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(54) DISPLAY DEVICE

(75) Inventor: Katsuya Anzai, Anpachi-gun (JP)

Correspondence Address:
MORRISON & FOERSTER LLP
1650 TYSONS BOULEVARD
SUITE 300
MCLEAN, VA 22102 (US)

(73) Assignee: Sanyo Electric Co., Ltd., Moriguchi-City (JP)

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(57) ABSTRACT

A source of a driving transistor for driving an organic EL element functions as a first capacitance electrode layer. A second capacitance electrode layer is formed on the source through a gate insulating film of the driving transistor. The second capacitance electrode layer is formed with the same layer and by the same process as the gate electrode. A third capacitance electrode layer is formed extending over the second capacitance electrode layer through the interlayer insulating film. The third capacitance electrode layer is formed with the same layer as the drain electrode and the drain signal line. The third capacitance electrode layer is connected to the source of the driving transistor. The forming area of the storage capacitance element for holding the video signal supplied to the gate of the driving transistor can be thus reduced, improving display quality as well as extending life span of the organic El element.

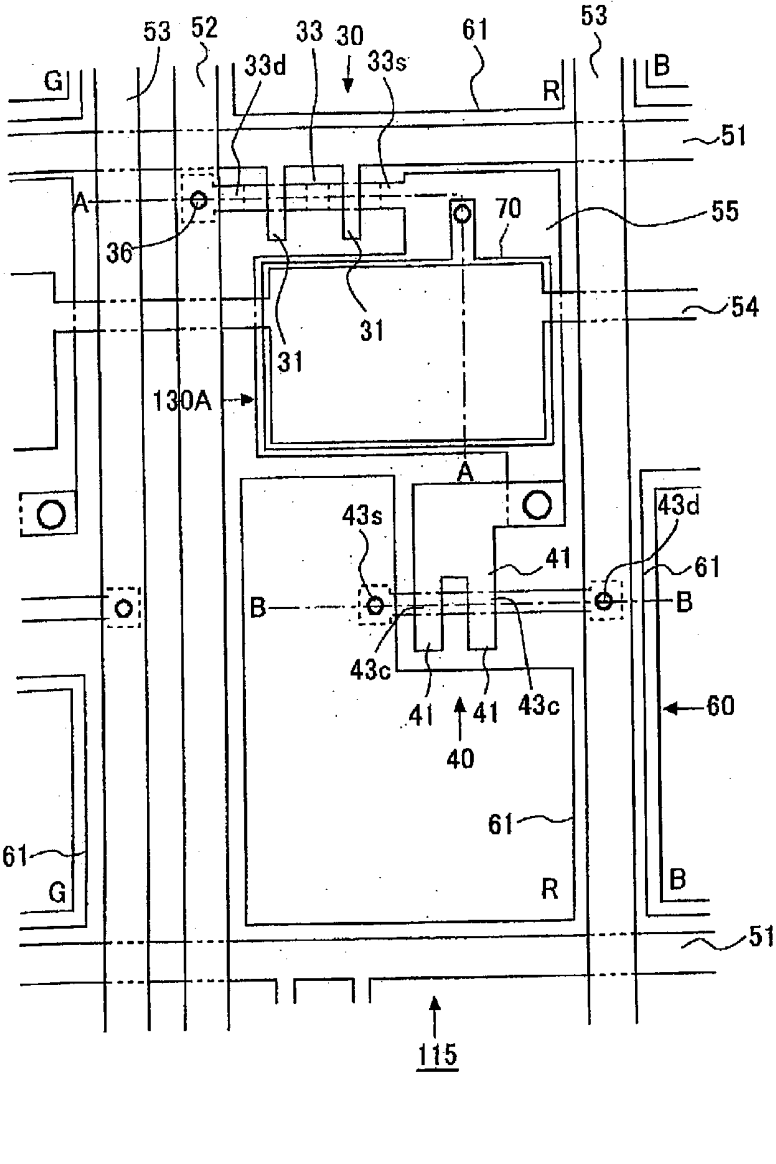


FIG. 1

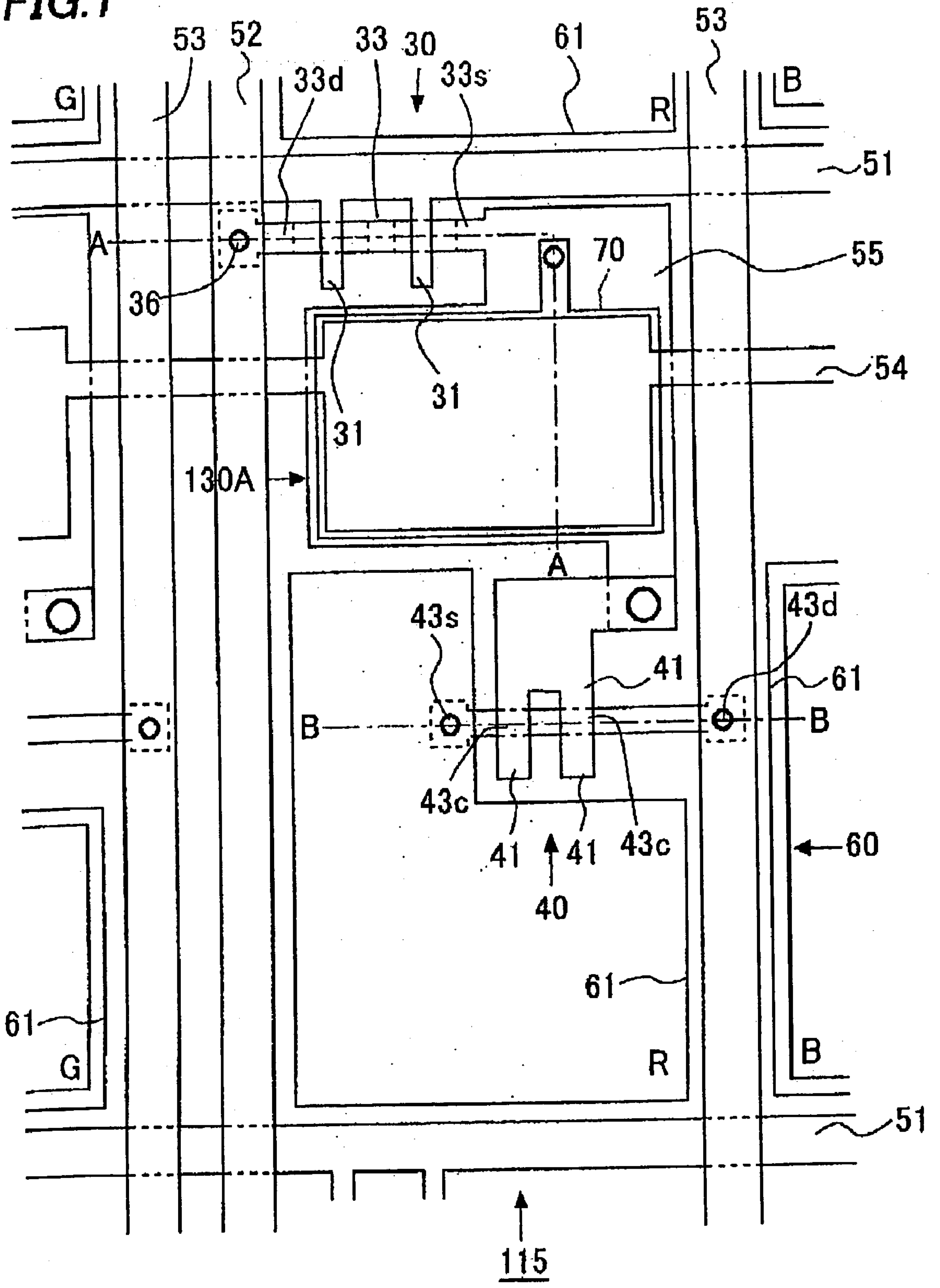

53
52
33
30
33d
33s
61
53
G
R
B
51
A
36
70
55
31
31
54
31
130A
A
43s
43d
41
61
B
B
43c
43c
41
41
40
60
61
61
G
R
B
51
115

