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Sung

(54) **MULTICOLOR ELECTROLUMINESCENT DISPLAY**

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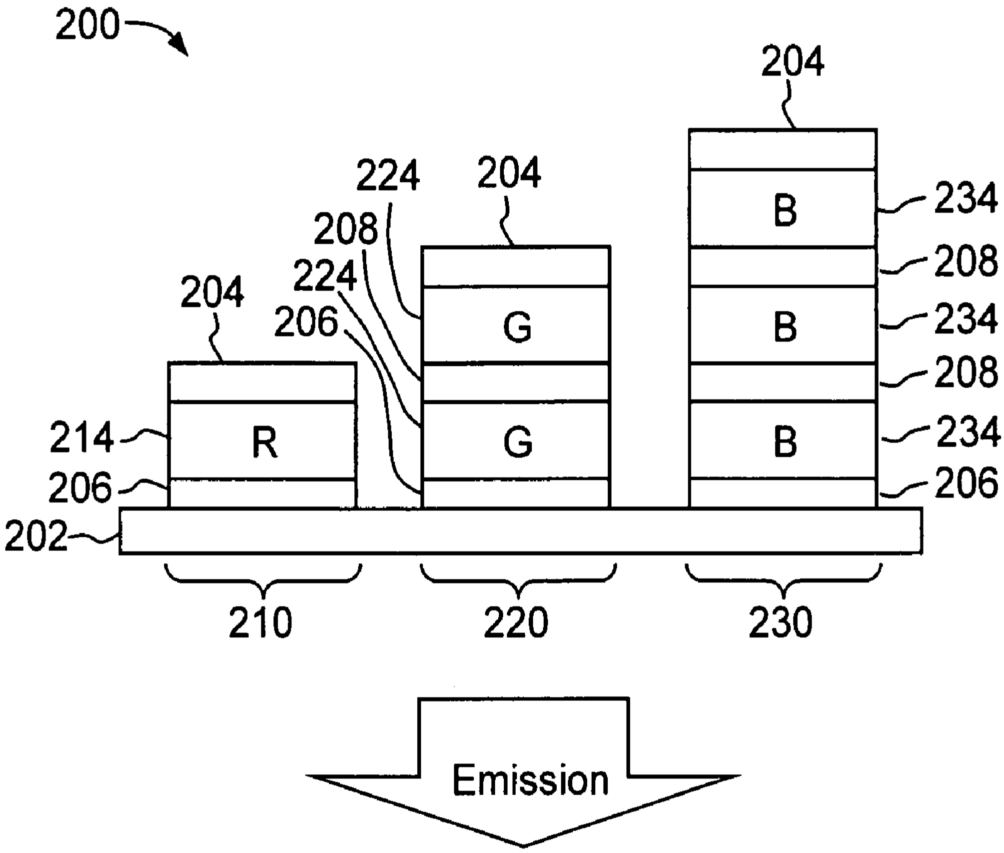
(57) **ABSTRACT**

In an organic electroluminescent display, a pixel includes a plurality of color light-emitting units that are arranged in multi-layer stacks of specific color emissions. The color light-emitting units include layers made of organic electroluminescent materials. The stacks of different color emissions include different numbers of color light-emitting units to compensate the degradation of specific color emissions.



