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Miyagawa (43) Pub. Date: **Dec. 16, 2004**(54) **DISPLAY DEVICE**(52) U.S. Cl. **345/76**(75) Inventor: **Keisuke Miyagawa, Atsugi (JP)**Correspondence Address:
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POTOMAC FALLS, VA 20165 (US)(57) **ABSTRACT**

By operating a driving TFT in a saturation region, luminance is not easily reduced when an EL element is degraded. However, such problems occur as a high voltage, high power consumption, and heat generation. In the case of operating a driving TFT in a saturation region, luminance varies due to a variation of driving TFTs. In view of the aforementioned problems, a high current capacity TFT is used in the high gray-scale and a low current capacity TFT is used in the low gray-scale. The high current capacity TFT can supply a large current with a lower Vgs, therefore, it does not easily operate in a linear region even when Vds is lowered. Thus, a luminance is not reduced easily even when an EL element is degraded, and an operation at a low voltage is realized. The low current capacity TFT supplies current when high Vgs is applied. With high Vgs, an effect of variation in characteristics of TFTs, especially in Vth can be ameliorated.

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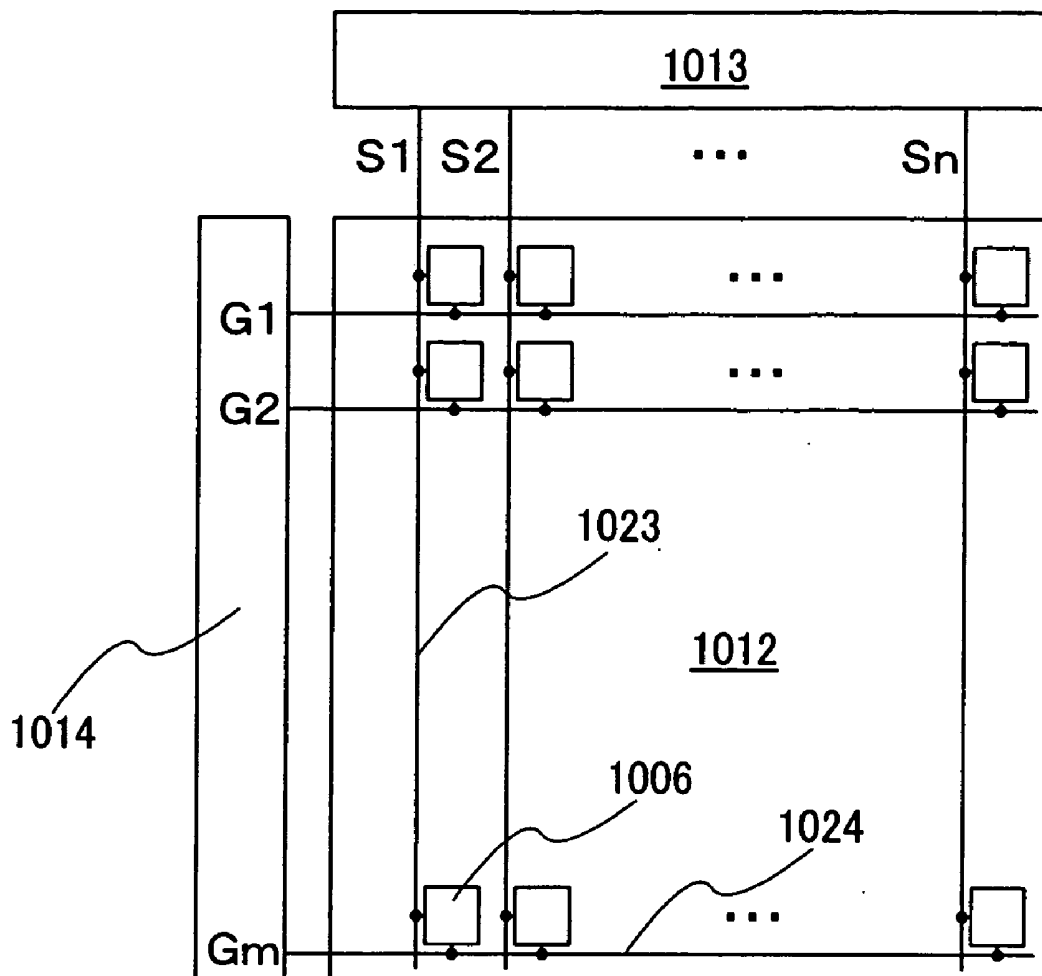
Publication Classification(51) Int. Cl.⁷ **G09G 3/30**

