

line 21 side of TFT 31 and gate bus line 21 is larger than that in the above-mentioned example of a conventional device shown in Figure 8. It was found that cutting can be effectively accomplished when distance X is 10 μm or greater. When distance X is smaller than this, not only is it impossible to effectively cut gate bus branch line 22 without damaging TFT 31, but light emitted from the laser has an adverse effect on the intersecting portion of gate bus line 21 and source bus line 23, and the insulation between bus lines 21 and 23 is sometimes rendered ineffective.

In the active-matrix display device of the configuration set forth above, defective picture elements are produced when TFT 31 malfunctions or there is a weak current leak between source bus line 23 and picture element electrode 41. In such cases, repairs can be effected in the following manner. First, the area 54 marked by broken lines in Figure 2 is irradiated with light energy to cut gate bus branch line 22. In this manner, gate bus

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branch line 22 is electrically insulated from gate bus line 21. Light energy from a YAG laser was used in the present embodiment. As stated above, gate base branch line 22 can be effectively cut because distance X is sufficiently large. Although light from the laser can be irradiated through either substrate 1 or 2, it is directed through substrate 1 when a light-blocking film is formed on substrate 2 as is often the case. The laser was directed through substrate 1 in the present embodiment. The laser is then directed to areas 52 and 53, shown by broken lines in Figure 2 and indicated by arrows 26 and 27 in Figure 3. In this manner, source electrode 32 and gate electrode 25 are electrically connected in area 52, and drain electrode 33 and gate electrode 25 are electrically connected in area 53. Source electrode 32 and drain electrode 33 are thus electrically connected via gate electrode 25.

The repaired picture element electrode cannot function normally since the signal of source bus line 23 is continuously applied to picture element electrode 41 (the repaired picture element electrode), connected to repaired TFT 31 in the manner set forth above. However, since picture elements displayed by

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the repaired picture element electrode are displayed as the equivalents of the effective value of the signal applied to source bus line 32, the picture element becomes neither a totally bright nor totally dark point, but is displayed with a brightness equivalent to the average of picture elements aligned along source bus line 23. The defective picture element thus becomes extremely hard to detect.

Despite the use of a laser as described above, no melted metal or the like contaminates liquid crystal layer 18, the display medium, since protective film 17 is formed over gate bus branch line 22 and TFT 31. Moreover, it was found that by varying the [intensity of the] laser it was possible to use the same laser both to connect metal layers by fusion and to cut them.

The configuration of the present invention also lends itself to an active-matrix display device having additional capacitance 42 as shown in Figure 4. Figure 4 shows the embodiment of Figures 1-3 provided with additional capacitance 42. Additional capacitance 42 is provided by the portion (hatched) of

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additional capacitance electrode 24, positioned parallel to gate bus line 21 on substrate 1, that overlaps picture element electrode 41. Defective picture elements can be repaired in the display device of Figure 4 in the same manner as in the embodiment of Figures 1-3.

The present invention is also suitable to an active-matrix display device having the configuration shown in Figure 5. The area of the opening reduced to provide additional capacitance 42 in the display device of Figure 4 is limited in this display device, ie, the width of gate bus line 21 is increased so that it overlaps a portion of picture element electrode 41. In this configuration, adjacent gate bus line 21 can be used in the unselected state as an electrode for additional capacitance. Moreover, since there is no space between gate bus line 21 and additional capacitance electrode 24 as shown in Figure 4, it is possible to limit reduction in the area of the opening. Defective picture elements are also repaired in this display device in the same manner as in the embodiment of Figures 1-3.

All the embodiments set forth above show the gate electrode /19 of TFT 31 formed below and the source and drain electrodes formed above, but a TFT of a type in which the gate electrode is formed above and the source and drain electrodes are formed below can also be used.

Furthermore, TFTs were used as switching elements in all the embodiments set forth above, but any switching element in which the signal line side electrode and the electrode on the picture element electrode side can be electrically connected by light energy from a laser or the like is suitable for use in the present invention.

Effect of the Invention

In the active-matrix display device of the present invention, defective picture elements can be repaired in assembled display devices, where they are readily detectable, in such a way as to be rendered inconspicuous. The present invention thus permits the high yield production of display devices, making it possible to reduce the cost of display devices.

4. Brief Description of the Figures

Figure 1 is a plan view of an active-matrix substrate employed in an embodiment of the active-matrix display device of the present invention. Figure 2 is an enlarged plan view of the area around the TFT of Figure 1. Figure 3 is the view of a /20 portion, indicated by section line III-III in Figure 1, of a display device employing the substrate of Figure 1. Figures 4 and 5 show plan views of other embodiments of the present invention. Figure 6 shows the relation between the signal applied to the scanning and signal lines and the voltage of the picture element electrode. Figures 7 and 8 show plan views of active-matrix substrates employed in conventional active-matrix display devices.

1, 2=glass substrates; 3=counter electrode; 9, 19=orientation film; 11=gate insulating film; 12=channel layer; 13=etching stopper layer; 14=contact layer; 18=liquid crystal layer; 21=gate bus line; 22=gate bus branch line; 23=source bus line; 24=additional capacitance electrode; 25=gate electrode; 31=TFT; 32=source electrode; 33=drain electrode; 41=picture element electrode; 42=additional capacitance.

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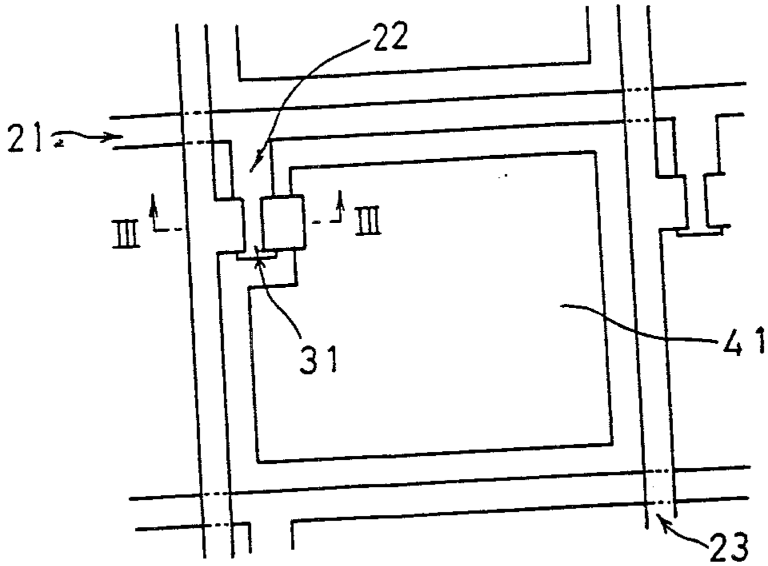
Key to Figure 6:

Time Selected (T_{ON})

Time Unselected (T_{OFF})

第１図



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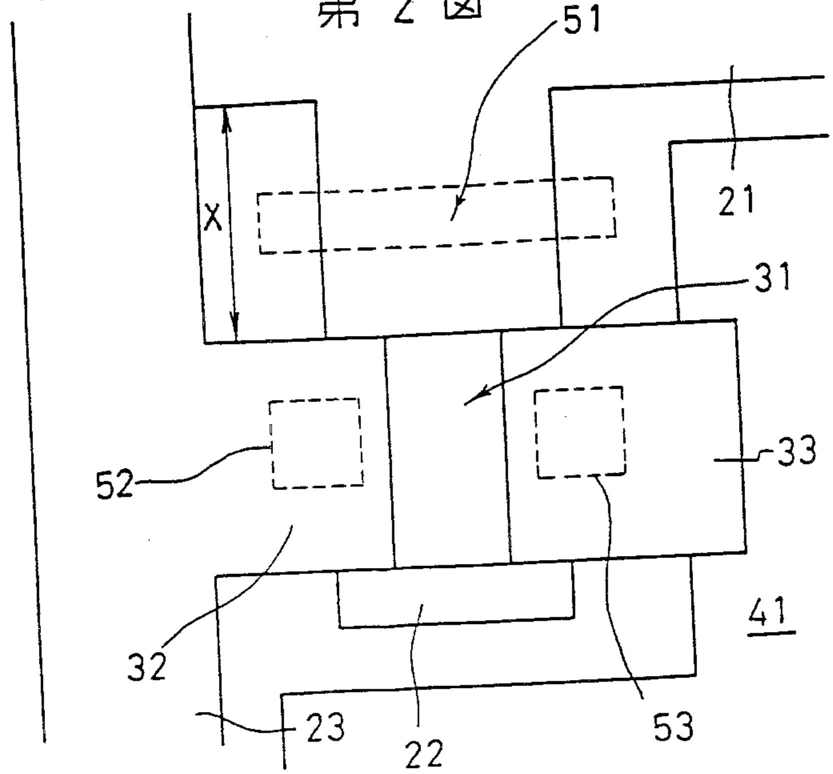

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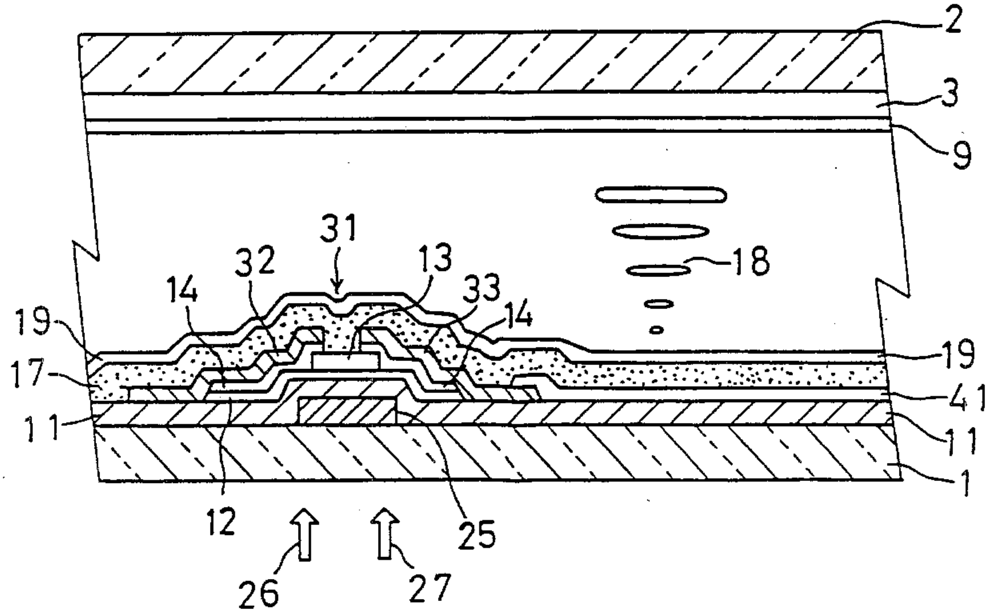

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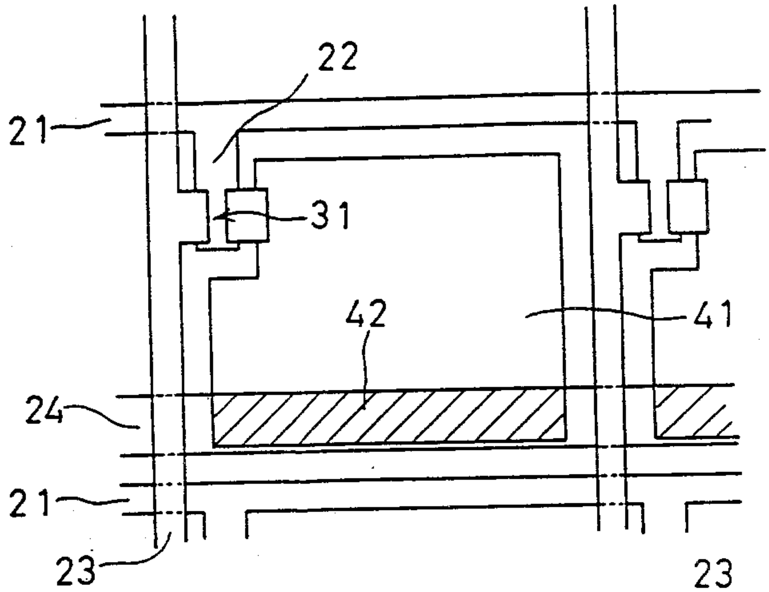
第４図



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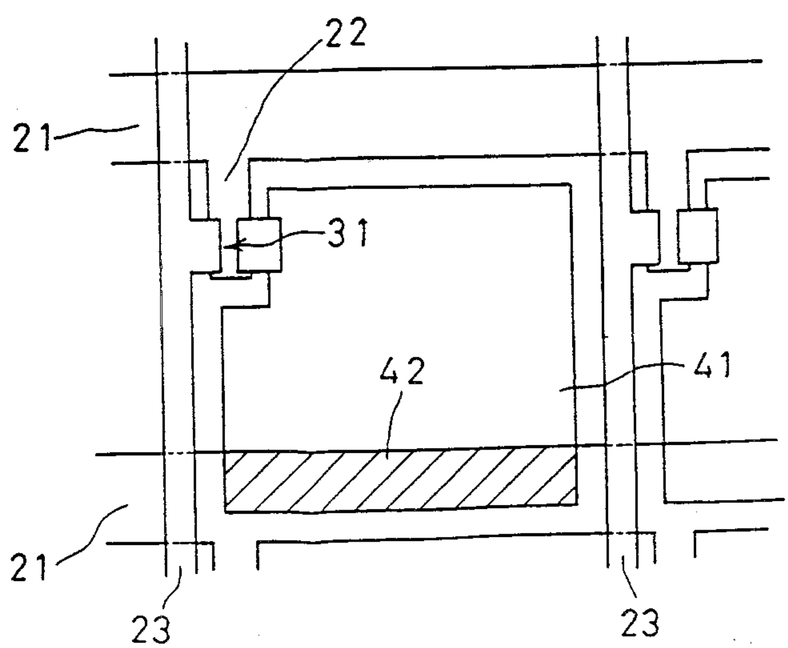
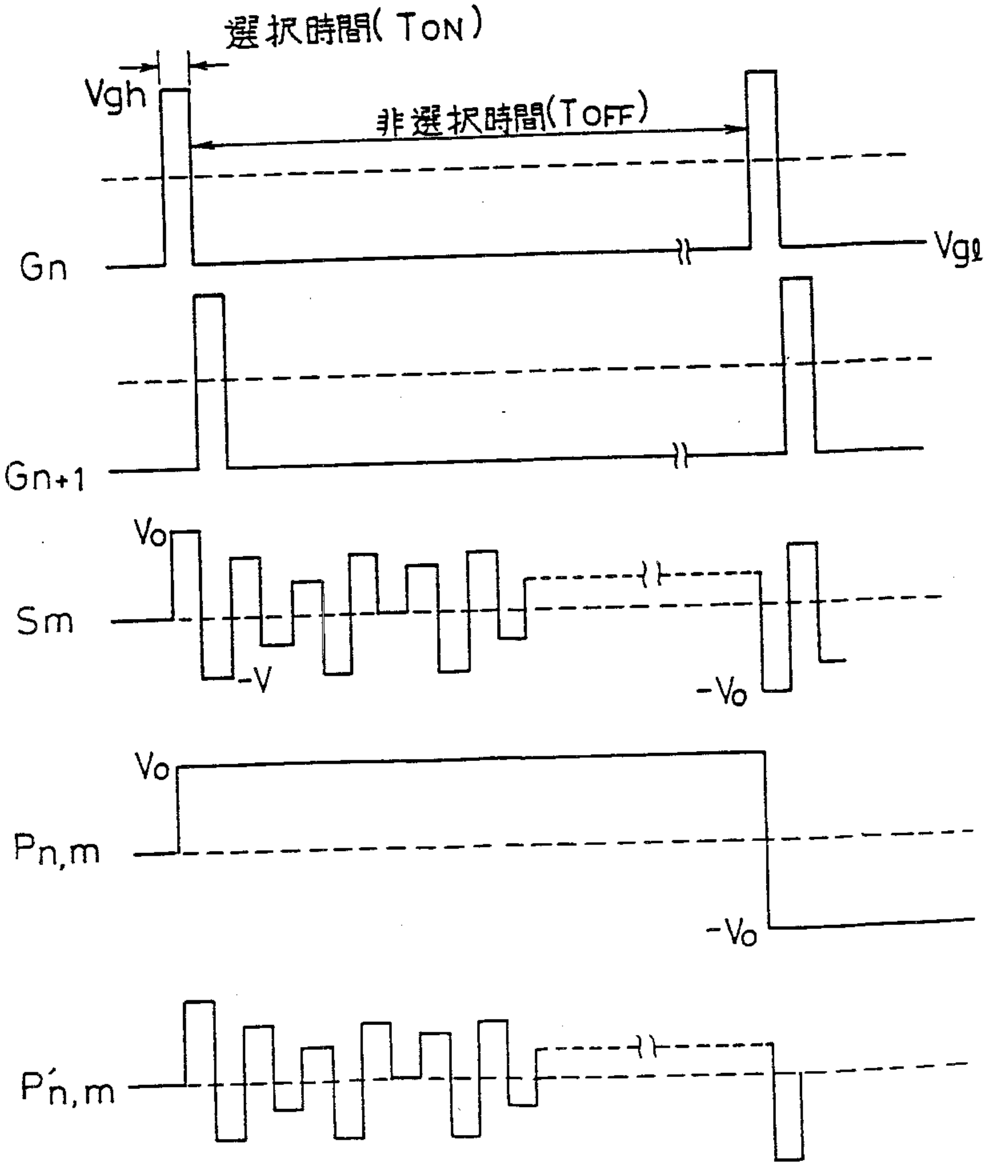


第 6 図



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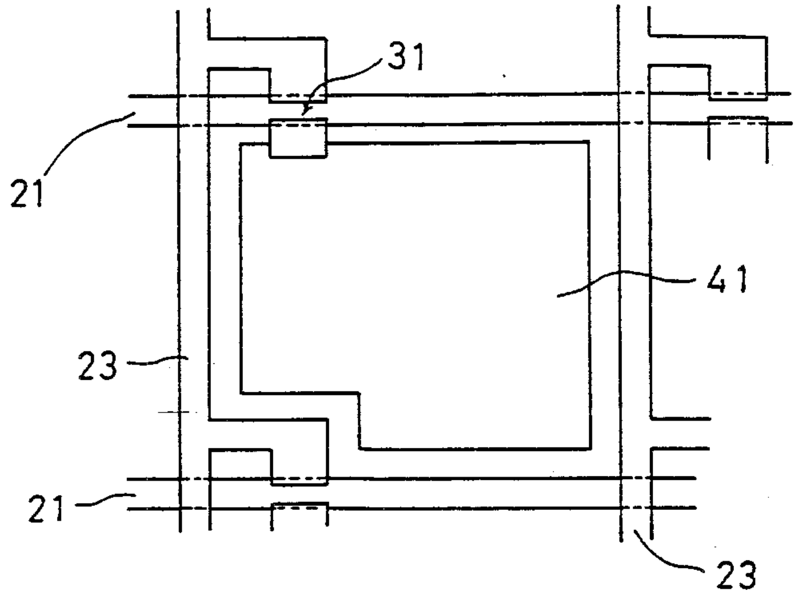
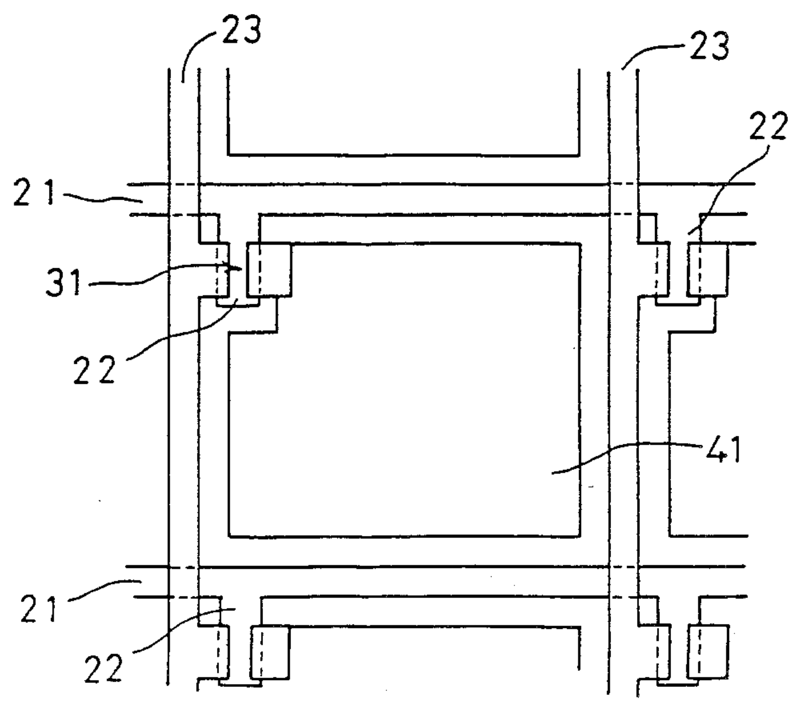


第 8 図



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(Translation)

PATENT OFFICE
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This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: May 11, 1990

Application Number : Heisei 2
Patent Appln. No. 121788

Applicant(s) : SHARP KABUSHIKI KAISHA

Wafer of the Patent Office

November 14, 1990

Satoshi UEMATSU

Commissioner,
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ACTIVE-MATRIX DISPLAY DEVICE

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UNITED STATES PATENT AND TRADEMARK OFFICE

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Specification

/1[1]

1. **Title: Active-Matrix Display Device**

2. **Claims**

1. An active-matrix display device provided with a pair of insulating substrates at least one of which is translucent; scanning lines and signal lines arranged orthogonally on one of said pair of substrates; and picture element electrodes connected to said scanning lines and signal lines via switching elements; the active-matrix display device being further provided with an electrically conductive layer located below, separated with an insulating film from, and overlapped by said signal lines and said picture element electrodes; and an electrically conductive plate formed between said picture element electrodes and said insulating layer.