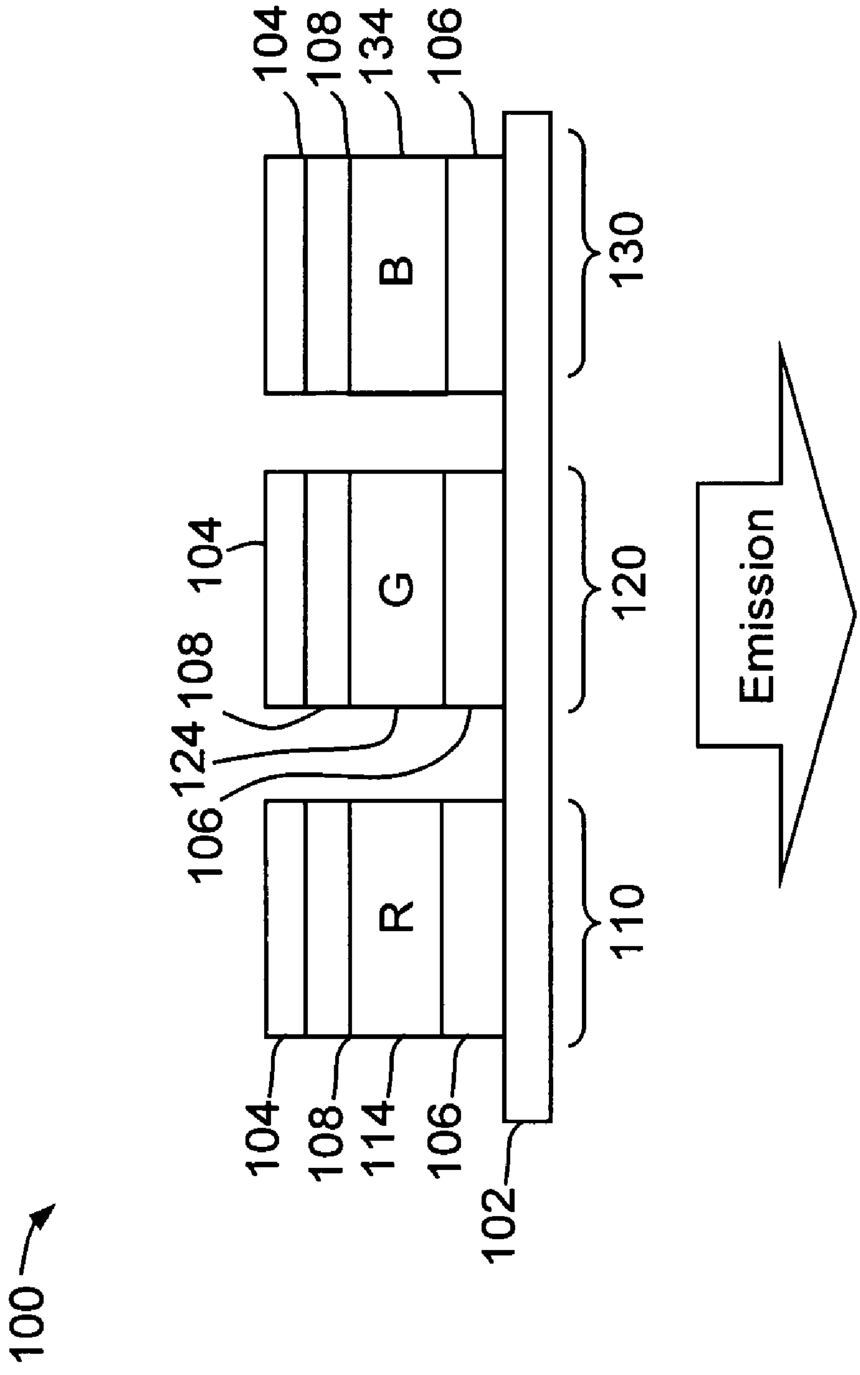


Figure 1A (Prior Art)

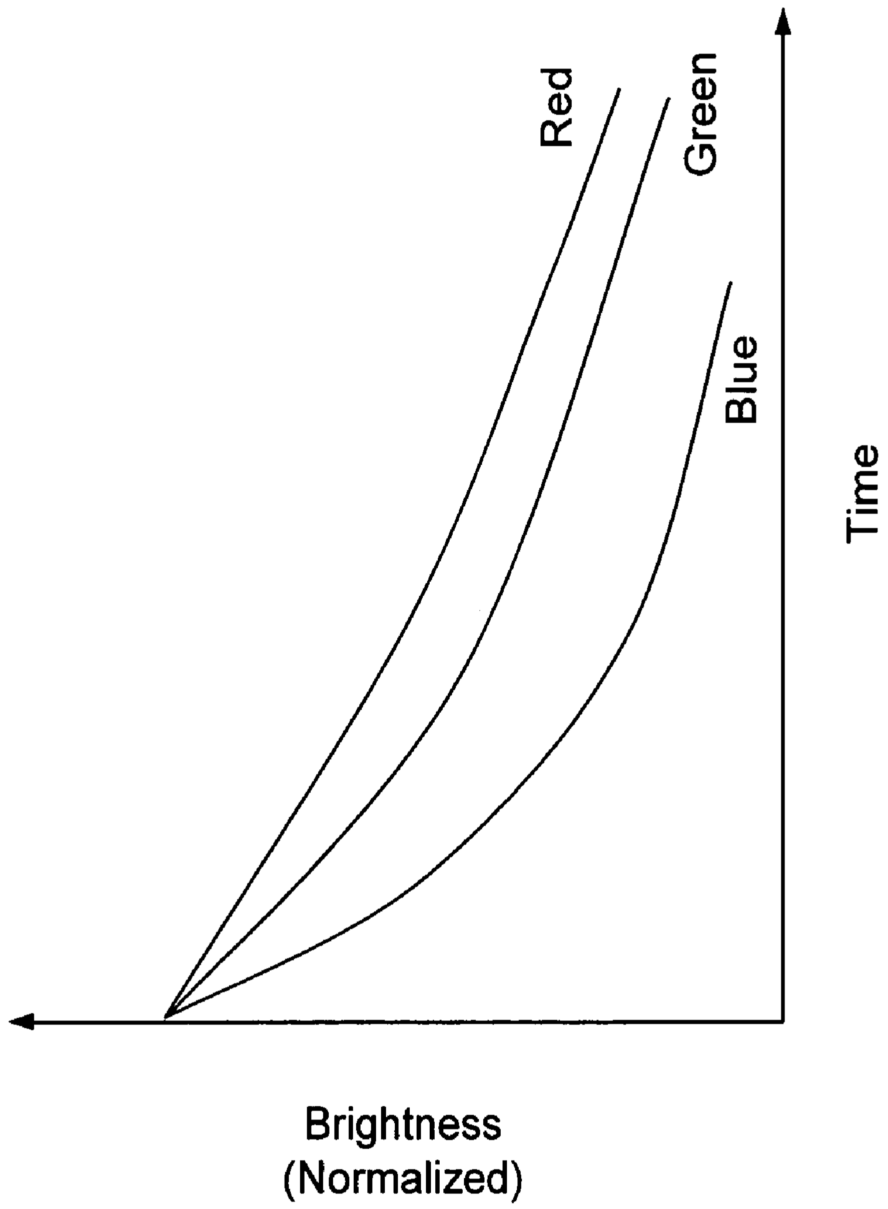


Figure 1B (Prior Art)