FIG.2A

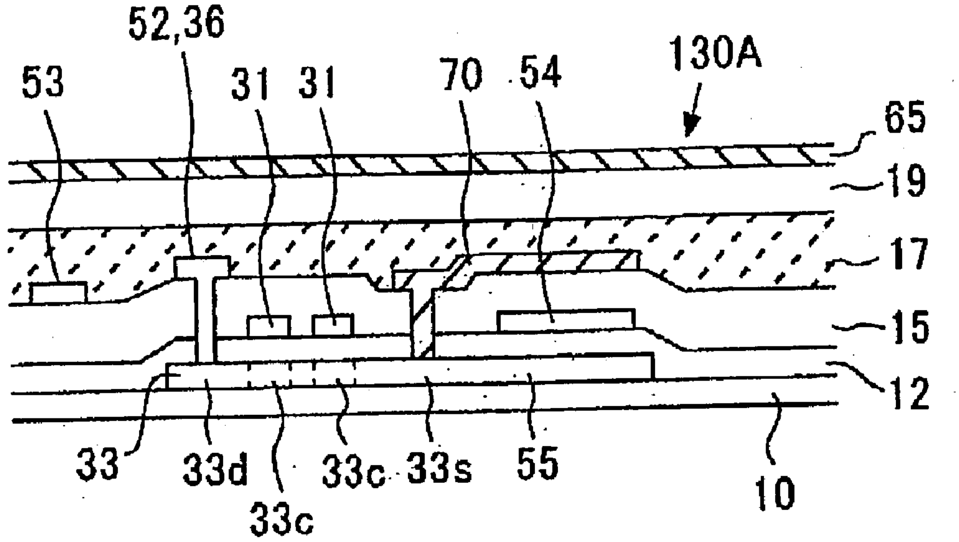

52,36
53
31
31
70
54
130A
65
19
17
15
12
10
33
33d
33c
33c
33s
55

FIG.2B

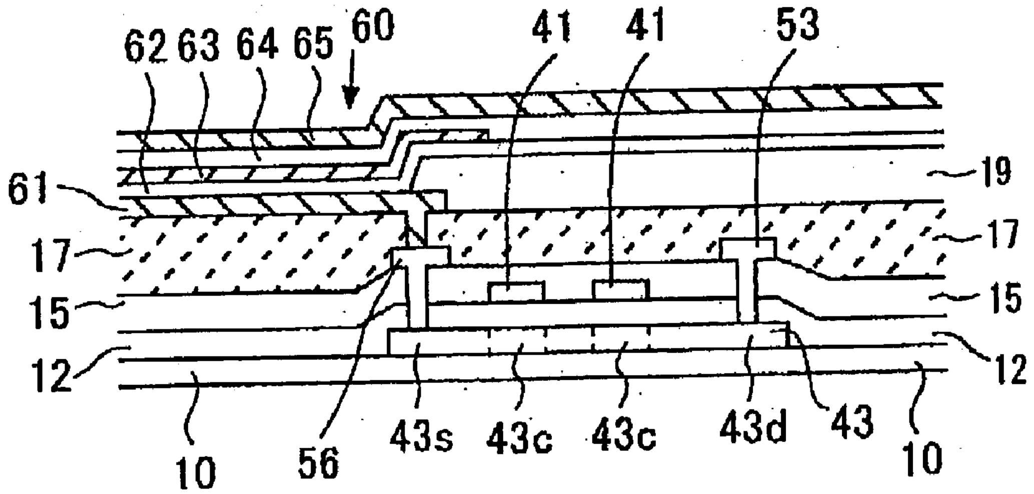

62
63
64
65
60
41
41
53
61
19
17
17
15
15
12
12
10
10
56
43s
43c
43c
43d
43

FIG.3A

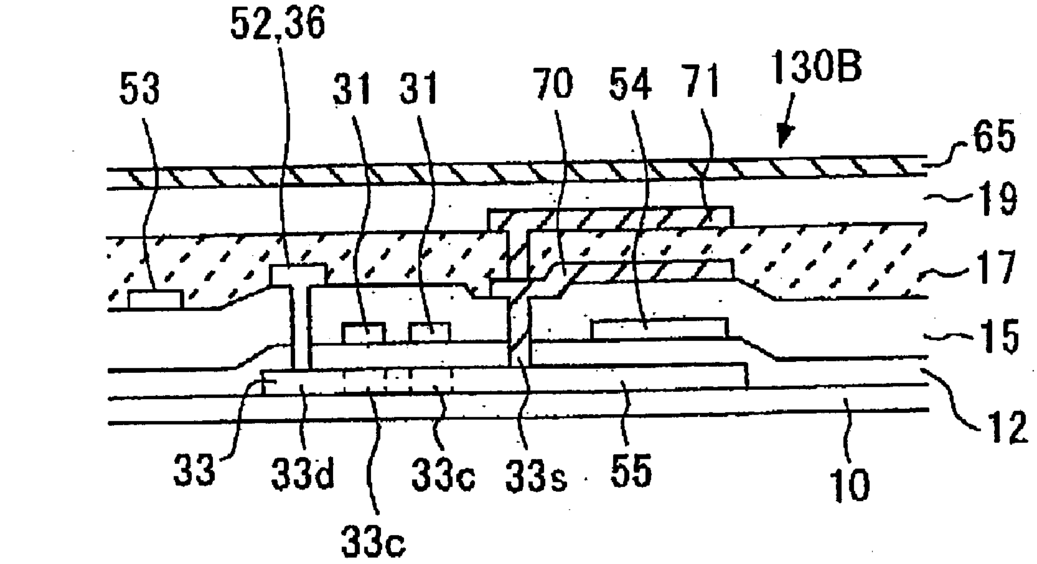

52,36
53
31 31
70 54 71
130B
65
19
17
15
12
33 33d 33c 33s 55 10
33c

FIG.3B

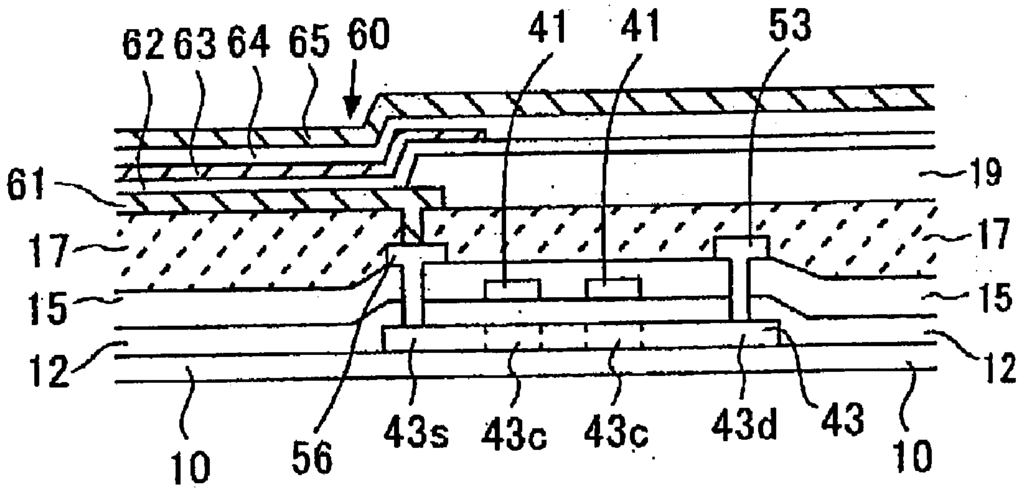
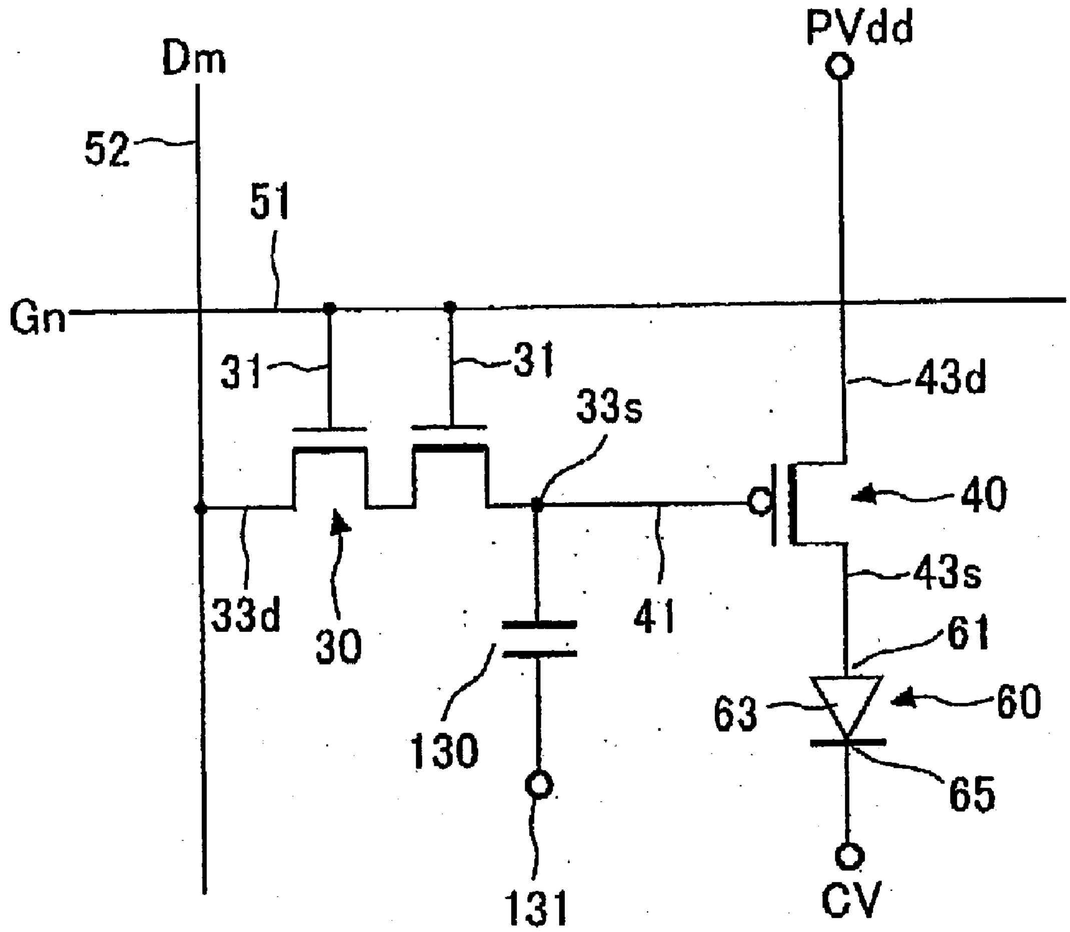
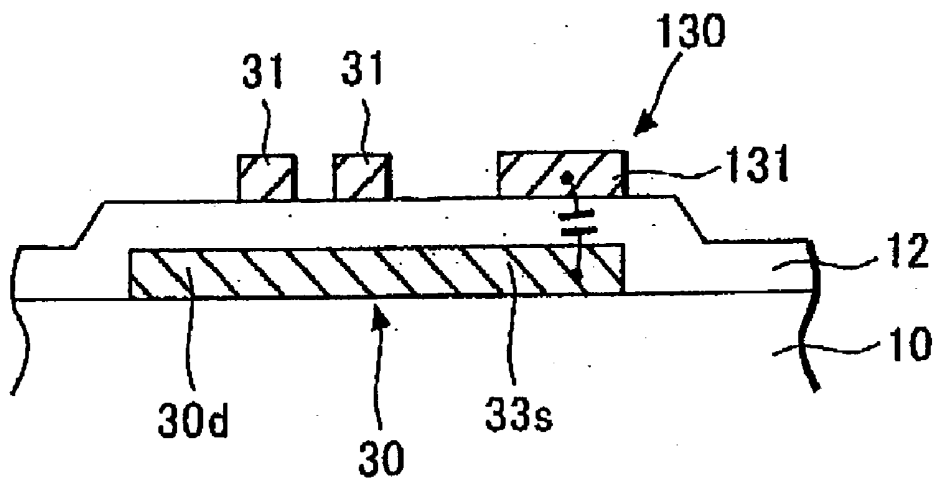

62 63 64 65 60
41 41
53
61
19
17
17
15
15
12
12
10 56 43s 43c 43c 43d 43 10

FIG.4



Dm
52
51
Gn
31
31
33s
PVdd
43d
40
33d
30
41
43s
61
60
63
130
65
131
CV

FIG.5



130
31
31
131
12
10
30d
30
33s

DISPLAY DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates to an electroluminescent display device, especially to an electroluminescent display device with a storage capacitance element for holding a video signal supplied to a gate of a driving transistor.