2. An active-matrix display device provided with a pair of insulating substrates at least one of which is translucent; scanning lines and signal lines arranged orthogonally on one of said pair of substrates; and picture element electrodes connected to said scanning lines and signal lines via switching elements; the active-matrix display device being further provided with

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an electrically conductive layer located below, separated with an insulating film from, and overlapped by said signal lines and a juxtaposed pair of said picture element electrodes; and

[1] Numbers in the margin indicate pagination in the foreign text.

electrically conductive plates formed between each of said pair of picture element electrodes and said insulating film.

3. The active-matrix display device of Claims 1 and 2 wherein said electrically conducting layer is electrically connected to scanning lines adjoining said scanning lines connected to said picture element electrodes, and an anodic oxide film is formed on said electrically conductive layer.

4. The active-matrix display device of Claims 1 and 2, further provided with electrodes for additional capacitance which face said picture element electrodes and are separated from them by said insulating film, said electrically conducting layer being electrically connected to said electrodes for additional capacitance and having an anodic oxide film formed on its surface.

3. Detailed Description of the Invention

Industrial Field of Application

The present invention relates to a display device that operates by applying a drive signal via switching elements to picture-element electrodes used for display; specifically, it

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relates to an active-matrix driven display device in which picture element electrodes are arrayed in a matrix to achieve a high-density display.

Prior Art

In conventional liquid-crystal, EL, and plasma displays, a display pattern is formed on a screen by selectively driving picture element electrodes arrayed in a matrix. Voltage is applied between selected picture element electrodes and counter electrodes to optically modulate a display medium such as liquid crystals positioned between sets of such electrodes. This optical modulation is then viewed in the form of a display pattern. A known method of driving picture element electrodes consists of connecting switching elements to each individual picture element electrode in an array of such picture element electrodes to drive them. Switching elements commonly used to selectively drive picture element electrodes include TFT (thin-film transistor) elements, MIM (metal-insulating layer-metal) elements, MOS transistor elements, diodes, and varistors. Active-matrix driven systems permit high-contrast display, and

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have already seen practical application in liquid crystal televisions, word processors, computer terminal displays and the like.

Figure 12 shows a plan view of an active-matrix substrate used in conventional active-matrix display devices. In the substrate of Figure 12, source bus lines 23 are laid out orthogonally to parallel gate bus lines 21. A picture element electrode 41 is positioned in the area within each of the rectangles delimited by gate bus lines 21 and source bus lines 23. A TFT 31, functioning as a switching element, is formed over gate bus branch line 22 which diverges from gate bus line 21. Part of gate bus branch line 22 functions as the gate electrode of TFT 31. The drain electrode of TFT 31 is electrically connected to picture element electrode 41. The source electrode of TFT 31 is connected to source bus line 23.

Problems to Be Solved by the Invention

A high-density display made using such display devices requires an array with an extremely large number of picture element electrodes 41 and TFTs 31. However, defective

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elements are sometimes formed during fabrication of TFTs 31 on the substrate. Picture element electrodes connected to such defective elements produce point defects in the display. Point defects severely compromise the picture quality of the display device and greatly reduce production yield.

The chief causes of point defects can be roughly divided into two groups. The first group comprises malfunctions occurring due to insufficient charging of the picture element electrodes once picture elements are selected by the scan signal (referred to hereinbelow as "ON malfunctions"). The other group comprises malfunctions in which charged picture element electrodes leak their charges when unselected (referred to hereinbelow as "OFF malfunctions"). ON malfunctions are caused by defective TFTs. OFF malfunctions are produced by leakage of electricity from TFTs or between picture element electrodes and bus lines. In both cases, point defects are produced because insufficient voltage is applied between the picture element electrode and the counter electrode. When the voltage between

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the picture element electrode and the counter electrode is zero in such malfunctions, a bright spot appears when transmittance is at a maximum in the normally white mode, and a dark spot appears when transmittance is at a minimum in the normally black mode.

Such defects can be corrected by laser trimming and the like. However, such repairs must be made to the active-matrix substrate before assembly of the display device. Although defective picture elements are readily detected once assembled into display devices, it is extremely difficult to detect them on the active-matrix substrate alone. In the case of large display devices having 100,000 to 500,000 or more picture elements, extremely high-precision testing instruments must be used to determine the electrical characteristics of all the picture element electrodes and discover malfunctioning TFTs. The inspection process becomes complicated, hindering mass production and raising costs. For such reasons, it is presently not

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possible to undertake repair of defective picture elements using the above-mentioned lasers at the substrate stage in large display devices having numerous picture elements.

Such problems have been solved in the present invention, the object of which is to provide an active-matrix display device in which even when defective picture elements are produced as a result of defective switching elements, it is possible to effect repairs in assembled display devices in such a way as to render the defective picture elements inconspicuous.

Means of Solving the Problems

The active-matrix display device of the present invention, provided with a pair of insulating substrates at least one of which is translucent, scanning lines and signal lines arranged orthogonally on one of the pair of substrates, and picture element electrodes connected to the scanning lines and signal lines via switching elements, achieves the above-stated object by being provided with both an electrically conductive layer located below, separated with an insulating film from, and overlapped by, the signal lines and picture element electrodes, and an electrically conductive plate formed between the picture element electrodes and the insulating film. /8

Additionally, the active-matrix display device of the present invention, provided with a pair of insulating substrates at least one of which is translucent, scanning lines and signal lines arranged orthogonally on one of the pair of substrates, and picture element electrodes connected to the scanning lines and signal lines via switching elements, achieves the above-stated object by being provided with both an electrically conductive layer located below, separated with an insulating film from, and overlapped by, the signal lines and a juxtaposed pair of said picture element electrodes, and electrically conductive plates formed between each of the pair of picture element electrodes and the insulating film.

A configuration is also possible in which the electrically conductive layer is electrically connected to scanning lines@ adjoining the aforementioned scanning lines connected to the picture element electrodes, and an anodic oxide film is formed on the electrically conductive layer.

Another configuration is possible in which an electrode for additional capacitance is further provided opposite the picture element electrode, separated from it by the insulating film, and the electrically conducting layer is electrically connected to this additional capacitance electrode and has an anodic oxide film formed on its surface. /9

Operation

When ON or OFF malfunctions occur in the active-matrix display device of the present invention due to defective switching elements, weak current leaking between signal lines and picture element electrodes, or the like, it is possible to repair the display device in assembled form. First, the overlapping portions of the signal line and electrically conductive layer are irradiated with light energy to form an electrical connection between them. Next, the overlapping portions of the electrically conductive layer and the electrically conductive plates are irradiated with light energy to form electrical connections between them. In this manner, the signal line and picture element electrode are not connected via the switching element, but are directly connected. Furthermore, in the configuration in which the electrically conductive layer is electrically connected to either the scanning line or the additional capacitance electrode, this electrical connection can be broken by irradiation with light energy.

The voltage applied to picture element electrodes directly connected to signal lines in the manner described above (referred to hereinbelow as "repaired picture element electrodes") will be described in reference to Figure 11. In Figure 11, G_n shows the

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relation between the signal voltage of the nth scan line (vertical axis) and time (horizontal axis). S_m shows the relation between the signal voltage of the mth scanning line (vertical axis) and time (horizontal axis). P_{nm} shows the voltage applied to a normal picture element electrode connected to the nth scanning line and the mth signal line. P'_{nm} shows the voltage applied to a repaired picture element electrode connected to the nth scanning line and the mth signal line.

As shown in G_n and G_{n+1}, signal (V_{gh}), which selects the serial switching elements, is output to the scanning line for a selection time of T_{on}. Corresponding to the selection time T_{on} of the scanning line, video signal voltage V_0 is output to the signal line. In a normal picture element electrode as shown in P_{nm}, signal voltage V_0 is maintained during the time the element is unselected, T_{off}. Then, when the next selected signal voltage V_{gh} is applied, video signal $-V_0$ is applied to the signal line.

By comparison, a repaired picture element electrode as shown in P'_{nm} cannot function normally since the video signal from the signal line is continuously applied. However, a repaired picture element electrode displays over a period of one cycle a picture /11

element equivalent to the effective value of the video signal applied to the signal line during the cycle. Such a picture element will thus not display a completely bright or dark spot, but the average brightness of picture elements along the signal line, making the defective picture element extremely hard to detect.

Resistance of portions connected by irradiation with light energy as set forth above must be lower than the resistance of switching elements in a selected state (referred to hereinbelow as "ON resistance"). The reason is as follows. The value of the ON resistance of switching elements is set so that only enough current to effect a complete charge is allowed to flow to the picture element electrodes while the switching elements are selected. Thus, when the resistance of portions connected as set forth above is greater than the ON resistance, the signal voltage changing each time a switching element is selected is not reliably applied to repaired picture element electrodes, and the effective value of the voltage applied to such elements decreases. Under these conditions, the difference in brightness between picture elements displayed by repaired picture element electrodes and normal picture elements becomes substantial, and defective picture elements can be visually detected. /12

Embodiments

Embodiments of the present invention are described below.

Figure 1 shows a plan view of the active-matrix substrate used in an embodiment of the display device of the present invention. Figure 2A shows an enlarged view of the vicinity of electrically conductive layer 34 in Figure 1, and Figure 2B shows a cross section view of the portion indicated by section line II-II in Figure 1. Figure 3 shows a portion, indicated by section line III-III in Figure 1, of the display device employing the substrate of Figure 1. The active-matrix display device of the present embodiment will be described according to the manufacturing process. In the present embodiment, transparent glass was employed for the insulating substrates. Gate bus line 21, functioning as a scanning line, gate bus branch line 22, diverging from gate bus line 21, and electrically conductive layer 34 were formed on glass substrate 1. Gate bus line 21 and gate bus branch line 22 are usually formed as single or multiple layers of metals such as Ta, Ti, Al, and Cr; Ta was employed in the present embodiment. Electrically conductive layer 34 was made of the same metal as gate bus line 21. Gate bus line 21, gate bus branch line 22, and electrically conductive layer 34

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were formed by patterning a layer of Ta formed by sputtering. Prior to forming gate bus line 21, gate bus branch line 22, and electrically conductive layer 34, it is possible to form a base coating of Ta_2O_5 or the like on glass substrate 1.

A base insulating film 11 was formed of SiN_x over the entire surface, including over gate bus line 21, gate bus branch line 22, and electrically conductive layer 34. Gate insulating film 11 was formed to a thickness of 3,000 Å by plasma CVD.

TFT 31, functioning as a switching element, was then formed on the forward end of gate bus branch line 22. Part of gate bus branch line 22 functions as the gate electrode 25 of TFT 31. After forming gate insulating film 11 as described above, an amorphous silicon (a-Si) layer which would become channel layer 12 was deposited, followed by a SiN_x film which would become etching stopper layer 13. The thickness of the a-Si film was 300 Å and that of the SiN_x film was 2,000 Å. The SiN_x film was

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then patterned to form etching stopper film 13. A layer of n^+ type a-Si to which P (phosphorus) had been added, later to become contact layers 14, 14, was then deposited by plasma CVD to a thickness of 800 Å over the entire surface of the a-Si and etching stopper 13 layers. The above-mentioned a-Si and n^+ type a-Si layers were then simultaneously patterned to form channel layer 12 and contact layers 14, 14.

Next, a Ti layer was formed which would become a source electrode 32, source bus line 23, functioning as the signal line, a drain electrode 33, and electrically conductive plate 35. Source bus line 23 and the like are normally formed as single or multiple layers of Ti, Al, Mo, Cr or the like; Ti was employed in the present embodiment. Source electrode 32, source bus line 23, drain electrode 33, and electrically conductive plate 35 were formed from this Ti layer by patterning. Source bus line 23 intersects gate bus line 21; the two sandwich gate insulating film 11 between them. As shown in Figure 2B, gate insulating

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film 11 is sandwiched between source bus line 23 and one end of electrically conductive layer 34, source bus line 23 being formed in this manner so as to overlap electrically conductive layer 34. Electrically conductive plate 35 is formed over the end of source electrically conductive layer 34 that is not overlapped by source bus line 23, where electrically conductive plate 35 and electrically conductive layer 34 sandwich gate insulating film 11.

As shown in Figure 1, picture element electrode 41 is formed of ITO (indium tin oxide) in the square area enclosed by gate bus lines 21 and source bus lines 23. Picture element electrode 41 overlaps the end of drain electrode 33 of TFT 31 and is electrically connected to drain electrode 33. As shown in Figure 2B, picture element electrode 41 is formed so as to overlap electrically conductive plate 35.

A protective film 17 of SiN_x was deposited over the entire surface of the substrate on which picture element electrodes 41 were formed. Protective film 17 can also be formed with a removed window-shaped section over the center of picture element 41. An orientation film 19 was formed over protective film 17. A counter electrode 3 and an orientation film 9 were formed on a glass substrate 2 opposite glass substrate 1. A liquid crystal layer 18 was sandwiched between substances 1 and 2 to

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complete the active-matrix display device of the present embodiment.

In the active-matrix display device of the configuration set forth above, defective picture elements are produced when TFT 31 malfunctions or there is a weak current leak between source bus line 23 and picture element electrode 41. In such cases, repairs can be effected in the following manner. First, as indicated by broken lines in Figure 2A, the area 61 of overlap of bus line 23 and electrically conductive layer 34 (also indicated by an arrow 65 in Figure 2B), and the area 62 of overlap of electrically conductive plate 35 and electrically conductive layer 34 (also indicated by an arrow 64 in Figure 2B) are irradiated with light energy to electrically connect source bus line 23, electrically conductive layer 34, and electrically conductive plate 35. Since Electrically conductive plate 35 and picture element electrode 41 are electrically connected, picture element electrode 41 and source bus line 23 are also electrically connected. A YAG laser (at a wavelength of 1064 nm) was used to provide light energy in the present embodiment. Although light from the laser can be irradiated through either substrate 1 or 2, it is directed through substrate 1 when a light-blocking film is formed on

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substrate 2 as is often the case. The laser was directed through substrate 1 in the present embodiment.

A repaired picture element electrode cannot function normally since the signal of source bus line 23 is continuously applied to picture element electrode 41 (the repaired picture element electrode), directly connected to source bus line 23 in the manner set forth above. However, since picture elements displayed by the repaired picture element electrode are displayed as the equivalents of the effective value of the signal applied to source bus line 32, the picture element becomes neither a totally bright nor totally dark point, but is displayed with a brightness equivalent to the average of picture elements aligned along source bus line 23. The defective picture element thus becomes extremely hard to detect.

Despite the use of a laser as described above, no melted metal or the like contaminates liquid crystal layer 18, the display medium, since protective film 17 is formed over the overlapping portions of electrically conductive layer 34 and source bus line 23, and over the overlapping portions of electrically conductive layer 34 and electrically conductive plate 35.

Figures 4A-4C show further embodiments of active matrix

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substrates employed in the display device of the present invention. In the substrate of Figure 4A, a protruding member 23 is provided which overlaps electrically conductive layer 34.

Other components of the configuration, such as electrically conductive plate 35, are arranged in the same manner as in Figure 1.

In the embodiment of Figure 1, although electrically conductive layer 34 and electrically conductive plate 35 are positioned at a distance from TFT 31, any such positions are possible provided they are in close proximity to source bus line 23. Figure 4B shows an example in which electrically conductive layer 34 is positioned in close proximity to TFT 31.

A source bus branch line 23b of source bus line 23 is formed in the embodiment of Figure 4C. Electrically conductive layer 35 is formed parallel with source bus line 23 and overlaps source bus branch line 23b.

In display devices employing any of the substrates of Figures 4A-4C, defective picture elements can be repaired in the same manner as in the embodiment of Figure 1. Although not shown in the figures, a configuration in which electrically conductive layer 34 and electrically conductive plate 35 are positioned on the bus line 23 on the opposite side of picture element electrode 41 is also possible. /19

Figures 5A and 5B show further embodiments of active matrix substrates employed in the display device of the present invention. In the active matrix substrates of Figure 1 and Figures 4A-4C, since only gate insulating film 11 is present between electrically conductive layer 34 and source bus line 23, the distances between source bus line 23 and electrically conductive layer 34 and between electrically conductive layer 34 and electrically conductive plate 35 is necessarily reduced. The active matrix substrate shown in 5A and 5B resolves this problem. Electrically conductive layer 34 on the substrate shown in Figure 5A is formed so that it is connected to gate bus line 21, which is adjacent to a gate bus line connected to picture element electrode 41, which is overlapped by electrically conductive layer 34. In order to reliable insulate gate bus line 21, several layers of an anodic oxide film are formed on its surface. As in the present embodiment, by forming electrically conductive layer 34 so that it is connected to gate bus line 21, it

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becomes possible to also form an anodic oxide film on electrically conductive layer 34. This precludes reduction of the distance between source bus line 23 and electrically conductive layer 34, and between electrically conductive layer 34 and electrically conductive plate 35.

