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(54) **Light emitting display, display panel, and driving method thereof**

Lichtemittierende Anzeigevorrichtung, Anzeigetafel, und Verfahren zur deren Ansteuerung

Dispositif d'affichage électroluminescent, panneau d'affichage, et sa méthode de commande

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- **PATENT ABSTRACTS OF JAPAN vol. 2003, no. 10, 8 October 2003 (2003-10-08) -& JP 2003 173165 A (TOSHIBA CORP), 20 June 2003 (2003-06-20)**
- **CHOI S-M ET AL: "AN IMPROVED VOLTAGE PROGRAMMED PIXEL STRUCTURE FOR LARGE SIZE AND HIGH RESOLUTION AM-OLED DISPLAYS" 25 May 2004 (2004-05-25), 2004 SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS. SEATTLE, WA, MAY 25 - 27, 2004, SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS, SAN JOSE, CA : SID, US, PAGE(S) 260-263 , XP001222795 * figure 4a ***

Remarks:

The file contains technical information submitted after the application was filed and not included in this specification

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Description**BACKGROUND OF THE INVENTION****(a) Field of the Invention**

[0001] The present invention relates to a light emitting display and a driving method thereof. More specifically, the present invention relates to an organic EL (electroluminescent) display.

(b) Description of the Related Art

[0002] In general, an organic EL display electrically excites a phosphorous organic compound to emit light, and it voltage- or current-drives NxM organic emitting cells to display images. As shown in FIG. 1, the organic emitting cell includes an anode (ITO), an organic thin film, and a cathode layer (metal). The organic thin film has a multi-layer structure including an EML (emitting layer), an ETL (electron transport layer), and an HTL (hole transport layer) for maintaining balance between electrons and holes and improving emitting efficiencies. The organic thin film further includes an EIL (electron injecting layer) and an HIL (hole injecting layer).

[0003] Methods for driving the organic emitting cells include a passive matrix method, and an active matrix method using TFTs (thin film transistors) or MOSFETs. In the passive matrix method, cathodes and anodes that cross over each other are formed and used to selectively drive lines. In the active matrix method, a TFT and a capacitor are connected with each ITO (indium tin oxide) pixel electrode to thereby maintain a predetermined voltage according to capacitance. The active matrix method is classified as either a voltage programming method or a current programming method based on signal forms supplied to maintain the voltage at the capacitor.

[0004] FIG. 2 shows a conventional voltage programming-type pixel circuit for driving an organic EL element (OLED), representing one of nxm pixels.

[0005] A transistor Ma coupled between the power supply voltage V_{DD} and an OLED controls the current flowing to the OLED. A transistor Mb transmits a data line voltage to a gate of the transistor Ma in response to a select signal applied from a scan line S_n . A capacitor C_{st} coupled between a source and the gate of the transistor Ma is charged with the data voltage and maintains the charged state for a predetermined time.

[0006] In detail, when the transistor Mb is turned on in response to a select signal applied to the gate of the switching transistor Mb, a data voltage from the data line D_m is applied to the gate of the transistor Ma. Accordingly, the current I_{OLED} corresponding to a voltage V_{GS} charged by the capacitor C_{st} between the gate and the source of the transistor Ma flows through the transistor Ma, and the OLED emits light corresponding to the current I_{OLED} .

[0007] By way of example, the current that flows to the OLED is given in Equation 1.

Equation 1

$$I_{OLED} = \frac{\beta}{2}(V_{GS} - V_{TH})^2 = \frac{\beta}{2}(V_{DD} - V_{DATA} - |V_{TH}|)^2$$

where I_{OLED} is the current flowing to the OLED, V_{GS} is a voltage between the source and the gate of the transistor Ma, V_{TH} is a threshold voltage at the transistor Ma, β is a constant, and V_{DD} is a power supply voltage for a pixel.

