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(54) Title of the Invention Liquid crystal display device

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Specifications

1. Title of the Invention

Liquid crystal display device

2. Claims

(1). An active matrix liquid crystal display device comprising thin-film transistors and picture element electrodes as a component for a picture element, with a picture signal wire being placed on one of the transparent substrates, and a drain electrode of said thin-film transistor being placed on the area corresponding to said signal wire on the other transparent substrate, wherein electrodes constituting the voltage retention elements along with said picture elements are provided.

(2). An active matrix liquid crystal display device comprising thin-film transistors and picture element electrodes as a component for a picture element, with a picture signal wire being placed on one of the transparent substrates, and a drain electrode of said thin-film transistors being placed on the area corresponding to said signal wire on the other transparent substrate, wherein at least either of a scanning signal wire or said picture signal wire consists of a plurality of conductive layers

3. Detailed Description on the Invention

[Industrial Field of the Invention]

The invention relates to a liquid crystal display device such as active matrix color liquid display devices comprising, for example, thin-film transistors and picture element electrodes

[Prior Art]

The existing active matrix liquid crystal display devices, as shown in Japan Display '86), page 84 – 87, include thin-film transistors, picture element electrodes, and a scanning signal wire placed on a lower transparent substrate, picture signal wire placed on an upper transparent substrate, with drain electrodes of the thin-film transistors placed on the area corresponding to the picture signal wire on the lower transparent substrate.

In a liquid crystal display device, the scanning signal wire is placed on the lower transparent substrate and the picture signal wire is placed on the upper transparent substrate, preventing short-out between the scanning signal wire and picture signal wire circuits, providing a good yield.

[Problem to be Solved by the Invention]

In such liquid crystal displays, however, a superposition capacitance is formed between a gate electrode and a source electrode, which imposes direct current components sometimes causing black stains and black surface defect. Furthermore, the scanning signal wire and picture signal wire being formed on the single conductive layer in the display increase the resistance of the scanning signal wire and picture signal wire, which sometimes causes a writing error in the picture element electrode. A possible solution for this problem is to increase the width of the scanning signal wire and picture signal wire, but this lowers the aperture ratio

This invention is intended to solve said problem, and the purpose is to provide a liquid crystal display device having a good yield without incurring black stains or black surface defects, and a liquid crystal display device having a good yield, no writing failure incurred by the picture element electrode, and a high aperture ratio.

[Means for Solving the Problem]

To achieve said purpose, in the invention, the thin-film transistors and picture element electrodes are used as components of the picture element, with the picture signal wire being placed on one of the transparent substrates, and the drain electrode of said thin-film being placed in the area corresponding to said signal wire on the other transparent substrate, wherein the electrodes constituting the voltage retention elements are provided in the active-matrix liquid crystal display.

Furthermore, in order to achieve said purpose, in the invention, the thin-film transistors and picture element electrodes are used as a component for the picture element, with the picture signal wire being placed on one of the transparent substrates, and the drain electrode of said thin-film transistors being placed in the area corresponding to said signal wire on the other transparent substrate, wherein at least either a scanning signal wire or said picture signal wire consists of a plurality of conductive layers in the active-matrix liquid crystal display.

[Operation of the Invention]

Because said liquid crystal display device has electrodes constitute the retention elements along with the picture element electrodes, no direct current components are imposed on the liquid crystals even if superposition capacitance is formed between the gate electrode and the source electrode.

Furthermore, because said liquid crystal display device has at least either a scanning signal wire or said picture signal wire consisting of a plurality of conductive layers, resistance of the scanning signal wire and picture signal wire are lowered even if the width of said wires is reduced.

[Embodiments]

FIG. 2 (plain view of the main part) shows a picture element of the active-matrix color liquid crystal display device, to which the invention is applied, and FIG. 3 shows a cross-sectional view based on the II–II section line. Furthermore, FIG. 4 (plain view of the main part) shows the main part of the liquid crystal display where there is a plurality of picture elements shown in FIG. 2.

As shown in FIG. 2 to FIG. 4, the liquid crystal display device has a thin-film transistor TFT and picture elements that have a transparent picture element electrode ITO on the inner surface of the upper transparent glass substrate SUB1. The lower transparent glass substrate SUB1, for example, is approximately 1.1 mm thick.

Each picture element is placed within an area where two neighboring scanning signal wires (gate signal wires or horizontal signal wires) GL and two neighboring picture signal wires (drain signal wires or vertical signal wires) DL cross (an area surrounded by the four signal wires). A plurality of scanning signal wires GL, as shown in FIG. 2 and FIG. 4, extends horizontally. A plurality of picture signal wires DL extends vertically and is arranged horizontally.