In the substrate of Figure 5B, electrically conductive layer 34 and electrically conductive plate 35 are positioned in a corner on the side opposite TFT 31. Therefore, in the present embodiment, electrically conductive layer 34 is overlapped by source bus line 23 which is adjacent to a source bus line connected to the picture element electrode which is overlapped by electrically conductive layer 34.

When picture element defects occur in display devices employing the substrates of Figures 5A and 5B, electrically conductive layer 34 and source bus line 23, as well as electrically conductive layer 34 and electrically conductive plate 35, are connected in the same manner as in the embodiment of Figure 1. In addition, area 63 indicated by broken lines on the substrates of Figures 5A and 5B is irradiated with light energy to sever the connection between electrically conductive layer 34 and gate bus line 21. By making and breaking connections with light energy in the manner set forth above, picture element 41 is directly connected to source bus line

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23. When making such repairs, although in the substrate of Figure 5A, as in the substrate of Figure 1, picture element electrode 41 is directly connected to source bus line 23 to which it had been connected via TFT 31, in the substrate of Figure 5B, picture element electrode 41 is connected to source bus line 23 [stet] which is adjacent source bus line 23, which picture element electrode 41 had been connected to via TFT 31.

Figure 6 shows a further embodiment of the active matrix substrate employed in the display device of the present invention. In the present embodiment, electrically conductive layer 34 is formed below juxtaposed picture element electrodes 41a and 41b and source bus line 23. In the present embodiment, one electrically conductive layer 34 is provided for every 2 picture element electrodes. Electrically conductive plates 35a and 35b are formed above the two ends of electrically conductive layer 34, from which they are separated by gate insulating film

11. Picture element electrodes 41a and 41b directly overlap electrically conductive plates 35a and 35b, respectively. Electrically conductive layer 34 is formed so that it is

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electrically connected to gate bus line 21, which is adjacent to the gate bus line connected to picture element electrodes 41a and 41b, which in turn overlap electrically conductive layer 34. Forming electrically conductive layer 34 so that it is connected to gate bus line 21 permits formation of an anodic oxide film on electrically conductive layer 34.

In the display device employing the substrate of the present embodiment, when either picture element electrode 41a or 41b is defective, the overlapping portions of source bus line 23 and electrically conductive layer 34 are first irradiated with a laser. Then, if the picture element defect is in picture element electrode 41a, the overlapping portions of electrically conductive layer 34 and electrically conductive plate 35a are irradiated by laser; if the picture element defect is in picture element electrode 41b, the overlapping portions of electrically conductive layer 34 and electrically conductive plate 35b are irradiated. Area 63, indicated by broken lines in Figure 6, is then irradiated by laser to break the electrical connection between electrically conductive layer 34 and gate bus line 21. In the repairs set forth above, the defective picture element electrode from among 41a and 41b is directly connected to source bus line 23. When both picture element electrodes 41a and 41b are defective, they can be repaired by directly connecting them to source bus line 23. Although a configuration in which

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electrically conductive layer 34 is connected to gate bus line 21 is shown in the present embodiment, a configuration in which electrically conductive layer 34 is not connected to gate bus line is also possible.

The configuration of Figure 1 can also be applied to an active matrix display device having additional capacitance 42, as shown in Figure 7. The display device shown in Figure 7 is the embodiment of Figure 4B which has been provided with additional capacitance 42. Additional capacitance 42 is formed by the overlapping portion (hatched) of additional capacitance electrode 24, positioned parallel to gate bus 21 on substrate 1, and picture element electrode 41. Defective picture elements can be repaired in the display device shown in Figure 7 in the same manner as in the embodiment of Figure 1. Electrically conductive layer 34, electrically conductive plate 35, and source bus line 23 can be configured as shown in Figures 1, 4A, and 4C. In Figure 7, electrically conductive layer 34 and electrically conductive plate 35 can be configured as shown in Figures 5A, 5B, and 6. When electrically conductive layer 34 and electrically conductive plate 35 are configured according to these figures, electrically conductive layer 34 is not electrically

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connected to gate bus line 21 but additional capacitance electrode 24. Figure 9 shows an example in which electrically conductive layer 34 and electrically conductive plate 35 are configured according to Figure 6. The active matrix substrate of Figure 9 is formed with electrically conductive layer 34 connected to additional capacitance 24. Several layers of an anodic oxide film are also formed on additional capacitance electrode 24. Therefore, by connecting electrically conductive layer 34 to additional capacitance electrode 24, an anodic oxide film can also be formed on electrically conductive layer 34.

The present invention is also applicable to an active matrix display device having the configuration of Figure 8. The area of the opening reduced to provide additional capacitance 42 in the display device of Figure 7 is limited in this display device, ie, the width of gate bus line 21 is increased so that it overlaps a portion of picture element electrode 41. In this configuration, adjacent gate bus line 21 can be used in the unselected state as an electrode for additional capacitance. Moreover, since there

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is no space between gate bus line 21 and additional capacitance electrode 24 as shown in Figure 7, it is possible to limit reduction in the area of the opening. Defective picture elements are also repaired in this display device in the same manner as in the embodiment of Figure 1. Electrically conductive layer 34, electrically conductive plate 35, and source bus line 23 can be configured in the present embodiment as shown in Figures 1, 4A, and 4C. In Figure 8, electrically conductive layer 34 and electrically conductive plate 35 can be configured as shown in Figures 5A, 5B, and 6. Figure 10 shows an example of a substrate in which electrically conductive layer 34 and electrically conductive plate 35 of Figure 8 are configured as shown in Figure 6.

The above embodiments show the gate electrode of TFT 31 formed below and the source and drain electrodes formed above, but a TFT of a type in which the gate electrode is formed above and the source and drain electrodes are formed below can also be used. TFT 31 was also formed on gate bus branch line 22, but a configuration in which TFT 31 is formed on gate bus branch 21 and the branch of source bus 23 is connected to the source electrode is also possible. /26

Moreover, although TFTs are employed as switching elements in all the above embodiments, it is also possible to use MIM elements, MOS transistor elements, diodes, varistors and the like.

Effect of the Invention

In the active-matrix display device of the present invention, defective picture elements can be repaired in assembled display devices, where they are readily detectable, in such a way as to be rendered inconspicuous. The present invention thus permits the high-yield production of display devices, making it possible to reduce the cost of display devices.

4. **Brief Description of the Figures**

Figure 1 is a plan view of an active-matrix substrate employed in an embodiment of the active-matrix display device of the present invention. Figure 2A is an enlarged plan view of the vicinity of the electrically conductive layer of Figure 1. Figure 2B is a view of a cross section indicated by section line II-II in Figure 1. Figure 3 is view of the cross section, indicated by section line III-III in Figure 1, of a display device employing the substrate of Figure 1. Figures 4A-4C, 5A, 5B, and 6 are plan views of further embodiments of the

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substrate used in the display device of the present invention. Figures 7 and 8 are plan views of further embodiments of substrates comprising the display device of the present invention which have additional capacitance electrodes. Figures 9 and 10 are plan views of further embodiments of substrates comprising the display device of the present invention which have additional capacitance electrodes. Figure 11 shows drawings indicating the relation between the signal applied to scanning lines and signal lines and the voltage of the picture element electrodes. Figure 12 is a plan view of an active-matrix substrate employed in conventional active-matrix display devices.

1, 2 = glass substrates; 3 = counter electrode; 9, 19 = orientation film; 11 = gate insulating film; 12 = channel layer; 13 = etching stopper layer; 14 = contact layer; 18 = liquid crystal layer; 21 = gate bus line; 22 = gate bus branch line; 23

= source bus line; 24 = additional capacity electrode; 25 = gate electrode; 31 = TFT; 32 = source electrode; 33 = drain electrode; 34 = electrically conductive layer; 35, 35a, 35b = electrically conductive plates; 41, 41a, 41b = picture element electrodes; 42 = additional capacitance

End /28

Applicant: Sharp K.K.

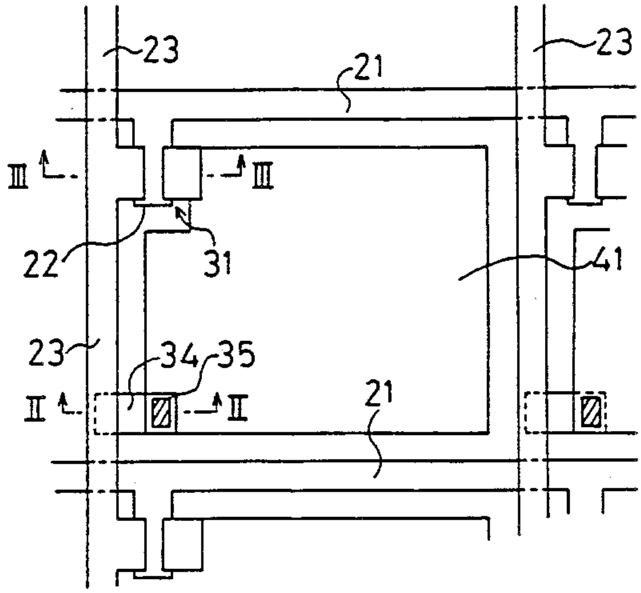
Agent: Hidesaku Yamamoto, Patent Attorney

Key to Figure 11:

Time Selected (T_{ON})

Time Unselected (T_{OFF})

第１図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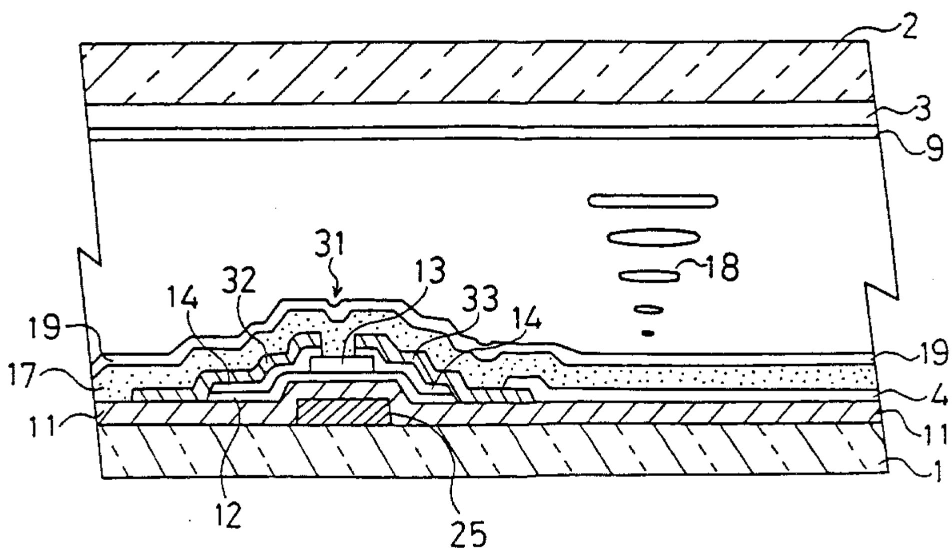
第３図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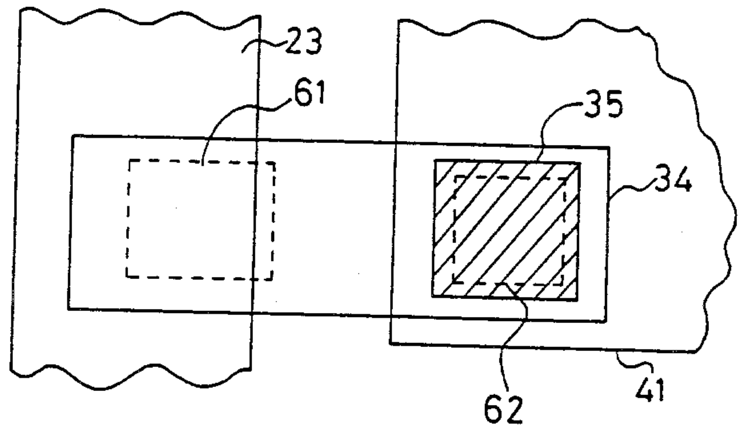

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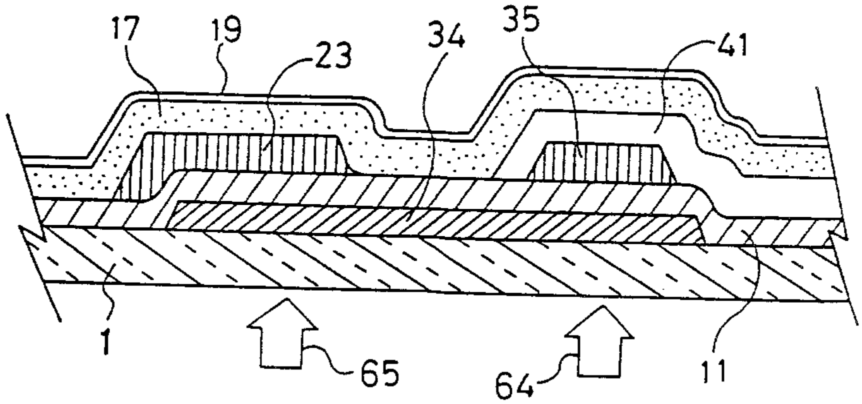

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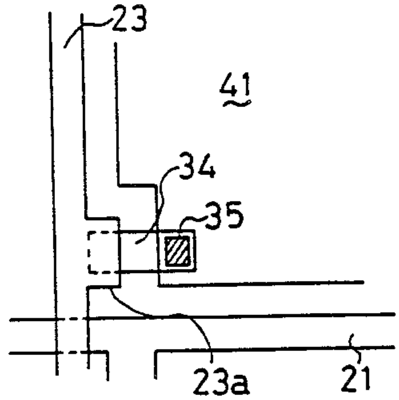

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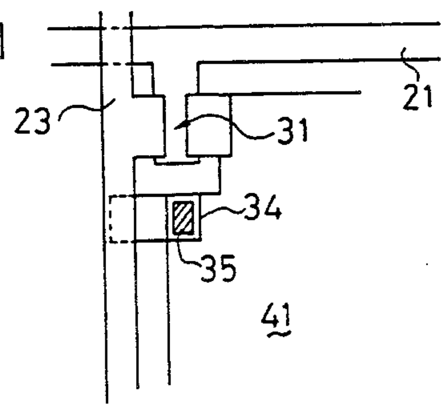

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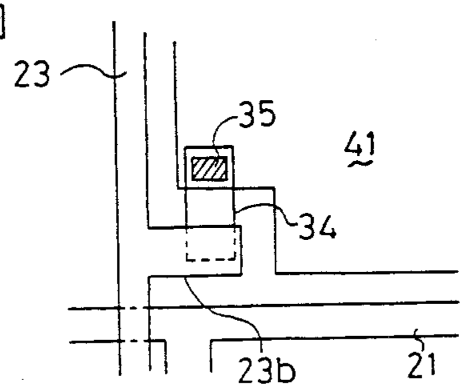

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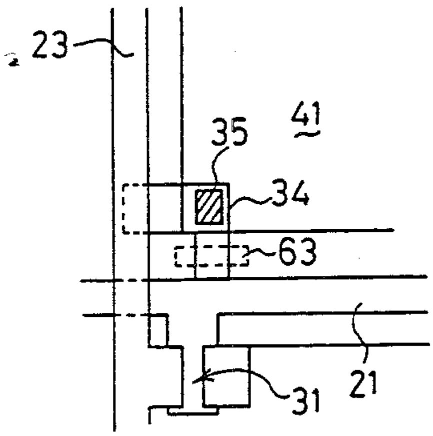

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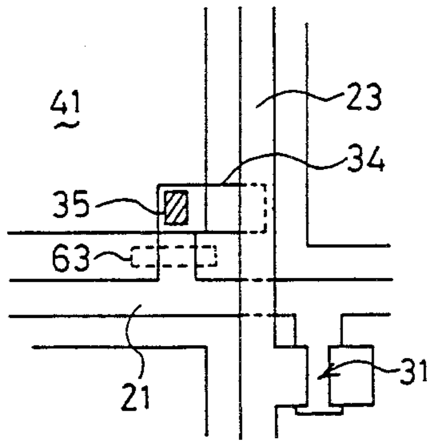

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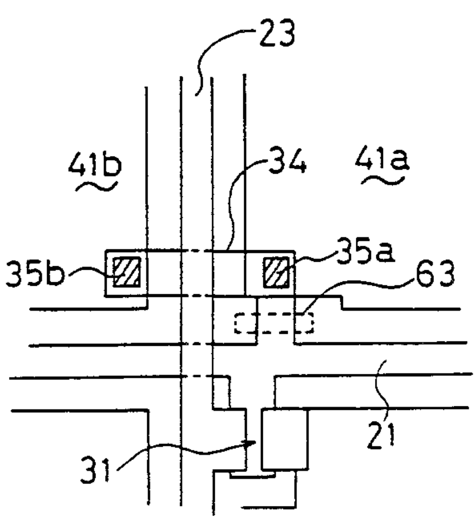

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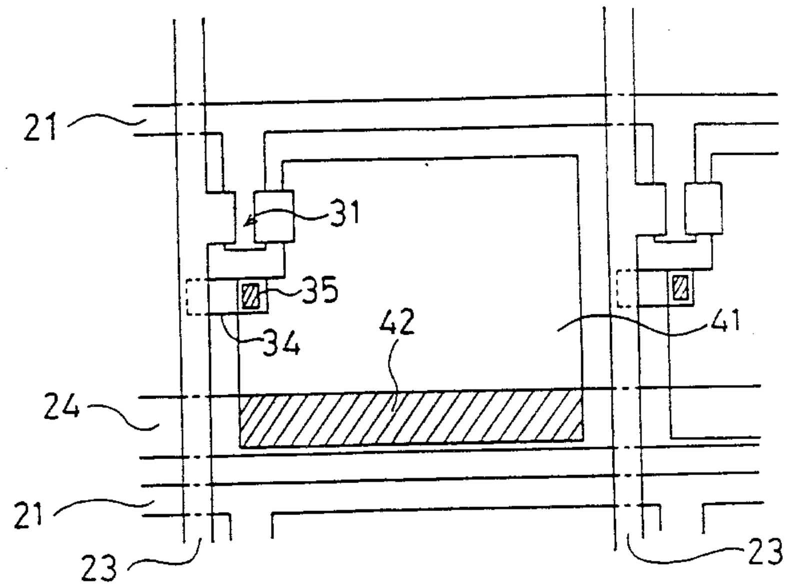
第 7 図



