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Nishikawa et al.

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(54) **ELECTROLUMINESCENT DISPLAY DEVICE**

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(51) **Int. Cl.**
H05B 33/22 (2006.01)
(52) **U.S. Cl.** **313/500**; 313/504
(58) **Field of Classification Search** 313/504, 313/506, 507, 508, 509, 500
See application file for complete search history.

(56) **References Cited**

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(57) **ABSTRACT**

The invention provides an electroluminescent display device in which purity of R, G, and B colors is prevented from lowering by minimizing white light leakage and color mixture caused by an escape of light to an outside of a color filter layer. An organic EL element driving TFT is formed on an insulating substrate. A first planarization insulating film is formed so as to cover the organic EL element driving TFT. A color filter layer is buried in the first planarization insulating film. An anode layer is connected with the organic EL element driving TFT and extends over the first planarization insulating film. A second planarization insulating film is formed so as to cover end portions of the anode layer. Here, a length of an overlapping area of the color filter layer and the second planarization insulating film is set larger than a sum of thicknesses of the anode layer and the first planarization insulating film. Accordingly, most of light radiated from an organic EL layer can be transmitted through the color filter layer **103**.

4 Claims, 5 Drawing Sheets

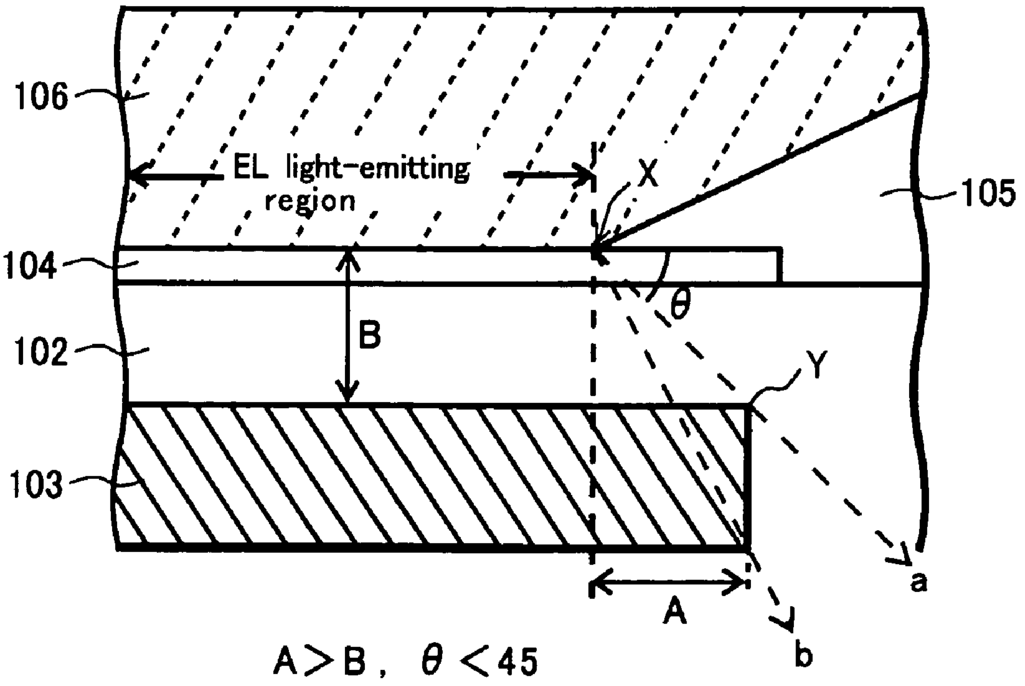


FIG.1

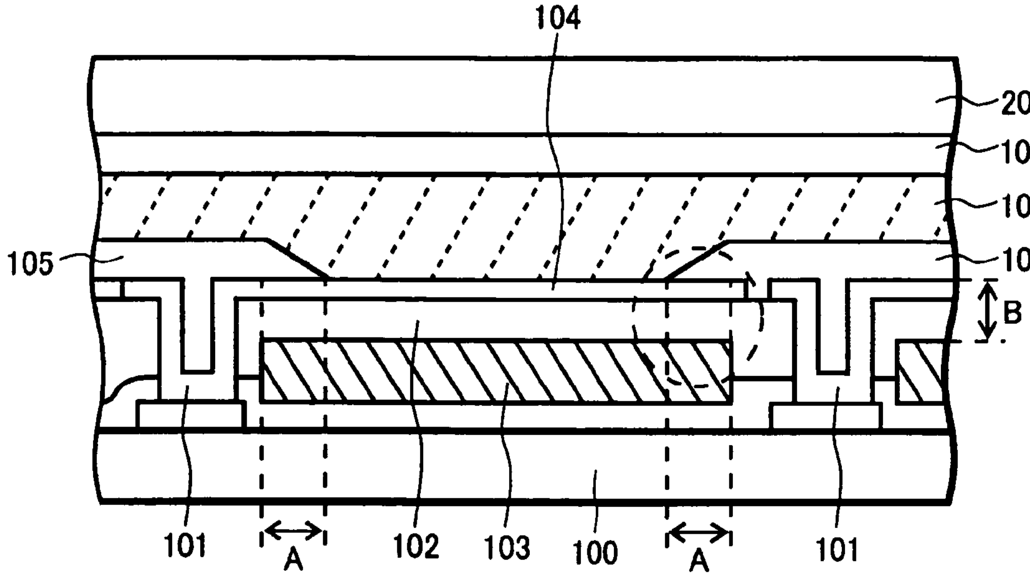
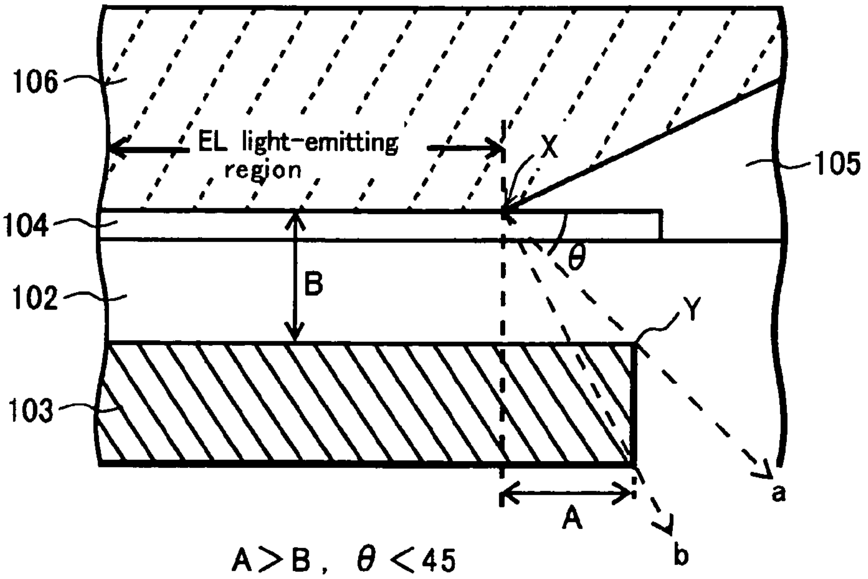
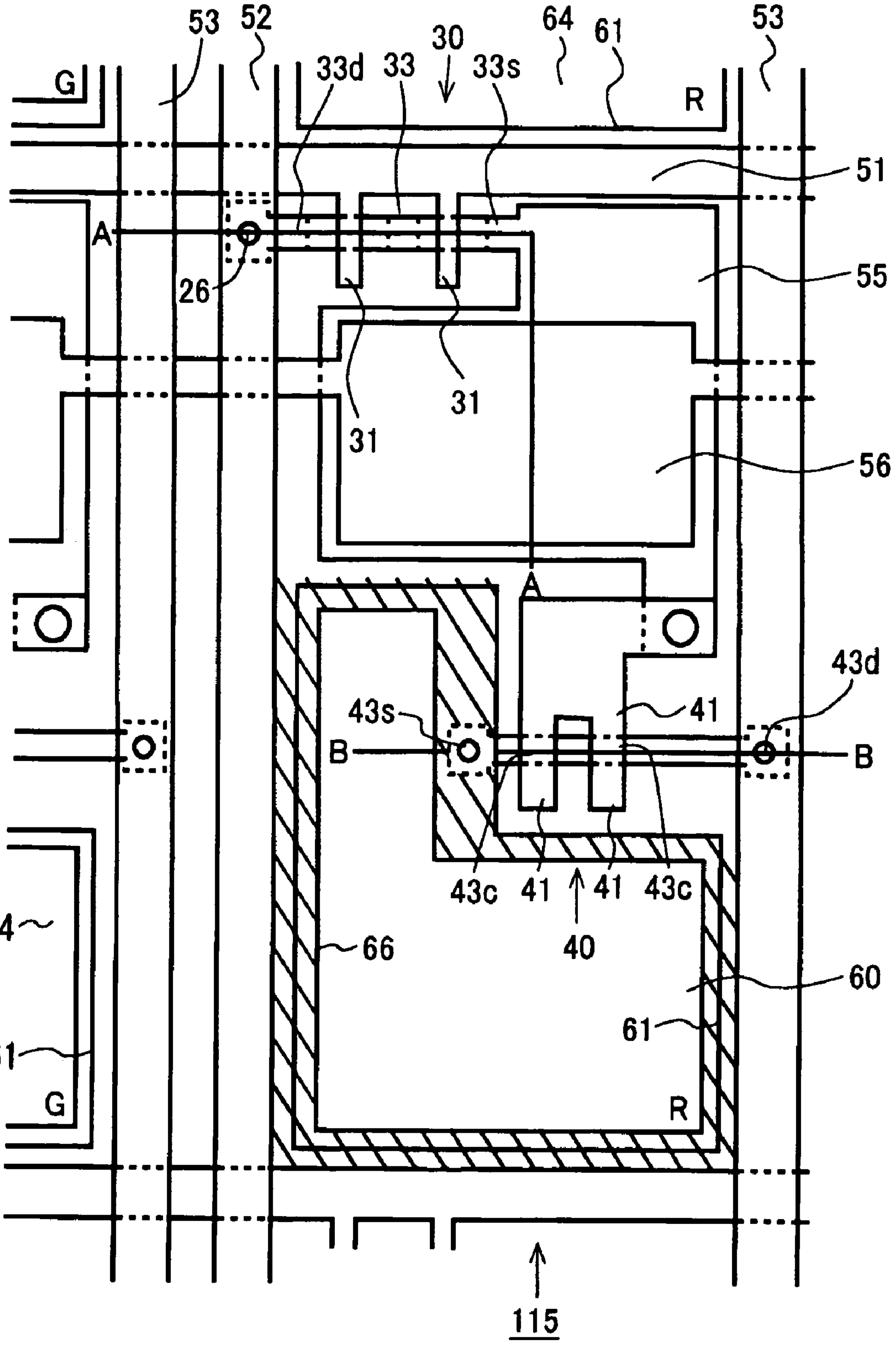