[0008] As given in Equation 1, the current corresponding to the applied data voltage is supplied to the OLED, and the OLED gives light corresponding to the supplied current, according to the pixel circuit of FIG. 2. In this instance, the applied data voltage has multi-stage values within a predetermined range so as to represent gray.

[0009] However, when a voltage drop (IR-drop) is generated on a line for supplying the power supply voltage V_{DD} , and the power supply voltage V_{DD} applied to a plurality of pixel circuits is not uniform, a desired amount of current may not flow to the OLED, thereby degrading image qualities, since the current flowing to the OLED is influenced by the power supply voltage V_{DD} in the conventional pixel circuit based on the voltage programming method. As the area of the organic EL display becomes larger, and the brightness increases, the voltage drop on the line for supplying the power supply voltage V_{DD} increases to generate further problems. JP2003173165 discloses an OLED pixel circuit that uses an arrangement of TFT switches and capacitors in order to compensate for the effects of the threshold voltage of the driving transistor.

SUMMARY OF THE INVENTION

[0010] In exemplary embodiments of the present invention, a current that flows to the OLED of a pixel circuit in a light

emitting display is substantially prevented from being influenced by a power supply voltage.

[0011] Further, a current that flows to the OLED of a pixel circuit in a light emitting display may be substantially prevented from being influenced by deviations of a threshold voltage of a driving transistor.

[0012] In exemplary embodiments of the present invention, a light emitting display suitable for application as a large screen and high brightness display is provided.

[0013] The invention is embodied in the apparatus and method of the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The accompanying drawings, together with the specification, illustrate exemplary embodiments of the present invention, and, together with the description, serve to explain the principles of the present invention:

FIG. 1 shows a conceptual diagram of an OLED;

FIG. 2 shows an equivalent circuit diagram of a conventional pixel circuit used with the voltage programming method;

FIG. 3 shows an organic EL display in an exemplary embodiment of the present invention;

FIG. 4 shows a brief diagram of a pixel circuit according to a first exemplary embodiment of the present invention;

FIG. 5 shows an internal circuit of a voltage compensator shown in FIG. 4;

FIG. 6A shows an application of the voltage compensator circuit of FIG. 5 to the pixel circuit of FIG. 4;

FIG. 6B shows a pixel circuit similar to the pixel circuit of FIG. 6A, in which an additional control signal is provided;

FIG. 6C shows a pixel circuit similar to the pixel circuit of FIG. 6A, in which an additional control signal is provided;

FIG. 7A shows a pixel circuit according to a second exemplary embodiment of the present invention;

FIG. 7B shows a pixel circuit similar to the pixel circuit of FIG. 7A, in which an additional control signal is provided;

FIG. 7C shows a pixel circuit similar to the pixel circuit of FIG. 7A, in which an additional control signal is provided;

FIG. 7D shows a pixel circuit similar to the pixel circuit of FIG. 7A, in which a diode-connected transistor and a driving transistor have channel type different from that of the pixel circuit of FIG. 7A;

FIG. 8 shows a waveform diagram of a select signal applied to the pixel circuits of FIGs. 7A, 7B, 7C and 7D;

FIG. 9A shows a pixel circuit according to an illustrative example not covered by the claims;

FIG. 9B shows a pixel circuit similar to the pixel circuit of FIG. 9A, in which an additional control signal is provided;

FIG. 9C shows a pixel circuit similar to the pixel circuit of FIG. 9A, in which an additional control signal is provided;

FIG. 9D shows a pixel circuit similar to the pixel circuit of FIG. 9A, in which an additional control signal is provided;

FIG. 10 shows a pixel circuit according to another exemplary embodiment of the present invention;

FIG. 11 shows a display panel which incorporates the pixel circuit of FIG. 6A; and

FIG. 12 is a graph that shows a relationship between the current that flows to the OLED and a voltage drop of the power supply voltage in pixel circuits of a light emitting display.

DETAILED DESCRIPTION

[0015] In the following detailed description, only certain exemplary embodiments of the present invention are shown and described, by way of illustration.