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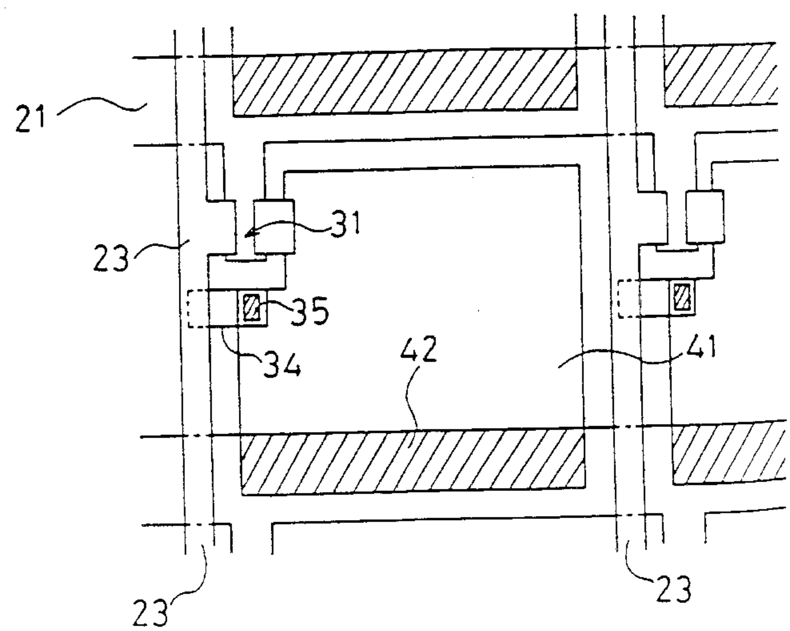
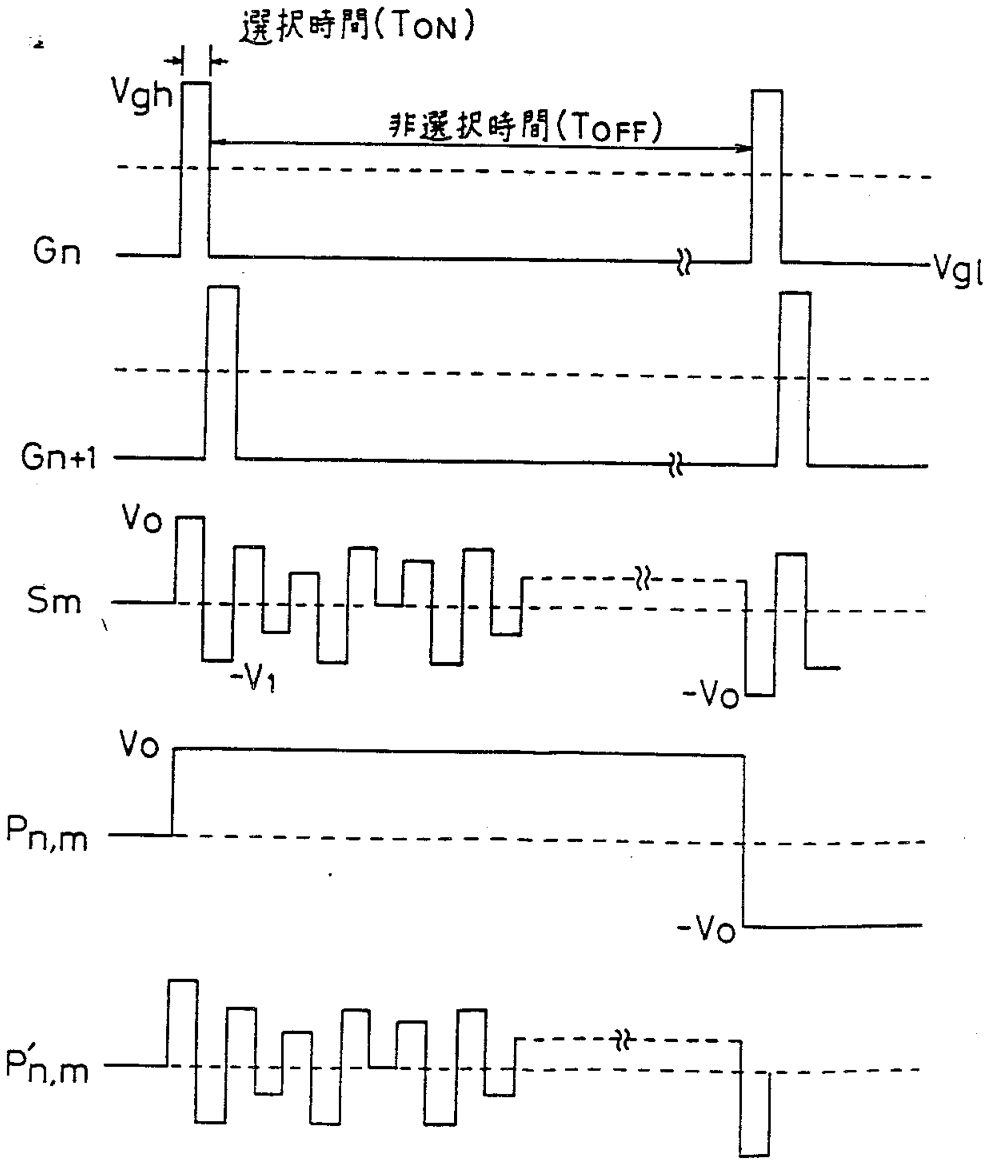


第11図



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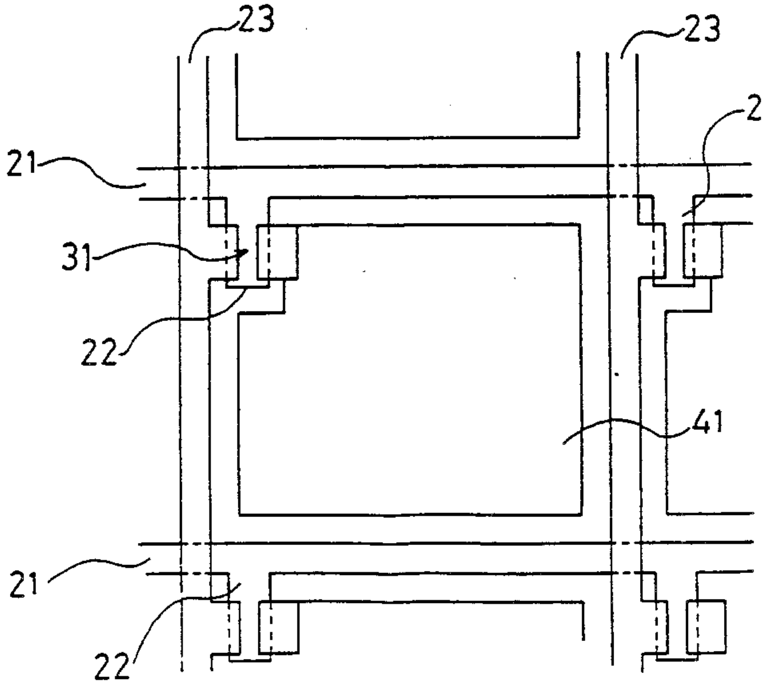

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(Translation)

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This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: June 4, 1990

Application Number : Heisei 2
Patent Appln. No. 146857

Applicant(s) : SHARP KABUSHIKI KAISHA

Wafer
of the
Patent
Office

November 14, 1990

Satoshi UEMATSU

Commissioner,
Patent Office

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Commissioner
of
the Patent
Office

Appln. Cert. Hei 2-65536

PTO 93-2708

Japan, Shutsugan
Hei 2-146857

ACTIVE-MATRIX DISPLAY DEVICE
[Aktibu Matorikusugata Hyōji Sōchi]

Yuzuru Kanamori, et al.

UNITED STATES PATENT AND TRADEMARK OFFICE

Washington, D.C. June 1993

Translated by: Schreiber Translations

SHC 001374

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Document No.	:	Hei 2-121787
Document Type	:	Shutsugan
Language	:	Japanese
Inventor	:	Yuzuru Kanamori, Mikio Katayama, Kiyoshi Nakazawa, Hidemitsu Okoto, Kozo Yano, Satoru Takahama
Applicant	:	Sharp K.K.
IPC	:	G 02 F 1/133
Application Date	:	June 4, 1990
Foreign Language Title	:	Aktibu Matorikusugata Hyōji Sōchi
English Title	:	ACTIVE-MATRIX DISPLAY DEVICE

Specification /1[1]

1. Title: Active-Matrix Display Device

2. Claims

1. An active-matrix display device provided with a pair of insulating substrates at least one of which is translucent, scanning lines arranged on one of said pair of substrates, branch scanning lines diverging from said scanning lines, switching elements formed on the front ends of said branch scanning lines, and picture element electrodes connected to said switching elements; wherein in the section of the scanning lines beyond the one where said switching elements are formed, there is a section that is narrower in width than the section of the scanning lines that has switching elements formed therein.

3. Detailed Description of the Invention

Industrial Field of Application

The present invention relates to a display device that operates by applying a drive signal via switching elements to picture-element electrodes used for display; specifically, it

/2

relates to an active-matrix driven display device in which picture element electrodes are arrayed in a matrix to achieve a high-density display.

Prior Art

In conventional liquid-crystal, EL, and plasma displays, a display pattern is formed on a screen by selectively driving

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[1] Numbers in the margin indicate pagination in the foreign text.

picture element electrodes arrayed in a matrix. Voltage is applied between selected picture element electrodes and counter electrodes to optically modulate a display medium such as liquid crystals positioned between sets of such electrodes. This optical modulation is then viewed in the form of a display pattern. A known method of driving picture element electrodes consists of connecting switching elements to each individual picture element electrode in an array of such picture element electrodes to drive them. Switching elements commonly used to selectively drive picture element electrodes include TFT (thin-film transistor) elements, MIM (metal-insulating layer-metal) elements, MOS transistor elements, diodes, and varistors. Active-matrix driven systems permit high-contrast display, and

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have already seen practial application in liquid crystal televisions, word processors, computer terminal displays and the like.

Figures 8 and 9 show plan views of active-matrix substrates used in conventional active-matrix display devices. In the substrate of Figure 8, source bus lines 23 are laid out orthogonally to parallel gate bus lines 21. A picture element electrode 41 is positioned in the area within each of the rectangles delimited by gate bus lines 21 and source bus lines 23. A TFT 31, functioning as a switching element, is formed over gate bus line 21 in close proximity to the intersecting portions of gate bus line 21 and source bus line 23. Part of gate bus hereinbelow as "OFF malfunctions"). ON malfunctions are caused

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by defective TFTs. OFF malfunctions are produced by leakage of electricity from TFTs or between picture element electrodes and bus lines. In both cases, point defects are produced because insufficient voltage is applied between the picture element electrode and the counter electrode. When the voltage between the picture element electrode and the counter electrode is zero during such malfunctions, a bright spot appears when transmittance is at a maximum in the normally white mode, and a dark spot appears when transmittance is at a minimum in the normally black mode.

Such defects can be corrected by laser trimming and the like. However, such repairs must be made to the active-matrix substrate before assembly of the display device. Although defective picture elements are readily detected once assembled into display devices, it is extremely difficult to detect them on the active-matrix substrate alone. In the case of large display devices having 100,000 to 500,000 or more picture elements,

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extremely high-precision testing instruments must be used to determine the electrical characteristics of all the picture element electrodes and discover malfunctioning TFTs. The inspection process becomes complicated, hindering mass production and raising costs. For such reasons, it is presently not possible to undertake repair of defective picture elements using the above-mentioned lasers at the substrate stage in large display devices having numerous picture elements.

Such problems have been solved in the present invention, the object of which is to provide an active-matrix display device in which even when defective picture elements are produced, it is possible to effect repairs in assembled display devices in such a way as to render the defective picture elements inconspicuous.

Means of Solving the Problems

The active-matrix display device of the present invention is provided with a pair of insulating substrates at least one of which is translucent, scanning lines arranged on one of the two substrates, branch scanning lines diverging from the scanning lines, switching elements formed on the front ends of the branch

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scanning lines, and picture element electrodes connected to the switching elements. To achieve the above-mentioned goal, in the section of the scanning lines beyond the one where said switching elements are formed, there is a section that is narrower in width than the section of the scanning lines that has switching elements formed therein.

Operation

When ON or OFF malfunctions occur in the active-matrix display device of the present invention due to defective switching elements, weak current leaking between signal lines and picture element electrodes, or the like, it is possible to repair the display device in assembled form. First, in the section of the scanning lines beyond the one where said switching elements are formed, i.e., a section that is narrower in width than the section of the scanning lines that has switching elements formed therein, the scanning branch lines are cut by a laser or the like. Since such a narrow section is formed in the displays of this invention, scanning lines can certainly be cut by irradiation with laser light or other luminous energy.

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Forming such a narrow section in the scanning lines has the following advantages. Firstly, since the length of the part to be cut is reduced, cutting by laser irradiation is facilitated. Since the amount of metal melted by laser irradiation is small, electric leaks between the scanning lines and signal lines caused by the metal sticking again to scanning lines or signal lines do not occur so easily. Secondly, since the distance between the section to be cut and the signal line is increased, signal lines are no longer damaged by laser irradiation. Thirdly, since the diatnce between the section to be cut and pixel electrodes is increased, no leaks develop between scanning lines and signal lines caused by melted metal sticking to them again.

Upon thus cutting scanning lines, the interval between the electrode connected to the pixel electrode of the scanning elements and the lectrode connected to signal lines becomes electrically connected by laser energy irradiation. When TFTs are used as switching elements, such electrical connections are made by irradiating the overlapping portions of the source electrodes and the gate electrodes, as well as the overlapping portions of the drain electrodes and the gate electrodes, with light energy. By using a laser as the source of light energy,

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spotlike holes are opened in these overlapping portions. The source electrodes and gate electrodes are electrically connected around these holes, as are the drain electrodes and gate electrodes. In this manner, the source and drain electrodes are electrically connected via the gate electrodes.

The voltage applied to picture element electrodes connected to switching elements repaired in the manner set forth above (referred to hereinbelow as "repaired picture element electrodes") will be explained in reference to Figure 7. In Figure 7, G_n shows the relation between the signal voltage of the nth scan line (vertical axis) and time (horizontal axis). S_m shows the relation between the signal voltage of the mth scanning line (vertical axis) and time (horizontal axis). P_{nm} shows the voltage applied to a normal picture element electrode connected to the nth scanning line and the mth signal line. P'_{nm} shows the voltage applied to a repaired picture element electrode connected to the nth scanning line and the mth signal line.

As shown in G_n and G_{n+1}, signal (V_{gh}), which selects the

/10

serial switching elements, is output to the scanning line for a are used as switching elements, such electrical connections are made by irradiating the overlapping portions of the source electrodes and the gate electrodes, as well as the overlapping portions of the drain electrodes and the gate electrodes, with light energy. By using a laser as the source of light energy,

/9

spotlike holes are opened in these overlapping portions. The source electrodes and gate electrodes are electrically connected around these holes, as are the drain electrodes and gate electrodes. In this manner, the source and drain electrodes are electrically connected via the gate electrodes.

The voltage applied to picture element electrodes connected to switching elements repaired in the manner set forth above (referred to hereinbelow as "repaired picture element electrodes") will be explained in reference to Figure 7. In Figure 7, G_n shows the relation between the signal voltage of the nth scan line (vertical axis) and time (horizontal axis). S_m shows the relation between the signal voltage of the mth scanning line (vertical axis) and time (horizontal axis). P_{nm} shows the voltage applied to a normal picture element electrode connected to the nth scanning line and the mth signal line. P'_{nm} shows the voltage applied to a repaired picture element electrode connected to the nth scanning line and the mth signal line.

As shown in G_n and G_{n+1}, signal (V_{gh}), which selects the

/10

serial switching elements, is output to the scanning line for a selection time of T_{on}. Corresponding to the selection time T_{on} of the scanning line, video signal voltage V_0 is output to the signal line. In a normal picture element electrode as shown in P_{nm}, signal voltage V_0 is maintained during the time the element is unselected, T_{off}. Then, when the next selected signal voltage V_{gh} is applied, video signal $-V_0$ is applied to the signal line.

By comparison, a repaired picture element electrode as shown in P'_{nm} cannot function normally since the video signal from the signal line is continuously applied. However, a repaired picture element electrode displays over a period of one cycle a picture element equivalent to the effective value of the video signal applied to the signal line during the cycle. Such a picture element will thus not display a completely bright or dark spot, but the average brightness of picture elements along the signal line, making the defective picture element extremely hard to detect.

Resistance of portions connected as set forth above must be lower than the resistance of switching elements in a selected state (referred to hereinbelow as "ON resistance"). The reason

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is as follows. The value of the ON resistance of switching elements is set so that only enough current to effect a complete charge is allowed to flow to the picture element electrodes while the switching elements are selected. Thus, when the resistance of portions connected as set forth above is greater than the ON resistance, the signal voltage changing each time a switching element is selected is not reliably applied to repaired picture element electrodes, and the effective value of the voltage applied to such elements decreases. Under these conditions, the difference in brightness between picture elements displayed by repaired picture element electrodes and normal picture elements becomes substantial, and defective picture elements can be visually detected.

Embodiments

Embodiments of the present invention are described below.

Figure 1 shows a plan view of the active-matrix substrate used in an embodiment of the display device of the present invention. Figure 3 shows a portion, indicated by section line III-III in Figure 1, of the display device employing the substrate of Figure 1. The active-matrix display device of the present embodiment will be described according to the

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manufacturing process. In the present embodiment, transparent glass was employed for the insulating substrates. Gate bus line 21, functioning as a scanning line, and gate bus branch line 22, diverging from gate bus line 21, were formed on glass substrate 1. Gate bus branch line 22 functions as the scanning branch line. Gate bus line 21 and gate bus branch line 22 are usually formed as single or multiple layers of metals such as Ta, Ti, Al, and Cr; Ta was employed in the present embodiment. Gate bus line 21 and gate bus branch line 22 were formed by patterning a layer of Ta formed by sputtering. Prior to forming gate bus line 21 and gate bus branch line 22, a base coating can be formed of Ta_2O_5 or the like on glass substrate 1. The length of gate bus branch line 22 will be dealt with further below.

A base insulating film 11 was formed of SiN_x over the entire surface, including gate bus line 21 and gate bus branch line 22. Gate insulating film 11 was formed to a thickness of 3,000 Å by plasma CVD.

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TFT 31, functioning as a switching element, was then formed on the forward end of gate bus branch line 22. Part of gate bus branch line 22 functions as the gate electrode 25 of TFT 31. After forming gate insulating-film 11 as described above, an amorphous silicon (a-Si) layer which would become channel layer 12 was deposited, followed by an SiN_x film which would become etching stopper layer 13. The thicknesses of the a-Si film was 300 Å and that of the SiN_x film was 2,000 Å. The SiN_x film was then patterned to form etching stopper film 13. A layer of n^+ type a-Si to which P (phosphorus) had been added, later to become contact layers 14, 14, was then deposited by plasma CVD to a thickness of 800 Å over the entire surface of the a-Si and etching stopper 13 layers. The above-mentioned a-Si and n^+ type a-Si layers were then simultaneously patterned to form channel layer 12 and contact layers 14, 14.

Next, a Ti layer was formed which would become a source electrode 32, source bus line 23, functioning as the signal line, and a drain electrode 33. Source bus line 23 and the like are normally formed as single or multiple layers of Ti, Al, Mo, Cr or the like; Ti was employed in the present embodiment. Source electrode 32, source bus line 23, and drain electrode 33 were formed by patterning this Ti layer. Source bus line 23 intersects gate bus line 21; the two sandwich gate insulating film 11 between them.

As shown in Figure 1, picture element electrode 41 is formed of ITO (indium tin oxide) in the square area enclosed by gate bus lines 21 and source bus lines 23. Picture element electrode 41 overlaps the end of drain electrode 33 of TFT 31 and is electrically connected to drain electrode 33.