[0003] 2. Description of the Related Art

[0004] An electroluminescent (referred to as EL hereinafter) display device with an EL element has been gathering attention as a display device substituting a CRT or an LCD. The development effort for the EL display device with a thin film transistor (referred to as TFT hereinafter) as a switching element for driving the EL element has been made accordingly.

[0005] **FIG. 4** is an equivalent circuit diagram of one pixel of an organic EL display device. A gate signal line **51** for supplying a gate signal Gn and a drain signal line **52** for supplying a drain signal, a video signal Dm, cross each other.

[0006] An organic EL element **60**, a driving TFT **40** for driving the organic EL element **60**, and a pixel selecting TFT **30** for selecting the pixel are disposed near the crossing of the two signal lines. The TFT **40** is P-channel type and the TFT **30** is N-channel type.

[0007] A drain **43***d* of the organic El element driving TFT **40** is provided with a plus source voltage PVdd. A source **43***s* of the TFT **40** is connected to an anode **61** of the organic EL element **60**.

[0008] The gate signal line **51** is connected to a gate **31** of the pixel selecting TFT **30** and provided with the gate signal Gn. The drain signal line **52** is connected to a drain **33***d* of the pixel selecting TFT **30** and provided with the video signal Dm. A source **33***s* of the TFT **30** is connected to a gate **41** of the TFT **40**. The gate signal Gn is outputted from a gate driver circuit not shown in the figure, and the video signal Dm is outputted from a drain driver circuit not shown in the figure.

[0009] Also, the organic EL element **60** includes the anode **61**, a cathode **65**, and an emissive layer **63** inserted between the anode **61** and the cathode **65**. The cathode **65** is provided with a minus source voltage CV.

[0010] A storage capacitance element **130** is connected to the gate **41** of the TFT **40**. That is, one of the electrodes of the storage capacitance element **130** is connected to the gate **41**, and the other electrode is connected to a storage capacitance electrode **131**. The storage capacitance element **130** is disposed in order to hold the video signal Dm of the display pixel for one field period by keeping the electric charge corresponding to the video signal Dm.

[0011] The operation of the EL display device with the above configuration is as follows. The TFT **30** turns on when the gate signal Gn becomes high level for one horizontal period. Then, the video signal Dm is supplied from the drain signal line **52** to the gate **41** of the TFT **40** through the TFT **30**. The conductance of the TFT **40** changes according to the video signal Dm supplied to the gate **41** and the corresponding driving electric current is applied to the organic EL element **60** through the TFT **40**. Thus, the organic EL element **60** emits light.

[0012] **FIG. 5** shows a cross-sectional view of the storage capacitance element **130** mentioned above. The TFT **30** is formed on an insulating substrate **10**. The TFT **30** has the source **33***s*, the drain **33***d*, and the gate **31** formed on a gate insulating film **12**. The storage capacitance electrode **131** is formed on the source **33***s* of the TFT **30** through the gate insulating film **12**. The storage capacitance electrode **131** is provided with a predetermined stable voltage.

[0013] The storage capacitance element **130** is disposed for each of the pixels, in the conventional organic El display device, in order to maintain the voltage applied to the gate of the driving transistor for controlling the quantity of the electric current, which determines the luminescence of the organic El element **60**.

[0014] When the voltage of the video signal Dm supplied to the pixel drops by a large quantity, it will affect the quality of the display. Therefore, a large capacitance value of the storage capacitance element **130** is required. That is, the area of the storage capacitance element **130** should be large.

[0015] There are a top emission type and a bottom emission type among the organic EL display devices. The light emitted from the organic EL element **60** radiates from the side of the organic EL element **60** opposite from the insulting substrate **10** in the top emission type display device. That is, the light radiates from the upper surface of the panel. On the other hand, the light emitted from the organic EL element **60** radiates from the side of the insulting substrate **10** in the bottom emission type display device.

[0016] When the area of the storage capacitance element **130** is large, it does not create any problem in the top emission type organic EL display device. However, the portion where the storage capacitance element is formed works as a blind in the bottom emission type display device, leading to decreased open aperture. In this configuration, the electric current supplied to the organic El element should be increased in order to acquire the necessary luminescence, compared to the case where the device has an enough open aperture. As a result, the life span of the organic EL element is shortened.

SUMMARY OF THE INVENTION

[0017] The invention provides an electroluminescent display device having a plurality of pixel portions. Each of the pixel portions includes an electroluminescent element, a driving transistor driving the electroluminescent element, a drain signal line, and a pixel selecting transistor supplying a signal from the drain signal line to a gate of the driving transistor. The pixel portion also includes a storage capacitance element holding the signal supplied to the gate of the driving transistor. The storage capacitance element includes an extension of a source of the pixel selecting transistor as a first capacitance electrode layer, a second capacitance electrode layer disposed above the extension of the source and a third capacitance electrode layer connected to the source and disposed above the second capacitance electrode layer.