FIG.2



A>B， θ<45

FIG.3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A
43d
43s
41
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43c
41
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43c
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64
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60
61
61
G
R
115

FIG.4

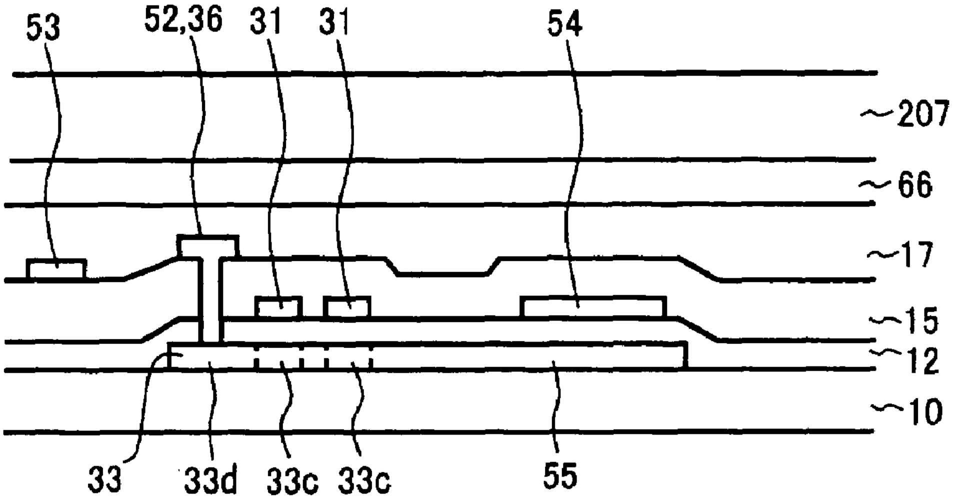
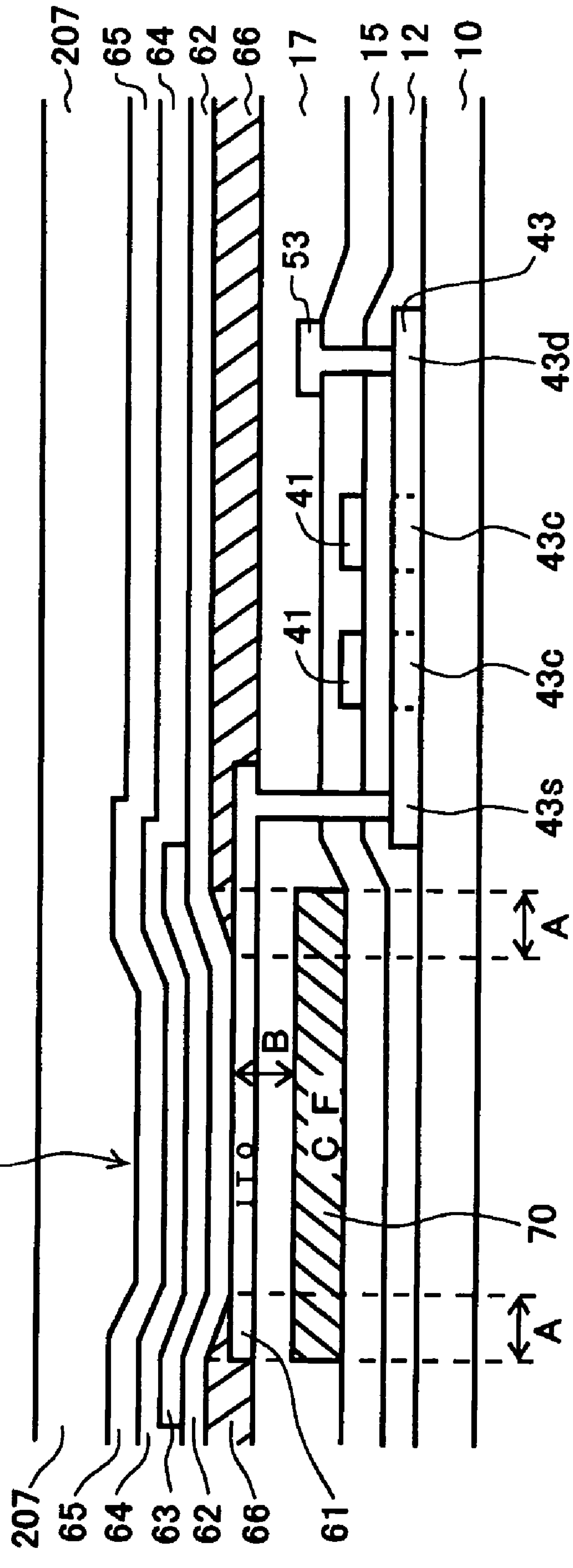


FIG.5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43d
41
43c
41
43c
43s
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ITO
CF
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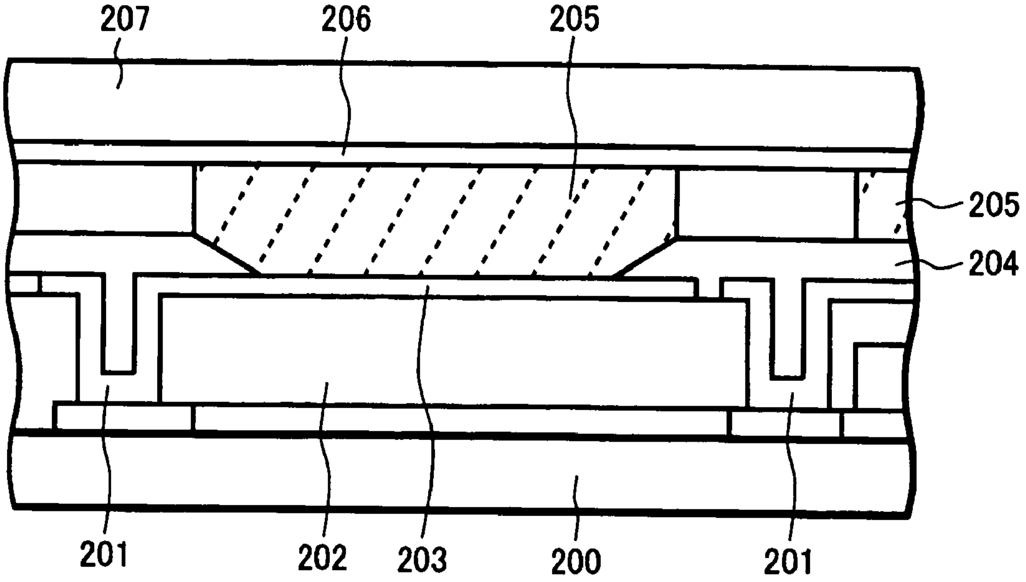
A
60
207
65
64
63
62
66
61