A protective film 17 was deposited over the entire surface of the substrate on which TFT 31 and picture element electrode 41 were formed. Protective film 17 can also be formed with a removed window-shaped section over the center of picture element 41. An orientation film 19 was formed over protective film 17. A counter electrode 3 and an orientation film 9 were formed on a

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glass substrate 2 opposite glass substrate 1. A liquid crystal layer 18 was sandwiched between substrates 1 and 2 to complete the active-matrix display device of the present embodiment.

The configuration in the proximity of TFT 31 will now be described. Figure 2 shows an enlarged view of the area around TFT 31. As stated above, TFT 31 is formed over gate bus line 22 branching off gate bus line 21. Drain electrode 33 of TFT 31 is electrically connected to picture element electrode 41, and source electrode 32 is electrically connected to source bus line 23. As regards gate bus branch line 22, in the section beyond the one where TFT 31 of the gate bus branch line 22 is formed, there is a section narrower than the one where TFT 31 of the gate bus branch line 22 is formed. Due to the availability of such a narrow section, the distance X to the gate bus branch line 22 can be increased to exceed that of Prior Art as described previously in Fig. 9. Since distance X is large enough, gate bus branch line 22 can be easily and reliably cut. If distance X exceeds 10

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μm, reliable cutting has been confirmed to be possible. When distance X is smaller than this, not only is it hard to effectively cut gate bus branch line 22 without damaging TFT 31, but light emitted from the laser has an adverse effect on the intersecting portion of gate bus line 21 and source bus line 23, and the insulation between bus lines 21 and 23 is sometimes rendered ineffective.

In the active-matrix display device of the configuration set forth above, defective picture elements are produced when TFT 31 malfunctions or there is a weak current leak between source bus line 23 and picture element electrode 41. In such cases, repairs can be effected in the following manner. First, the area 51 marked by broken lines in Figure 2 is irradiated with light energy to cut gate bus branch line 22. Light energy from a YAG laser was used in the present embodiment. In this manner, gate bus branch line 22 is electrically insulated from gate bus line 21. As mentioned above, in the section beyond the one where TFT 31 of the gate bus branch line 22 is formed, the gate bus branch /17 line 22 features a section narrower than the one where TFT 31 of the gate bus branch line 22 is formed. Therefore, the gate bus branch line 22 can be easily and reliably cut. Although light from the laser can be irradiated through either substrate 1 or 2, it is directed through substrate 1 when a light-blocking film is formed on substrate 2 as is often the case. The laser was directed through substrate 1 in the present embodiment.

The laser is then directed to areas 52 and 53, shown by broken lines in Figure 2 and indicated by arrows 26 and 27 in Figure 3. In this manner, source electrode 32 and gate electrode 25 are electrically connected in area 52, and drain electrode 33 and gate electrode 25 are electrically connected in area 53. Source electrode 32 and drain electrode 33 are thus electrically connected via gate electrode 25.

The repaired picture element electrode cannot function normally since the signal of source bus line 23 is continuously applied to picture element electrode 41 (the repaired picture element electrode), connected to repaired TFT 31 in the manner set forth above. However, since picture elements displayed by /18 the repaired picture element electrode are displayed as the equivalents of the effective value of the signal applied to source bus line 32, the picture element becomes neither a totally bright nor totally dark point, but is displayed with a brightness equivalent to the average of picture elements aligned along source bus line 23. The defective picture element thus becomes extremely hard to detect.

Despite the use of a laser as described above, no melted metal or the like contaminates liquid crystal layer 18, the display medium, since protective film 17 is formed over gate bus branch line 22 and TFT 31. Moreover, it was found that by varying the [intensity of the] laser it was possible to use the same laser both to connect metal layers by fusion and to cut them.

In the above-mentioned repair, it is also possible to first connect the gate electrode 25 of the TFT 31 to the source electrode 32 and the drain electrode 33, and then cut the gate branch line 22.

The gate branch line 22 can also have a planar configuration

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as shown in Figures 4 (a) and (b). As regards the gate bus branch line 22 in Figure 4 (a), the narrower section thereof is formed by removing only the part of the gate bus branch line 22 in the above-mentioned Fig. 9 that is situated on the side of the picture element electrode 41. In a similar manner, as regards the gate bus branch line 22 in Figure 4 (b), the narrower section thereof is formed by removing only the part of the gate bus branch line 22 in the above-mentioned Fig. 9 that is situated on the side of the source bus line 23.

The configuration of the present invention also lends itself to an active-matrix display device having additional capacitance 42 as shown in Figure 5. Figure 5 shows the embodiment of Figures 1-3 provided with additional capacitance 42. Additional capacitance 42 is provided by the portion (hatched) of additional capacitance electrode 24, positioned parallel to gate bus line 21 on substrate 1, that overlaps picture element electrode 41. Defective picture elements can be repaired in the display device of Figure 5 in the same manner as in the embodiment of Figures 1-3.

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The present invention is also suitable to an active-matrix display device having the configuration shown in Figure 6. The area of the opening reduced to provide additional capacitance 42 in the display device of Figure 5 is limited in this display device, i.e, the width of gate bus line 21 is increased so that it overlaps a portion of picture element electrode 41. In this configuration, adjacent gate bus line 21 can be used in the unselected state as an electrode for additional capacitance. Moreover, since there is no space between gate bus line 21 and additional capacitance electrode 24 as shown in Figure 5, it is possible to limit reduction in the area of the opening. Defective picture elements are also repaired in this display device in the same manner as in the embodiment of Figures 1-3.

All the embodiments set forth above show the gate electrode of TFT 31 formed below and the source and drain electrodes formed above, but a TFT of a type in which the gate electrode is formed above and the source and drain electrodes are formed below can also be used.

Furthermore, TFTs were used as switching elements in the embodiments set forth above, but any switching element in which the signal line side electrode and the electrode on the picture element electrode side can be electrically connected by light energy from a laser or the like is suitable for use in the present invention.

Effect of the Invention

In the active-matrix display device of the present invention, defective picture elements can be repaired in assembled display devices, where they are readily detectable, in such a way as to be rendered inconspicuous. The present invention thus permits the high yield production of display devices, making it possible to reduce the cost of display devices.

4. Brief Description of the Figures

Figure 1 is a plan view of an active-matrix substrate employed in an embodiment of the active-matrix display device of the present invention. Figure 2 is an enlarged plan view of the area around the TFT of Figure 1. Figure 3 is the view of a portion, indicated by section line III-III in Figure 1, of a display device employing the substrate of Figure 1. Figures 4

(a) and (b) show plan views of gate bus lines other embodiments of the present invention. Figures 5 and 6 show plan views of other embodimnets of the present invention. Figure 7 shows the relation between the signal applied to the scanning and signal lines and the voltage of the picture element electrode. Figures 8 and 9 show plan views of active-matrix substrates employed in conventional active-matrix display devices.

1, 2=glass substrates; 3=counter electrode; 9, 19=orientation film; 11=gate insulating film; 12=channel layer; 13=etching stopper layer; 14=contact layer; 18=liquid crystal layer; 21=gate bus line; 22=gate bus branch line; 23=source bus line; 24=additional capacitance electrode; 25=gate electrode; 31=TFT; 32=source electrode; 33=drain electrode; 41=picture element electrode; 42=additional capacitance.

Applicant: Sharp K.K.

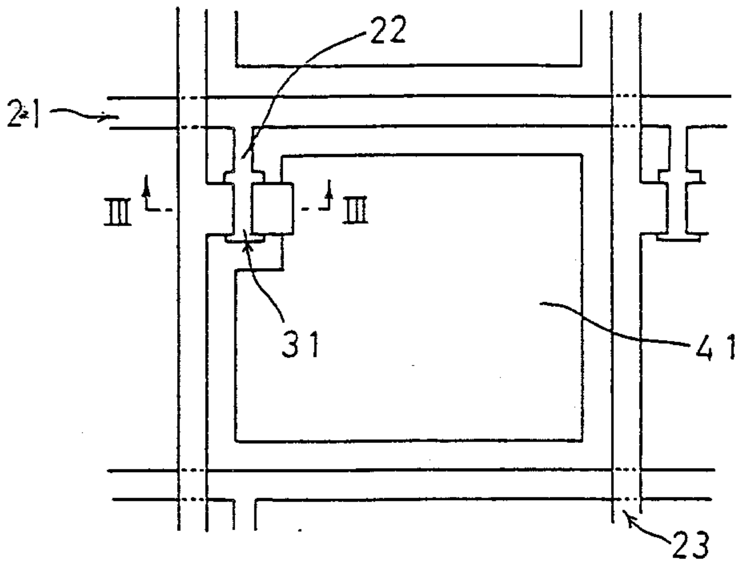
Agent: Hidesaku Yamamoto, Patent Attorney

Key to Figure 7:

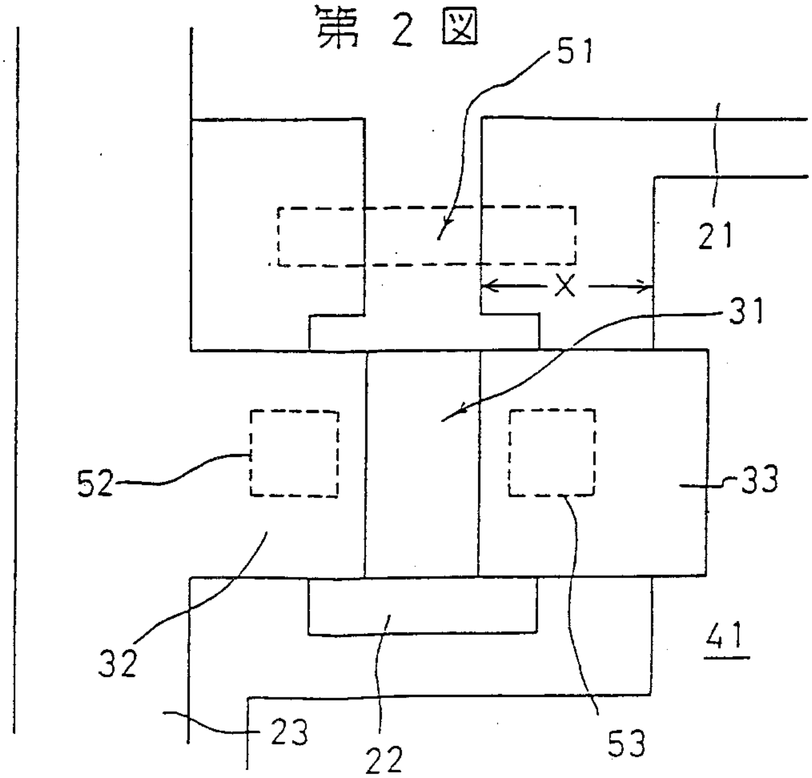
Time Selected (T_{ON})

Time Unselected (T_{OFF})

第 1 図



第 2 図



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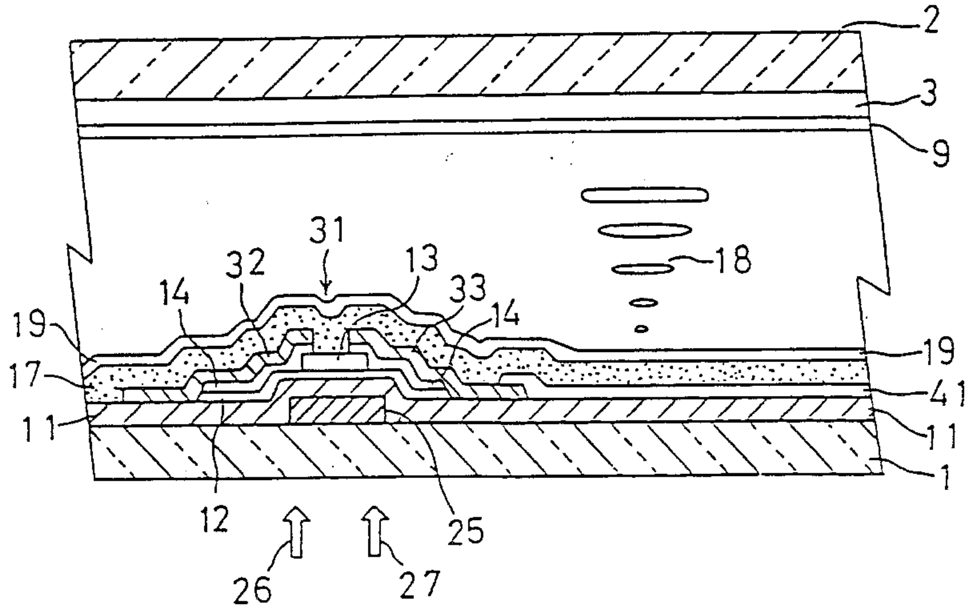
第 3 図



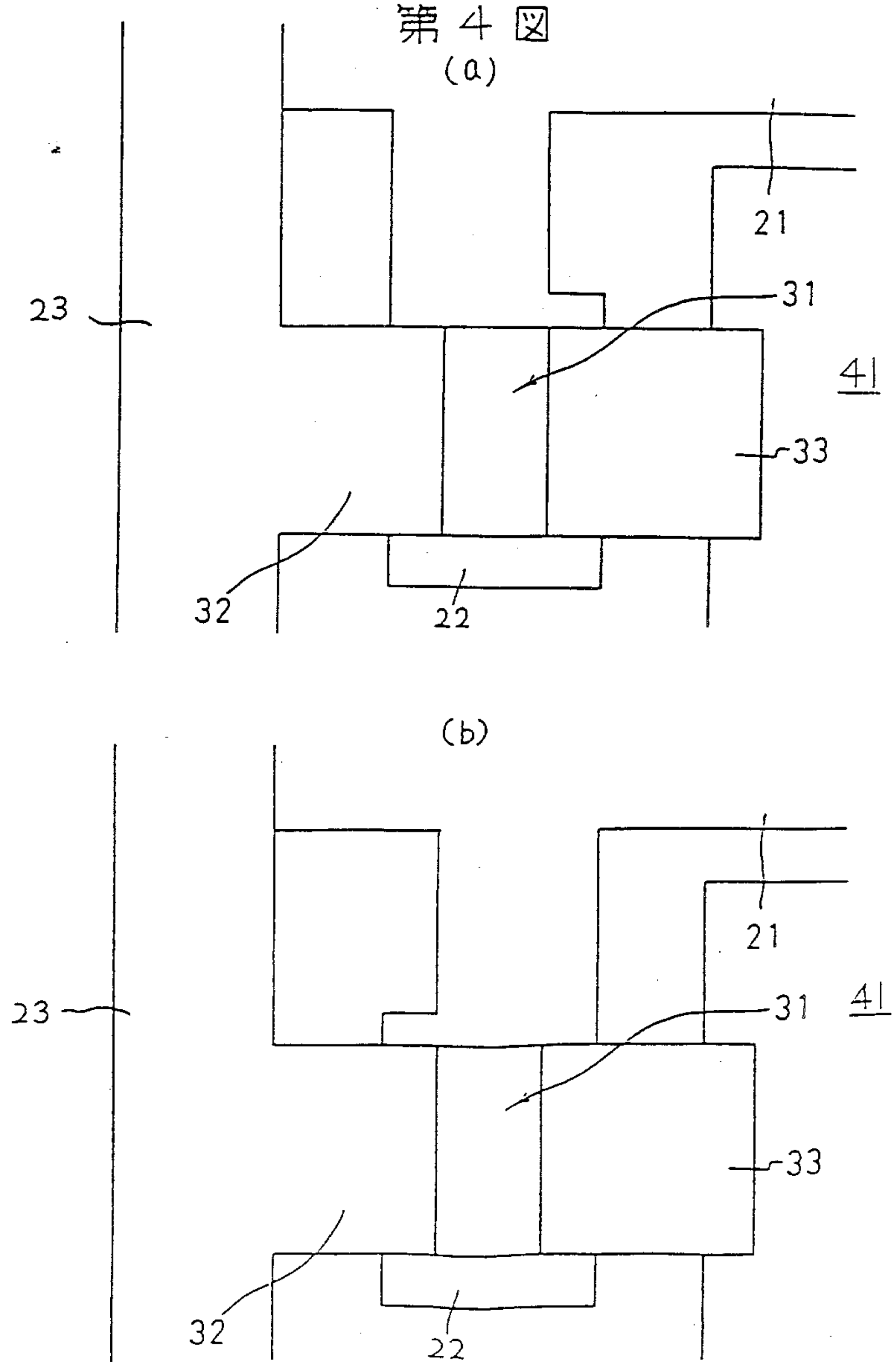
出願人　　シャープ株式会社

代理人　　弁理士　山本秀策

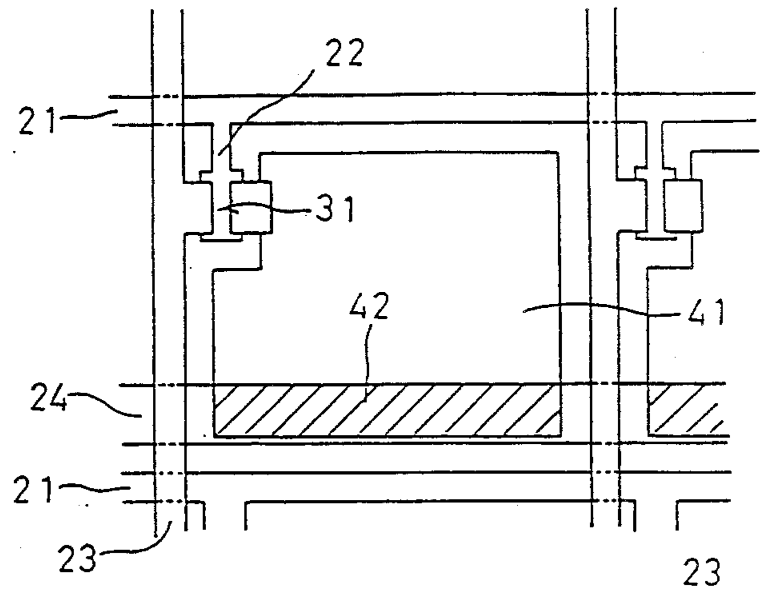
第4図

(a)

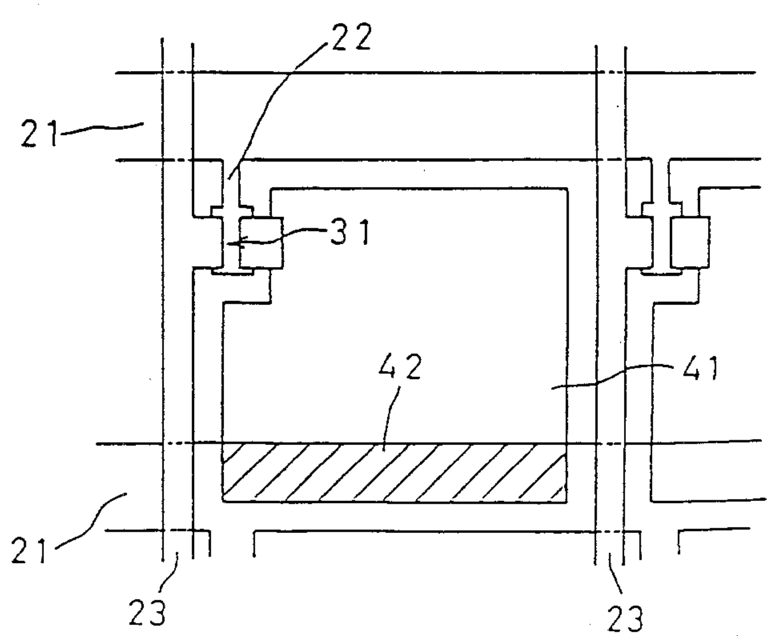
(b)