[0016] FIG. 3 shows an organic EL display according to an exemplary embodiment of the present invention.

[0017] As shown, the organic EL display includes an organic EL display panel 100, a scan driver 200, and a data driver 300.

[0018] The organic EL display panel 100 includes a plurality of data lines D_1 through D_m , each extending in a column direction, a plurality of scan lines S_1 through S_n , each extending in a row direction, and a plurality of pixel circuits 10. The data lines D_1 through D_m transmit data voltages that correspond to video signals to the pixel circuits 10, and the scan lines S_1 through S_n transmit select signals for selecting the pixel circuits 10. Each pixel circuit 10 is formed at a pixel region defined by two adjacent data lines D_1 through D_m , and two adjacent scan lines S_1 through S_n .

[0019] The scan driver 200 sequentially applies select signals to the scan lines S_1 through S_n , and the data driver 300 applies the data voltage that corresponds to video signals to the data lines D_1 through D_m .

[0020] The scan driver 200 and/or the data driver 300 may be coupled to the display panel 100, or may be installed, in a chip format, in a TCP (tape carrier package) coupled to the display panel 100. The same can be attached to the display panel 100, and installed, in a chip format, on an FPC (flexible printed circuit) or a film coupled to the display panel 100, which is referred to as a CoF (chip on flexible board, or chip on film) method. In other embodiments, the scan driver 200 and/or the data driver 300 may be installed on a glass substrate of the display panel. Further, the same can be substituted for the driving circuit formed in the same layers as the scan lines, the data lines, and TFTs on the glass substrate, or directly installed on the glass substrate.

[0021] Referring to FIGs. 4 through 6A, a pixel circuit that can be used as the pixel circuit 10 of the organic EL display 100 will be described.

[0022] FIG. 4 shows a brief diagram of the pixel circuit. For ease of description, the pixel circuit coupled to the m-th data line D_m and the n-th scan line S_n will be described.

[0023] As shown, the pixel circuit according to the first exemplary embodiment of the present invention includes an organic EL element (OLED), transistors M1 and M2, and a voltage compensator 11. In the described embodiment, the transistors M1 and M2 are P-type transistors having a P-type channel.

[0024] The transistor M1 is a driving transistor for controlling the current that flows to the OLED, and it has a source coupled to the power supply voltage V_{DD} , and a drain coupled to an anode of the OLED. A cathode of the OLED is coupled to a reference voltage V_{SS} and emits light that corresponds to the current applied from the transistor M1. The reference voltage V_{SS} is a voltage lower than the power supply voltage V_{DD} . By way of example, the ground voltage can be used as the reference voltage V_{SS} .

[0025] The transistor M2 transmits a data voltage applied to the data line D_m to the voltage compensator 11 in response to a select signal from the scan line S_n .

[0026] The voltage compensator 11 is coupled between a gate of the transistor M1 and a drain of the transistor M2, receives the data voltage transmitted by the transistor M2 and applies a compensated data voltage based on the data voltage and the power supply voltage V_{DD} to the gate of the transistor M1.

[0027] FIG. 5 shows an internal circuit for the voltage compensator 11 of FIG. 4.

[0028] As shown, the voltage compensator 11 includes transistors M3 and M4, and a capacitor C_{st1} . It can be seen in FIG. 5 that the transistor M3 is a P-type transistor, while the transistor M4 is an N-type transistor having an N-type channel. In other embodiments, the transistors may have different channel types.

[0029] A first electrode A of the capacitor C_{st1} is coupled to the gate of the transistor M1, and a second electrode B thereof is coupled to the drain of the transistor M2.

[0030] The transistor M3 is coupled between the power supply voltage V_{DD} and the first electrode A of the capacitor C_{st1} , and applies the power supply voltage V_{DD} to the first electrode A of the capacitor C_{st1} in response to the select signal from the scan line S_n .

