Abstract

A liquid crystal device is provided which includes: a first substrate and a second substrate that are disposed to face each other; a liquid crystal layer that is sandwiched between the first substrate and the second substrate; a first electrode that is provided on the liquid crystal layer side of the first substrate; an insulating layer that is provided on the liquid crystal layer side of the first electrode; and a second electrode that is provided on the liquid crystal layer side of the insulating layer, in which the first substrate has formed thereon a plurality of data lines and a plurality of scan lines which intersect each other; sub-pixels are formed at regions surrounded by the data lines and the scan lines; the second electrode has a plurality of linear electrodes that is disposed with a gap therebetween; each of the plurality of linear electrodes extends in a long-axis direction of the sub-pixels and has at least one bent portion; the bent portion has such a shape that both sides thereof are inclined in opposite directions with respect to the long-axis direction of the sub-pixels; and the data lines or the scan lines are bent in an extending direction of the linear electrodes having the bent portion.

CROSS REFERENCES TO RELATED APPLICATIONS

~~The present invention contains subject matter related~~This application is a continuation application of U.S. patent application Ser. No. 12/397,408 filed Mar. 4, 2009, which application claims priority to Japanese Patent Application No. 2009-009615 filed in the Japanese Patent Office on Jan. ~~20, 2009~~20, 2009, and Japanese Patent Application No. 2008-055867 filed in the Japanese Patent Office on Mar. 6, 2008, the entire contents of which are incorporated herein by reference.

BACKGROUND

1. Technical Field

The invention relates to a liquid crystal device and an electronic apparatus.

2. Related Art

Hitherto, as one means for achieving a wide viewing angle of an liquid crystal device, there has been used a mode in which an electric field is applied to a liquid crystal layer in a direction of a substrate plane to thereby control alignment of liquid crystal molecules (such a mode will be referred to as a lateral electric field mode), and an IPS (In-Plane Switching) mode and an FFS (Fringe-Field Switching) mode have been known as such a lateral electric field mode. In a lateral electric field mode liquid crystal device, a pixel electrode and a common electrode are typically formed on the same substrate. In the case of the IPS mode, the pixel electrode and the common electrode are formed on the same layer and have a comb-teeth shape. On the other hand, in the case of the FFS mode, the pixel electrode and the common electrode are formed on different layers, respectively, and one of them has a comb-teeth shape and the other has a beta shape. In particular, in the case of the FFS mode, since the pixel electrode and the common electrode are formed on different layers, a strong electric field is generated from a fringe portion of the electrode in a direction inclined with respect to the substrate plane. Therefore, the FFS mode has a merit that the alignment of liquid crystal molecules disposed right above the electrode can be easily controlled compared with the IPS mode.

As a method for achieving a further wider viewing angle with the lateral electric field mode liquid crystal device, there is a known method that forms a plurality of regions, a so-called multi-domain, in which liquid crystal molecules within one sub-pixel are aligned in different directions upon voltage application (a region where liquid crystal molecules are aligned in approximately one direction is referred to as a domain). Since the viewing angle characteristics corresponding to inherent contrast ratios of respective domains are compensated by forming multiple domains, it is possible to achieve a wide viewing angle. In order to form a multi-domain structure, the shape of a comb-teeth shaped electrode needs to be studied. When electrode fingers constituting a comb-teeth shaped electrode are referred to as "linear electrodes," rather than arranging the entire linear electrodes within one sub-pixel to extend in the same direction, for example, as illustrated in FIG. 11, linear electrodes **101** *a* corresponding an upper half part of one sub-pixel are arranged to be inclined toward the top left corner in FIG. 11 and linear electrodes **101** *b* corresponding to a lower half part thereof are arranged to be inclined toward the bottom left corner. A electric field is generated in a direction perpendicular to the extending direction of the linear electrodes **101** *a* and **101** *b* upon application of an electric voltage. Liquid crystal molecules are caused to be aligned in accordance with the electric field. In the case of FIG. 11, two regions (the upper half part and the lower half part of the sub-pixel) where liquid crystal molecules are aligned in different directions are generated, whereby a dual-domain structure is achieved.