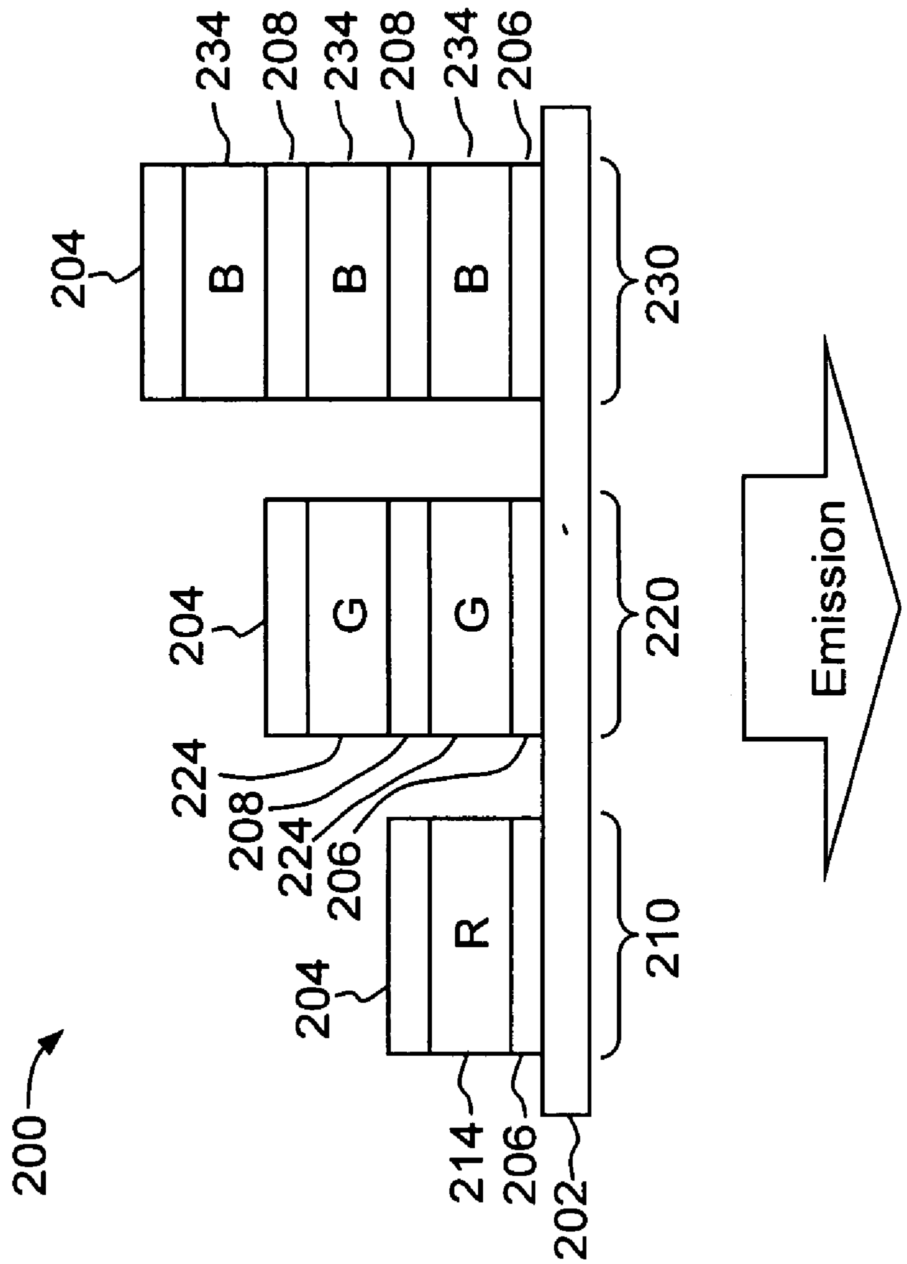

200
204
234
208
234
208
234
206
B
B
B
230
204
G
G
220
224
208
224
206
204
R
214
206
202
210
Emission