FIG.1

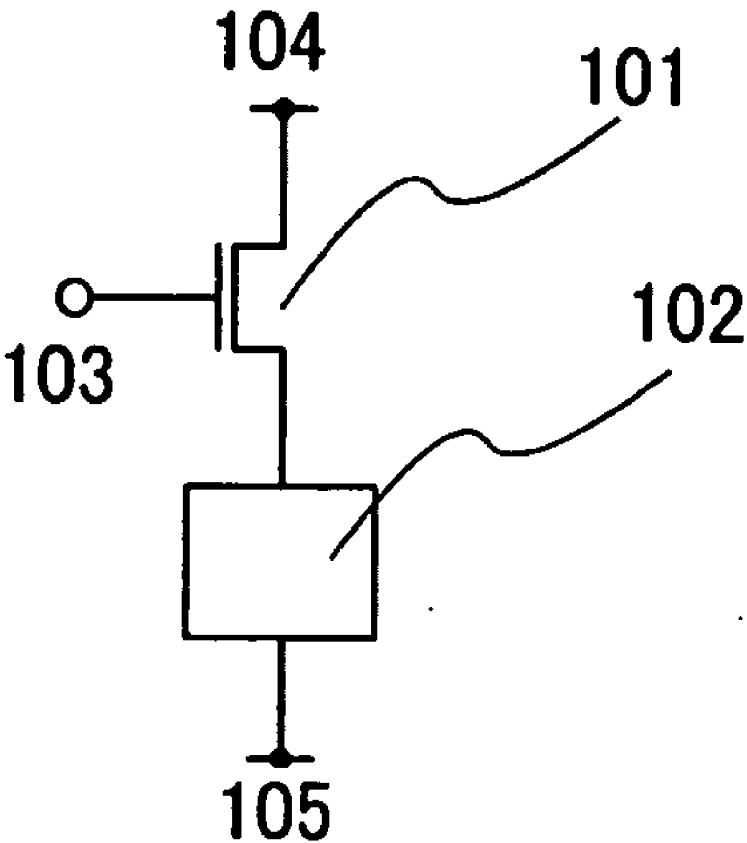


FIG.2

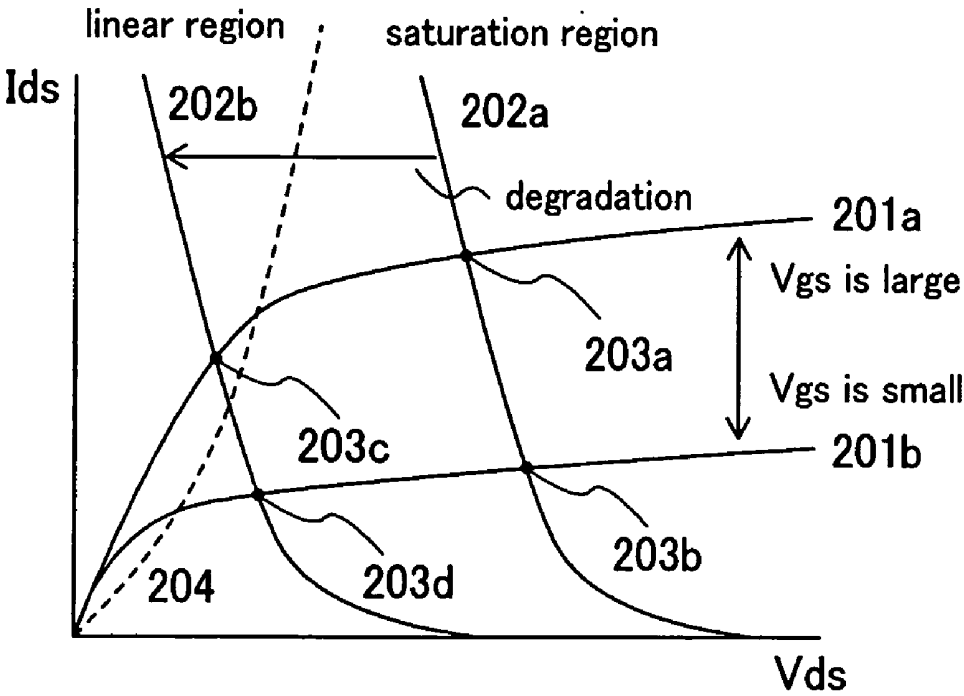


FIG.3

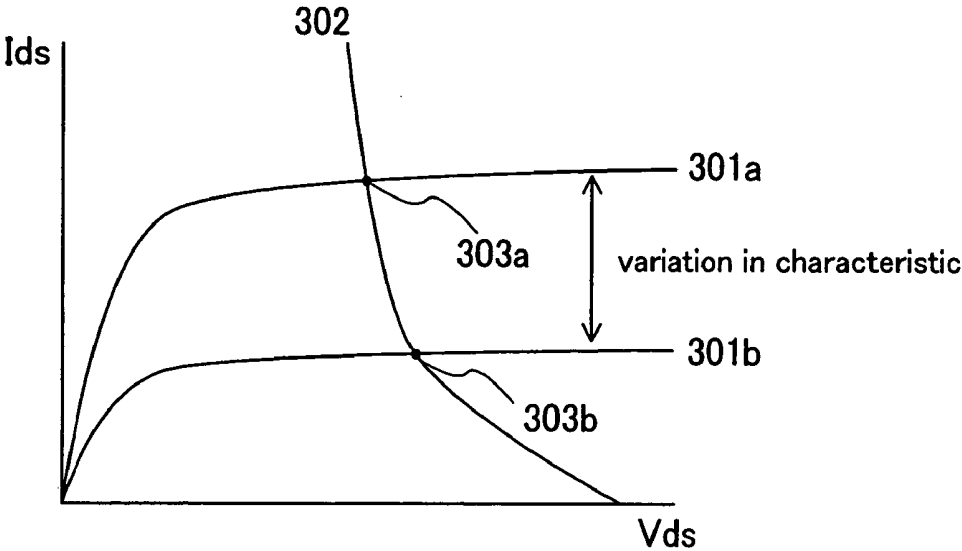


FIG.4

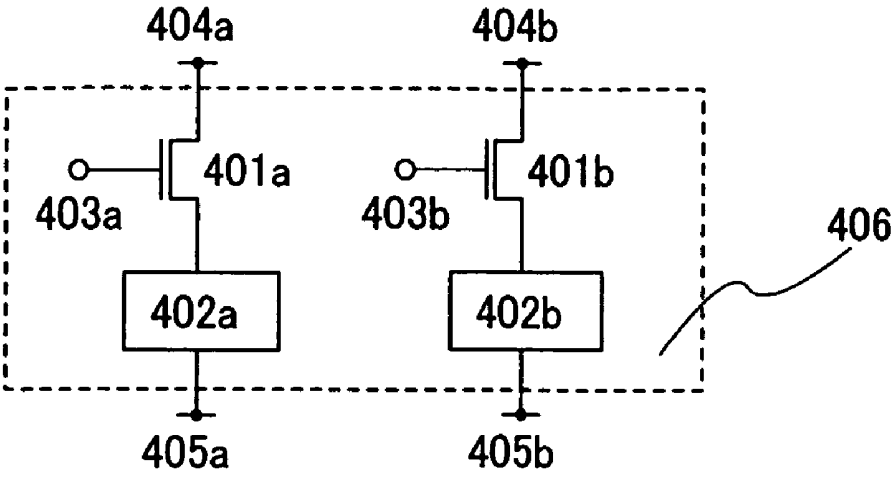


FIG.5

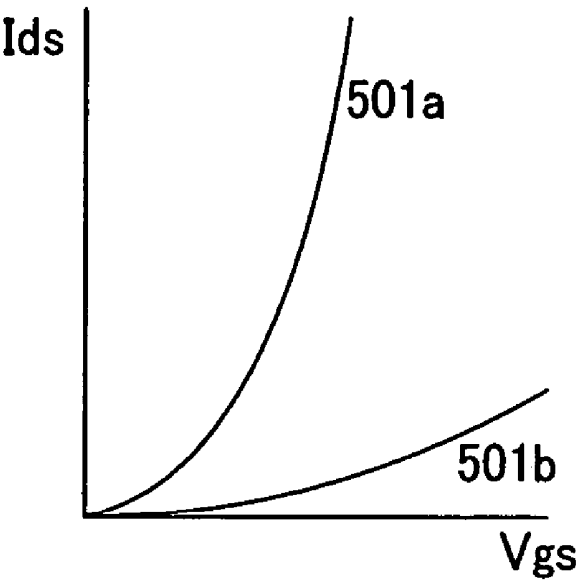


FIG.6

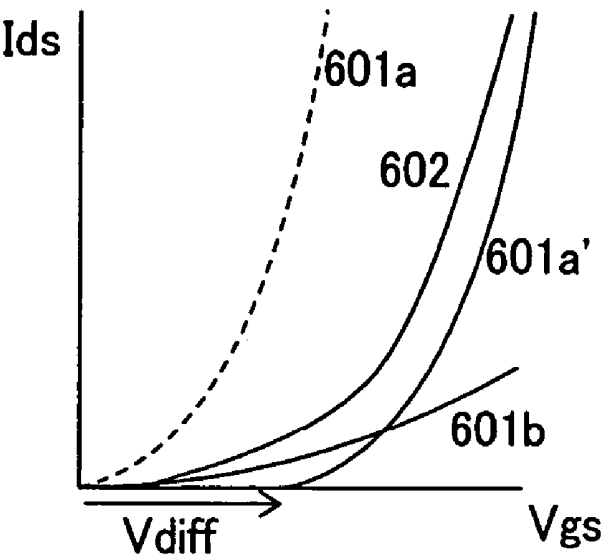


FIG. 7A

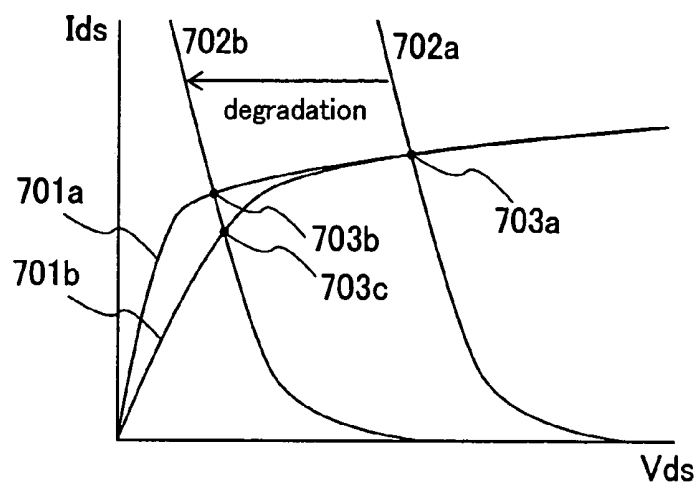


FIG.7B

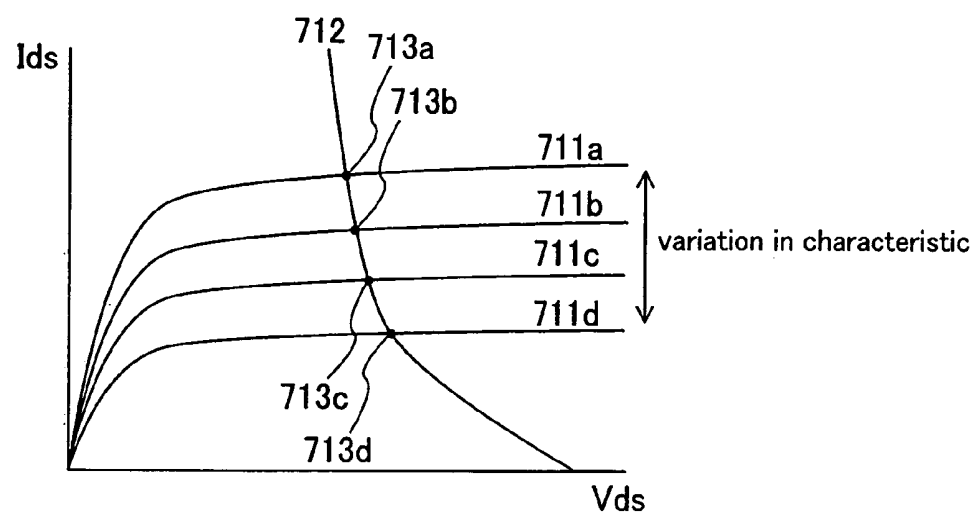


FIG.8A

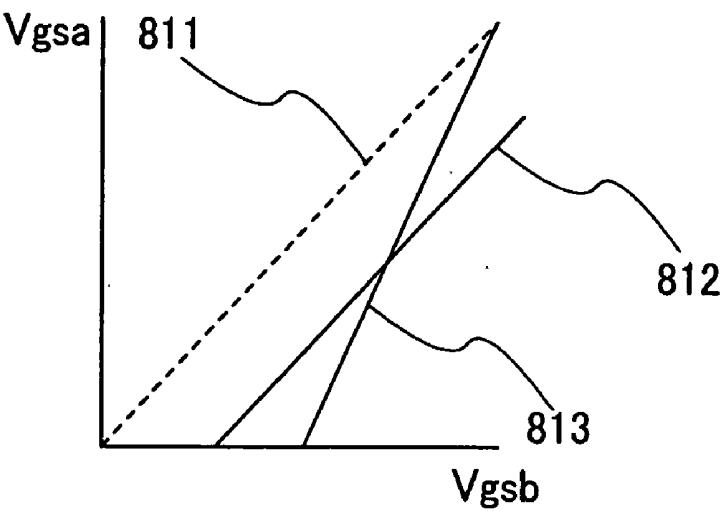


FIG.8B

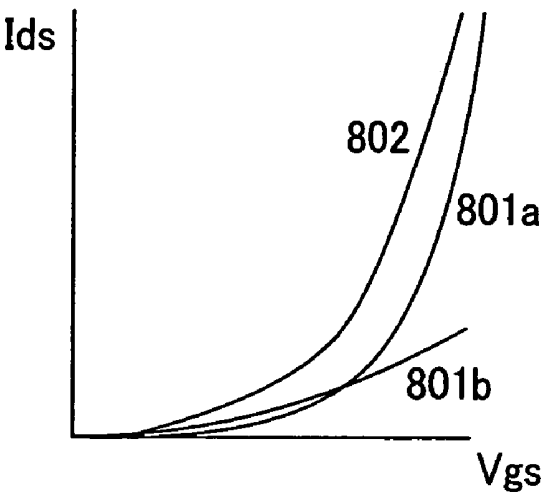


FIG.9

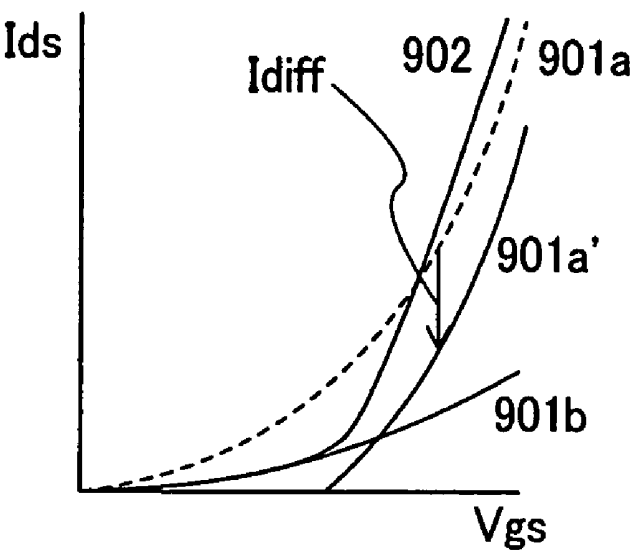


FIG.10

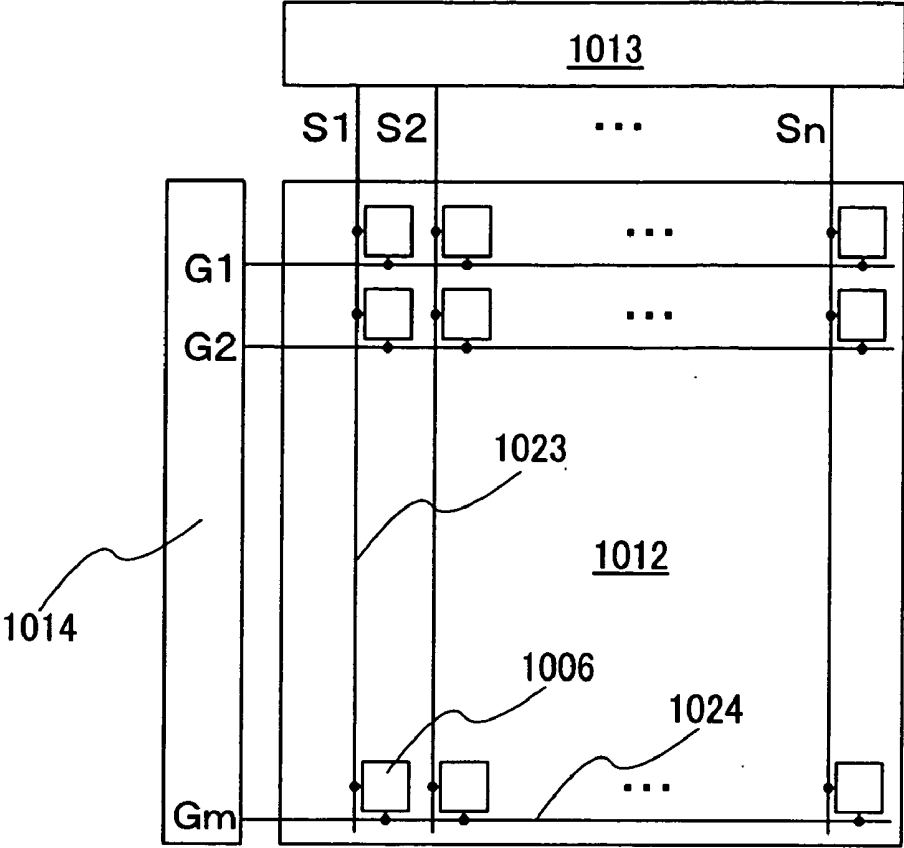


FIG.11

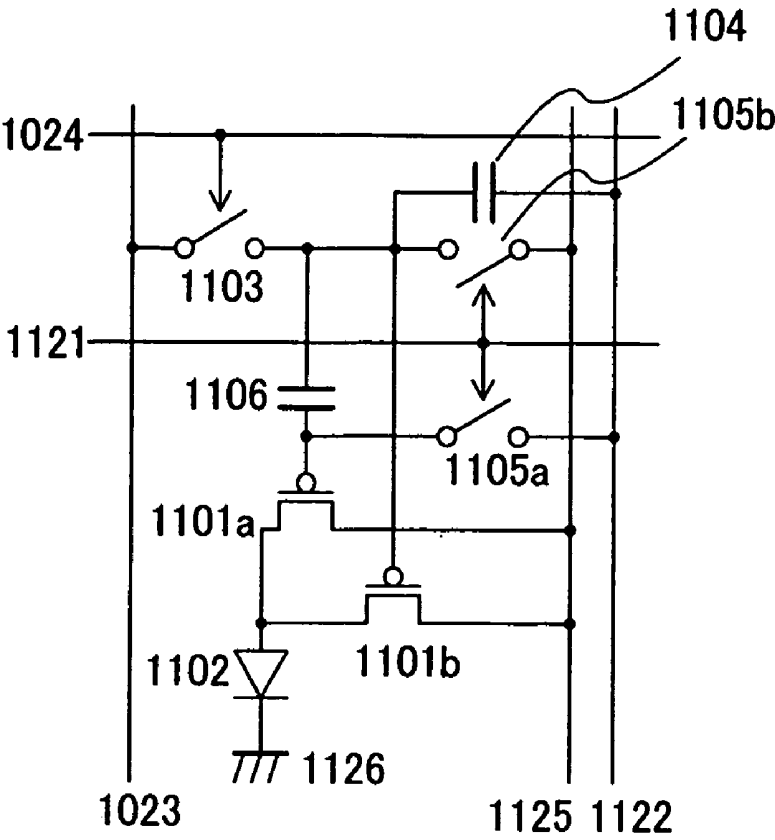


FIG.12

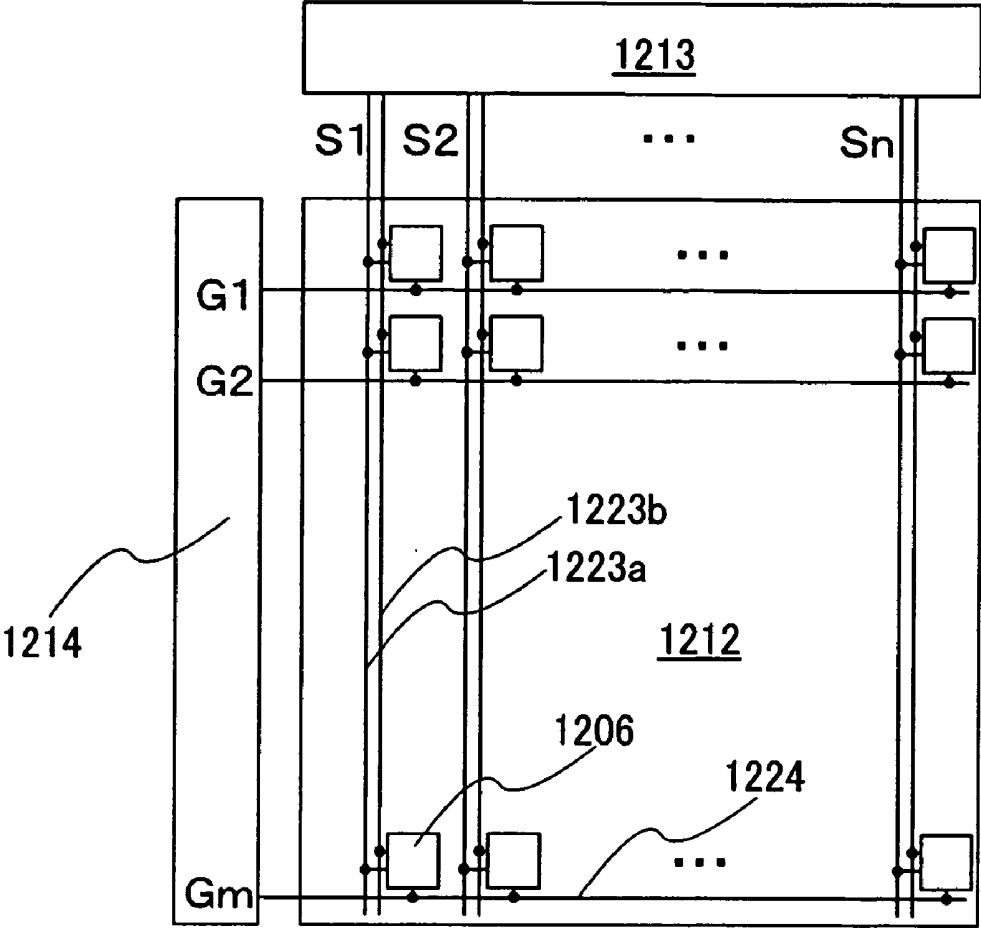


FIG.13

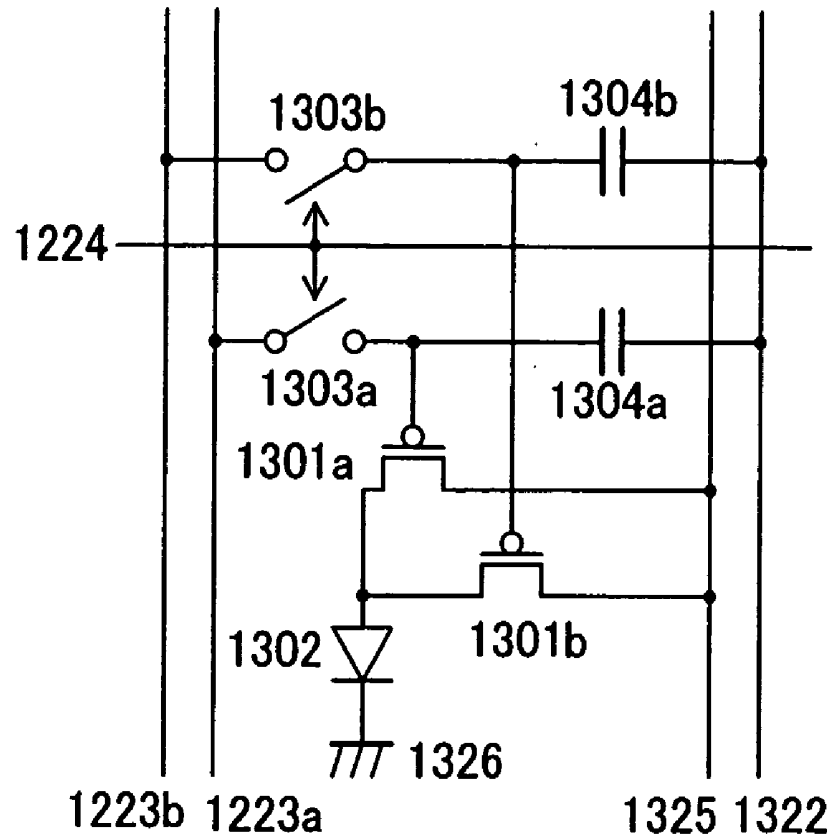


FIG.14

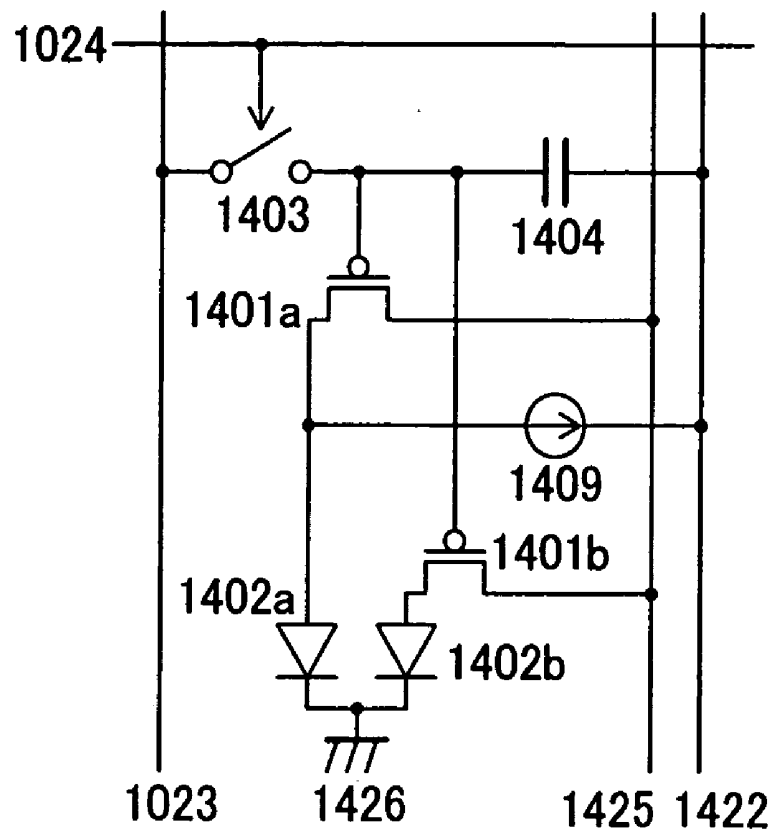


FIG.15A

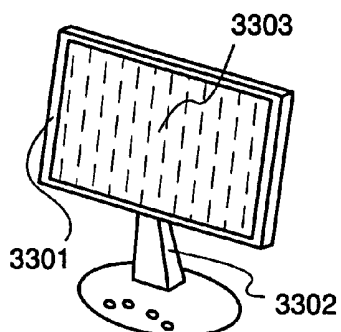


FIG.15B

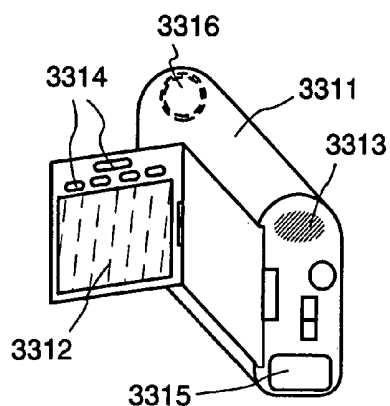


FIG.15C

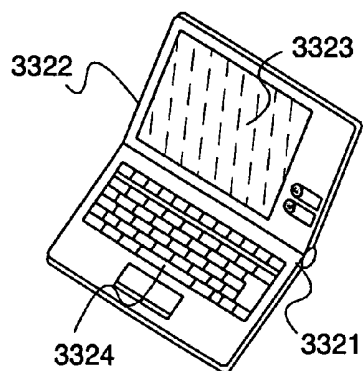


FIG.15D

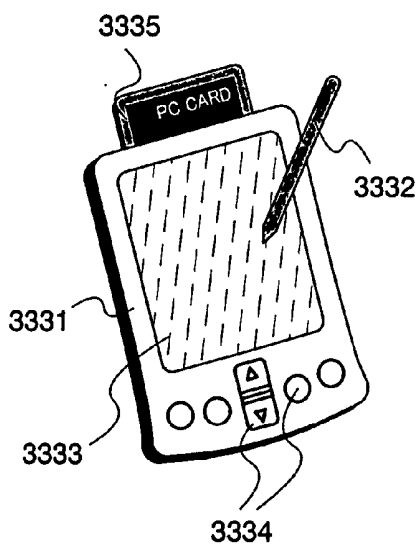


FIG.15E

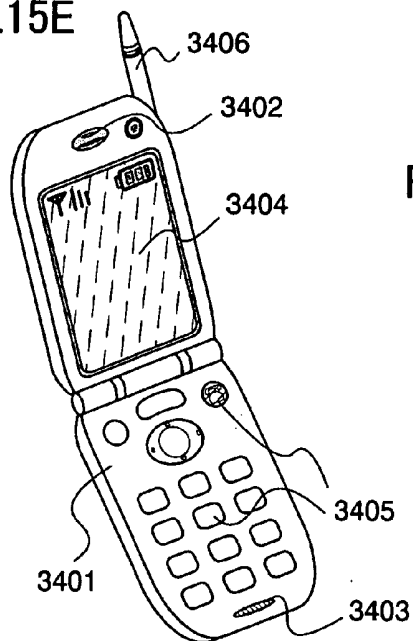
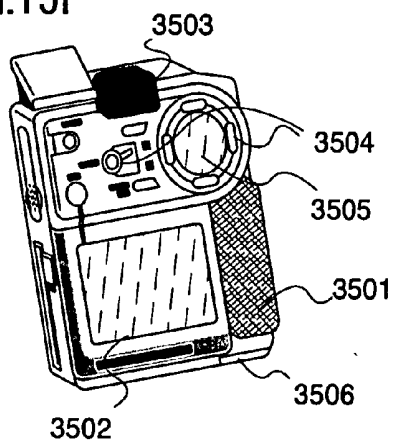


FIG.15F



DISPLAY DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The invention relates to a display device having a transistor. More specifically, the invention relates to a display device having an EL element and a thin film transistor (hereinafter referred to as a TFT) and the like formed on an insulator. Further, the invention relates to an electronic device having such a display device.

[0003] 2. Description of the Related Art

[0004] In recent years, a display device having a light emitting element such as an electro luminescence (EL) element is actively developed. The light emitting element emits light by itself and does not use backlight which is required in a liquid crystal display (LCD) and the like, therefore, it is highly visible and suitable for fabricating in a thin form. Furthermore, its viewing angle is almost unlimited.

[0005] Generally, an EL element emits light when a current is supplied. Therefore, a different pixel configuration from LCD is suggested (refer to Non-patent Document 1).

[0006] [Non-patent Document 1]

[0007] "Material technology and fabrication of elements regarding an organic EL display", Technical Information Institute, January 2002, p.179-195

SUMMARY OF THE INVENTION

[0008] In aforementioned Non-patent Document 1, by operating a driving TFT in a saturation region, a luminance is not easily reduced even when an EL element is degraded. However, a voltage with an estimated degradation has to be applied in advance, therefore, there are such problems as a high power consumption and heat generation caused by high voltage. Further, in the case of operating driving TFTs in a saturation region, luminance varies due to the variation of the driving TFTs. In view of the aforementioned problems, the invention provides a display device which is not affected by degradation of the EL elements, capable of operating with a low voltage, and has a circuit configuration that can ameliorate the effect of the variation of driving TFTs.