[0031] The transistor M4 is coupled between a compensation voltage V_{sus} and the second electrode B of the capacitor C_{st1} , and applies the compensation voltage V_{sus} to the second electrode B of the capacitor C_{st1} in response to the select signal of the scan line S_n .

[0032] The select signal from the scan line S_n is applied to the gates of the transistors M3 and M4 in FIG. 5. A control signal other than the select signal may be applied to at least one of the transistors M3 and M4. In such cases, the transistors M3 and M4 may have the same type of channel.

[0033] FIG. 6A shows an application of the voltage compensator 11 of FIG. 5 to the pixel circuit of FIG. 4.

[0034] Operation of the pixel circuit according to the first exemplary embodiment will be described with reference to FIG. 6A.

[0035] When the select signal from the scan line S_n becomes low level, the transistor M2 is turned on and the data voltage is applied to the second electrode B of the capacitor C_{st1} . Further, the transistor M3 is turned on and the power supply voltage V_{DD} is applied to the first electrode A of the capacitor C_{st1} . Here, no current flows to the OLED since the power supply voltage V_{DD} is applied to the gate and the source of the transistor M1. With the low level select signal from the present scan line S_n , the transistor M4 is turned off, thereby substantially electrically isolating the compensation voltage V_{sus} from the second electrode B of the capacitor C_{st1} .

[0036] When the select signal from the scan line S_n becomes high level, the transistor M4 is turned on and the compensation voltage V_{sus} is applied to the second electrode B of the capacitor C_{st1} .

[0037] Therefore, the voltage applied to the second electrode B of the capacitor C_{st1} is changed to the compensation voltage V_{sus} from the data voltage. In this instance, the charges charged in the capacitor C_{st1} is substantially constantly maintained since no current path is formed in the pixel circuit. That is, the voltage V_{AB} between the electrodes of the capacitor C_{st1} is to be maintained substantially constantly, and the voltage at the first electrode A of the capacitor C_{st1} is varied by a voltage variation ΔV_B of the second electrode B thereof. A voltage V_A of the first electrode A of the capacitor C_{st1} is given in Equation 2.

Equation 2

$$V_A = V_{DD} + \Delta V_B$$

where ΔV_B is a voltage variation of the second electrode B of the capacitor C_{st1} and is given in Equation 3.

Equation 3

$$\Delta V_B = V_{sus} - V_{DATA}$$

[0038] In this instance, the current flows to the OLED through the transistor M1, and the current is given as Equation 4.

Equation 4

$$\begin{aligned} I_{OLED} &= \frac{\beta}{2} (V_{GS1} - V_{TH1})^2 = \frac{\beta}{2} ((V_{DD} + \Delta V_B) - V_{DD} - V_{TH1})^2 = \frac{\beta}{2} (\Delta V_B - V_{TH1})^2 \\ &= \frac{\beta}{2} (V_{sus} - V_{DATA} - V_{TH1})^2 \end{aligned}$$

where V_{GS1} is a voltage between the gate and the source of the transistor M1, and V_{TH1} is a threshold voltage of the transistor M1.

[0039] As can be seen from Equation 4, the current flowing to the OLED is substantially not influenced by the power supply voltage V_{DD} . Also, substantially no voltage drop is generated since the compensation voltage V_{sus} forms no current path, differing from the power supply voltage V_{DD} . Hence, the substantially the same compensation voltage V_{sus} is applied to all the pixel circuits, and the current that corresponds to the data voltage flows to the OLED.

[0040] Also, since the transistor M1 has a P-type channel, the voltage V_{GS} between the gate and the source of the transistor M1 is to be less than the threshold voltage V_{TH1} in order to turn on the transistor M1. Therefore, the voltage obtained by subtracting the data voltage V_{DATA} from the compensation voltage V_{sus} is to be less than the threshold voltage of the transistor M1.