[0018] The invention also provides an electroluminescent display device having a plurality of pixel portions. Each of the pixel portions includes an electroluminescent element having an anode layer, an emissive layer and a cathode layer, a driving transistor driving the electroluminescent element, a drain signal line, and a pixel selecting transistor supplying a signal from the drain signal line to a gate of the driving transistor. The pixel portion also includes a storage capacitance element holding the signal supplied to the gate of the driving transistor. The storage capacitance element includes an extension of a source of the pixel selecting transistor as a first capacitance electrode layer, a second capacitance electrode layer disposed above the extension of the source, a third capacitance electrode layer connected to the source and disposed above the second capacitance electrode layer, a fourth capacitance electrode layer connected to the third capacitance electrode layer and disposed above the third capacitance electrode layer and a fifth capacitance electrode layer disposed above the fourth capacitance electrode layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] **FIG. 1** is a plan view of one pixel portion of an organic EL display device of a first embodiment of this invention.

[0020] **FIGS. 2A and 2B** are cross-sectional views of the pixel portion of **FIG. 1**.

[0021] **FIGS. 3A and 3B** are cross-sectional views of a pixel portion of an organic EL display device of a second embodiment of this invention.

[0022] **FIG. 4** is an equivalent circuit diagram of a pixel portion of a conventional organic El display device.

[0023] **FIG. 5** is a cross-sectional view of the pixel portion of **FIG. 4**.

DETAILED DESCRIPTION OF THE INVENTION

[0024] A first embodiment of this invention will be explained hereinafter. **FIG. 1** is a plan view showing a pixel portion of an organic EL display device. **FIG. 2A** is a cross-sectional view of one pixel portion along the A-A line and, **FIG. 2B** is a cross-sectional view of the pixel portion along the B-B line in **FIG. 1**. The equivalent circuit diagram of the pixel portion is the same as shown in **FIG. 4**.

[0025] The pixel portion **115** is formed in the region surrounded with a gate signal line **51** and a drain signal line **52**, as shown in **FIGS. 1, 2A** and 2B. A plurality of pixel portions is disposed in a matrix configuration, forming a display region.

[0026] An organic EL element **60**, which is a self emissive element, a pixel election TFT **30** for controlling the timing of supplying electric current to the organic EL element **60**, an organic El element driving TFT **40** for supplying electric current to the organic EL element **60**, and a storage capacitance element **130**A are disposed in the pixel portion **115**. The organic EL element **60** includes an anode layer **61**, an emissive layer made of an emissive material and a cathode layer **65**.

[0027] The pixel selecting TFT **30** is disposed near the crossing of a gate signal line **51** a drain signal line **52**. A source **33***s* of the TFT **30** works also as a first capacitance electrode layer **55**, and is connected to a gate **41** of the TFT **40**. A second capacitance electrode layer **54** is formed above the source **33***s* of the TFT **30** through a gate insulating film **12**. The second capacitance electrode layer **54** is made of chrome or molybdenum, and disposed parallel to the gate signal line **51**. Also, a third capacitance electrode layer **70** is formed above the second capacitance electrode layer **54** through an interlayer insulating film **15**.

[0028] A source **43***s* of the organic EL element driving TFT **40** is connected to the anode layer **61** of the organic EL element **60**, and a drain **43***d* is connected to a driving source line **53**, which is an electric source supplied to the organic EL element **60**.

[0029] The organic EL display device includes the TFTs and the organic EL element deposited sequentially on an insulating substrate **10**, which is either a substrate made of a glass, a synthetic resin, a conductive material or a semiconductor, as shown in **FIGS. 2A and 2B**. When a conductive substrate or a semiconductor substrate is used as the insulating substrate **10**, an insulating film **12** such a SiO_2 film or a SiN film should first be disposed before forming the TFTs **30**, **40** and the organic EL element. Both TFTs have a top-gate configuration, where a gate electrode is disposed above an active layer through the gate insulating film **12**.

[0030] Next, the detailed configuration of the pixel selecting TFT **30** and the storage capacitance element **130**A will be explained. An amorphous silicon film (referred to as a-Si film hereinafter) is formed through a CVD method on the insulating substrate. The a-Si film is irradiated by a laser beam for re-crystallization from melt, forming a polycrystalline silicon film (referred to as a p-Si film, hereinafter). This layer functions as the active layer **33**. Single layer or multiple layers of a SiO_2 film and a SiN film are formed on the p-Si film as the gate insulating film **12**.

[0031] Then, the gate signal line **51** also working as the gate electrode **31** made of a metal with a high-melting point such as Cr and Mo as well as the drain signal line **52** made of Al are disposed. Also, the driving source line **53**, which is made of Al and is an electric source of the organic El element **60**, is disposed.

[0032] A SiO_2 film, a SiN film and a SiO_2 film are sequentially deposited to form the interlayer insulating film **15** on the entire surface of the gate insulating film **12** and the active layer **33**. A drain electrode **36**, which is formed by filling a contact hole formed at the location corresponding to the drain **33***d* with a metal such as Al, is disposed, and a first planarization film **17** made of an organic resin for flattening the surface is formed on the entire surface.