[0009] As a source and a drain of a TFT can be of the same structure, they are referred to as a first electrode and a second electrode in this specification. A state that a voltage over a threshold voltage is applied between the gate and source of a TFT and a current flows between the source and drain is referred to as being ON. Further, a state that a voltage below the threshold voltage is applied between the gate and source of a TFT and a current does not flow between the source and drain is referred to as being OFF. Note that a TFT is used as an element forming a display device in this specification, however, the invention is not limited to this. For example, a MOS transistor, an organic transistor, a bipolar transistor, a molecular transistor and the like may be used instead. A mechanical switch may be used as well.

[0010] In this specification, an EL element is used as a light emitting element, however, the invention is not limited to this. For example, a light emitting diode and the like may be used.

[0011] In a display device in which a driving TFT **101** and an EL element **102** are connected as shown in **FIG. 1**, the gate of the driving TFT **101** is connected to a signal terminal **103**, a first terminal is connected to a first power supply terminal **104**, a second terminal is connected to a first terminal of an EL element **102**, a second terminal of the EL element **102** is connected to a second terminal of a power supply terminal **105**. In the aforementioned display device, the driving TFT **101** controls a current flowing to the EL element **102** and determines luminance of the EL element **102**. By operating the driving TFT **101** in a saturation region, a current I_{ds} between the source and drain of the driving TFT **101** can be controlled by a voltage V_{gs} between the gate and source thereof. In **FIG. 1**, the driving TFT **101** may be an N-channel TFT or a P-channel TFT.

[0012] It should be noted that a terminal does not have to be actually provided as long as a wiring is electrically connected, although it is referred to as a terminal for convenience in this specification. Moreover, a voltage between the gate and source of the TFT is referred to as V_{gs} , a voltage between the source and drain of the TFT is referred to as V_{ds} , a current between the drain and source of the TFT is referred to as I_{ds} , and a threshold voltage of the TFT is referred to as V_{th} in this specification.

[0013] In the case of operating the driving TFT in a saturation region, the following two problems occur. The source terminal and the drain terminal are determined depending on a voltage applied to the driving TFT **101**, therefore, a terminal on the first power supply terminal **104** side in **FIG. 1** may be either a source terminal or a drain terminal. The source terminal and the drain terminal are determined depending on a voltage applied to the first and second electrodes of the driving TFT **101** and a polarity whether the driving TFT **101** is Nch TFT or Pch TFT.

[0014] A first problem is that the driving TFT **101** tends to be operated in a linear region especially in a high gray-scale in which a large current flows into the EL element **102**. **FIG. 2** shows V_{ds} - I_{ds} characteristic lines **201a** and **201b** of the driving TFT **101** and V - I characteristic lines **202a** and **202b** of the EL element **102** in load lines. The characteristic line **201a** shows the case of a high gray-scale where V_{gs} is high and I_{ds} is large and the characteristic line **201b** shows the case of a low gray-scale where V_{gs} is low and I_{ds} is