FIG.6

PRIOR ART



ELECTROLUMINESCENT DISPLAY DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to an electroluminescent display device, particularly to an electroluminescent display device having color filter layers.

2. Description of the Related Art

An organic electroluminescent (hereafter, referred to as EL) element is a self-emissive element. An organic EL display device using the organic EL elements is receiving an attention as a new display device substituted for a CRT or an LCD.

FIG. **6** is a schematic cross-sectional view showing a pixel of a full-color organic EL display device of the conventional art. A numeral **200** designates a glass substrate, a numeral **201** designates an organic EL element driving TFT (thin film transistor) formed on the glass substrate **200**, and a numeral **202** designates a first planarization insulating film. A numeral **203** designates an anode layer made of ITO (indium tin oxide) which is connected with the TFT **201** and extends over the first planarization insulating film **202**, and a numeral **204** designates a second planarization insulating film formed so as to cover end portions of the anode layer **203**. A numeral **205** designates R (red), G (green), and B (blue) organic EL layers each formed on the anode layer **203**, and a numeral **206** designates a cathode layer formed on the organic EL layers **205**.

A glass substrate **207** covers the cathode layer **206**. The glass substrate **207** and the glass substrate **200** are attached at their edges to enclose the R, G, and B organic EL layers **205** therein. Here, the R, G, and B organic EL layers **205** are respectively formed by selectively performing vapor-deposition of each of R, G, and B organic EL materials by using a metal mask.

On the other hand, as a method of realizing a full-color organic EL display device without the above R, G, and B organic EL layers **205**, using color filter layers has been proposed. In this method, a combination of a white organic EL layer and color filter layers has been employed.

The organic EL display device of this type is described in Japanese Patent Application Publication No. Hei 8-321380.

However, when employing the combination of the white organic EL layer and the color filter layers, the color filter layers must be disposed under the organic EL layer and the second planarization insulating film. In this conventional EL device, light from the white organic EL layer leaks from the display panel so that color purity lowers.

Therefore, an object of the invention is to prevent lowering of purity of R, G, and B colors by minimizing white light leakage and color mixture caused by an escape of light to an outside of a color filter layer.

SUMMARY OF THE INVENTION

The invention provides an electroluminescent display device that includes a plurality of pixels disposed on an insulating substrate, a color filter layer provided in each of the pixels and formed above the insulating substrate, an anode layer disposed above each of the color filter layers, a first planarization insulating film interposed between the color filter layers and the anode layers, a second planarization insulating film disposed on the first planarization insulating film and extending over the anode layers so as to cover end portions of the anode layers, an electroluminescent layer disposed above each of the anode layers, and a cathode layer disposed above the electroluminescent layers. Each of the color filter layers overlaps with the second planarization insulating film by a length that is larger than a sum of a thickness of the anode layer and a thickness of the first planarization insulating film located above the color filter layers.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic cross-sectional view of a pixel of an organic EL display device of an embodiment of the invention.

FIG. **2** is an enlarged view of a portion enclosed with a broken line in FIG. **1**.

FIG. **3** is a plan view of the pixel and its periphery of the organic EL display device of the embodiment of the invention.

FIG. **4** is a cross-sectional view along line A—A of FIG. **3**.

FIG. **5** is a cross-sectional view along line B—B of FIG. **3**.

FIG. **6** is a schematic cross-sectional view of a pixel of an organic EL display device of the conventional art.

DETAILED DESCRIPTION OF THE INVENTION

An embodiment of the invention will be described with reference to the drawings in detail. FIG. **1** is a schematic cross-sectional view showing a pixel of an organic EL display device of the embodiment. FIG. **2** is an enlarged view of a portion enclosed with a broken line in FIG. **1**. In an actual organic EL display device, a plurality of the pixels is arranged in a matrix.