[0033] Next, the configuration of the storage capacitance element **130**A will be explained. The source **33***s* of the TFT **30** functions also as the first capacitance electrode layer **55** The second capacitance electrode layer **54** is formed above the source **33***s* of the TFT **30**, through the gate insulating film **12**. The second capacitance electrode layer **54** is made of Cr or Mo, and formed in the same layer as the gate electrode **31** and by the same process as the gate electrode **31**. The third capacitance electrode layer **70** extends over the second capacitance layer **54** through the interlayer insulating film **15**. The third capacitance layer **70** is formed in the same layer as, and by the same process as the drain electrode **36** and the drain signal line **52**. The third capacitance electrode layer **70** is connected to the source **33***s* of the TFT **30** through a contact hole.

[0034] That is, the storage capacitance element **130** has a multiple-layer configuration with the second capacitance electrode layer **54** sandwiched by the first capacitance electrode layer **55** and the third capacitance electrode layer **70** through the insulating films. Therefore, the storage capacitance element **130** can form a large capacitance in a relatively small area.

[0035] It is also possible to acquire the larger capacitance by extending the cathode layer **65** over the third capacitance electrode layer **70** through the first planarization film **17** and a second planarization film **19**.

[0036] Next, the organic EL element driving TFT **40** will be explained. The a-Si film is formed on the insulating substrate **10**. The a-Si film is irradiated by a laser beam for forming a poly-crystalline silicon film functioning as an active layer **43**. The gate insulating film **12**, and the gate electrode **41** made of a metal with a high-melting point such as Cr and Mo are deposited on the active layer **43**. Channels **43***c* are formed in the active layer **43**. The source **43***s* and the drain **43***d* are also formed at both sides of the channels **43***c*. A SiO_2 film, a SiN film and a SiO_2 film are sequentially deposited to form the interlayer insulating film **15** on the entire surface of the gate insulating film **12** and the active layer **43**. The driving source line **53**, which is connected to the driving source by filling a contact hole formed at the location corresponding to the drain **43***d* with a metal such as Al, is disposed. A source electrode **56** is also formed by filling a contact hole formed at the location corresponding to the source **43***s* with a metal such as Al.

[0037] Furthermore, the first planarization film **17** made of an organic resin for flattening the surface is deposited on the entire surface. A contact hole is formed in the first planarization film **17** at the location corresponding to the source electrode **56**. The anode layer **61** of the organic EL element, which is a transparent electrode made of ITO, making contact with the source electrode **56** through the contact hole described above is formed on the first planarization film **17**. The second planarization film **19** is further disposed on the first planarization film **17**. This film is removed from the area above the anode layer **61**.

[0038] The organic EL element **60** includes the anode layer **61** made of the transparent electrode such as ITO (Indium Tin Oxide), a hole transportation layer **62** having a first hole transportation layer made of MTDATA (4,4-bis(3-mathylphenylphenylamino) biphenyl) and a second hole transportation layer made of TPD (4,4,4-tris (3-methylphenylphenylamino) triphenylanine), an emissive layer **63** made of Bebq2 (bis(10-hydroxybenzo[h]quinolinato)beryllium) including quinacridone derivative, an electron transportation layer **64** made of Bebq2, and the cathode layer **65** made of either magnesium-indium alloy, aluminum or aluminum alloy.

[0039] The holes inputted from the anode layer **61** and the electrons inputted from the cathode layer **65** are re-combined in the emissive layer of the organic EL element **60**, activating organic molecules in the emissive layer. When the activated molecules are deactivated due to radiation, light is emitted from the emissive layer, and light then reaches outside through the transparent anode layer **61** and the insulating substrate **10**.

[0040] Next, a second embodiment of this invention will be explained. **FIGS. 3A and 3B** are cross-sectional views of one pixel portion of this embodiment. **FIG. 3A** is a cross sectional view of the pixel portion along the A-A line of **FIG. 1**, and **FIG. 3B** is a cross sectional view along the B-B line of **FIG. 1**, respectively. The structure f the pixel portion of this embodiment is the same as that of the first embodiment except the capacitance electrode structure described below. The equivalent circuit diagram of the pixel portion of this embodiment is also the same as shown in **FIG. 4**.

[0041] The storage capacitance element **130**A has a multiple-layer configuration with the second capacitance electrode layer **54** sandwiched by the first capacitance electrode layer **55** and the third capacitance electrode layer **70** through the insulating films in the first embodiment. The storage capacitance element **130**B of the second embodiment has an additional electrode layer to increase capacitance per unit area.

[0042] A fourth capacitance electrode layer **71** is deposited extending over the third capacitance electrode layer **70** through the first planarization layer **17** in addition to the configuration of the first embodiment. The fourth capacitance electrode layer **71** is in the same layer as and formed by the same process as the anode layer **61**.

[0043] Additionally, the cathode layer **65** is deposited extending over the fourth capacitance electrode layer **71** through the second planarization layer **19**. The cathode layer **65** functions as a fifth capacitance electrode layer.