Figure 2A

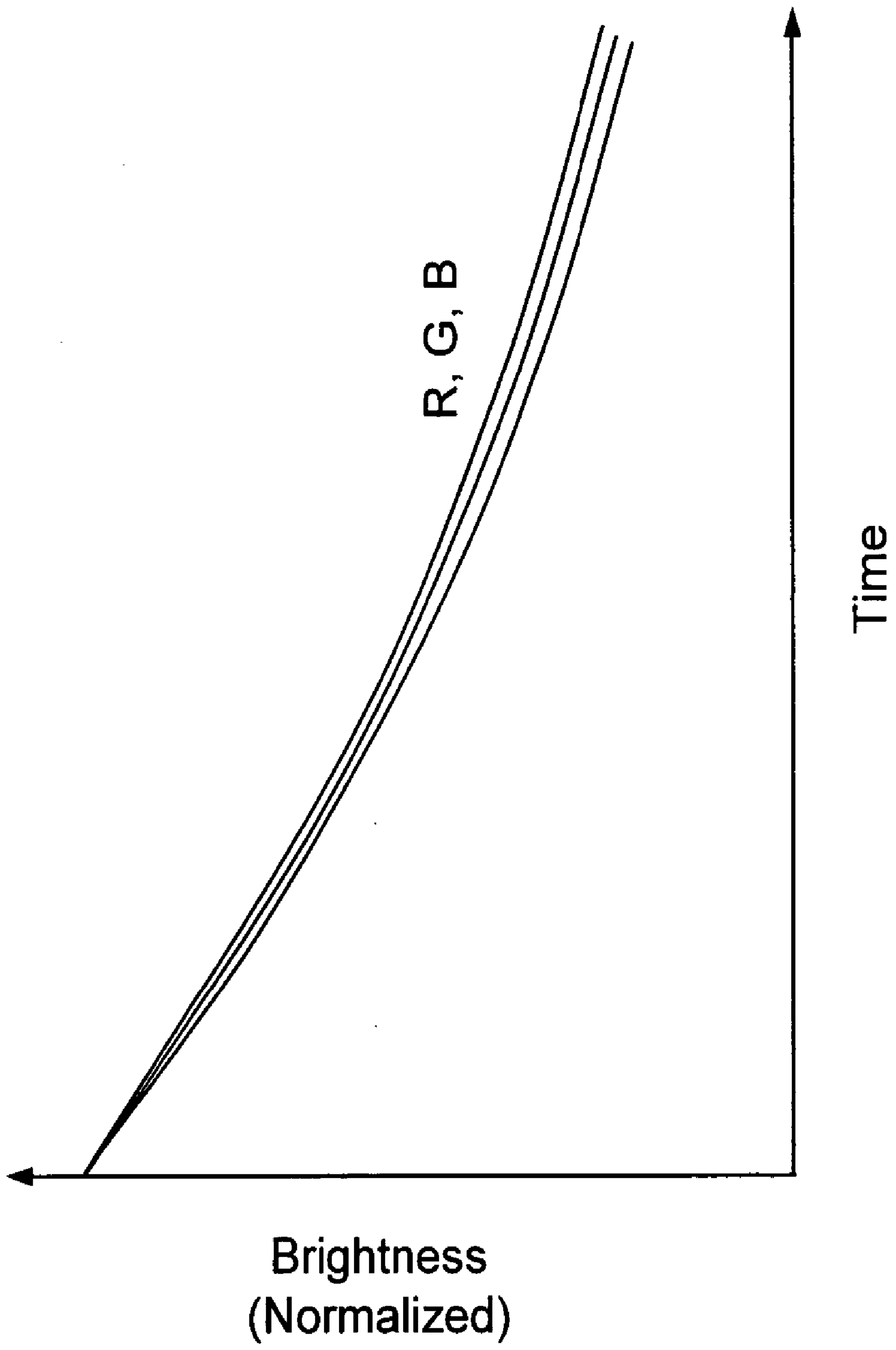


Figure 2B

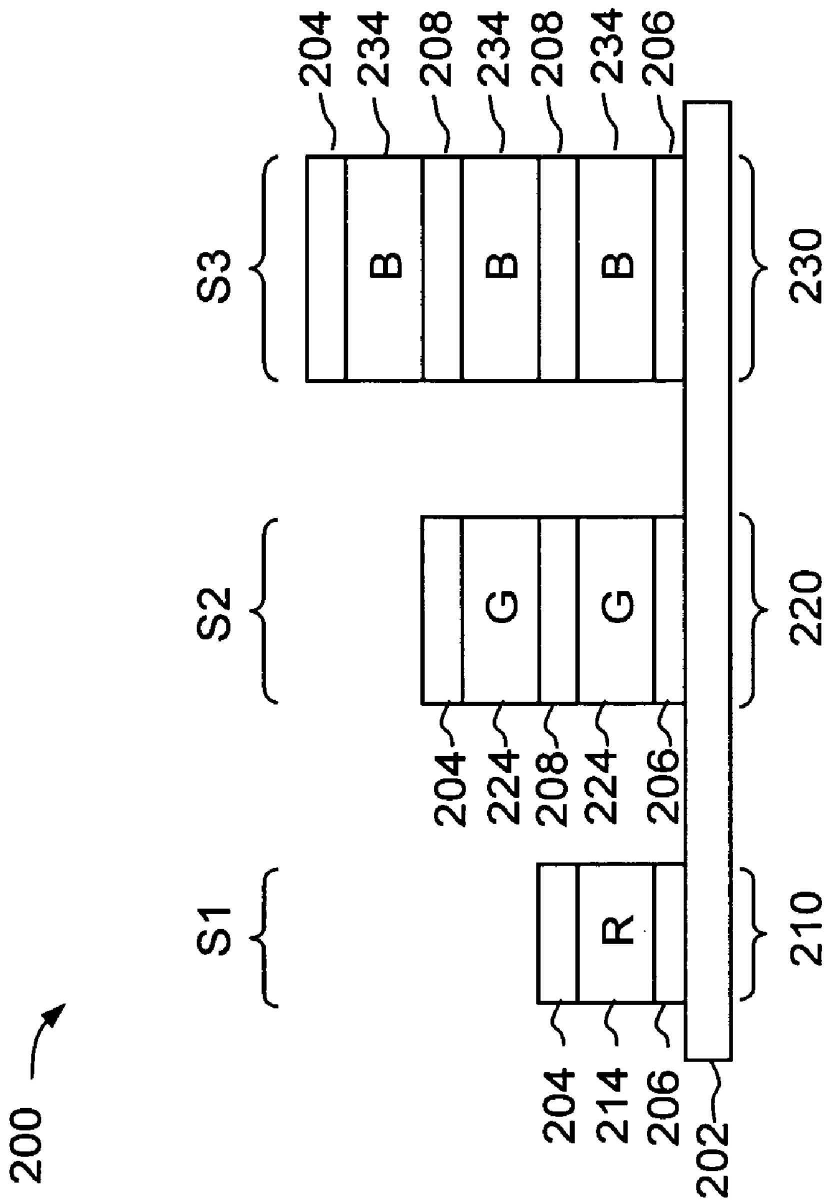

200
S1
S2
S3
R
G
G
B
B
B
204
214
206
202
204
224
208
224
206
204
234
208
234
208
234
206
210
220
230

Figure 2C

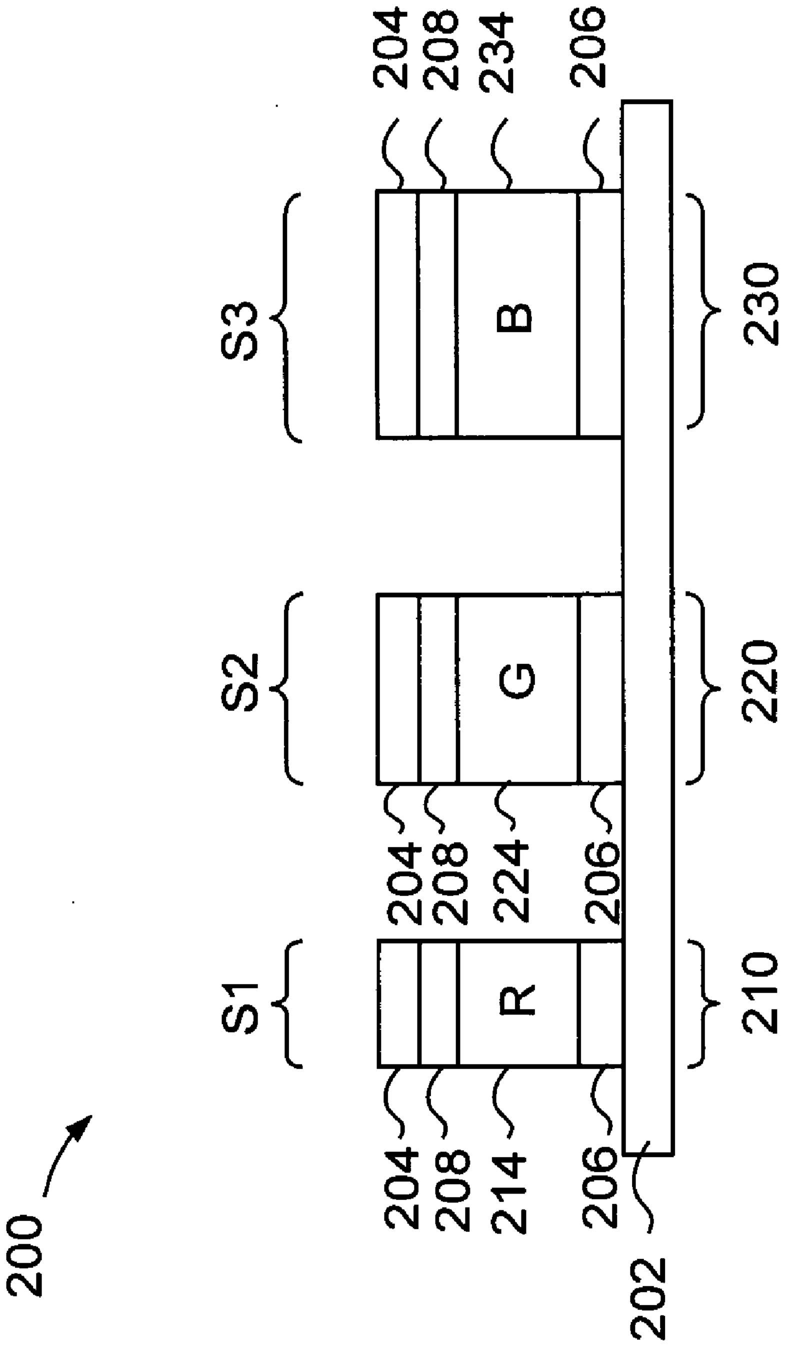


Figure 2D

MULTICOLOR ELECTROLUMINESCENT DISPLAY

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates to multicolor electroluminescent displays, and more particularly to the pixel structure of a multicolor electroluminescent display that can compensate the degradation of specific color emissions in the pixel.