第5図



第6図



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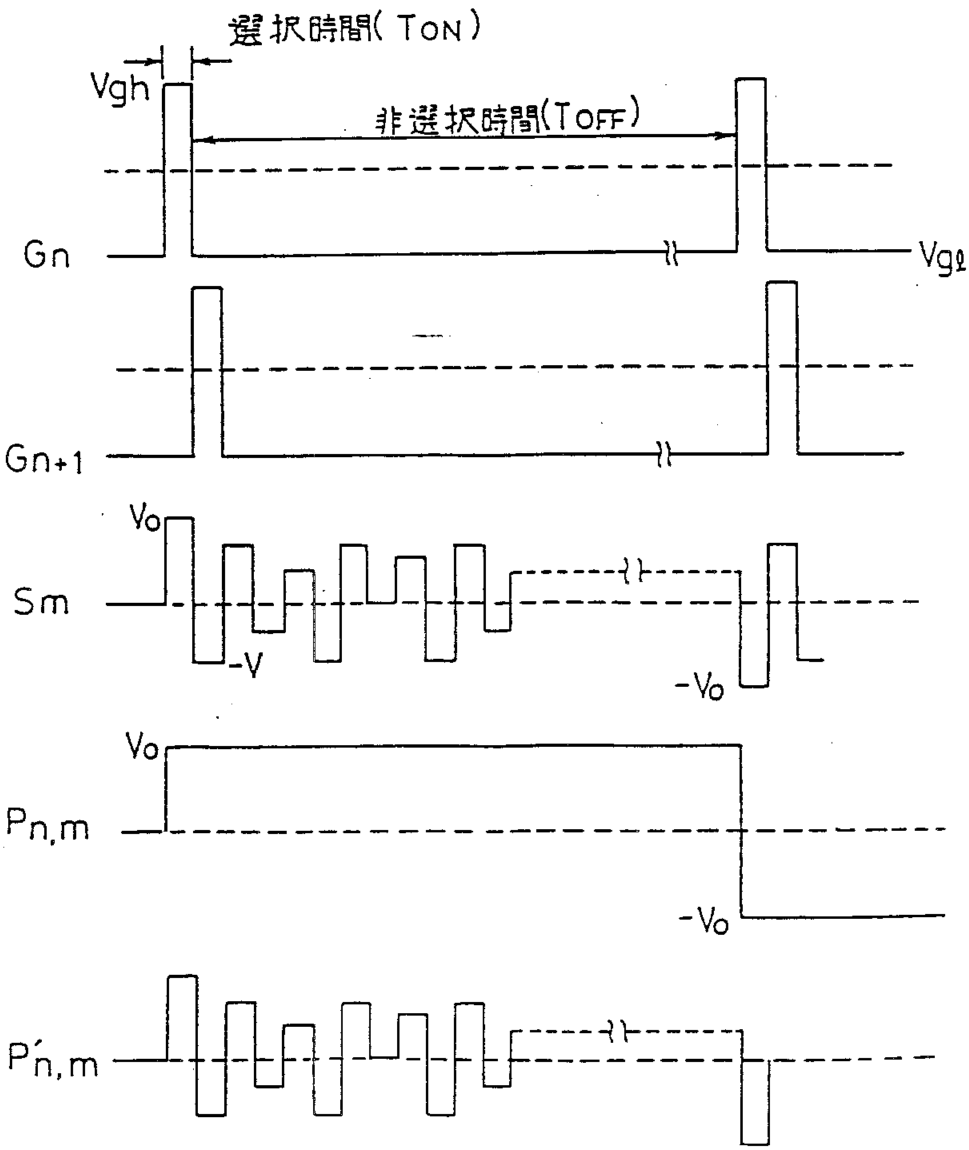
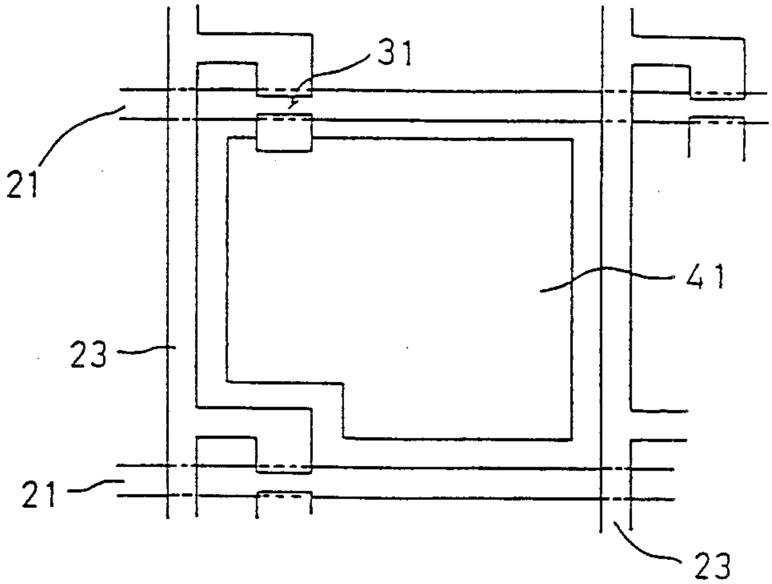
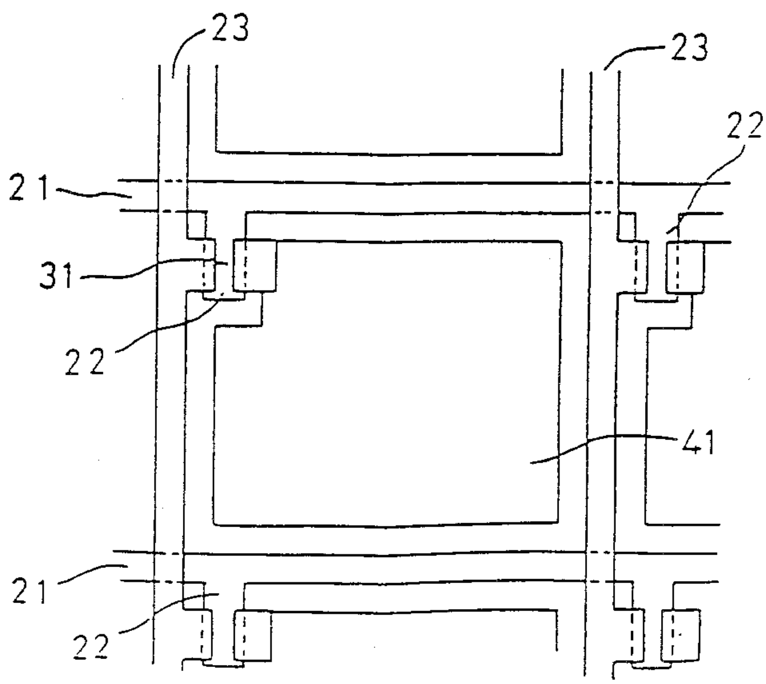
第７図



第8図



第9図



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(Translation)

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This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Patent Appln. No. 125191

Applicant(s) : SHARP KABUSHIKI KAISHA

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1. Title of Invention

METHOD OF MANUFACTURING ACTIVE MATRIX TYPE DISPLAY

2. Scope of Patent Claims

1. A method of manufacturing active matrix type display that comprises

a process of forming active matrix substrate that is equipped with dielectric base, scanning lines and signal lines arranged horizontally and vertically on the above-mentioned base, scanning branches that branch out of the above-mentioned scanning lines, switching elements formed on the tip portions of the above-mentioned scanning branches, and pixel electrodes connected to these switching elements; and wherein the distance from the lateral part of these switching elements on the scanning line side to the scanning lines is big enough to cut off the above-mentioned scanning lines by irradiating with light energy;

a process of gluing together the above-mentioned active matrix substrate and a counter substrate, sealing a display medium between said active matrix substrate and counter substrate;

[1]Numbers in the margin indicate pagination in the foreign text.

a process of applying drive voltage to said pixel electrodes from the above-mentioned scanning lines and signal lines via said switching elements, and detecting pixel defects;

a process of electrically connecting the above-mentioned defective pixel electrodes to signal lines by irradiating switching elements connected to defective pixel electrodes that develop in said pixel defects, with luminous energy' and moreover, a process of cutting off said scanning lines from [the other] scanning lines by irradiating said scanning lines with luminous energy.

2. A method of manufacturing active matrix type display that comprises

a process of forming active matrix substrate that is equipped with dielectric base, scanning lines and signal lines arranged vertically and horizontally on said substrate, pixel electrodes connected to said scanning lines and said signal lines via switching elements, a conductive layer with an insulating film sandwiched and folded under said signal lines and pixel electrodes, a conductive chip formed between said pixel electrodes and said insulating film;

a process of gluing together the above-mentioned active matrix substrate and a counter substrate, sealing a display medium between said active matrix substrate and counter substrate;

a process of applying drive voltage to said pixel electrodes from the above-mentioned scanning lines and signal lines via said switching elements, and detecting pixel defects;

a process of irradiating the overlapping part of the conductive chip connected to defective pixel electrodes that develop pixel defects and said conductive layer with

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luminous energy, connecting electrically the above-mentioned defective pixel electrodes and conductive layer, and, moreover, connecting electrically said signal lines and the conductive layer by irradiating the overlapping part of the above-mentioned signal lines and conductive layer with luminous energy.

3. Detailed explanation of Invention

(Field of Application in Industry)

This invention pertains to a method of manufacturing displays that carry out displaying by applying drive voltage to pixel electrodes for the display through switching elements, especially, to a method of manufacturing an active matrix drive type of display that carries out high density displaying by arraying pixel electrodes in a matrix.

(Prior Art)

In conventional liquid-crystal, EL, and plasma displays, a display pattern is formed on a screen by selectively driving pixel electrodes arrayed in a matrix. Voltage is applied between /4 selected pixel electrodes and counter electrodes to optically modulate a display medium such as liquid crystals positioned between these electrodes. This optical modulation is then visually recognized as a display pattern. A known method of driving pixel electrodes consists of connecting switching elements to each individual pixel electrode in an array of such picture element electrodes to drive them. Switching elements commonly used to selectively drive picture element electrodes include TFT (thin film transistor) elements, MIM (metal-insulating layer-metal) elements, MOS transistor elements, diodes, and varistors, etc. Active matrix driven systems permit high-contrast display, and have already seen practical application in liquid crystal television, word processors, computer terminal displays and the like.

Figures 11 and 12 show plan views of active matrix substrates used in conventional active matrix display devices. In the substrate of Figure 11, source bus lines 23 are laid out at a right angle to parallel gate bus lines 21. A pixel electrode 41 is positioned in the area within each of the rectangles delimited by gate bus lines 21 and source bus lines 23. A TFT 31, functioning as a switching element, is formed over gate bus line 21 close to the intersecting portions of gate bus line 21 and source bus line 23. Part of gate bus line 21 functions as the gate electrode of TFT 31. The drain electrode of TFT 31 is electrically connected to pixel electrode 41. A branch line from source bus line 23 is electrically connected to the source electrode of TFT 31.

The active matrix substrate of Figure 12 is similar to that of Figure 11 except for a different configuration in the area of TFT 31, i.e., TFT 31 is formed over a gate bus line 22 diverging from gate bus line 21. Part of gate bus branch line 22 functions as the gate electrode of TFT 31.

Problems to Be Solved by the Invention

A high-density display made using such display devices requires an array with an extremely large number of pixel electrodes 41 and TFTs 31. However, defective elements are sometimes formed during fabrication of TFTs 31 on the substrate. Picture element electrodes connected to such defective elements produce point defects that do not affect the display. Point defects severely compromise the picture quality of the display device and greatly reduce production yield.

The chief causes of point defects can be roughly divided into two groups. The first group comprises malfunctions occurring due to insufficient charging of the pixel electrodes once picture elements are selected by the scan signal (henceforth referred to as "ON malfunctions"). The other group comprises malfunctions in which charged pixel electrodes leak their charges when non-selected (henceforth referred to as "OFF malfunctions"). ON malfunctions are caused by defective TFTs. OFF malfunctions are produced by leakage of electricity through TFTs or between picture element electrodes and bus lines. In both cases, point defects are produced because insufficient voltage is applied between the pixel electrode and the counter electrode. In such malfunctions, when the voltage between the pixel electrode and the counter electrode is zero, a bright spot appears when transmittance is at a maximum in the normally white mode, and a dark spot appears when transmittance is at a minimum in the normally black mode.

Such defects can be corrected by laser trimming and the like. However, such repairs must be made to the active matrix substrate before assembly of the display device. Although defective picture elements are readily detected once assembled into display devices, it is extremely difficult to detect them at the active matrix substrate stage. In the case of large display devices having 100,000 to 500,000 or more picture elements, extremely high-precision testing instruments must be used to determine the electrical characteristics of all the picture element electrodes and discover malfunctioning TFTs. The inspection process becomes complicated, hindering mass production and raising costs. For such reasons, it is presently not possible to undertake repair of defective picture elements using the above-mentioned lasers at the substrate stage in large

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display devices having numerous picture elements.

Such problems have been solved in the present invention, the object of which is to provide an method of manufacturing active matrix display device in which even when defective picture elements are produced, it is possible to effect repairs in assembled display devices in such a way as to render the defective picture elements inconspicuous, even though pixel defects have been caused by malfunctions of switching elements.

Means of Solving the Problems

The method of manufacturing active matrix type displays of this invention achieves the above-stated goal due to comprising a process of forming active matrix substrate that is equipped with dielectric base, scanning lines and signal lines arranged horizontally and vertically on the above-mentioned base, scanning branches that branch out of the above-mentioned scanning lines, switching elements formed on the tip portions of the above-mentioned scanning branches, and pixel electrodes connected to these switching elements; and wherein the distance from the lateral part of these switching elements on the scanning line side to the scanning lines is big enough to cut off the above-mentioned scanning lines by irradiating with light energy; a process of gluing together the above-mentioned active matrix substrate and a counter substrate, sealing a display medium between said active matrix substrate and counter substrate; a process of applying drive voltage to said pixel electrodes from the above-mentioned scanning lines and signal lines via said switching elements, and detecting pixel defects; a process of electrically connecting the above-mentioned defective pixel electrodes to signal lines by irradiating switching elements connected to defective pixel electrodes that develop in said pixel defects, with luminous energy, and moreover, a process of cutting off said scanning lines from [the other] scanning lines by irradiating said scanning lines with luminous energy.

Moreover, the method of manufacturing active matrix type display of this invention achieves the above-stated goal due to comprising a process of forming active matrix substrate that is equipped with dielectric base, scanning lines and signal lines. arranged vertically and horizontally on said substrate, pixel electrodes connected to said scanning lines and said signal lines via switching elements, a conductive layer with an insulating film sandwiched and folded under said signal lines and pixel electrodes, a conductive chip formed between said pixel electrodes and said insulating film; a process of gluing together the above-mentioned active matrix substrate and a counter substrate, sealing a display medium between said active matrix

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substrate and counter substrate; a process of applying drive voltage to said pixel electrodes from the above-mentioned scanning lines and signal lines via said switching elements, and detecting pixel defects; a process of irradiating the overlapping part of the conductive chip connected to defective pixel electrodes that develop pixel defects and said conductive layer with luminous energy, connecting electrically the above-mentioned defective pixel electrodes and conductive layer, and, moreover, connecting electrically said signal lines and the conductive layer by irradiating the overlapping part of the above-mentioned signal lines and conductive layer with luminous energy.

(Effect)

When ON or OFF malfunctions are detected in the active matrix display manufacturing method of this invention due to defective switching elements, weak leakage current between signal lines and picture element electrodes, or the like, it is possible to repair the display device in assembled form. First, the scanning branch lines connected to the pixel electrode that generates pixel defects are cut by laser irradiation or the like.

Scanning branch lines can be reliably cut in the display manufacturing method of this invention since the distance from

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the scanning line side of the switching elements to the scanning lines is left large enough to permit cutting scanning branch lines by irradiation with light energy from a laser or the like. The interval between the electrodes connected to the picture element electrodes of the switching elements and the electrodes connected to the signal lines can then be electrically connected by irradiation with luminous energy. Thus defective pixel electrodes can be connected directly to signal lines.

When TFTs are used as switching elements, such electrical connections are made by irradiating the overlapping portions of the source electrodes and the gate electrodes, as well as the overlapping portions of the drain electrodes and the gate electrodes, with light energy. By using a laser as the source of luminous energy, spot-like holes are opened in these overlapping portions. The source electrodes and gate electrodes are electrically connected around these holes, as are the drain electrodes and gate electrodes. In this manner, the source and drain electrodes are electrically connected via the gate electrodes.

In the method of manufacturing an active type matrix display of this invention that has a conductive layer and conductive chip

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formed therein, when pixel defects caused by ON malfunctions or OFF malfunctions are detected, pixel defects can be repaired once the display device is assembled.First the overlapping section of the signal lines and conductive layer is subjected to luminous energy irradiation, and the interval between signal lines and conductive layer is electrically connected. In this manner, the signal lines and pixel electrodes are connected directly without the intermediary of switching elements.

The voltage applied to pixel electrodes (henceforth referred to as repaired pixel electrodes) thus connected to signal lines will be explained in reference to Fig. 10. In Fig. 10, G_n shows the relation between the signal voltage of the nth scan line (vertical axis) and time (horizontal axis). S_m shows the relation between the signal voltage of the mth signal line (vertical axis) and time (horizontal axis). P_{nm} shows the voltage applied to a normal pixel electrode connected to the nth scanning line and the mth signal line. P'_{nm} shows the voltage applied to a repaired pixel electrode connected to the nth

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scanning line and the mth signal line.

As shown in G_n and G_{n+1}, signal (V_{gh}), which selects consecutive switching elements, is output to the scanning line for a selection time of T_{on}. Corresponding to the selection time T_{on} of the scanning line, video signal voltage V_0 is output to the signal line. In a normal pixel electrode, as shown in P_{nm}, signal voltage V_0 is maintained during the non-selection time T_{off}. Then, when the next selected signal voltage V_{gh} is applied, video signal $-V_0$ is applied to the signal line.

By contrast, a repaired pixel electrode, as shown in P'_{nm}, cannot function normally since the video signal from the signal line is continuously applied. If, however, a repaired pixel electrode is considered over 1 cycle, it displays a pixel equivalent to the effective value of the video signal applied to the signal line during the cycle. Such a pixel will thus not display a completely bright or dark spot, but the average brightness of picture elements along the signal line, making the defective pixel extremely hard to detect.

Resistance in sections connected as set forth above by irradiating with luminous energy etc. must be lower than the

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resistance of switching elements in a selected state (henceforth referred to as "ON resistance"). The reason is as follows. The value of the ON resistance of switching elements is set so that only enough current to effect a complete charge is allowed to flow to the picture element electrodes while the switching elements are selected. Thus, when the resistance of portions connected as set forth above is greater than the ON resistance, the signal voltage changing whenever a switching element is selected is not reliably entered to repaired pixel electrodes, and the effective value of the voltage applied to such elements is reduced. Under these circumstances, the difference in brightness between pixels displayed by repaired pixel electrodes and normal pixels increases, so that they become visually recognized as defective pixels.