small. Further, the characteristic line **202a** shows the case before the EL element **102** is degraded, and the characteristic line **202b** shows the case after the EL element **102** is degraded. Intersections of the characteristic lines **201a** and **201b**, and the characteristic lines **202a** and **202b** correspond to operation points **203a** to **203d**. When transferring from the characteristic line **202a** to the characteristic line **202b** due to the degradation of the EL element **102**, the operation points **203a** and **203b** transfer to the operation points **203c** and **203d**. At this time, V_{ds} of the driving TFT **101** is lowered. In the case of the characteristic line **201a** of the high gray-scale in particular, a driving state is changed with the operation point **203a** in a saturation region transfers to the operation point **203c** in a linear region as shown in **FIG. 2** when V_{ds} is lowered. This is because higher V_{ds} of the characteristic line **201a** is included in a linear region since V_{gs} is high. It should be noted that $V_{gs}=V_{ds}$ is a border between a linear region and a saturation region, which is shown in a dotted line **204** in **FIG. 2**. In a linear region, I_{ds} changes drastically when V_{ds} changes, which changes a

current to flow into the EL element **102**. Thus, luminance changes and display quality is lowered because of an image persistence and the like. In a linear region, I_{ds} does not change much when V_{gs} changes, therefore a luminance cannot be controlled easily by controlling V_{gs} . In order to avoid these problems, a voltage with an estimated degradation is applied so as not to be operated in a linear region, however, such problems occur as a high power consumption, a heat generation, and a faster degradation of a TFT element.

[0015] In the characteristic line **201b** of the low gray-scale with small I_{ds} , the driving TFT operates in a saturation region even when the operation point **203b** transfers to the operation point **203d**. This is because lower V_{ds} of the characteristic line **201b** is included in a saturation region since V_{gs} is low.

[0016] A second problem is that the EL element **102** is easily affected by variation in characteristics of TFTs especially in a low gray-scale where a small current flows to the EL element **102**. FIG. 3 shows V_{ds} - I_{ds} characteristic lines **301a** and **301b** of the driving TFT **101** and V-I characteristic line **302** of the EL element **102** in load lines. The characteristic lines **301a** and **301b** show the case where a characteristic of the driving TFT **101** varies. Intersections of the characteristic lines **301a**, **301b** and **302** correspond to operation points **303a** and **303b**. Characteristics of TFTs are not uniform, but have variation in V_{th} , for example. When the characteristic line **301a** transfers to the characteristic line **301b** due to the variation in characteristic of the driving TFT **101**, the operation point **303a** transfers to the operation point **303b**, which changes I_{ds} . I_{ds} is in proportion to $(V_{gs}-V_{th})^2$, however, it is easily affected by the variation in V_{th} since V_{gs} is low in the low gray-scale with small I_{ds} . This causes luminance variation of a display device and decrease of display quality.