[0003] 2. Description of the Related Art

[0004] Electroluminescent display technology has recently attracted many researches and developments in the field of emissive displays. Compared to other types of emissive displays such as the plasma display, the electroluminescent display promises advantages such as a lower power consumption, a reduced size, and high image brightness and sharpness. An electroluminescent display system conventionally includes a mesh of scan and data lines that define an array of pixels in each of which is coupled one light-emitting device. The light-emitting device particularly can be an organic light-emitting device (OLED), and is usually driven by a driving circuit associated to each pixel.

[0005] Conventionally, a basic OLED cell is constructed from a stack of layers made of organic material and sandwiched between two electrode layers, i.e. one anode and one cathode. The organic layers usually include a hole transport layer, an emissive layer, and an electron transport layer. When an adequate voltage is applied between the anode and the cathode, the injected positive and negative charges recombine in the emissive layer to produce light.

[0006] The particular color emitted by one OLED cell depends on the type of organic material incorporated therein. In a multicolor electroluminescent display, the pixel structure therefore is generally configured to include a plurality of OLED of different basic color emissions. In operation, these color lights are mixed to provide a full spectrum of display colors.

[0007] **FIG. 1A** is a schematic view of the conventional pixel structure implemented in a multicolor electroluminescent display known in the art. The pixel **100** is conventionally divided into at least three color subpixels **110, 120, 130**, each of which includes an OLED formed on a transparent substrate **102** and configured to irradiate red (R), green (G), and blue light (B), respectively. In each color subpixel **110, 120, 130**, the OLED can be constructed from the stack of a light-emitting unit **114, 124, 134** and a charge generation layer **108** between top and bottom electrode layers **104, 106**.

[0008] One major technical issue encountered in the conventional electroluminescent display is its reliability. After a time of service, the screen of the electroluminescent display usually becomes nonuniform due to the difference in the aging rate of each color light-emitting unit. The difference of aging rate is due to a characteristic alteration that varies between different electroluminescent materials. Experimentally, it can be observed that red OLED has a service life of about 10,000 hours, green OLED about 3,000 hours, and blue OLED about 1,000 hours at experiment brightness.

[0009] The graph of **FIG. 1B** depicts this difference in the aging rate of the red, green and blue OLED. It can be observed that the decay of blue color is very fast, while green and red color degrade relatively slower. Consequently, the white color balance of the electroluminescent displaye is significantly biased after a period of time due to the specific color brightness degradation. This disadvantage usually results in a short service life of the organic electroluminescent display.

[0010] Some technical approaches have been made to remedy this reliability issue. One of the solution known in the art proposes the addition of a feedback control circuit to adjust the electric current flowing through the OLED, and thereby compensate the intrinsic property degradation of the light-emitting unit. However, this approach provide limited results, and still fail to prolong the service life of the organic electroluminescent display.

[0011] Therefore, there is presently a need for an electroluminescent display that can overcome the above disadvantages, does not experiences color bias, and have a longer service life.

SUMMARY OF THE INVENTION

[0012] The invention provides a pixel structure for a multicolor electroluminescent display which can mitigate the degradation of specific color emissions. In one embodiment, the multicolor electroluminescent display comprises a plurality of color light-emitting units, including electroluminescent materials configured to irradiate color lights, which are arranged in multi-layer stacks of specific color emissions in one pixel area. In this arrangement, at least two stacks of two specific colors have different sizes to compensate a difference in the degradation of color emission in the two stacks. In one embodiment, the two stacks of different color emissions include different numbers of color light-emitting units. In another embodiment, the two stacks of different color emissions occupy different surface areas on the transparent substrate.

[0013] The foregoing is a summary and shall not be construed to limit the scope of the claims. The operations and structures disclosed herein may be implemented in a number of ways, and such changes and modifications may be made without departing from this invention and its broader aspects. Other aspects, inventive features, and advantages of the invention, as defined solely by the claims, are described in the non-limiting detailed description set forth below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] **FIG. 1A** is a schematic view of the conventional pixel structure implemented in a multicolor electroluminescent display known in the art;

[0015] **FIG. 1B** is a graph depicting a nonuniform color brightness degradation observed in a multicolor electroluminescent display known in the art;

[0016] **FIG. 2A** is a schematic view of the pixel structure implemented in a multicolor electroluminescent display according to an embodiment of the invention;

[0017] **FIG. 2B** is a graph depicting a uniform color brightness degradation observed in a multicolor electroluminescent display according to an embodiment of the invention; and

[0018] **FIGS. 2C and 2D** are schematic views of the pixel structure implemented in a multicolor electroluminescent display according to variant embodiments of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENT(S)

[0019] The application describes a multicolor electroluminescent display. The multicolor electroluminescent display includes an array of pixels, each of which is comprised of color subpixels constructed from multi-layer structures including light-emitting units. The size of the multi-layer structure increases as the aging rate of its light-emitting unit is faster so as to compensate the difference in brightness degradation of the color subpixels.