[0044] In the first embodiment, a capacitance is formed between the third capacitance electrode layer **70** and the cathode layer **65** when the cathode electrode is used as a fourth capacitance electrode layer. Both the first planarization film **17** and the second planarization film **19** function as the capacitance insulating film in this configuration. In the second embodiment, however, a capacitance is formed between the fourth capacitance electrode layer **71** and the cathode layer **65**, i.e., the fifth capacitance electrode. Since the second planarization layer **19** is the only layer working as the capacitance insulating layer in this configuration, the capacitance insulating film between the capacitance electrodes facing each other is thinner compared to that of the first embodiment. Accordingly, the corresponding capacitance increases.

What is claimed is:

1. An electroluminescent display device having a plurality of pixel portions, each of the pixel portions comprising:

an electroluminescent element;

a driving transistor driving the electroluminescent element;

a drain signal line;

a pixel selecting transistor supplying a signal from the drain signal line to a gate of the driving transistor; and

a storage capacitance element holding the signal supplied to the gate of the driving transistor, the storage capacitance element including an extension of a source of the pixel selecting transistor as a first capacitance electrode layer, a second capacitance electrode layer disposed above the extension of the source and a third capacitance electrode layer connected to the source and disposed above the second capacitance electrode layer.

2. The electroluminescent display device of claim 1, wherein the second capacitance electrode layer is in a same wiring layer as a gate of the pixel selecting transistor.

3. The electroluminescent display device of claim 1, further comprising a gate insulating film of the pixel selecting transistor, wherein a part of the gate insulating film is disposed between the first and second capacitance electrode layers.

4. The electroluminescent display device of claim 1, wherein the third capacitance electrode layer is in a same wiring layer as the drain signal line.

5. The electroluminescent display device of claim 1, further comprising an interlayer insulating film disposed between the gate of the pixel selecting transistor and the drain signal line, wherein a part of the interlayer insulating film is disposed between the second and third capacitance electrode layers.

6. The electroluminescent display device of claim 1, further comprising a cathode electrode layer of the electroluminescent element, the cathode electrode layer extending over the third capacitance electrode layer and being configured to work as a fourth capacitance electrode layer of the storage capacitance element.

7. An electroluminescent display device having a plurality of pixel portions, each of the pixel portions comprising:

an electroluminescent element including an anode layer, an emissive layer and a cathode layer;

a driving transistor driving the electroluminescent element;

a drain signal line;

a pixel selecting transistor supplying a signal from the drain signal line to a gate of the driving transistor; and

a storage capacitance element holding the signal supplied to the gate of the driving transistor, the storage capacitance element including an extension of a source of the pixel selecting transistor as a first capacitance electrode layer, a second capacitance electrode layer disposed above the extension of the source, a third capacitance electrode layer connected to the source and disposed above the second capacitance electrode layer, a fourth capacitance electrode layer connected to the third capacitance electrode layer and disposed above the third capacitance electrode layer and a fifth capacitance electrode layer disposed above the fourth capacitance electrode layer.

8. The electroluminescent display device of claim 7, wherein the second capacitance electrode layer is in a same wiring layer as a gate of the pixel selecting transistor.

9. The electroluminescent display device of claim 7, further comprising a gate insulating film of the pixel selecting transistor, wherein a part of the gate insulating film is disposed between the first and second capacitance electrode layers.

10. The electroluminescent display device of claim 7, wherein the third capacitance electrode layer is in a same wiring layer as the drain signal line.

11. The electroluminescent display device of claim 7, further comprising an interlayer insulating film disposed between the gate of the pixel selecting transistor and the drain signal line, wherein a part of the interlayer insulating film is disposed between the second and third capacitance electrode layers.

12. The electroluminescent display device of claim 7, wherein the fourth capacitance electrode layer is in a same wiring layer as the anode layer.

13. The electroluminescent display device of claim 7, further comprising a planarization layer disposed on the drain signal line, wherein a part of the planarization layer is disposed between the third and fourth capacitance electrode layers.

14. The electroluminescent display device of claim 7, wherein the fifth capacitance electrode layer is an extension of the cathode layer.

15. The electroluminescent display device of claim 7, further comprising a planarization layer disposed partially on the anode layer, wherein a part of the planarization layer is disposed between the fourth and fifth capacitance electrode layers.

* * * * *

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[标]申请(专利权)人(译)	三洋电机株式会社		
申请(专利权)人(译)	SANYO ELECTRIC CO. , LTD.		
当前申请(专利权)人(译)	SANYO ELECTRIC CO. , LTD.		
[标]发明人	ANZAI KATSUYA		
发明人	ANZAI, KATSUYA		
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摘要(译)

用于驱动有机EL元件的驱动晶体管的源极用作第一电容电极层。通过驱动晶体管的栅极绝缘膜在源极上形成第二电容电极层。第二电容电极层由与栅电极相同的层和通过相同的工艺形成。形成第三电容电极层，其通过层间绝缘膜在第二电容电极层上延伸。第三电容电极层形成有与漏电极和漏极信号线相同的层。第三电容电极层连接到驱动晶体管的源极。因此，可以减小用于保持提供给驱动晶体管的栅极的视频信号的存储电容元件的形成区域，从而提高显示质量并延长有机EL元件的寿命。