[0017] In the high gray-scale with large I_{ds} , I_{ds} is not easily affected by the variation in V_{th} since V_{gs} is high.

[0018] In the invention, a high current capacity TFT is used in a high gray-scale (display) while a low current capacity TFT is used in a low gray-scale (display) as a driving TFT.

[0019] A high current capacity TFT is used as a driving TFT in a high gray-scale because it can supply a large current even with a lower V_{gs} , therefore, it does not operate in a linear region easily even when V_{ds} is lowered. Therefore, luminance is not reduced when the EL element is degraded and operation with low voltage is possible. Thus, low power consumption and low heat generation can be realized, which prevents degradation of a TFT element.

[0020] A low current capacity TFT supplies current when high V_{gs} is applied. A low current capacity TFT is used for low gray-scale as a driving TFT because an effect of variation in characteristics of a TFT, in V_{th} particularly can be ameliorated by operating with a high V_{gs} . The use of this TFT is efficient particularly in the low gray-scale in which V_{gs} is low, and can enhance a display quality. Further, by designing a channel length L of the TFT long in order to suppress a current capacity, a variation in characteristics can be ameliorated.

[0021] A configuration of the invention is described now. A display device of the invention comprises at least a signal line which is inputted an analog signal, a scan line, a

plurality of transistors, and a light emitting element. The display device further comprises a first transistor connected to a first signal line and the scan line, a first driving transistor connected to the light emitting element, a second transistor connected to a second signal line and the scan line, and a second driving transistor connected to the light emitting element.

[0022] A display device of the invention comprises at least a signal line which is inputted an analog signal, a scan line, a plurality of transistors, and a light emitting element. The display device further comprises a first transistor connected to a first signal line and the scan line, a first capacitor connected to the first transistor and a power supply line, a first driving transistor of which gate electrode is connected to the first capacitor and of which one electrode is connected to the light emitting element, a second transistor connected to a second signal line and the scan line, a second capacitor connected to the second transistor and the power supply line, and a second driving transistor of which gate electrode is connected to the second capacitor and of which one electrode is connected to the light emitting element.

[0023] In the aforementioned configuration, the first and the second driving transistors may have different current capacities. As another configuration, display in high gray-scale can be performed by making the current capacity of the first driving transistor higher than that of the second driving transistor. Further, display in low gray-scale can be performed by making the current capacity of the second driving transistor lower than that of the first driving transistor.

[0024] Furthermore, in the aforementioned configuration, a voltage between the gate and drain of the first driving transistor may be different from that of the second driving transistor.

[0025] The display device of the invention may comprise a unit for selecting a plurality of driving transistors connected to the light emitting element according to the luminance thereof.

[0026] According to the invention, by using a plurality of driving TFTs having different characteristics, an effect by the degradation of an EL element and variation in characteristic of the driving TFTs can be small and an operation at a low voltage is realized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] FIG. 1 is a circuit diagram showing light emission of an EL element.

[0028] FIG. 2 is a load line diagram showing characteristics of the circuit in FIG. 1.

[0029] FIG. 3 is a load line diagram showing characteristics of the circuit in FIG. 1.

[0030] FIG. 4 is a diagram showing a configuration of the display device of the invention.

[0031] FIG. 5 is a diagram showing characteristics of a driving TFT.

[0032] FIG. 6 is a diagram showing operations of the display device of the invention.

[0033] FIGS. 7A and 7B are load line diagrams showing operations of the display device of the invention.

[0034] FIGS. 8A and 8B are diagrams showing operations of the display device of the invention.

[0035] FIG. 9 is a diagram showing an operation of the display device of the invention.

[0036] FIG. 10 is a diagram showing an embodiment of the invention.

[0037] FIG. 11 is a diagram showing an embodiment of the invention.

[0038] FIG. 12 is a diagram showing an embodiment of the invention.

[0039] FIG. 13 is a diagram showing an embodiment of the invention.

[0040] FIG. 14 is a diagram showing an embodiment of the invention.

[0041] FIGS. 15A to 15F are examples of electronic devices to which the invention is applicable.

DETAILED DESCRIPTION OF THE INVENTION

EMBODIMENT MODE 1

[0042] This application is based on Japanese Patent Application serial no. 2003-139665 filed in Japan Patent Office on 16th, May, 2003, the contents of which are hereby incorporated by reference.

[0043] Although the present invention will be fully described by way of example with reference to the accompanying drawings, it is to be understood that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention, they should be construed as being included therein. Note that like components are denoted by like numerals in different drawings as of the configuration of the invention.

[0044] FIG. 4 shows an embodiment mode of the invention. A display device includes one or more of a pixel 406, and the pixel 406 comprises EL elements 402a and 402b respectively, driving TFTs 401a and 401b for driving the EL elements 402a and 402b, signal terminals 403a and 403b connected to gates of the driving TFTs 401a and 401b respectively, first power supply terminals 404a and 404b connected to first terminals of the driving TFTs 401a and 401b respectively, and second power supply terminals 405a and 405b connected to second terminals of the EL elements 402a and 402b respectively. Second terminals of the driving TFTs 401a and 401b are connected to first terminals of the EL elements 402a and 402b respectively.

[0045] The driving TFT 401a and the driving TFT 401b have different characteristics. By using TFTs of different characteristics, a display device can be operated favorably in both a high gray-scale and a low gray-scale. Characteristics of TFTs can be made different by making the size or shape of the TFTs different, making the kind of dopant or the amount of doping of the TFTs different, and making the number of TFTs connected in series or parallel different.

[0046] It should be noted that other elements may be provided between the gates of the driving TFTs 401a and 401b and the signal terminals 403a and 403b respectively,

between the first terminals of the driving TFTs 401a and 401b and the first power supply terminals 404a and 404b respectively, between the second terminals of the EL elements 402a and 402b and the second power supply terminals 405a and 405b respectively, and between the second terminals of the driving TFTs 401a and 401b and the first terminals of the EL elements 402a and 402b respectively. For example, by providing switches between the first terminals of the driving TFTs 401a and 401b and the first power supply terminals 404a and 404b respectively, emission and non-emission of the EL elements 402a and 402b can be controlled regardless of the states of the signal terminals 403a and 403b.

[0047] The driving TFTs 401a and 401b may be an N-channel TFT or a P-channel TFT.

[0048] The EL elements 402a and 402b, the first power supply terminals 404a and 404b, and the second power supply terminals 405a and 405b can be common respectively, but may be separated. By separating them, operations in the high gray-scale and the low gray-scale can be controlled separately. For example, an element area of the EL element 402a is designed wide for displaying the high gray-scale and that of the EL element 402b is designed narrow for displaying the low gray-scale separately. An EL element of narrower area generally has higher resistance, and a smaller current flows in the lower gray-scale, therefore, potential of operation points of the EL elements can be close to each other in the high gray-scale and the low gray-scale. Each Vds of the driving TFTs 401a and 401b corresponds to the voltage that deducted the fall in voltage in the EL elements 402a and 402b from the difference between the first power supply terminals 404a and 404b, and the second power supply terminals 405a and 405b. When potential of the operation points of the EL elements are close to each other in the high gray-scale and the low gray-scale, Vds of the driving TFTs 401a and 401b can be close to each other. Typically, Ids of TFT tends to rise slightly when Vds rises even in a saturation region, which is an obstacle for an accurate luminance control. By controlling Vds so as to be close to each other in the high gray-scale and the low gray-scale, more accurate luminance control can be performed.

[0049] The signal terminals 403a and 403b are separated, however, they may be one common terminal as well.

[0050] An operation of the display panel of the invention is described with reference to FIG. 5.

[0051] FIG. 5 shows a relation between Vgs and Ids of the driving TFTs 401a and 401b. As an example, a high current capacity TFT is used as the driving TFT 401a and a low current capacity TFT is used as the driving TFT 401b. A characteristic line 501a corresponds to Vgs-Ids characteristic of the driving TFT 401a and the characteristic line 501b corresponds to Vgs-Ids characteristic of the driving TFT 401b. It should be noted that Ids flows into the EL elements 402a and 402b in FIG. 4.

[0052] In an EL element, current and luminance are in proportion generally. Therefore, a luminance can be controlled by controlling Ids. The luminance of a display device corresponds to a sum of the currents flowing into the EL elements 402a and 402b.

[0053] Each Vgs of the driving TFT 401a and the driving TFT 401b is controlled separately. Here, Vgs of the driving TFT 401a is referred to as Vgsa, and Vgs of the driving TFT 401b is referred to as Vgsb. The driving TFTs 401a and 401b controlled separately supply currents Idsa and Idsb into the EL elements 402a and 402b corresponding to Vgsa and Vgsb respectively. A current Idsa+Idsb determines the luminance of the display device.

[0054] In the high gray-scale of high luminance, Ids of the driving TFT 401a is made higher than that of the driving TFT 401b, while in the low gray-scale of low luminance, Ids of the driving TFT 401b is made higher than that of the driving TFT 401a.

[0055] FIG. 6 shows an example where the gates of the driving TFTs 401a and 401b have different voltages. Vgsa and Vgsb are determined so as to satisfy the following formula.

$$Vgsa = Vgsb - Vdiff \quad [\text{Formula 1}]$$

[0056] A characteristic line 601a' shows the case where Vgsa is applied to the gate of the driving TFT 401a and a characteristic line 601b shows the case where Vgsb is applied to the gate of the driving TFT 401b. Note that the characteristic line 601a' corresponds to a characteristic line 601a in which Vgsb is applied to the gate of the driving TFT 401a is shifted by Vdiff.

[0057] A current Ids in a saturation region is expressed by the following formula when a drain current of the driving TFT 401a is Idsa' and a drain current of the driving TFT 401b is Idsb.

$$\begin{aligned} Idsa' &= \frac{Wa}{La} \mu a Ca \frac{(Vgsa - Vtha)^2}{2} \\ &= \frac{Wa}{La} \mu a Ca \frac{(Vgsb - Vdiff - Vtha)^2}{2} \\ Idsb &= \frac{Wb}{Lb} \mu b Cb \frac{(Vgsb - Vthb)^2}{2} \end{aligned} \quad [\text{Formula 2}]$$

[0058] Here, Wa, Wb, La, Lb, μa , μb , Ca, Cb, Vtha, and Vthb are gate width, gate length, mobility, capacitance per unit area of an oxide film, and threshold voltage of the driving TFTs 401a and 401b respectively.