A numeral **100** designates a transparent insulating substrate such as a glass substrate, a numeral **101** designates an organic EL element driving TFT (thin film transistor) formed on the insulating substrate **100**, and a numeral **102** designates a first planarization insulating film. A numeral **103** designates a color filter layer buried in the first planarization insulating film **102**, a numeral **104** designates an anode layer made of ITO (indium tin oxide) which is connected with the TFT **101** and extends over the first planarization insulating film **102**, and a numeral **105** designates a second planarization insulating film formed so as to cover end portions of the anode layer **104**.

The second planarization insulating film **105** is formed with an opening except above the end portions of the anode layer **104**. A white organic EL layer **106** is formed on the anode layer **104** exposed in the opening, and a cathode layer **107** is formed on the organic EL layer **106**. A glass substrate **207** covers the cathode layer **107**, and the glass substrate **207** and the glass substrate **100** are attached at their edges to enclose the organic EL layer **106** therein.

Here, providing the second planarization insulating film **105** is for preventing a short circuit between the anode layer **104** and the cathode layer **107** by a short distance between the end portions of the anode layer **104** and the cathode layer **107**.

The color filter layer **103** and the second planarization insulating film **105** overlap by a predetermined length A. This length A is larger than B, which is a sum of thicknesses of the anode layer **104** and the first planarization insulating film **102** above the color filter layer **103**.

Accordingly, most of light generated by the white organic EL layer **106** is transmitted through the color filter layer **103** so that the white light leakage and color mixture due to the escape of light to the outside of the color filter layer are minimized to prevent the lowering of purity of R, G, and B colors.

This will be further described in detail. The organic EL layer **106** emits light only at a region which is in contact with the anode layer **104**. Therefore, the end of the light-emitting region is the end X of the second planarization insulating film **105** which covers the anode layer **104**. The outside region of the light-emitting region (right side of the end X in FIG. **2**) is a non-emitting region since the anode layer **104** is not contact with the organic EL layer **106**.

Description will be made using the light radiated from the end X as an example since the light radiated from the end X is the most possible source of light leakage. When considering the angle between the surface of the anode layer **104** and the light emitting direction from the end X, the angle θ between the surface of the anode layer **104** and a direction of light "a" shown in FIG. **2** is a critical angle. The light "a" is radiated from the end X and then comes into contact with an upper end Y of the color filter layer **103**. When the angle between the surface of the anode layer **104** and the direction of the light radiated from the end X is larger than the critical angle θ (light "b" in FIG. **2**, for example), the light is transmitted through the color filter layer **103**. When it is smaller than the critical angle θ, the light is not transmitted through the color filter layer **103** but escapes to the outside through the glass substrate **100** as white light leakage.

Here, the above relation can be expressed by an equation, i.e. $\tan\theta = B/A$. For example, when A equals B, θ equals 45 degrees. In this case, when the angle between the surface of the anode layer **104** and the direction of the light radiated from the end X is larger than this critical angle of 45 degrees, the light is transmitted through the color filter layer **103**. Experiments have shown that the lowering of purity of R, G, and B colors can be prevented by keeping the relation of $A>B$ and $\theta<45°$.

Next, a structure of the organic EL display device will be described. FIG. **3** is a plan view of the pixel and its periphery of the organic EL display device. FIG. **4** is a cross-sectional view along a line A—A of FIG. **3**, and FIG. **5** is a cross-sectional view along a line B—B of FIG. **3**.

A pixel **115** is formed in a region enclosed with a gate signal line **51** and a drain signal line **52**. A plurality of the pixels **115** is arranged in a matrix.

An organic EL element **60** as a self-emissive element, a switching TFT (thin film transistor) **30** for controlling a timing of supplying an electric current to the organic EL element **60**, a driving TFT **40** for supplying an electric current to the organic EL element **60**, and a storage capacitor **56** are disposed in the pixel **115**. The organic EL element **60** is formed of an anode layer **61**, a white EL layer made of a white emissive material, and a cathode layer **65**.

The switching TFT **30** is provided in a periphery of an intersection of the both signal lines **51** and **52**. A source **33***s* of the switching TFT **30** serves as a capacitor electrode **55** for forming a capacitor with a storage capacitor electrode line **54** and is connected with a gate electrode **41** of the driving TFT **40**. A source **43***s* of the driving TFT **40** is connected with the anode layer **61** of the organic EL element **60**, while a drain **43***d* is connected with a driving source line **53** as a current source for the organic EL element **60**.