[0020] **FIG. 2A** is a schematic view of the multi-layer structure implemented in a multicolor electroluminescent display according to an embodiment of the invention. **FIG. 2A** shows the area of approximately one pixel. The pixel **200** includes a plurality of color subpixels **210**, **220**, **230**. The illustrated embodiment exemplary implements a color system comprised of the three basic colors red (R), green (G) and blue (B), which results in at least three sets of color subpixels in each pixel **200**, i.e. red, green and blue color subpixels.

[0021] Each color subpixel **210**, **220**, **230** includes a number of light-emitting units **214**, **224**, **234** stacked on a transparent substrate **202**. The transparent substrate **202** can be made of an insulating transparent material such as sapphire, glass, SiC or the like. Each of the light-emitting units **214**, **224**, **234** can include stacked layers made of organic-based electroluminescent materials such as polymer electroluminescent materials. The number of light-emitting units **214**, **224**, **234** in each stack varies according to the particular color of the corresponding subpixel. For the purpose of illustration, **FIG. 2A** exemplary shows an implementation in which the red subpixel **210** includes one red light-emitting unit **214**, the green subpixel **220** includes the stack of two green light-emitting units **224**, and the blue subpixel **230** includes the stack of three blue light-emitting units **234**. In the present embodiment, the faster the aging rate of one particular light-emitting unit, the higher the number of corresponding light-emitting units included in the color subpixel to compensate the brightness degradation.

[0022] As shown in **FIG. 2A**, the red subpixel **210** is formed from a multi-layer stack comprised of a red light-emitting unit **214** sandwiched between two electrode layers **204**, **206**. In an example of implementation, the red light-emitting unit **214** can be formed of a multi-layer structure including a hole transporting layer made of 4,4'bis[N-1-naphthyl-N-phenyl-amino]biphenyl (α-NPD), a red emissive layer made of 3% of [2-methyl-6-[2-(2,3,6,7-tetrahydro-1H,5H-benzo quinolizin-9-yl)ethenyl]-4H-pyran-4-ylidene]propane-dinitrile (DCM2) doped in tris(8-hydroxyquinoline) aluminum (III) (Alq_3), and an electron transporting layer made of Alq_3.

[0023] The green subpixel **220** includes a multi-layer stack comprised of green light-emitting units **224** alternated with charge generation layers **208** between top and bottom electrode layers **204**, **206**. In an embodiment, the green light-emitting unit **224** can exemplary include a α-NPD layer as hole transporting layer and an Alq_3 layer acting as electron transporting layer.

[0024] The blue subpixel **230** includes a multi-layer stack comprised of blue light-emitting units **234** alternated with charge generation layers **208** between top and bottom electrode layers **204**, **206**. The blue light-emitting unit **234** can include a hole transporting layer made of α-NPD, a blue emissive layer made of bis-(8-hydroxy)quinaldine aluminum phenoxide (Alq_2 OPh) and an electron transporting layer made of Alq_3.

[0025] The electrode layer **206** can be made of a transparent conductive material such as indium tin oxide, indium zinc oxide or the like, while the electrode layer **204** can be made of a conductive metal or metallic alloy such as aluminum, an alloy of aluminum and manganese, or the like. In an example of implementation, the electrode layer **204** can have a thickness of about 1500 Å to 4000 Å, while the electrode layer **206** can have a thickness of about 1000 Å.

[0026] In operation, the application of a voltage bias between the top and bottom electrodes **204**, **206** produces a flow of electric current from the top electrode **204** towards the bottom electrode **206**. As a result, the light-emitting unit **214**, **224**, **234** of each color subpixel **210**, **220**, **230** are stimulated to emit different color lights.

[0027] **FIG. 2B** is a graph depicting the degradation of color brightness obtained for an electroluminescent display according to an embodiment of the invention. As shown, the brightness degradation of the red, green and blue colors are uniform and close to one another. The multicolor display therefore does not experience adverse color intensity bias as encountered in the multicolor electroluminescent displays know in the prior art. Further, it can be observed that the slope of the degradation curve is less steep than that of the prior art, which results in a longer service life of the electroluminescent display.

[0028] **FIG. 2C** is a schematic view of the multi-layer structure implemented in a multicolor electroluminescent display according to a variant embodiment of the invention. The stack of each color subpixel **210**, **220**, **230**, including one or more light-emitting unit **214**, **224**, **234**, occupies a surface area S1, S2, S3 over the substrate **202**. The surface areas S1, S2, S3 can vary according to the different aging rates, i.e. the faster the aging rate of the light-emitting unit, the larger the surface area S of the multi-layer structure.

[0029] **FIG. 2D** illustrates another variant embodiment in which each stack of color subpixel **210**, **220**, **230** can include a single light-emitting unit **214**, **224**, **234**, respectively. The light-emitting unit **214**, **224**, **234** is respectively stacked between top and bottom electrode layers **204**, **206**. An optional charge generation layer **208** can be interposed between the light-emitting unit **214**, **224**, **234** and the top electrode layer **204**. The surface area S1, S2, S3 increases from red **210**, green **220** to blue subpixel **230**, according to the increasing speed of aging rate to compensate the brightness degradation.