(Practical Examples)

Practical Examples of this invention are described below.

Figure 1 shows a planar view of the active-matrix substrate based on the manufacturing method of the active matrix type display of this invention. Figure 3 is a cross-section, along

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line III-III in Figure 1, of the display employing the substrate of Figure 1. We will now describe the manufacturing process of the active matrix type display of this Practical Example. In the present Practical Example, transparent glass was employed for the insulating substrates. Gate bus line 21, functioning as a scanning line, and gate bus branch line 22, diverging from gate bus line 21, were formed on glass substrate 1. Gate bus line 21 and gate bus branch line 22 are usually formed as single or multiple layers of metals such as Ta, Ti, Al, and Cr; Ta was employed in the present Practical Example. Gate bus line 21 and gate bus branch line 22 were formed by patterning a layer of Ta formed by sputtering. Prior to forming gate bus line 21 and gate bus branch line 22, a base coating can be formed of Ta_2O_5 or the like on glass substrate 1. The gate bus branch line 22 will be dealt with further below.

A base insulating film 11 was formed of SiN_x over the entire surface of the gate bus line 21 and gate bus branch line 22. Gate insulating film 11 was formed to a thickness of 3,000 Å by

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plasma CVD.

TFT 31, functioning as a switching element, was then formed on the tip of the gate bus branch line 22. Part of the gate bus branch line 22 functions as the gate electrode 25 of TFT 31. After forming gate insulating film 11 as described above, an amorphous silicon (a-Si) layer which would become channel layer 12 was deposited, followed by an SiN_x film which would become etching stopper layer 13. The thicknesses of the a-Si film was 300 Å and that of the SiN_x film was 2,000 Å. The SiN_x film was then patterned to form etching stopper film 13. Layers of n^+ type a-Si to which P (phosphorus) had been added, later to become contact layers 14, 14, were then deposited by plasma CVD to a thickness of 800 Å over the entire surface of the a-Si layer and the etching stopper 13 layer. The above-mentioned a-Si and n^+ type a-Si layers were then simultaneously patterned to form channel layer 12 and contact layers 14, 14.

Next, a Ti layer was formed which would become a source electrode 32, source bus line 23, functioning as the signal line, and a drain electrode 33. Source bus line 23 and the like are

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normally formed as single or multiple layers of Ti, Al, Mo, Cr or the like; Ti was employed in the present Practical Example. Source electrode 32, source bus line 23, and drain electrode 33 were formed by patterning this Ti layer. Source bus line 23 intersects gate bus line 21; the two sandwich the above-mentioned gate insulating film 11 between them.

As shown in Figure 1, pixel electrode 41 made of ITO (indium tin oxide) is formed in the rectangular area enclosed by gate bus lines 21 and source bus lines 23. Pixel electrode 41 overlaps the tip of drain electrode 33 of TFT 31 and is electrically connected to drain electrode 33.

A protective film 17 made of SiN_x was deposited over the entire surface of the substrate on which TFT 31 and pixel electrode 41 were formed. Protective film 17 can also be formed in the shape of a window removed over the center of pixel 41. An orientation film 19 was formed over protective film 17. A

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counter electrode 3 and an orientation film 9 were formed on a glass substrate 2 opposite glass substrate 1. A liquid crystal layer 18 was sealed between substrates 1 and 2.

The configuration in the proximity of TFT 31 will now be described. Fig. 2 shows an enlarged view of the vicinity of TFT 31. As stated above, TFT 31 is formed over gate bus branch line 22 branching off gate bus line 21. Drain electrode 33 of TFT 31 is electrically connected to pixel electrode 41, and source electrode 32 is electrically connected to source bus line 23. The distance X between the gate bus line 21 side of TFT 31 and gate bus line 21 is larger than that in the above-mentioned example of a conventional device shown in Fig. 12, which means large enough to permit use of light energy from a laser or the like to cut gate bus branch line 22. It was found that cutting can be reliably accomplished when distance X is 10 μm or greater. When distance X is smaller than this, not only is it impossible to cut gate bus branch line 22 without damaging TFT 31, but the irradiating laser light has an adverse effect on the intersecting

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portion of gate bus line 21 and source bus line 23, and the insulation between bus lines 21 and 23 is sometimes rendered ineffective.

Upon sealing, as described above, the liquid crystal layer 18 between substrates 1 and 2 drive voltage from the gate bus line 21 and source bus line 23 is applied to every pixel electrode 41 via TFT 31. Pixel defects are produced when TFT 31 malfunctions or there is a weak leakage current between source bus line 23 and pixel electrode 41. As soon as the location of pixel defect is confirmed, repairs can be effected in the following manner. First, the area 51 marked by broken lines in Figure 2 is irradiated with light energy to cut gate bus branch line 22. In this manner, gate bus branch line 22 is electrically insulated from gate bus line 21. Luminous energy from a YAG laser (wavelength 1064 nm) was used in the present Practical Example. As stated above, gate base branch line 22 can be reliably cut because distance X is sufficiently large. Although light from the laser can be emitted through either substrate 1 or

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2, it is directed through substrate 1 when a light-blocking film is formed on substrate 2 as is often the case. In this Practical Example, too, the laser beam was directed through substrate 1. The laser is then directed to areas 52 and 53, shown by broken lines in Figure 2 and indicated by arrows 26 and 27 in Figure 3. In this manner, source electrode 32 and gate electrode 25 are electrically connected in area 52, and drain electrode 33 and gate electrode 25 are electrically connected in area 53. Source electrode 32 and drain electrode 33 are thus electrically connected via gate electrode 25.

The repaired pixel electrode cannot function normally since the signal of source bus line 23 is continuously applied to pixel electrode 41 (the repaired pixel electrode), connected to repaired TFT 31 in the manner set forth above. However, since pixels displayed by the repaired pixel electrode are displayed as the equivalents of the effective value of the signal applied to source bus line 23, the pixel becomes neither a totally bright nor totally dark point, but is displayed with a brightness equivalent to the average of pixels aligned along source bus line

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23. This pixel thus becomes a pixel defect that is extremely hard to detect.

Despite the use of laser irradiation, as described above, no melted metal or the like contaminates liquid crystal layer 18, which is the display medium, since protective film 17 is formed over gate bus branch line 22 and TFT 31, thus display is not affected. Moreover, it was found that by varying the irradiation characteristics of the laser it was possible to use the same laser both to connect metal layers by fusion and to cut them.

The configuration of this invention also lends itself to an active matrix display having additional capacitance 42 as shown in Fig. 4. Fig. 4 shows the Practical Example of Figs. 1-3 provided with additional capacitance 42. Additional capacitance

42 is provided by the portion (hatched) of additional capacitance electrode 24, positioned parallel to gate bus line 21 on substrate 1, that overlaps pixel electrode 41. Pixel defects can be repaired in the display device of Fig. 4 in the same manner as in the Practical Example of Figs. 1-3.

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This invention is also suitable to an active matrix display having the configuration shown in Figure 5. This display eliminates the shortcoming of the display of Fig. 4 which was reducing the pixel area by the portion allocated to additional capacitance 42. The width of gate bus line 21 in this display is increased so that it overlaps a portion of pixel electrode 41. In this configuration, adjacent non-selected gate bus line 21 can be used as an electrode for additional capacitance. Moreover, since there is no space between gate bus line 21 and additional capacitance electrode 24, as shown in Figure 4, pixel area reduction can be suppressed. Pixel defects are also repaired in this display device in the same manner as in the Practical Example of Figs. 1-3.

Fig. 6 shows a planar view of the active matrix substrate based on another method of manufacturing displays of this invention. Fig. 7A is an enlargement of the vicinity of the conductive layer 34 in Fig. 6. Fig. 7B is a cross-section of

Fig. 6 along line VII-VII. The cross-section of the display that employs the substrate of Fig. 6 along lines III'-III' in Fig. 6 /23 is the same as in the above-described Fig. 3. The method of manufacturing active matrix displays of this Practical Example will be explained according to the manufacturing method. In this Practical Example, too, a transparent glass substrate was used as an insulating substrate. Gate bus line 21, functioning as a scanning line, and gate bus branch line 22, diverging from gate bus line 21, and conductive layer 34 were formed on glass substrate 1. Gate bus line 21 and gate bus branch line 22 were formed of Ta. Conductive layer 34 was formed of the same metal as gate bus branch line 21. Gate bus line 21 and gate bus branch line 22, and conductive layer 34 were formed by patterning a layer of Ta formed by sputtering. Prior to forming gate bus line 21, gate bus branch line 22, and conductive layer 34 a base coating can be formed of Ta_2O_5 or the like on glass substrate 1.

A base insulating film 11 was formed of SiN_x over the entire surface of the gate bus line 21, gate bus branch line 22, and conductive layer 34. Gate insulating film 11 was formed to a thickness of 3,000 Å by plasma CVD.

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TFT 31, functioning as a switching element, was then formed on the tip of the gate bus branch line 22. The cross-sectional configuration of TFT 31 is the same as described above in Fig. 3. Part of the gate bus branch line 22 functions as the gate electrode 25 of TFT 31. After forming gate insulating film 11 as described above, an a-Si layer was deposited to a thickness of 300 Å and a SiN_x layer was deposited to a thickness of 2,000 Å. The SiN_x film was then patterned to form etching stopper film 13. Layers of n^+ type a-Si to which P (phosphorus) had been added, were then deposited by plasma CVD to a thickness of 800 Å over the entire surface of the a-Si layer and the etching stopper 13 layer to form channel layer 12 and contact layers 14, 14.

Next, a Ti layer was formed by sputtering. The Ti metal layer was patterned to form a source electrode 32, source bus line 23, a drain electrode 33, and conductive chip 35. Source

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Source bus line 23 intersects gate bus line 21; the two sandwich the above-mentioned gate insulating film 11 between them. Moreover, as indicated in Fig. 7B, source bus line 23 is formed so as to overlap the gate insulating film 11 at one of the tips of conductive layer 34, said film 11 being sandwiched between them. Conductive layer 34 is formed to sandwich gate insulation film 11 over the other tip of conductive layer 34 that is not overlapped by the source bus line 23.

As shown in Figure 6, pixel electrode 41 made of ITO (indium tin oxide) is formed in the rectangular area enclosed by gate bus lines 21 and source bus lines 23. Pixel electrode 41 overlaps the tip of drain electrode 33 of TFT 31 and is electrically connected to drain electrode 33. As indicated in Fig. 7B, pixel electrode 41 overlaps also conductive chip 35 and is electrically connected thereto.

A protective film 17 made of SiN_x was deposited over the entire surface of the substrate on which pixel electrode 41 was formed. An orientation film 19 was formed over protective film 17. A counter electrode 3 and an orientation film 9 were formed on a glass substrate 2 opposite glass substrate 1. A liquid

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crystal layer 18 was sealed between substrates 1 and 2.

Drive voltage from the gate bus line 21 and source bus line 23 is applied to every pixel electrode 41 via TFT 31, and pixel defects are detected. Pixel defects are produced when TFT 31 malfunctions or there is a weak leakage current between source bus line 23 and pixel electrode 41. As soon as the location of pixel defect is confirmed, repairs can be effected in the following manner. First, the overlapping area 61 of the source bus line 23 and conductive layer 34 (section marked by arrow 65 in Fig. 7B) marked by broken lines in Fig. 7A, as well as the overlapping area 62 of conductive layer 34 and conductive chip 35 (marked by arrow 64 in Fig. 7B) are irradiated with luminous energy. In this manner, source bus line 23 is electrically connected to conductive layer 34, and conductive chip 35. Since conductive chip 35 is electrically connected to pixel electrode

41, pixel electrode 41 is thus electrically connected to source bus line 23.

Since the signal of source bus line 23 is continuously /27 applied to pixel electrode 41 (the repaired pixel electrode), directly connected source bus line 23 in the manner set forth above, the pixel displayed by the repaired pixel electrode becomes neither a totally bright nor totally dark point, but is displayed with a brightness equivalent to the average of pixels aligned along source bus line 23. This pixel thus becomes a pixel defect that is extremely hard to detect.

Despite the use of laser irradiation, as described above, no melted metal or the like contaminates liquid crystal layer 18, which is the display medium, since protective film 17 is formed over the overlapping part conductive layer 34 and source bus line 23, as well as the overlapping portion of conductive layer 34 and conductive chip 35, thus display is not affected.

As shown in Fig. 8, the configuration of Fig. 6, also lends itself to an active matrix display having additional capacitance 42. The substrate of Fig. 8, similar to that of Fig. 4, has conductive layer 34 and conductive chip 35 installed on an active matrix substrate, that has an additional capacitance 42 thereon.

Pixel defects can be repaired in the display device of Fig. 8 in the same manner as in the Practical Example of Fig. 6.

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The configuration of Fig. 6 is also suitable to an active matrix display having the configuration shown in Figure 9. This display suppresses the reduction of the pixel area by the portion allocated to additional capacitance 42. Pixel defects are also repaired in this display device in the same manner as in the Practical Example of Fig. 6.

All the Practical Examples set forth above show the gate electrode of TFT 31 formed below and the source and drain electrodes formed above, but a TFT of a type in which the gate electrode is formed above and the source and drain electrodes are formed below can also be used.

Furthermore, TFTs were used as switching elements in all the Practical Examples set forth above, but any switching element in which the signal line side electrode and the electrode on the pixel electrode side can be electrically connected by light energy from a laser or the like is suitable for use in this invention.

(Effect of the Invention)

Based on the method of manufacturing active matrix display /29 of this invention, a display can be obtained wherein pixel defects can be readily detected and repaired in such a way as to be rendered inconspicuous. This invention thus permits the high yield production of display devices, contributing to reducing the cost of display devices.

4. Brief Description of the Figures

Fig. 1 is a planar view of an active matrix substrate according to the method of manufacturing display device of this invention. Fig. 2 is an enlarged planar view of the vicinity of the TFT of Fig. 1. Fig. 3 is a cross-section of Fig. I along lines III-III. Figs. 4 and 5 show planar views of other active matrix substrates featuring additional capacitance according to the manufacturing method of this invention. Fig. 6 shows planar views of other active matrix substrates based on the manufacturing method of this invention. Fig. 7A is an enlarged plan of the vicinity of conductive layer of Fig. 6. Fig. 7B is a cross-section of Fig. 6 along lines VII-VII. Figs. 8 and 9 are planar views of substrates featuring additional capacitance based on the manufacturing method of this invention. Fig. 10 shows the relation between the signal applied to the scanning and signal lines and the voltage of the pixel electrode. Figs. 11 and 12 show planar views of active matrix substrates employed in active matrix displays of Prior Art.

1, 2 - glass substrates; 3 - counter electrode; 9, 19 - orientation film; 11 - gate insulating film; 12 - channel layer; 13 - etching stopper layer; 14 - contact layer; 18 - liquid crystal layer; 21 - gate bus line; 22 - gate bus branch line; 23 - source bus line; 24 - additional capacitance electrode; 25 - gate electrode; 31 - TFT; 32 - source electrode; 33 - drain electrode; 34 - conductive layer; 35 - conductive chip; 41 - pixel electrode; 42 - additional capacitance.

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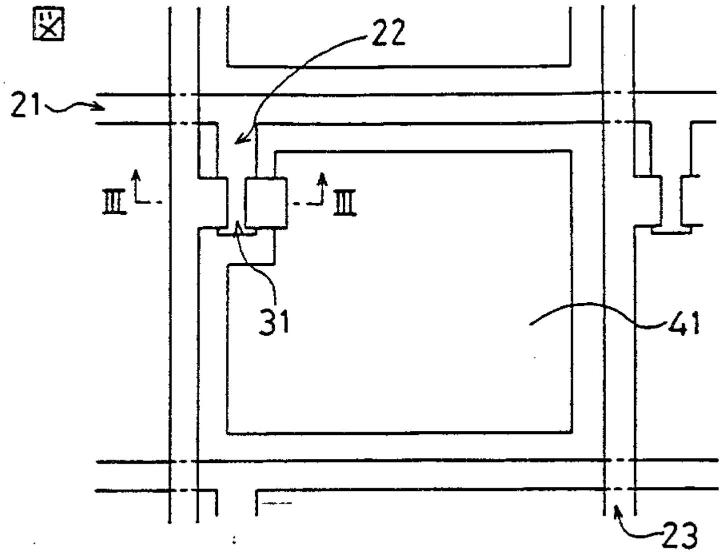
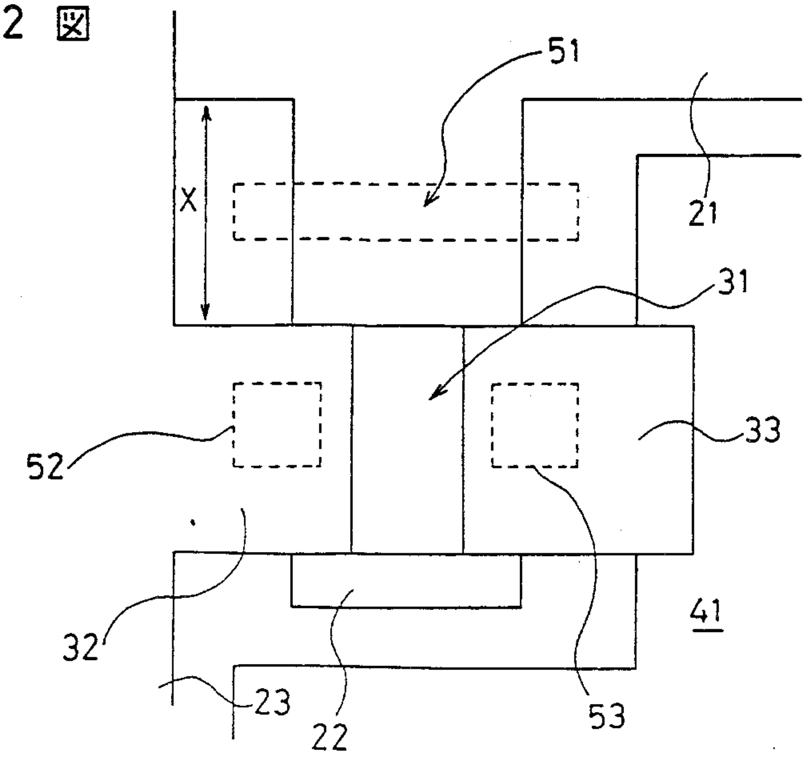
Key to Figure 10:

1 - selection time (T_{ON}); 2 - non-selection time (T_{OFF})