A cross-sectional structure of the organic EL display device will be described with reference to FIGS. **4** and **5**. The organic EL display device is formed by laminating the TFTs and the organic EL element sequentially on a substrate **10**, such as a substrate made of a glass or a synthetic resin, a substrate having a conductivity, or a semiconductor substrate. When using a substrate having a conductivity or a semiconductor substrate as the substrate **10**, however, an insulating film made of SiO_2 or SiN_x is formed on the substrate **10**, and then the switching TFT **30**, the driving TFT **40** and the organic EL element **60** are formed thereon. Each of TFTs **30** and **40** has a so-called top gate structure in which a gate electrode is disposed above an active layer with a gate insulating film being interposed therebetween.

The structure of the switching TFT **30** will be described first. As shown in FIG. **4**, an amorphous silicon film (hereafter, referred to as an a-Si film) is formed on the insulating substrate **10** made of silica glass or a non-alkali glass by a CVD method and so on. The a-Si film is irradiated with laser beams for melting and recrystalizing to form a poly-silicon film (hereafter, referred to as a p-Si film) as an active layer **33**.

On the active layer **33**, a single-layer or a multi-layer of an SiO_2 film and an SiN_x film is formed as the gate insulating film **12**. There are disposed on the gate insulating film **12** the gate signal line **51** made of metal having a high melting point such as Cr (chromium) or Mo (molybdenum) and also serving as a gate electrode **31**, the drain signal line **52** made of Al (aluminum), and the driving source line **53** made of Al and serving as a driving source of the organic EL element **60**.

An interlayer insulating film **15** laminated with an SiO_2 film, an SiN_x film and an SiO_2 film sequentially is formed on the whole surfaces of the gate insulating film **12** and the active layer **33**. A drain electrode **36** is provided by filling a contact hole provided above a drain **33***d* with metal such as Al. Furthermore, a first planarization insulating film **17** for planarizing the surface, which is made of organic resin, is formed on the whole surface.

Next, the structure of the driving TFT **40** will be described. As shown in FIG. **5**, an active layer **43** formed by poly-crystalizing an a-Si film by radiating laser beams, the gate insulating film **12**, and the gate electrode **41** made of a metal having a high melting point, such as Cr or Mo, are formed sequentially on the insulating substrate **10**.

A channel **43***c*, and a source **43***s* and a drain **43***d* are provided in the active layer **43**. The source **43***s* and the drain **43***d* are placed on both sides of the channel **43***c*. The interlayer insulating film **15** includes an SiO_2 film, an SiN_x film and an SiO_2 film sequentially formed on the whole surfaces of the gate insulating film **12** and the active layer **43**. The driving source line **53** is connected with a driving source by a contact hole provided above the drain **43***d*.

A color filter layer **70** is formed on the interlayer insulating film **15** adjacent the driving TFT **40**. The color filter layer **70** is formed in each of the pixels, having spectral characteristics of each of R, G, and B colors. For example, a pixel R is formed with the color filter layer **70** having spectral characteristics of red.

Furthermore, the planarization insulating film **17** for planarizing the surface, which is made of, for example, an organic resin, is formed on the whole surface. A contact hole is formed in a position corresponding to the source **43***s* in the planarization insulating film **17**. The anode layer **61** of the organic EL element, which is an transparent electrode made of ITO and is in contact with the source **43***s* through the contact hole, is formed on the planarization insulating film **17**. The anode layer **61** is formed on the color filter layer **70** in each of the pixels, being isolated as an island.

A second planarization insulating film **66** is further formed on the first planarization insulating film **17**, covering end portions of the anode layer **61**. The second planarization insulating film **66** is removed from the light-emitting region of the anode layer **61**.

The organic EL element **60** is formed by laminating blue and yellow materials as white light emissive materials in order to emit white light. The organic EL element **60** is formed by laminating the anode layer **61** made of a transparent electrode such as ITO, a hole transport layer **62** made of NPB, an emissive layer **63** formed of yellow emitter layer containing yellow dopant and a blue emitter layer, an electron transport layer **64** made of Alq^3(8-tris-hydroxyquinoline aluminum), and the cathode layer **65** made of magnesium-indium alloy, Al or Al alloy, in this order.