[0041] While the select signal from the scan line S_n is applied to the gates of both the transistors M3 and M4 in FIG. 6A, an additional control signal having substantially the same characteristics as the select signal from the scan line S_n may be applied to the gate of either the transistor M3 or the transistor M4. For example, FIG. 6B shows that an additional control signal is applied to the gate of the transistor M3. In addition, FIG. 6C shows that an additional control signal is applied to the gate of the transistor M4.

[0042] Referring to FIGs. 7A and 8, a pixel circuit according to a second exemplary embodiment of the present invention will be described. As to definition of scan lines, a "present scan line" represents a scan line for transmitting a present select signal, and a "previous scan line" indicates a scan line that has transmitted a select signal before the present select signal is transmitted.

[0043] FIG. 7A shows a pixel circuit according to a second exemplary embodiment of the present invention, and FIG. 8 shows a waveform diagram of a select signal applied to FIG. 7A.

[0044] In the pixel circuit of FIG. 7A, transistors M11, M12, M13, M14 and a capacitor C_{st2} are connected together in substantially the same relationship as the M1, M2, M3, M4 and the capacitor C_{st1} of FIG. 6A, except for the connection between the transistor M12, the transistor M14 and the capacitor C_{st2} . The capacitor C_{st2} has electrodes A2 and B2 similar to the electrodes A and B of the capacitor C_{st1} . This pixel circuit according to the second exemplary embodiment is different from the pixel circuit of FIG. 6A in that the pixel circuit of FIG. 7A further includes a compensation transistor M15, which is diode-connected for compensating the threshold voltage of the driving transistor M11, and a transistor M16 for applying a pre-charge voltage V_{pre} so that the compensation transistor M15 may be forward biased.

[0045] The drain of the transistor M12 is coupled to a source of the diode-connected compensation transistor M15. The transistor M16 is coupled between a drain of the diode-connected compensation transistor M15 and the pre-charge voltage V_{pre} . A previous scan line S_{n-1} is coupled to a gate of the transistor M16.

[0046] An operation of the pixel circuit according to the second exemplary embodiment of the present invention will be described with reference to FIG. 8.

[0047] When a select signal from the previous scan line S_{n-1} becomes low level during the pre-charge period $t1$, the transistor M16 is turned on, and the pre-charge voltage V_{pre} is transmitted to the drain of the transistor M15. In this instance, it is desirable for the pre-charge voltage V_{pre} to be a little less than the voltage applied to the gate of the transistor M15, that is, the lowest data voltage applied through the data line D_m , so that the pre-charge voltage V_{pre} may reach the maximum gray level. Accordingly, when the data voltage is applied through the data line D_m , the data voltage becomes greater than the voltage applied to the gate of the transistor M15, and the transistor M15 is coupled forward.

[0048] Next, the select signal from the present scan line S_n becomes low level and the transistor M12 is turned on during the data charging period $t2$, and hence, the data voltage is applied to the source of the transistor M15 through the transistor M12. In this instance, since the transistor M15 is diode-connected, a voltage that corresponds to a difference

between the data voltage and a threshold voltage V_{TH15} of the transistor M15 is applied to the second electrode B2 of the capacitor C_{st2} . Further, the transistor M13 is turned on and the power supply voltage V_{DD} is applied to the first electrode A2 of the capacitor C_{st2} .

[0049] No current flows to the OLED since the voltage applied to the source and the gate of the transistor M11 corresponds to the power supply voltage V_{DD} during the data charging period t2.

[0050] With the low level select signal from the present scan line S_n , the transistor M14 is turned off, thereby substantially electrically isolating the compensation voltage V_{sus} from the second electrode B2 of the capacitor C_{st2} . The select signal from the present scan line S_n becomes high level and the transistor M14 is turned on during the light emitting period t3. The compensation voltage V_{sus} is applied to the second electrode B2 of the capacitor C_{st2} through the transistor M14, and the voltage of the second electrode B2 of the capacitor C_{st2} is changed to the compensation voltage V_{sus} . In this instance, since the voltage V_{AB2} between the electrodes of the capacitor C_{st2} is to be substantially constantly maintained, the voltage of the first electrode A2 of the capacitor C_{st2} is varied by the voltage variation of the second electrode B2. The voltage V_{A2} is given in Equation 5 below.