[0030] Realizations in accordance with the present invention have been described in the context of particular embodiments. These embodiments are meant to be illustrative and not limiting. Many variations, modifications, additions, and improvements are possible to implement the inventive features described herein. Accordingly, plural instances may be provided for components described herein as a single instance. Additionally, structures and functionality presented as discrete components in the exemplary configurations may be implemented as a combined structure or component. These and other variations, modifications, additions, and improvements may fall within the scope of the invention as defined in the claims that follow.

What is claimed is:

1. A multicolor electroluminescent display, comprising:

a pixel area defined on a substrate; and

a plurality of color light-emitting units including electroluminescent materials configured to irradiate color lights, the color light-emitting units being arranged in multi-layer stacks of specific color emissions in the pixel area of the substrate;

wherein at least two stacks of two color emissions include different numbers of color light-emitting units.

2. The multicolor electroluminescent display according to claim 1, wherein the color light-emitting units are configured to emit red, green and blue colors.

3. The multicolor electroluminescent display according to claim 2, wherein the number of stacked blue light-emitting units is greater than the number of stacked green light-emitting units.

4. The multicolor electroluminescent display according to claim 2, wherein the number of stacked green light-emitting units is greater than the number of stacked red light-emitting units.

5. The multicolor electroluminescent display according to claim 1, wherein the number of color light-emitting units in a first stack is greater than the number of color light-emitting units in a second stack if the specific color emission of one color light-emitting unit degrades faster in the first stack than in the second stack.

6. The multicolor electroluminescent display according to claim 1, wherein one stack of a specific color emission includes color light-emitting units alternated with one or more charge generation layer between a top electrode and a bottom electrode.

7. The multicolor electroluminescent display according to claim 6, wherein one of the top or bottom electrode is made of a transparent conductive material, while the other of the top or bottom electrode is made of a conductive metallic material.

8. The multicolor electroluminescent display according to claim 1, wherein at least two multi-layer stacks of two specific color emissions occupy surface areas of different size on the substrate.

9. The multicolor electroluminescent display according to claim 8, wherein the area occupied by a first stack on the substrate is greater than the area occupied by a second stack on the substrate if the specific color emission of one color light-emitting unit degrades faster in the first stack than in the second stack.

10. The multicolor electroluminescent display according to claim 1, wherein the substrate is made of a transparent material including sapphire, glass, SiC or the like.

11. The multicolor electroluminescent display according to claim 1, wherein the color light-emitting units include layers made of an organic electroluminescent material.

12. A multicolor electroluminescent display, comprising:

a pixel area defined on a substrate; and

a plurality of color light-emitting units respectively including electroluminescent materials configured to irradiate color lights, the color light-emitting units being arranged in multi-layer stacks of specific color emissions in the pixel area of the substrate;

wherein the respective sizes of at least two stacks of two specific color emissions differ from each other so as to compensate a difference in the degradation of color emission in the two stacks.

13. The multicolor electroluminescent display according to claim 12, wherein at least two stacks of two specific color emissions include different numbers of color light-emitting units.

14. The multicolor electroluminescent display according to claim 12, wherein at least two multi-layer stacks of two specific color emissions occupy surface areas of different size on the substrate.

15. The multicolor electroluminescent display according to claim 12, wherein the size of a first stack of color light-emitting units is greater than the size of a second stack of color light-emitting units if the color emission of one color light-emitting unit degrades faster in the first stack than in the second stack.

16. The multicolor electroluminescent display according to claim 12, wherein the color light-emitting units are configured to emit red, green and blue color.

17. The multicolor electroluminescent display according to claim 12, wherein one stack of a specific color emission includes color light-emitting units alternated with one or more charge generation layer between a top electrode and a bottom electrode.

18. The multicolor electroluminescent display according to claim 17, wherein one of the top or bottom electrode is made of a transparent conductive material, while the other of the top or bottom electrode is made of a conductive metallic material.

19. The multicolor electroluminescent display according to claim 12, wherein the substrate is made of a transparent material including sapphire, glass, SiC or the like.

* * * * *

专利名称(译)	多色电致发光显示器		
公开(公告)号	US20050242712A1	公开(公告)日	2005-11-03
申请号	US10/834530	申请日	2004-04-29
[标]申请(专利权)人(译)	SUNG赵琴		
申请(专利权)人(译)	SUNG超CHIN		
当前申请(专利权)人(译)	友达光电股份有限公司		
[标]发明人	SUNG CHAO CHIN		
发明人	SUNG, CHAO-CHIN		
IPC分类号	H05B33/12 G09F9/30 H01L27/32 H01L51/50 H01L51/52 H05B33/00 H05B33/14		
CPC分类号	H01L51/5278 H01L27/3211		
外部链接	Espacenet USPTO		

摘要(译)

在有机电致发光显示器中，像素包括多个彩色发光单元，这些彩色发光单元以特定颜色发射的多层堆叠排列。彩色发光单元包括由有机电致发光材料制成的层。不同颜色发射的堆叠包括不同数量的彩色发光单元，以补偿特定颜色发射的退化。