The yellow emitter layer containing yellow dopant is formed by adding rubrene as yellow dopant to an NPB (host). The NPB (host) is an abbreviation for N,N'-Di (naphthalene-1-yl)-N,N'-diphenyl-benzidine. The blue emitter layer is made of $Zn (BOX)^2$, which is an abbreviation for bis((2-hydroxyphenyl) benzoxazole) zinc. The cathode layer **65** is covered with the glass substrate **207**.

In the organic EL element **60**, a hole injected from the anode layer **61** and an electron injected from the cathode layer **65** are recombined in the emissive layer **63**, and an exciton is formed by exciting an organic module forming the emissive layer **63**. Light is emitted from the emissive layer **63** in a process of radiation of the exciton and then released outside after going through the transparent anode layer **61** to the transparent insulating substrate **10**, thereby completing a light-emission.

The color filter layer **70** and the second planarization insulating film **66** overlap by a predetermined length A. This length A is larger than B which is a sum of thicknesses of the anode layer **61** and the first planarization insulating film **17**.

Accordingly, most of light radiated by the white light emissive layer **63** is transmitted through the color filter layer **70** so that the white light leakage and color mixture due to the escape of light to the outside of the color filter layer **70** are minimized to prevent the lowering of purity of R, G, and B colors.

What is claimed is:

1. An electroluminescent display device comprising:

a plurality of pixels disposed on an insulating substrate;

a color filter layer provided in each of the pixels and formed above the insulating substrate;

an anode layer disposed above each of the color filter layers;

a first planarization insulating film interposed between the color filter layers and the anode layers;

a second planarization insulating film disposed above the first planarization insulating film and extending over the anode layers so as to cover end portions of the anode layers;

an electroluminescent layer disposed above each of the anode layers; and

a cathode layer disposed above the electroluminescent layers,

wherein each of the color filter layers is confined to an area of a corresponding pixel and overlaps with the second planarization insulating film by a length that is larger than a sum of a thickness of the anode layer and a thickness of the first planarization insulating film located above the color filter layers.

2. The electroluminescent display device of claim **1**, wherein the electroluminescent layer comprises a white electroluminescent layer.

3. The electroluminescent display device of claim **2**, wherein the white electroluminescent layer is an organic electroluminescent layer.

4. An electroluminescent display device comprising:

a color filter layer that is disposed in a pixel so as not to exceed an area of the pixel;

a first planarization insulating film disposed on the color filter layer;

an anode layer disposed on the first planarization insulating film;

a second planarization insulating film disposed above the first planarization insulating film and extending over the anode layer;

an electroluminescent layer disposed on the anode layer; and

a cathode layer disposed above the electroluminescent layer,

wherein the color filter layer overlaps with the second planarization insulating film by a length that is larger than a sum of a thickness of the anode layer and a thickness of the first planarization insulating film.

* * * * *

专利名称(译)	电致发光显示装置		
公开(公告)号	US7061174	公开(公告)日	2006-06-13
申请号	US10/758597	申请日	2004-01-16
[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	NISHIKAWA RYUJI MAEDA KAZUYUKI		
发明人	NISHIKAWA, RYUJI MAEDA, KAZUYUKI		
IPC分类号	H05B33/22 G02B5/20 G09F9/30 G09G3/12 H01L27/32 H01L51/50 H05B33/02 H05B33/04 H05B33/12 H05B33/14		
CPC分类号	H01L27/3246 H01L27/322		
代理机构(译)	美富律师事务所		
审查员(译)	帕特尔ASHOK		
优先权	2003012382 2003-01-21 JP		
其他公开文献	US20040207570A1		
外部链接	Espacenet USPTO		

摘要(译)

本发明提供一种电致发光显示装置，其中通过最小化由光逃逸到滤色器层外部引起的白光泄漏和颜色混合来防止R，G和B颜色的纯度降低。有机EL元件驱动TFT形成在绝缘基板上。形成第一平坦化绝缘膜以覆盖有机EL元件驱动TFT。滤色器层埋在第一平坦化绝缘膜中。阳极层与有机EL元件驱动TFT连接，并在第一平坦化绝缘膜上延伸。形成第二平坦化绝缘膜以覆盖阳极层的端部。这里，滤色器层和第二平坦化绝缘膜的重叠区域的长度设定为大于阳极层和第一平坦化绝缘膜的厚度之和。因此，从有机EL层辐射的大部分光可以透过滤色器层103。