the embodiment a high cure temperature material is used for the first alignment layer. The high cure temperature material may be selected to resist ion migration and/or provide a high value for the tilt angle.

It would be desirable to have an LCD whose
10 alignment layers do not require a curing temperature that damages the electronics or color filters during fabrication, have a minimum of twist ambiguities, and minimize ionic migration.

BRIEF DESCRIPTION OF THE DRAWING

15 The sole FIGURE is a cross-sectional view of a LCD which embodies the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The FIGURE shows a portion of an LCD 10 comprising first and second substrates 12 and 14. First
20 and second polarizing layers 16 and 18 are disposed on the outer surfaces of the substrates 12 and 14, respectively. A first electrode 20 overlies the substrate 12, and a first aligning layer 22 overlies the electrode 20. Adjacent the second substrate 14 is a color filter 24 enclosed in an
25 encapsulating layer 26. A second electrode 28 lies adjacent the encapsulating layer 26, while a second alignment layer 30 lies adjacent the second electrode 28. Between the alignment layers 22 and 30 is LCM 32. For active matrix LCDs, the plane of the first electrode 20
30 typically also comprises the active drive element, such as a diode or a transistor (not shown), and addressing lines (not shown), all as known in the art. If desired, the active element can be disposed in the plane of the second electrode 28.

35 The substrates 12 and 14 can be of a transparent material such as glass, fused quartz, or plastic. The electrodes 20 and 28 can be made of a transparent

conductive layer such as tin oxide or indium tin oxide of about 200 nanometers (nm) in thickness. The color filter 24 can comprise an organic dye or a pigment, while the encapsulating layer 26 can be a transparent organic polymer, such as methylmethacrylate. The LCM 32 can be a twisted nematic type such as a mixture of phenylcyclohexane, biphenylcyclohexane and cyclohexylbiphenylcyclohexane, made by the E. Merck Co., Rahway, N.J., as "ZLI2293".

The first alignment layer 22 can be made of a polyimide of about 100 nm in thickness to block ion migration and having a relatively high, about 250°C, cure temperature. The second alignment layer 30 can be made of a low cure temperature material, for example, a

monomolecular layer of an organosilane, such as N-methylaminopropyltrimethoxy silane, which has a cure temperature of about 90°C. This avoids the possibility of damage to the filter 24 during curing. The polarizing layers 16 and 18 can comprise polyvinylalcohol doped with iodine.

Each of the substrates 12 and 14, together with their respective layers are separately cured, rubbed, and assembled. Then the edges are sealed in known manner leaving a space and the LCM 32 introduced into the space therebetween. Finally the fill hole (not shown) is sealed in known manner.

EXAMPLE

An LCD was made using the materials given above, i.e. a polyimide for the first alignment layer 22 and an organosilane for the second alignment layer 30. The tilt angle was measured using the technique disclosed in the article "Accurate Optical Measurement of Small Tilt Angles in Thin Twisted Nematic Layers", by H. Birecki and F. J. Kahn, in the book "The Physics and Chemistry of Liquid Crystal Devices", G. F. Sporkel, Plenum Press, N.Y. 1980. An average tilt angle of about 0.5 to 0.6 degree was obtained for the LCM 32, which was found by visual inspection to be sufficiently large to eliminate ambiguities.

COUNTER EXAMPLE NO. 1

In contradistinction to the example above, an LCD was made wherein both of the alignment layers 22 and 30 comprise the same material, the organosilane. The average tilt angle was found to be about 0.3 degree, which resulted in ambiguities in the liquid crystal material layer.

COUNTER EXAMPLE NO. 2

When both of the alignment layers 22 and 30 comprise a polyimide, a tilt angle for the LCD of 2 to 3 degrees was obtained. This was sufficient to eliminate ambiguities in the LCM 32. However, the high cure temperature would degrade the color filter 24.

CLAIMS:

1. A display device comprising:
first and second opposing substrates having
first and second electrodes, respectively thereon;
a color filter between the second substrate and
the second electrode; and
first and second alignment layers overlying the
first and second electrodes, respectively, the second
alignment layer having a lower cure temperature than that
of the first alignment layer.
2. A display device according to Claim 1,
further comprising electronic devices on the second
substrate.
3. A display device according to Claim 1 or 2
wherein the cure temperature of the second alignment
layer is less than the withstand temperature of the color
filter or filter and electronic devices.
4. A display device according to Claim 3
wherein the cure temperature of the first alignment layer
is such as would damage at least the filter.
5. A device according to Claim 1, 2, 3 or 4
wherein said substrates comprise a transparent material.
6. A device according to Claim 1, 2, 3, 4 or
5 wherein said electrodes each comprise a transparent
conductive layers.
7. A device according to any one of the
preceding claims, wherein said first and second alignment
layers comprise a polyimide and an organosilane,
respectively.

8. A device according to any one of the preceding claims, comprising liquid crystal material disposed between said alignment layers.

9. A device according to Claim 8, wherein the first alignment layer resists ion migration and/or provides a high value of tilt angle.

10. A device according to any one of the preceding claims, further comprising a pair of polarizing layers adjacent said substrates, respectively, on the surface opposite said electrodes.

11. A display device substantially as hereinbefore described and shown with reference to the figure of the accompanying drawing.