Here, since a uniform lateral electric field is generated in portions (encircled region indicated by symbol A in FIG. 11) of an liquid crystal layer disposed in the vicinity of the center portions of the linear electrodes **101** *a* and **101** *b*, images can be properly displayed. However, since lateral electric fields are generated in various directions in portions (encircled regions indicated by symbol B in FIG. 11) of the linear electrodes **101** *a* and **101** *b* disposed in the vicinity of end portions thereof, the alignment of the liquid crystals is disordered, and thus, light transmittance during bright display is remarkably deteriorated at these locations. Therefore, in this configuration, the area capable of substantially contributing to display is decreased, and thus, it is difficult to obtain a sufficient aperture ratio of the pixel and to achieve a high display luminance. In this respect, there is proposed a multi-domain liquid crystal display device in which in lieu of the configuration of FIG. 11 where the linear electrodes are arranged to extend in a short-axis direction of the sub-pixel, the linear electrodes are arranged to extend in the long-axis direction of the sub-pixel (see Japanese Unexamined Patent Application Publication No. 2002-014374). Specifically, the pixel electrode and the common electrode are arranged to extend in the long-axis direction of the sub-pixel so that they are bent several times.

According to the configuration disclosed in Japanese Unexamined Patent Application Publication No. 2002-014374, since the area of the end portions of the linear electrodes within one sub-pixel is small compared with the configuration illustrated in FIG. 11, it is possible to increase the area, which is able to substantially contribute to display, to thereby increase the aperture ratio of the pixel. However, since the pixel electrode and the common electrode are bent with respect to the sub-pixel having an approximately rectangular shape, there is generated a triangular dead space which does not contribute to display along the data line (the longer side of the sub-pixel), and thus, the aperture ratio is decreased in this portion. Consequently, there is a problem that it is difficult to achieve a high display luminance.

SUMMARY

An advantage of some aspects of the invention is that it provides a liquid crystal device having a high pixel aperture ratio, a high display luminance and a wide viewing angle and an electronic apparatus using the liquid crystal device.

According to an aspect of the invention, there is provided a liquid crystal device including a first substrate and a second substrate that are disposed to face each other; a liquid crystal layer that is sandwiched between the first substrate and the second substrate; a first electrode that is provided on the liquid crystal layer side of the first substrate; an insulating layer that is provided on the liquid crystal layer side of the first electrode; and a second electrode that is provided on the liquid crystal layer side of the insulating layer, in which the first substrate has formed thereon a plurality of data lines and a plurality of scan lines which intersect each other; sub-pixels are formed at regions surrounded by the data lines and the scan lines; the second electrode has a plurality of linear electrodes that is disposed with a gap therebetween; each of the plurality of linear electrodes extends in a long-axis direction of the sub-pixels and has at least one bent portion; the bent portion has such a shape that both sides thereof are inclined in opposite directions with respect to the long-axis direction of the sub-pixels; and the data lines or the scan lines are bent in an extending direction of the linear electrodes having the bent portion. Here, "sub-pixel" in the invention is a region which serves as the minimum unit of displaying an image. Moreover, the sub-pixels are provided so as to correspond to colored layers having different colors of color filters, and one pixel is formed by a plurality of adjacent sub-pixels.

According to the liquid crystal device of the above aspect of the invention, since each of the linear electrodes constituting the second electrode is generally arranged to extend in the long-axis direction of the sub-pixels and includes at least one bent portion, and the bent portion has such a shape that both sides thereof are inclined in opposite directions with respect to the long-axis direction of the sub-pixels, a multi-domain structure is formed, and thus, it is possible to achieve a wide viewing angle. Moreover, since the data line is bent in the extending direction of the linear electrodes having the bent portion, it is possible to suppress dead spaces which do not contribute to display from generating along the longer sides of the sub-pixel, and thus, a high aperture ratio can be maintained.

In the above aspect of the invention, the first electrode may be a pixel electrode and the second electrode may be a common electrode.

According to such a configuration, since the insulating layer is formed on the pixel electrode and the common electrode having a plurality of linear electrodes is formed on the surface of the insulating layer so as to cover the entire sub-pixels, it is possible to maximize the aperture ratio of the sub-pixels.

In the aspect of the invention, each of the plurality of linear electrodes may be linearly symmetric about a short-axis direction of the bent portion.

In the aspect of the invention, a region disposed between bent portions of two linear electrodes adjacent in a short-axis direction of the sub-pixels may be a gap between the two adjacent linear electrodes.