[0059] A sum Iel of the current flowing into the EL elements 402a and 402b can be expressed by the following formula.

$$\begin{aligned} Iel &= Idsa' + Idsb \\ &= \frac{Wa}{La} \mu a Ca \frac{(Vgsb - Vdiff - Vtha)^2}{2} + \\ &\quad \frac{Wb}{Lb} \mu b Cb \frac{(Vgsb - Vthb)^2}{2} \end{aligned} \quad [\text{Formula 3}]$$

[0060] Further, Iel can be expressed by a characteristic line 602 in FIG. 6. This Iel determines the luminance of a display device.

[0061] The driving TFT 401a has a higher current capacity than the driving TFT 401b. Idsa' is comparatively larger in a high gray-scale where a consumption current is large, while Idsb is comparatively larger in a low gray-scale where a consumption current is small and an effect of variation in characteristics of the driving TFTs is preferably small. By selectively using driving TFTs according to the gray-scale, a display device which is not largely affected by the degradations of the EL elements 402a and 402b and the variation in characteristics of the driving TFTs, and consumes less power can be provided.

[0062] Idsa' becomes almost zero when the formula $=vgsb - Vdiff - Vtha = 0$ is satisfied, therefore, luminance of a display device is almost dependent on the current supplied by the driving TFT 401b. Further, as Vgsa and Vgsb get higher, a current supplied by the driving TFT 401a becomes larger than the current supplied by the driving TFT 401b. As described above, the current supplied by the driving TFT 401b is large in the low gray-scale and the current supplied by the driving TFT 401a is large in the high gray-scale.

[0063] An advantage of the case of using a high current capacity TFT in the high gray-scale is shown by load lines in FIG. 7A. When Vds-Ids characteristic in the case of using a high current capacity TFT as the driving TFT 401a is a characteristic line 701a, Vds-Ids characteristic in the case of using a low current capacity TFT is a characteristic line 701b. Further, V-I characteristic before the EL element 402a is degraded is a characteristic line 702a and V-I characteristic after degradation is a characteristic line 702b. Intersections of the characteristic lines 701a and 701b, and the characteristic lines 702a and 702b corresponds to operation points 703a to 703c. At this time, Vgs of a driving TFT is controlled so that Ids of the characteristic lines 701a and 701b become the same at the operation point 703b. In the high current capacity TFT, characteristic of current rises sharply in a linear region. As lower Vds enters a saturation region, the high current capacity TFT does not operate in a linear region easily even when the EL element 402a degrades and Vds is lowered. In FIG. 7A, an operation point 703b corresponds to the case of using a high current capacity TFT and an operation point 703c corresponds to the case of using a low current capacity TFT when the EL element 402b is degraded.

[0064] An advantage in the case of using a low current TFT in the low gray-scale is shown by a load line in FIG. 7B. When Vds-Ids characteristic in the case of using a high current capacity TFT as the driving TFT 401b varies in the region from a characteristic line 711a to a characteristic line 711d, Vds-Ids characteristic in the case of using a low current capacity TFT varies in the region from a characteristic line 711b to the characteristic line 711c, which is narrower than the case of using a high current TFT. Further, V-I characteristic of the EL element 402b corresponds to a characteristic line 712. Intersections of the characteristic lines 711a to 711d and the characteristic line 712 correspond to operation points 713a to 713d. The operation point varies in the case of using a high current capacity TFT in the region from 713a to 713d, while it varies in the region from the operation points 713b to 713c in the case of using a low current capacity TFT, which is narrower than the case of using a high current TFT.

[0065] A reason why the variation is narrower in the case of using a low current capacity TFT is described now. I_{ds} of a TFT in a saturation region can be expressed by the following formula.

$$I_{ds} = \frac{W}{L} \mu C \frac{(V_{gs} - V_{th})^2}{2} \quad [\text{Formula 4}]$$

[0066] Here, W , L , μ , C , and V_{th} correspond to gate width, gate length, mobility, capacitance per unit area of an oxide film, and threshold voltage respectively. When W/L is small, current capacity is lowered. By the above formula, the lower the current capacity of the driving TFT 401b is, the higher V_{gs} is applied even with the same I_{ds} . By applying higher V_{gs} , an effect of the variation in V_{th} to I_{ds} can be small, which makes the variation in I_{ds} small.

[0067] V_{gs} is high in high gray-scale, therefore, an effect of V_{th} is small. Thus, a high current TFT may be used as the driving TFT 401a. Further, V_{gs} is low in the low gray-scale, therefore, a driving TFT is easily operated in a saturation region. Thus, a low current capacity TFT may be used as the driving TFT 401b.

[0068] In this embodiment mode, the driving TFT 401a which provides a high current capacity is used as a power supply in the high gray-scale, while the driving TFT 401b which provides a low current capacity is used as a power supply in the low gray-scale. By selectively using the driving TFTs according to the gray-scale, a display device in which luminance is not easily reduced even when the EL elements 402a and 402b are degraded and which is not easily affected by the variation of the TFTs can be provided.

[0069] An additional voltage for the voltage fall caused by the increased resistance of the EL elements 402a and 402b in the case where the EL elements 402a and 402b are degraded is applied in advance between the first power supply terminals 404a and 404b and the second power supply terminals 405a and 405b besides the driving voltage of the EL elements 402a and 402b and the voltage for the driving TFTs 401a and 401b to reach a saturation region. In this manner, the driving TFTs 401a and 401b do not operate in a linear region even when V_{ds} of the driving TFTs 401a and 401b are lowered by the increased voltage fall of the EL elements 402a and 402b. Thus, luminance is not reduced. However, by applying a voltage for the voltage fall caused by the increased resistance of the EL elements 402a and 402b, power consumption may be increased. In this embodiment mode, by mainly using a high current capacity TFT in the high gray-scale, lower V_{ds} of the driving TFT is included in a saturation region. As the lower V_{ds} is in a saturation region, degradations of the EL elements 402a and 402b do not have much effect even when the first power supply terminals 404a and 404b and the second power supply terminals 405a and 405b have small voltage between them. As described above, a display device which consumes less power, generates less heat, and of which TFTs are not degraded easily can be provided.

[0070] An example of a method for applying a potential difference V_{diff} between V_{gsa} and V_{gsb} is described now. A capacitor having potential difference in each end is provided between a gate and signal terminals 403a and 403b

of one or both of the driving TFT 401a and 401b. As a result, one or both of the gates of the driving TFTs 401a and 401b which is provided with a capacitor is applied a voltage which is a sum of the voltage of the signal terminals 403a and 403b and the potential difference between both ends of the capacitor. In this example, a potential difference V_{diff} can be applied to the gates of the driving TFTs 401a and 401b by using a capacitor even when the signal terminals 403a and 403b are one terminal. Provided that the signal lines 403a and 403b are common, control of the driving TFTs 401a and 401b can be easy.

EMBODIMENT MODE 2

[0071] An embodiment mode of the invention is described with reference to FIGS. 8A and 8B. In order to set V_{gs} of the driving TFTs 401a and 401b at different voltages, a voltage of the driving TFT 401a is shifted in Embodiment Mode 1. A relation between V_{gs} of the driving TFT 401a and V_{gs} of the driving TFT 401b is shown in FIG. 8A. Here, V_{gs} of the driving TFT 401a is V_{gsa} and V_{gs} of the driving TFT 401b is V_{gsb} . When a characteristic line 811 shows the case of applying the same voltage as V_{gsa} and V_{gsb} , it corresponds to a characteristic line 812 in Embodiment Mode 1. In this embodiment mode, a different method for setting a voltage from Embodiment Mode 1 is described.

[0072] V_{gsa} is set so as to be low relatively to V_{gsb} in low gray-scale, while V_{gsb} is set so as to be close to V_{gsa} in higher gray-scale. A voltage setting in this embodiment mode is shown by a characteristic line 813.

[0073] FIG. 8B shows a V_{gs} - I_{ds} characteristic line 801a of the driving TFT 401a which is applied the aforementioned V_{gs} , a V_{gs} - I_{ds} characteristic line 801b of the driving TFT 401b, and a characteristic line 802 of a sum of the current of the driving TFTs 401a and 401b. I_{ds} of the driving TFT 401b becomes larger in the low gray-scale while I_{ds} of the driving TFT 401a becomes larger in the high gray-scale. A display device in which luminance is not easily reduced even when the EL elements 401a and 401b are degraded and which is not easily affected by variation of the driving TFTs 401a and 401b can be provided.

[0074] It is preferable that the driving TFTs 401a and 401b operate in a saturation region with lower V_{ds} so that luminance is not changed due to the degradation of the EL elements 402a and 402b. At this time, a saturation region begins from V_{ds} that is equal to V_{gs} , therefore, V_{gs} is preferred to be as low as possible in order to avoid an effect of a degradation of the EL elements 402a and 402b. V_{gs} changes according to the gray-scale and becomes a maximal value in the highest gray-scale. That is to say, it is efficient that V_{gs} of the driving TFTs 401a and 401b in the highest gray-scale be as low as possible. In order to make V_{gs} the lowest while making the currents of the driving TFTs 401a and 401b the largest in the highest gray-scale, V_{gs} in the highest gray-scale are set to be the same.

[0075] According to this embodiment mode, an effect of variation of TFTs can be small in the low gray-scale, and an effect of a degradation of an EL element can be small in the high gray-scale. Further, V_{gs} can be made as low as possible in the gray-scale which is affected the most by the degradation, therefore, the effect of the degradation can be even smaller.

EMBODIMENT MODE 3

[0076] An embodiment mode of the invention is described with reference to FIG. 9. Vgs of the driving TFTs 401a and 401b are set at different voltages in Embodiment Modes 1 and 2. In this embodiment mode, the driving TFT 401a can be mainly used in the high gray-scale and the driving TFT 401b can be mainly used in the low gray-scale even when Vgs of the driving TFTs 401a and 401b are the same.

[0077] It is assumed that a current supplied from the driving TFT 401a is Idsa and a current supplied from the driving TFTs 401b is Idsb. In this embodiment mode, a current that deducted a constant current Idiff from Idsa is supplied to the EL element 402a. A current Iel supplied to the EL elements 402a and 402b can be expressed by the following formula.

$$\begin{aligned} I_{el} &= I_{dsa} - I_{diff} + I_{dsb} \quad \dots \quad (I_{dsa} > I_{diff}) \quad I_{el} = I_{ds} \quad \dots \quad \\ & \quad (I_{dsa} \leq I_{diff}) \end{aligned} \quad [\text{Formula 5}]$$

[0078] FIG. 9 shows a Vgs-Ids characteristic line 901a of the driving TFT 401a which is applied Vgs, a characteristic line 901a' that deducted Idiff from the characteristic line 901a, a Vgs-Ids characteristic line 901b of the driving TFT 401b, and a characteristic line 902 which is a sum of the characteristic line 901a' and the characteristic line 901b. Here, the characteristic line 901a corresponds to Idsa, the characteristic line 901b corresponds to Idsb, and the characteristic line 902 corresponds to Iel. Ids of the driving TFT 401b is comparatively larger in the low gray-scale, while Ids of the driving TFT 401a is comparatively larger in the high gray-scale. Thus, a display device in which a luminance is not easily reduced when the EL elements 402a and 402b are degraded and which is not easily affected by a variation in characteristics of the driving TFTs 401a and 401b can be provided.