第 1 図



第 2 図



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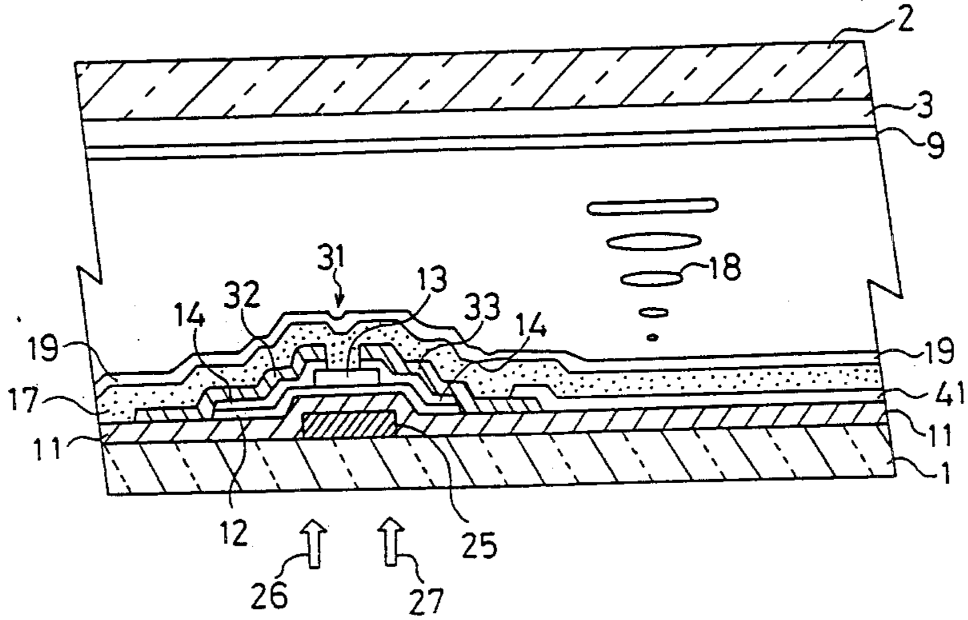
第 3 図



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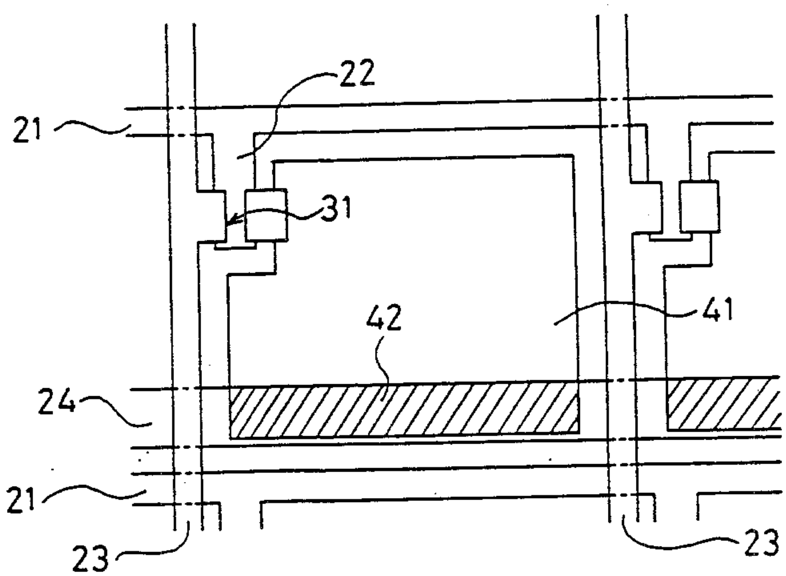
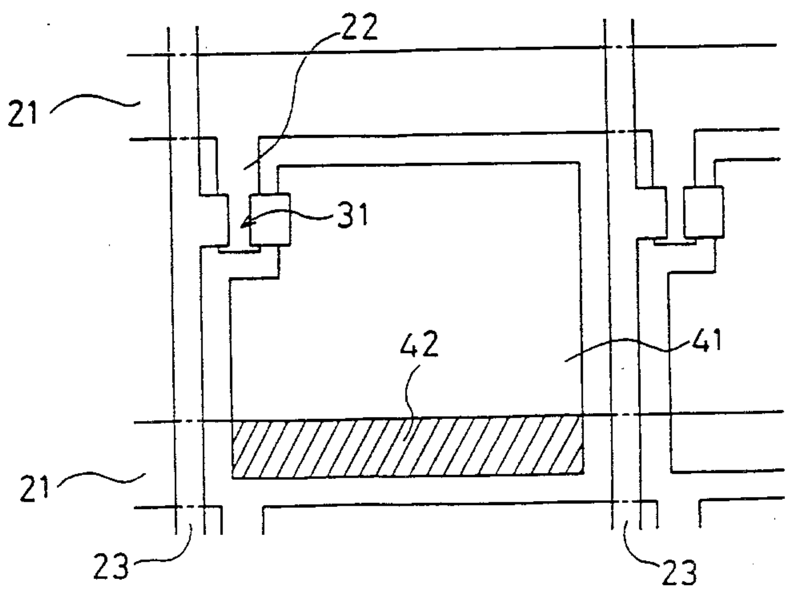
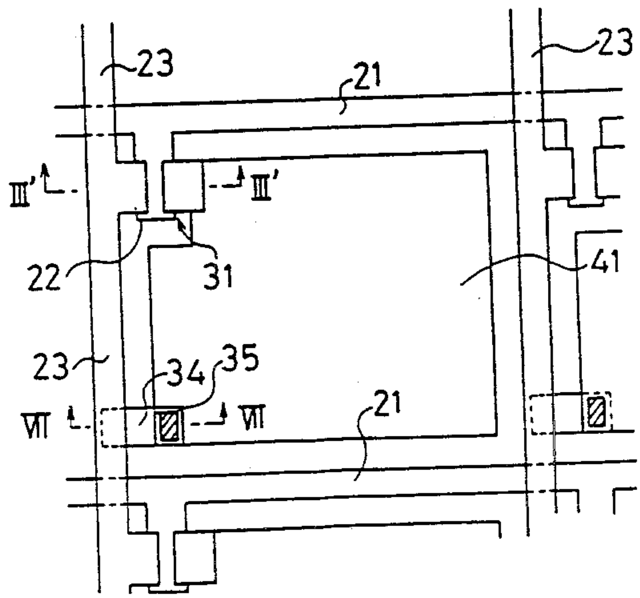
第４図



第５図



第 6 図



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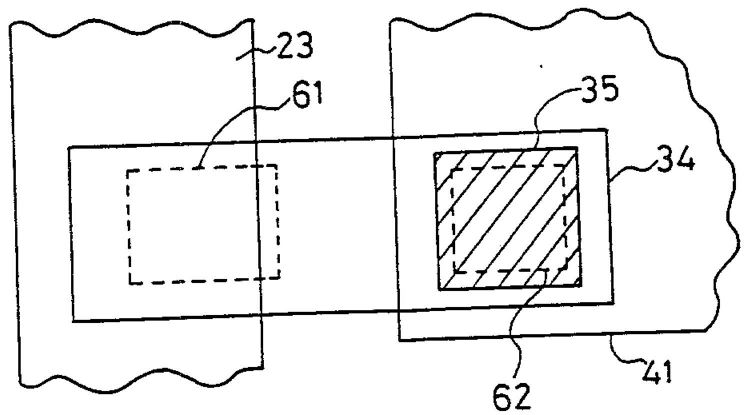
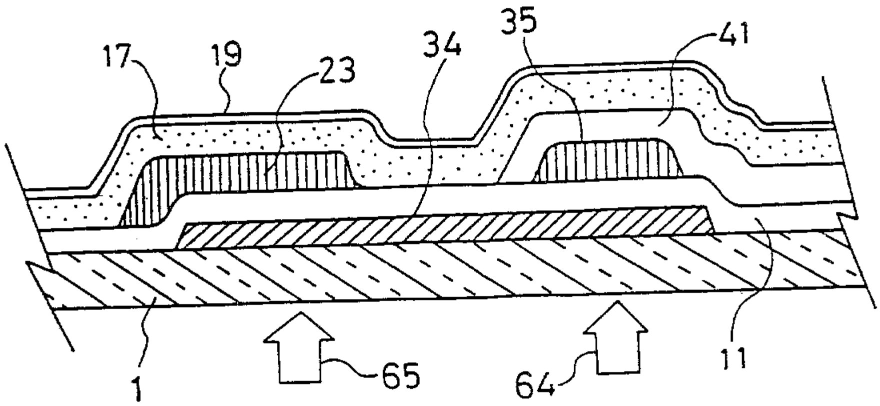
SHC 001430

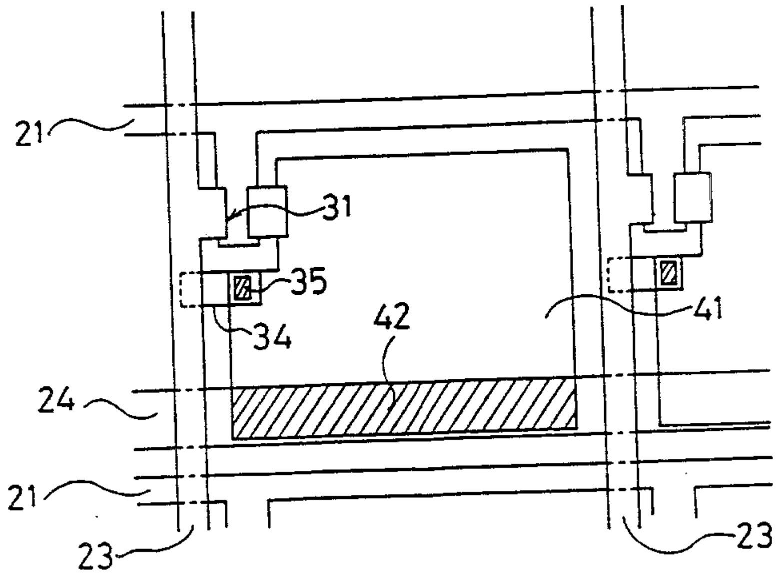
第７Ａ図



第７Ｂ図



第８図



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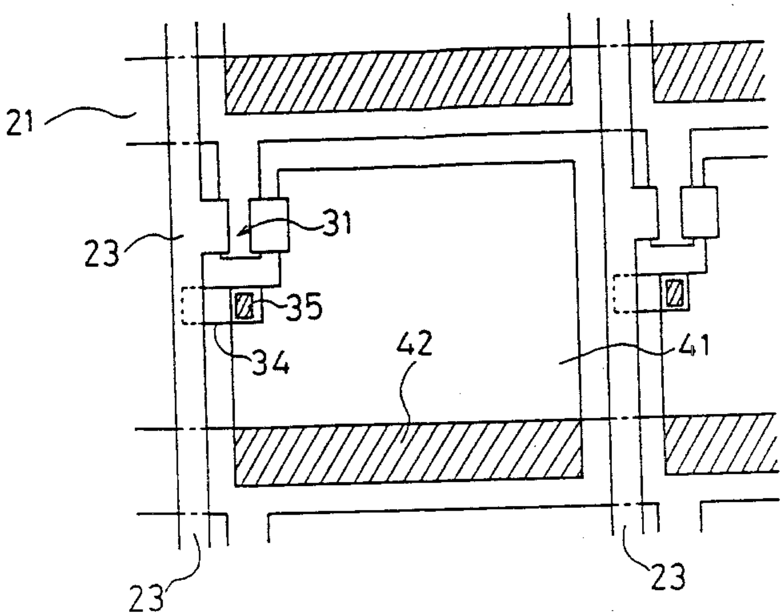
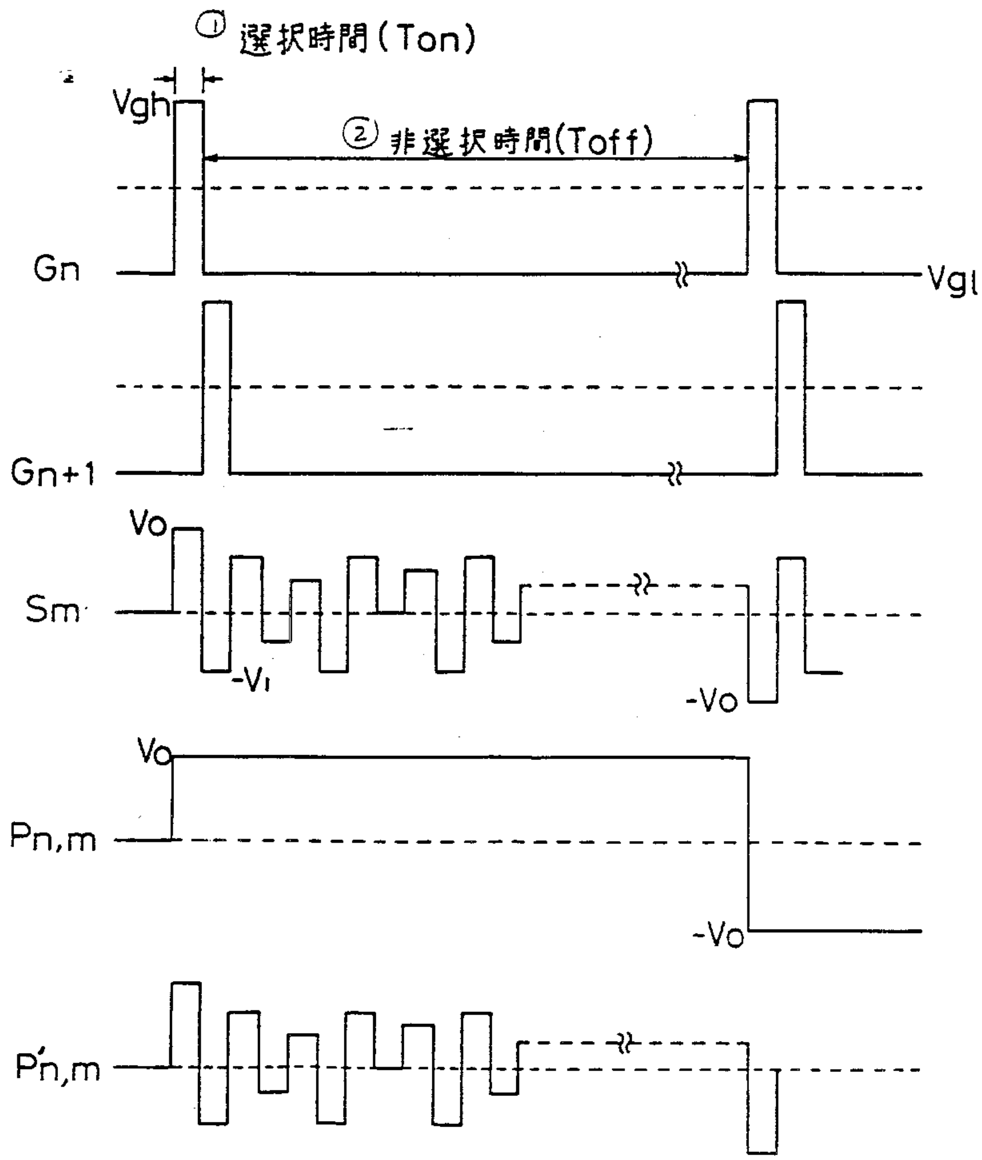
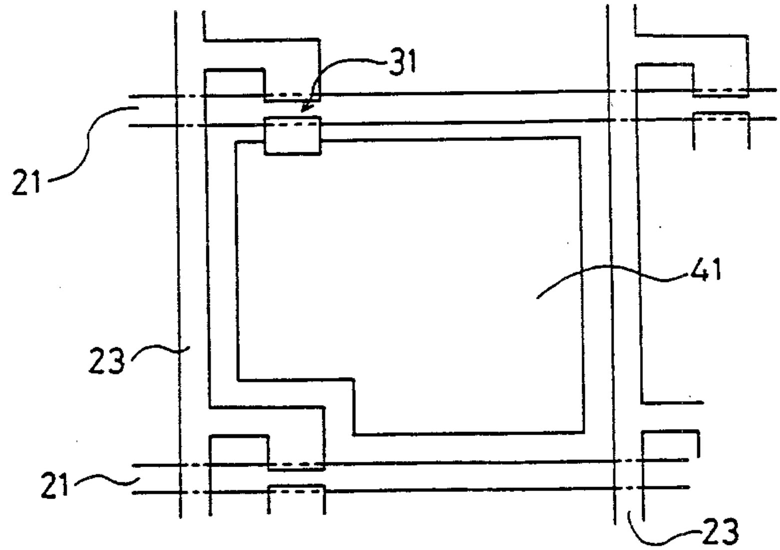


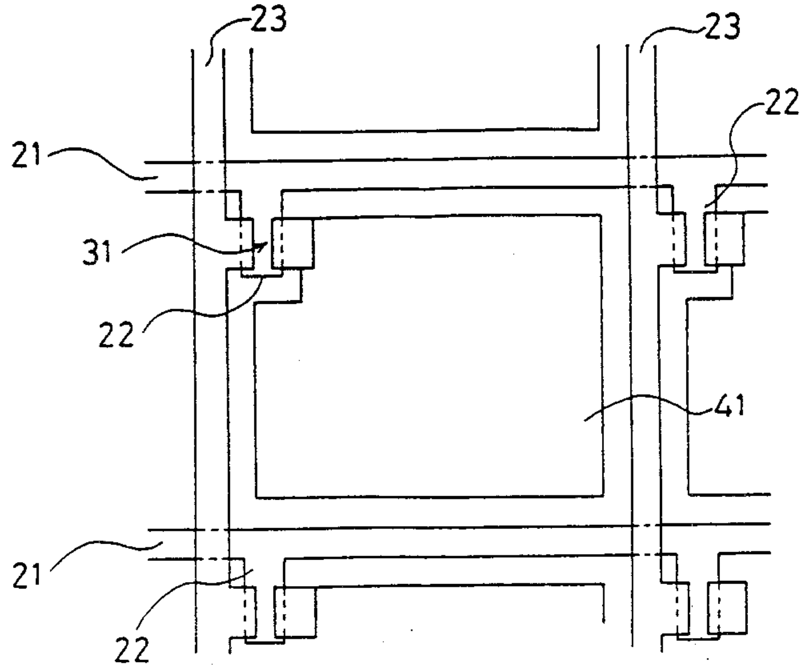
第10図



第11 図



第12 図



日本国特許庁
PATENT OFFICE
JAPANESE GOVERNMENT

別紙添付の書類は下記の出願書類の謄本に相違ないことを証明する。
This is to certify that the annexed is a true copy of the following application as filed with this Office.

出願年月日 Date of Application:	1990年6月4日
出願番号 Application Number:	平成2年特許願第146857号
出願人 Applicant (s):	シャープ株式会社

1990年 11月 14日

特許庁長官
Commissioner,
Patent Office

植松 敏

出証平 2－65536

SHC 001435

国際特許分類	
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G02F	1/133

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特　許　願　(2)

平成2年6月4日

特許庁長官殿

1．発明の名称

アクティブマトリクス型表示装置

2．請求項の数：1

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特許庁 2.6.6

2　146357

[redacted]

方式審査　小松

SHC 001436

6．添付書類の目録

(1)委任状　　1通

(2)願書副本　　1通

(3)明細書　　1通

(4)図面　　1通

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明　細　書

1．発明の名称

アクティブマトリクス型表示装置

2．特許請求の範囲

1．少なくとも一方が透光性を有する一対の絶縁性基板と、該一対の基板の何れか一方の基板上に配線された走査線と、該走査線から分岐した走査支線と、該走査支線の先端部に形成されたスイッチング素子と、該スイッチング素子に接続された絵素電極と、を備えたアクティブマトリクス型表示装置であって、

該走査支線が、該走査支線の該スイッチング素子が形成されている部分以外の部分に於いて、該走査支線の該スイッチング素子が形成されている部分より幅の小さい部分を有するアクティブマトリクス型表示装置。

3．発明の詳細な説明

（産業上の利用分野）

本発明は、表示用絵素電極にスイッチング素子を介して駆動信号を印加することにより、表示を