Equation 5

$$V_{A2} = V_{DD} + \Delta V_{B2} = V_{DD} + (V_{sus} - (V_{DATA} - V_{TH15})) = V_{DD} + V_{sus} - V_{DATA} + V_{TH15}$$

where ΔV_{B2} is a voltage variation of the second electrode B2 of the capacitor C_{st2} .

[0051] In this instance, the driving transistor M11 is turned on, and the current flows to the OLED. The current flowing to the OLED is given as Equation 6.

Equation 6

$$I_{OLED} = \frac{\beta}{2} (V_{GS11} - V_{TH11})^2 = \frac{\beta}{2} ((V_{DD} + V_{sus} - V_{DATA} + V_{TH15}) - V_{DD} - V_{TH11})^2$$

[0052] When the threshold voltage of the transistor M11 substantially corresponds to that of the transistor M15, the current flowing to the OLED is given as Equation 7.

Equation 7

$$I_{OLED} = \frac{\beta}{2} (V_{sus} - V_{DATA})^2$$

[0053] Therefore, the current that corresponds to the data voltage applied to the data line D_m flows to the OLED irrespective of the power supply voltage V_{DD} and the threshold voltage V_{TH11} of the transistor M11.

[0054] Also, since the compensation voltage V_{sus} forms no current path, a substantially uniform compensation voltage V_{sus} is applied to all the pixel circuits, thereby enabling more fine gray representation.

[0055] As shown in FIG. 7A, the previous scan line S_{n-1} is used to control the transistor M16 in the second exemplary embodiment. Alternatively, an additional control line (not illustrated) for transmitting a control signal for turning on the transistor M16 during the pre-charge period t1 may be used.

[0056] Further, while the select signal from the scan line S_n is applied to the gates of both the transistors M13 and M14 in FIG. 7A, an additional control signal having substantially the same characteristics as the select signal from the scan line S_n may be applied to the gate of either the transistor M13 or the transistor M14. For example, FIG. 7B shows that an additional control signal is applied to the gate of the transistor M13. In addition, FIG. 7C shows that an additional control signal is applied to the gate of the transistor M14.

[0057] FIG. 7D illustrates a pixel circuit including transistors M11', M12', M13', M14', M15', M16' and a capacitor C_{st2}' having electrodes A2' and B2', that are connected together in substantially the same relationship as the transistors M11, M12, M13, M14, M15, M16 and the capacitor C_{st2} of FIG. 7A. However, the transistors M11' and M15' have an N-type channel, unlike the transistors M11 and M15 which have a P-type channel. A drain of the transistor M11' is connected to the power supply voltage V_{DD} , and a source of the transistor M11' is connected to the light emitting element OLED. A drain of the transistor M15' is connected to the transistor M12', and a gate and a source of the transistor M15' is connected together and also to the transistor M16'. Other than the fact that voltage levels may be different, the pixel circuit of FIG. 7D operates in substantially the same manner as the pixel circuit of FIG. 7A.

[0058] FIG. 9A shows a pixel circuit according to an illustrative example not covered by the claims.

[0059] In the pixel circuit of FIG. 9A, transistors M21, M22, M24 and a capacitor C_{st3} are connected together in substantially the same relationship as the transistors M11, M12, M14 and the capacitor C_{st2} of FIG. 7A, except that a drain of the transistor M22 is connected to a second electrode B3 of the capacitor C_{st3} . The capacitor C_{st3} has electrodes A3 and B3 similar to the electrodes A2 and B2 of the capacitor C_{st2} . The pixel circuit according to the example in FIG. 9A is different from the pixel circuit of FIG. 7A because in the pixel circuit of FIG. 9A, a source of a transistor M23 is coupled to a drain of the transistor M21, and the pixel circuit of FIG. 9A further includes a transistor M25 connected between the transistor M21 and the OLED. In the pixel circuit illustrated in FIG. 9A, the transistor M23 is P-type, while the transistor M25 is N-type. Gates of the transistors M23 and M25 are coupled to the present scan line S_n .