[0079] Unlike Embodiment Mode 1 in which Vgs of the driving TFT 401a is shifted and Embodiment Mode 2 in which Vgs of the driving TFTs 401a and 401b are controlled separately, Vgs of the driving TFTs 401a and 401b are equal in this embodiment mode. When Vgs are equal, the signal terminals 403a and 403b can be common and a gray-scale can be controlled simply.

EMBODIMENT MODE 4

[0080] In Embodiment Modes 1 to 3, three or more driving TFTs may be used. In the case of using three driving TFTs for example, a gray-scale is divided into three levels: low gray-scale, middle gray-scale, and high gray-scale, then a driving TFT having an appropriate characteristic is provided to each level. By using three or more driving TFTs, an effect of degradation and variation can be suppressed in the case of a light emission at an extremely low luminance and a light emission at a high luminance.

[0081] In the case of a display device which is used both in darkness and brightness such as a portable device, a light emission at an extremely low luminance is required in darkness and a light emission at high luminance is required in brightness. In the case of using three driving TFTs for example, two driving TFTs are used at each of the extremely low luminance and the high luminance. In the light emission at an extremely low luminance, a first driving TFT which

provides a low current capacity and a second driving TFT which provides a middle current capacity are used. The first driving TFT is used in a lower gray-scale at the extremely low luminance, while the second driving TFT is used in a higher gray-scale therein. Further, in the light emission at a high luminance, the second driving TFT which provides a middle current capacity and a third driving TFT which provides a high current capacity are used. The second driving TFT is used in a lower gray-scale in the high gray-scale, while the third driving TFT is used in a higher gray-scale at the high luminance. At the extremely low luminance, a power supply voltage can be low in order to maintain an operation in a saturation region even when Vds is low, thus a power consumption can be reduced. By using three or more driving TFTs as described above, an optimal drive regardless of a luminance can be produced. It is needless to say that three or more driving TFTs may be used at the same time in a single luminance level.

EMBODIMENT

[0082] An embodiment of the invention is described now.

Embodiment 1

[0083] In this embodiment, a structure of the display device described in Embodiment Mode 1 is described. FIG. 10 is a structure of the display device. The display device comprises a pixel portion 1012 in which a plurality of pixels 1006 are arranged in matrix of m rows and n columns, and a signal driver circuit 1013 and a row selection driver circuit 1014 in the periphery of the pixel portion 1012. Each signal line 1023 denoted as S1 to Sn is connected to the plurality of pixels 1006 according to the columns and also connected to the signal driver circuit 1013. A row selection line 1024 denoted as G1 to Gm is connected to the plurality of pixels 1006 according to the rows, and also connected to the row selection driver circuit 1014. The display device comprises a power supply line and the like other than the aforementioned components, however, they are not shown in FIG. 10.

[0084] FIG. 11 shows a configuration of the pixel 1006. The pixel 1006 comprises driving TFTs 1101a and 1101b, an EL element 1102, a write switch 1103, a first capacitor (pixel capacitor) 1104, a voltage shift capacitor switches 1105a and 1105b, and a second capacitor (voltage shift capacitor) 1106. A second terminal of the EL element 1102 is connected to a cathode 1126, drains of the driving TFTs 1101a and 1101b are connected to a first terminal of the EL element 1102, and the sources thereof are connected to an anode 1125. The gate of the driving TFT 1101a is connected to a second terminal of the voltage shift capacitor 1106 and also connected to a wiring (pixel capacitor line) 1122 via the voltage shift capacitor switch 1105a. The gate of the driving TFT 1101b and a first terminal of the voltage shift capacitor 1106 are connected to a signal line 1023 via the write switch 1103 and also connected to the anode 1125 via the voltage shift capacitor switch 1105b, and further connected to a first terminal of the pixel capacitor 1104. A second terminal of the pixel capacitor 1104 is connected to the pixel capacitor line 1122. The write switch 1103 is controlled by the scan line (row selection line) 1024 and the voltage shift capacitor switches 1105a and 1105b are controlled by a wiring (voltage shift capacitor control signal line) 1121.

[0085] An operation of the pixel 1006 in this embodiment is described now.

[0086] An arbitrary voltage V_{diff} is applied to the voltage shift capacitor 1106. It should be noted that the voltage V_{diff} is a difference between V_{gs} of the driving TFT 1101a and that of the driving TFT 1101b. A potential difference V_{diff} is supplied to the anode 1125 and the pixel capacitor line 1122 and the voltage shift capacitor switches 1105a and 1105b are turned ON by the voltage shift capacitor control signal line 1121. After a charge corresponding to a voltage V_{diff} is charged in the voltage shift capacitor 1106, the voltage shift capacitor switches 1105a and 1105b are turned OFF by the voltage shift capacitor control signal line 1121. By the aforementioned operation, a voltage difference V_{diff} can be applied to both ends of the voltage shift capacitor 1106. It should be noted that the write switch 1103 is preferably OFF during the aforementioned operation, however, the invention is not limited to this.

[0087] The write switch 1103 is turned ON by the row selection line 1024 while the potential difference V_{diff} is applied to both ends of the voltage shift capacitor 1106. At this time, voltage V_{signal} which is appropriate for a luminance of the EL element 1102 is applied to the signal line 1023. After a first terminal of the pixel capacitor 1104 reaches V_{signal} , the write switch 1103 is turned OFF by the row selection line 1024. By the aforementioned operation, a gate of the driving TFT 1101b is applied V_{signal} and a gate of the driving TFT 1101a is applied $V_{signal}-V_{diff}$.

[0088] By the aforementioned operation, the EL element 1102 emits light. As characteristics of the driving TFT 1101a and the driving TFT 1101b are different and V_{gs} of the driving TFT 1101a and that of the driving TFT 1101b are different, a display device having the characteristics described in Embodiment Mode 1 can be provided.

[0089] Further, different V_{gs} can be supplied to the driving TFTs 1101a and 1101b rather simply.

[0090] A reason why a potential difference between the anode 1125 and the pixel capacitor line 1122 is used in order that the voltage shift capacitor 1106 may have a potential difference is described now. The anode 1125 is required to be controlled in accordance with a characteristic of the EL element 1102. Further, V_{diff} is also required to be controlled in accordance with characteristics of the driving TFTs 1101a and 1101b and of the EL element 1102. A potential of the pixel capacitor line 1122, however, is generally arbitrary and may be set at an appropriate potential and can be determined in accordance with the anode 1125 and V_{diff} .

Embodiment 2

[0091] In this embodiment, a structure of the display device described in Embodiment Mode 2 is described. FIG. 12 shows an example of a structure of the display device. The display device comprises a pixel portion 1212 in which a plurality of pixels 1206 are arranged in matrix of m rows and n columns, and a signal driver circuit 1213 and a row selection driver circuit 1214 in the periphery of the pixel portion 1212. Signal lines 1223a and 1223b denoted as S1 to Sn are connected to the plurality of pixels 1206 according to the columns and also connected to the signal driver circuit 1213. A row selection line 1224 denoted as G1 to Gm is connected to the pixel 1206 according to the rows, and also

connected to the row selection driver circuit 1214. The display device comprises a power supply line and the like other than the aforementioned components, however, they are not shown in FIG. 12.

[0092] FIG. 13 shows an example of a configuration of the pixel 1206. The pixel 1206 comprises driving TFTs 1301a and 1301b, an EL element 1302, write switches 1303a and 1303b, and pixel capacitors 1304a and 1304b. A second terminal of the EL element 1302 is connected to a cathode 1326, drains of the driving TFTs 1301a and 1301b are connected to a first terminal of the EL element 1302, sources thereof are connected to an anode 1325. Gates of the driving TFTs 1301a and 1301b are connected to first terminals of the pixel capacitors 1304a and 1304b respectively, and also connected to signal lines 1223a and 1223b respectively via write switches 1303a and 1303b respectively. Second terminals of the pixel capacitors 1304a and 1304b are connected to a pixel capacitor line 1322. The write switches 1303a and 1303b are controlled by the row selection line 1224.

[0093] An operation of the pixel 1206 is described now.

[0094] The write switches 1303a and 1303b are turned ON by the row selection line 1224. At this time, the signal lines 1223a and 1223b are applied voltages $V_{signal a}$ and $V_{signal b}$ corresponding to a luminance of the EL element 1302. $V_{signal a}$ and $V_{signal b}$ are set at different voltages here. After first terminals of the pixel capacitors 1304a and 1304b reach $V_{signal a}$ and $V_{signal b}$, the write switches 1303a and 1303b are turned OFF by the row selection line 1224. By the aforementioned operation, gates of the driving TFTs 1301a and 1301b are applied $V_{signal a}$ and $V_{signal b}$.

[0095] By the aforementioned operation, the EL element 1302 emits light. As characteristics of the driving TFTs 1301a and 1301b are different and V_{gs} of the driving TFT 1301a and that of the driving TFT 1301b are different, a display device having the characteristics described in Embodiment Mode 2 can be provided.

[0096] Further, V_{gs} of the driving TFT 1301a and that of the driving TFT 1301b can be set separately in accordance with a gray-scale, therefore, it is flexibly controlled. Moreover, a reliability can be enhanced because of a simple configuration.

Embodiment 3

[0097] In this embodiment, a structure of the display device described in Embodiment Mode 3 is described. A structure of the display device is described in Embodiment 1 with reference to FIG. 10. Note that a configuration of the pixel 1006 is different here from Embodiment 1.

[0098] FIG. 14 shows a configuration of the pixel 1006. The pixel 1006 comprises driving TFTs 1401a and 1401b, EL elements 1402a and 1402b, a write switch 1403, and a pixel capacitor 1404. Second terminals of the EL elements 1402a and 1402b are connected to a cathode 1426, drains of the driving TFTs 1401a and 1401b are connected to first terminals of the EL elements 1402a and 1402b respectively, and sources thereof are connected to an anode 1425. The first terminal of the EL element 1402a is also connected to a current source 1409. The current source 1409 is connected to a pixel capacitor line 1422, however, the invention is not limited to this. Gates of the driving TFTs 1401a and 1401b

are connected to a first terminal of a pixel capacitor **1404** and also connected to a signal line **1023** via a write switch **1403**. A second terminal of the pixel capacitor **1404** is connected to the pixel capacitor line **1422**. The write switch **1403** is controlled by a row selection line **1024**.