The thin-film transistor TFT in each picture element is divided into three (plurality)—TFT1, TFT2, and TFT3—within the picture element. All of the thin-film transistors TFT1 to TFT3 have substantially the same size (same channel length and width). The divided thin-film transistors TFT1 to TFT3 are mainly constituted of a gate electrode GT, an insulating film GI, an i-type semiconductor layer AS comprising i-type (intrinsic, not doped with conductive type determinant impurity) silicon (Si), and a pair of a source electrode SD1 and a drain electrode SD2. It should be understood that the source and drain electrodes change their position during operation, as they are principally determined by a bias electrode in between and are reversed during operation in the circuit of the liquid crystal display device. For convenience, the electrodes are, however, referred to as the source electrode and drain electrode in the following description.

Said gate electrode GT, as shown in FIG. 5 (a plain view of the main part in the specific manufacturing process), is placed vertically (downward in FIG. 2 and FIG. 5) protruding from the scanning signal wire GL to form a T-shape (branched into T-shape). That is, the gate electrode GT is placed so as to extend substantively parallel to the picture signal wire DL. The gate electrode GT is placed so as to reach the thin-film transistors TFT 1 to TFT3 in the respective formation areas. The thin transistors TFT1 to TFT3 share one gate electrode GT (as a common electrode), which is formed to connect with the same scanning signal wire GL. The gate electrode GT is constituted of a single 1st conductive film g1 to minimize disalignment in the formation area of the thin-film transistor TFT. The 1st conductive film g1 is formed with a thickness of approximately 1100 Å using a chromium (Cr) film formed by sputtering, for example.

The gate electrode GT is—as shown in FIG. 2, FIG. 3, and FIG. 6—formed slightly larger than the i-type semiconductor layer AS (as viewed from below) to cover the entire layer. Thus, when a backlight such as a fluorescent lamp is placed under the lower transparent glass substrate SUB1, the gate electrode GT constituted of nontransparent chrome blocks light protecting the i-type semiconductor layer AS from the backlight, which reduces the conductive phenomenon, which is deterioration of off characteristics of the thin-film transistor TFT caused by said lighting. The minimum size of the gate electrode GT that has a sufficient width to cover the source and drain electrodes SD1 and SD2 (including extra space to adjust the gate electrode and the source and drain electrode positions), in principle, and the depth determining the channel width W is determined in comparison with space between the source and drain electrodes (channel length) L, which is a factor W/L determining the interactive conductance gm.

The size of the gate electrode in the liquid crystal display device, of course, should be larger than the aforementioned minimum size.

When only the gate and the light-blocking feature of the gate electrode GT are considered, the gate electrode GT and its wiring GL may be integrated into a single layer, and in such a case, the nontransparent conductive material can be selected from aluminum (Al) containing silicon, pure aluminum, aluminum containing palladium (Pd), aluminum containing silicon and titanium (Ti), aluminum containing silicon and copper (Cu) for examples.

Said scanning signal wire GL is constituted of a compounded film comprising the 1st conductive layer g1 and the 2nd conductive layer g2 placed on the g1 The 1st conductive layer g1 is formed in the same procedure as the 1st conductive layer g1 in said gate electrode GT and has the same structure. The 2nd conductive layer g2 forms a thickness of approximately 900 to 4,000 Å thick using an aluminum film formed by sputtering, for example. The 2nd conductive layer g2 is designed to lower the resistance value of the scanning signal wire GL and to enhance the signaling speed (information write characteristic of the picture element).

Furthermore, in the scanning signal wire GL, the 2nd conductive layer g2 is smaller than the 1st conductive layer g1. That is, the scanning signal wire GL can reduce step levels on the sidewall, which smoothes the surface of the insulating film GI in the upper layer.

The insulating film GI is used as the gate insulating film in thin-film transistors TFT1 to TFT3 The insulating film GI is formed in the upper layer of the gate electrode GT and scanning signal wire GL. The insulating film GI forms a thickness of approximately 3500 Å using a silicon nitride film formed by a plasma CVD, for example. As mentioned above, the surface of the insulating film GI is smoothed in the formation areas of thin-film transistors TFT1 to TFT3 and in the formation area of the scanning signal wire GL.

The i-type semiconductor layer AS is—as shown in detail in FIG. 6 (a plain view of the main part in the specific manufacturing process)—used as the respective channel formation areas for divided thin-film transistors TFT1 to TFT3. Divided thin-film transistors TFT1 to TFT3 share one i-type semiconductor layer AS within the picture

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