The configuration can be restated as follows: when the gap between two adjacent linear electrodes is referred to as a “slit,” since the slit is formed between bent portions of the two adjacent linear electrodes, the configuration means that the slits are connected with each other across both sides of the bent portions in the long-axis direction of the sub-pixels. According to such a configuration, it is possible to maximize the aperture ratio of the sub-pixels.

Alternatively, a connection portion may be provided to a region disposed between bent portions of two adjacent linear electrodes in a short-axis direction of the sub-pixels so as to connect the two adjacent linear electrodes with each other.

The configuration can be restated as follows: the configuration means that the slits on both sides of the bent portions in the long-axis direction of the sub-pixels are divided by the connection portion. When the slits are connected with each other across both sides of the bent portions, there is a fear that it may cause problems that display defects resulting from an alignment disorder (disclination) of liquid crystals at the bent portions may spread or that the display defects may be unstably transferred to other positions upon application of an external force to the liquid crystal device. However, it is possible to solve the problems by dividing the slits on both sides of the bent portions by the connection portion.

In the above aspect of the invention, among the linear electrodes and the gaps alternately arranged in a short-axis direction of the sub-pixels, the linear electrode and the gap disposed at a region located close to the bent data line (or the bent scan line) may have a width larger than a width of the linear electrode and the gap disposed at a region located distant from the bent data line (or the bent scan line).

Alternatively, among the plurality of linear electrodes arranged in a short-axis direction of the sub-pixels, the linear electrode disposed at a region located close to the bent data line (or the bent scan line) may have a width larger than a width of the linear electrode disposed at a region located distant from the bent data line (or the bent scan line).

Alternatively, among a plurality of the gaps arranged in a short-axis direction of the sub-pixels, the gap disposed at a region located close to the bent data line (or the bent scan line) may have a width larger than a width of the gap disposed at a region located distant from the bent data line (or the bent scan line).

According to the configuration of the above aspect of the invention, although it is possible to provide a high aperture ratio, there is a fear that when a larger part of the outer border of the second electrode is located in close proximity of the data line, due to the influence of an electric field generated between the data line and the second electrode, the alignment of the liquid crystal molecules between them is disordered, thus leading to display defects. Therefore, when the width of at least one of the linear electrode and the gap disposed at a region located in the vicinity of the circumference of the sub-pixel and close to the data line is larger than the width of at least one of the linear electrode and the gap disposed at a region located in the vicinity of the center of the sub-pixel and distant from the data line, it is possible to make the second electrode less likely to be influenced by the data line to thereby suppress the alignment disorder of the liquid crystal molecules between them.

The liquid crystal device according to the above aspect may further include a light shielding film configured to overlap with the data line (or the scan line) which is at least bent in plan view, the light shielding film being provided on the first substrate.

According to such a configuration, since the data line and the light shielding film are formed on the first substrate, it is possible to perform the positional alignment between the data line and the light shielding film with a high accuracy compared with the case where the data line and the light shielding film are formed on different substrates. Accordingly, it is possible to achieve a high aperture ratio.

Further, the liquid crystal device may further include a light shielding film configured to overlap with the data line (or the scan line) which is at least bent in plan view, the light shielding film being provided on the second substrate.

According to another aspect of the invention, there is provided an electronic apparatus having the liquid crystal device according to the above aspect of the invention. According to such a configuration, it is possible to realize an electronic apparatus having a liquid crystal display unit capable of achieving a high display luminance and a wide viewing angle.

Additional features and advantages are described herein, and will be apparent from the following Detailed Description and the figures.

BRIEF DESCRIPTION OF THE ~~DRAWINGS~~FIGURES

~~The invention will be described with reference to the accompanying drawings, wherein like numbers reference like elements.~~

FIG. 1 is an equivalent circuit diagram of an liquid crystal device according to a first embodiment of the invention.

FIG. 2 is a plan view illustrating a configuration of one pixel of the liquid crystal device according to the first embodiment.

FIG. 3 is a cross-sectional view illustrating the configuration of one pixel of the liquid crystal device according to the first embodiment.

FIG. 4 is a plan view illustrating a configuration of one pixel of a liquid crystal device according to a second embodiment of the invention.

FIG. 5 is a plan view illustrating a configuration of one pixel of a liquid crystal device according to a third embodiment of the invention.

FIG. 6 is a plan view illustrating a configuration of one pixel of a liquid crystal device according to a fourth embodiment of the invention.

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