[0099] An operation of the pixel **1006** in this embodiment is described now.

[0100] The write switch **1403** is turned ON by the row selection line **1024**. At this time, a voltage V_{signal} which is appropriate for a luminance of the EL elements **1402a** and **1402b** is applied to the signal line **1023**. After the first terminal of the pixel capacitor **1404** reaches V_{signal} , the write switch **1403** is turned OFF by the row selection line **1024**. By the aforementioned operation, gates of the driving TFTs **1401a** and **1401b** are applied V_{signal} .

[0101] By the aforementioned operation, the EL elements **1402a** and **1402b** emit light. As characteristics of the driving TFTs **1401a** and **1401b** are different and a current supply to the EL element **1402a** is decreased due to the current source **1409** connected to the drain of the driving TFT **1401a**, a display device having the characteristics described in Embodiment Mode 3 can be provided.

[0102] Further, the driving TFTs **1401a** and **1401b** can be used separately in a high gray-scale and a low gray-scale rather simply.

[0103] The current source **1409** can be realized easily by using a TFT. By setting V_{gs} of a TFT so as to operate in a saturation region, a current can be reduced regardless of a drain voltage of the driving TFT **1401a**. Further, the drain voltage is lowered when a current supply to the driving TFT **1401a** is small, and a TFT of the current source **1409** operates in a linear region, thus a current to be reduced itself becomes small.

[0104] A capacitor line and an anode may be common in Embodiments 2 and 3. Further, three or more driving TFTs may be used in Embodiments 1 to 3.

Embodiment 4

[0105] The display device of the invention can be used for a variety of applications. In this embodiment, examples of electronic devices that the invention can be applied to are described.

[0106] Such electronic devices include a portable information terminal (an electronic book, a mobile computer, a portable phone and the like), a video camera, a digital camera, a personal computer, a television and the like. Examples of the aforementioned electronic devices are shown in FIGS. 15A to 15F.

[0107] FIG. 15A illustrates an EL display including a housing **3301**, a support base **3302**, a display portion **3303** and the like. The display device of the invention can be used in the display portion **3303**.

[0108] FIG. 15B illustrates a video camera including a body **3311**, a display portion **3312**, an audio input portion **3313**, operation switches **3314**, a battery **3315**, an image receiving portion **3316** and the like. The display device of the invention can be used in the display portion **3312**.

[0109] FIG. 15C illustrates a personal computer including a body **3321**, a housing **3322**, a display portion **3323**, a keyboard **3324** and the like. The display device of the invention can be used in the display portion **3323**.

[0110] FIG. 15D illustrates a portable information terminal including a body **3331**, a stylus **3332**, a display portion **3333**, operation buttons **3334**, an external interface **3335** and the like. The display device of the invention can be used in the display portion **3333**.

[0111] FIG. 15E illustrates a portable phone including a body **3401**, an audio output portion **3402**, an audio input portion **3403**, a display portion **3404**, operation switches **3405**, an antenna **3406** and the like. The display device of the invention can be used in the display portion **3404**.

[0112] FIG. 15F illustrates a digital camera including a body **3501**, a display portion A **3502**, an eyepiece portion **3503**, operation switches **3504**, a display portion B **3505**, a battery **3506** and the like. The display device of the invention can be used in the display portions A **3502** and B **3505**.

[0113] As described above, an application range of the invention is quite wide, and the invention can be applied to a variety of fields of electronic devices.

What is claimed is:

1. A display device comprising:

- a first signal line;
- a second signal line;
- a scan line;
- a light emitting element;
- a first transistor connected to the first signal line and the scan line;
- a first driving transistor connected to the light emitting element;
- a second transistor connected to the second signal line and the scan line; and
- a second driving transistor connected to the light emitting element.

2. The display device according to claim 1, further comprising a unit for selecting driving transistors connected to the light emitting element in accordance with a luminance of the light emitting element.

3. The display device according to claim 1, the display device is used for an electronic device selected from the group consist of an E1 display, a video camera, a personal computer, a portable information terminal, a portable phone, and a digital camera.

4. A display device comprising:

- a first signal line;
- a second signal line;
- a scan line;
- a light emitting element;
- a power supply line;
- a first transistor connected to the first signal line and the scan line;

- a first capacitor connected to the first transistor and the power supply line;
- a first driving transistor of which a gate electrode is connected to the first capacitor and one electrode is connected to the light emitting element;
- a second transistor connected to the second signal line and the scan line;
- a second capacitor connected to the second transistor and the power supply line; and
- a second driving transistor of which a gate electrode is connected to the second capacitor and one electrode is connected to the light emitting element.

5. The display device according to claim 4, further comprising a unit for selecting driving transistors connected to the light emitting element in accordance with a luminance of the light emitting element.

6. The display device according to claim 4, the display device is used for an electronic device selected from the group consist of an E1 display, a video camera, a personal computer, a portable information terminal, a portable phone, and a digital camera.

7. A display device comprising:

- a first signal line;
- a second signal line;
- a scan line;
- a light emitting element;
- a first transistor connected to the first signal line and the scan line;
- a first driving transistor connected to the light emitting element;
- a second transistor connected to the second signal line and the scan line; and
- a second driving transistor connected to the light emitting element,

wherein the first driving transistor and the second driving transistor have different current capacities.

8. The display device according to claim 7, wherein the first driving transistor has a higher current capacity than the second driving transistor and used for a high gray-scale display.

9. The display device according to claim 7, wherein the second driving transistor has a lower current capacity than the first driving transistor and used for a low gray-scale display.

10. The display device according to claim 7, further comprising a unit for selecting driving transistors connected to the light emitting element in accordance with a luminance of the light emitting element.

11. The display device according to claim 7, the display device is used for an electronic device selected from the group consist of an E1 display, a video camera, a personal computer, a portable information terminal, a portable phone, and a digital camera.

12. A display device comprising:

- a first signal line;
- a second signal line;

- a scan line;
- a light emitting element;
- a power supply line;
- a first transistor connected to the first signal line and the scan line;
- a first capacitor connected to the first transistor and the power supply line;
- a first driving transistor of which a gate electrode is connected to the first capacitor and one electrode is connected to the light emitting element;
- a second transistor connected to the second signal line and the scan line;
- a second capacitor connected to the second transistor and the power supply line; and
- a second driving transistor of which a gate electrode is connected to the second capacitor and one electrode is connected to the light emitting element,

wherein the first driving transistor and the second driving transistor have different current capacities.

13. The display device according to claim 12, wherein the first driving transistor has a higher current capacity than the second driving transistor and used for a high gray-scale display.

14. The display device according to claim 12, wherein the second driving transistor has a lower current capacity than the first driving transistor and used for a low gray-scale display.

15. The display device according to claim 12, further comprising a unit for driving transistors connected to the light emitting element in accordance with a luminance of the light emitting element.

16. The display device according to claim 12, the display device is used for an electronic device selected from the group consist of an E1 display, a video camera, a personal computer, a portable information terminal, a portable phone, and a digital camera.

17. A display device comprising:

- a first signal line;
- a second signal line;
- a scan line;
- a light emitting element;
- a first transistor connected to the first signal line and the scan line;
- a first driving transistor connected to the light emitting element;
- a second transistor connected to the second signal line and the scan line; and
- a second driving transistor connected to the light emitting element,

wherein a voltage between a gate and a drain of the first driving transistor and a voltage between a gate and a drain of the second driving transistor are different.

18. The display device according to claim 17, further comprising a unit for driving transistors connected to the light emitting element in accordance with a luminance of the light emitting element.

19. The display device according to claim 17, the display device is used for an electronic device selected from the group consist of an E1 display, a video camera, a personal computer, a portable information terminal, a portable phone, and a digital camera.

20. A display device comprising:

- a first signal line;
- a second signal line;
- a scan line;
- a light emitting element;
- a power supply line;
- a first transistor connected to the first signal line and the scan line;
- a first capacitor connected to the first transistor and the power supply line;
- a first driving transistor of which a gate electrode is connected to the first capacitor and one electrode is connected to the light emitting element;
- a second transistor connected to the second signal line and the scan line;
- a second capacitor connected to the second transistor and the power supply line; and
- a second driving transistor of which a gate electrode is connected to the second capacitor and one electrode is connected to the light emitting element,

wherein a voltage between a gate and a drain of the first driving transistor and a voltage between a gate and a drain of the second driving transistor are different.

21. The display device according to claim 20, further comprising a unit for driving transistors connected to the light emitting element in accordance with a luminance of the light emitting element.

22. The display device according to claim 20, the display device is used for an electronic device selected from the group consist of an E1 display, a video camera, a personal computer, a portable information terminal, a portable phone, and a digital camera.

23. A display device comprising:

- a signal line;
- a scan line;
- a first light emitting element;
- a second light emitting element;
- a transistor connected to the signal line and the scan line;
- a first driving transistor connected to the first light emitting element;
- a current source connected to the first driving transistor; and
- a second driving transistor connected to the second light emitting element.

24. The display device according to claim 23, the display device is used for an electronic device selected from the group consist of an E1 display, a video camera, a personal computer, a portable information terminal, a portable phone, and a digital camera.

25. A display device comprising:

- a signal line;
- a scan line;
- a first light emitting element;
- a second light emitting element;
- a transistor connected to the signal line and the scan line;
- a first driving transistor connected to the first light emitting element;
- a current source connected to the first driving transistor; and
- a second driving transistor connected to the second light emitting element,

wherein the first driving transistor and the second driving transistor have different current capacities.

26. The display device according to claim 25, the display device is used for an electronic device selected from the group consist of an E1 display, a video camera, a personal computer, a portable information terminal, a portable phone, and a digital camera.

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摘要(译)

通过在饱和区域中操作驱动TFT，当EL元件劣化时，亮度不容易降低。然而，这些问题出现在高电压，高功耗和发热的情况下。在饱和区域中操作驱动TFT的情况下，亮度由于驱动TFT的变化而变化。鉴于上述问题，在高灰度级中使用高电流容量TFT，在低灰度级中使用低电流容量TFT。高电流容量TFT可以提供具有较低 V_{gs} 的大电流，因此，即使当 V_{ds} 降低时，它也不容易在线性区域中操作。因此，即使当EL元件劣化时也不容易降低亮度，并且实现低电压操作。当施加高 V_{gs} 时，低电流容量TFT提供电流。对于高 V_{gs} ，可以改善TFT特性，特别是 V_{th} 的特性变化的影响。