[0060] An operation of the pixel circuit according to this example will now be described with reference to FIG. 9A.

[0061] When a low-level select signal from the scan line S_n is applied, the transistor M22 is turned on, and the data voltage from the data line D_m is applied to the second electrode B3 of the capacitor C_{st3} . Further, the transistor M23 is turned on and the driving transistor M21 is diode-connected. Therefore, the threshold voltage V_{TH21} of the driving transistor M21 is applied between a gate and a source of the driving transistor M21. In this instance, since the source of the driving transistor M21 is coupled to the power supply voltage V_{DD} , the voltage V_{A3} applied to the first electrode A3 of the capacitor C_{st3} is given as Equation 8.

Equation 8

$$V_{A3} = V_{DD} + V_{TH21}$$

[0062] With the low level select signal from the scan line S_n , the transistor M24 is turned off, thereby substantially electrically isolating the compensation voltage V_{sus} from the second electrode B3 of the capacitor C_{st3} . Further, the transistor M25 is turned off, thereby substantially electrically isolating the drain of the transistor M21 from the OLED.

[0063] When the select signal from the scan line S_n becomes high level, the transistor M24 is turned on to apply the compensation voltage V_{sus} to the second electrode B3 of the capacitor C_{st3} . In this instance, since no current path is formed in the pixel circuit, the voltage of both electrodes of the capacitor C_{st3} is to be substantially constantly maintained. Therefore, the voltage applied to the first electrode A3 of the capacitor C_{st3} is varied by a voltage variation of the second electrode B3. Hence, the voltage at the first electrode A3 is given in Equation 9.

Equation 9

$$V_{A3} = V_{DD} + V_{TH21} + \Delta V_{B3}$$

where ΔV_{B3} is a voltage variation of the second electrode B3 of the capacitor C_{st3} and is obtained by subtracting the data voltage from the compensation voltage V_{sus} .

[0064] Further, the transistor M25 is turned on, the current of the transistor M21 is transmitted to the OLED, and the OLED emits light in response to the applied current. By way of example, the current I_{OLED} flowing to the OLED is given as Equation 10.

Equation 10

$$I_{OLED} = \frac{\beta}{2} (V_{GS21} - V_{TH21})^2 = \frac{\beta}{2} ((V_{DD} + V_{TH21} + \Delta V_{B3}) - V_{DD} - V_{TH21})^2 = \frac{\beta}{2} (\Delta V_{B3})^2$$

[0065] Therefore, the current flowing to the OLED is substantially not influenced by a deviation between the power supply voltage V_{DD} and the threshold voltage V_{TH21} of the driving transistor M21.

[0066] While the select signal from the scan line S_n is applied to the gates of the transistors M23, M24 and M25 in FIG. 9A, an additional control signal having substantially the same characteristics as the select signal from the scan line S_n may be applied to the gate of any of the transistors M23, M24 and M25. For example, FIG. 9B shows that an additional control signal is applied to the gate of the transistor M23. In addition, FIG. 9C shows that an additional control signal is applied to the gate of the transistor M24. Further, FIG. 9D shows that an additional control signal is applied to the gate of the transistor M25.

[0067] FIG. 10 shows a pixel circuit according to another exemplary embodiment of the present invention.

[0068] In the pixel circuit of FIG. 10, transistors M31, M32 and a capacitor C_{st4} are connected together in substantially

the same relationship as the transistors M1, M2 and the capacitor C_{st1} of FIG. 6A. The capacitor C_{st4} has electrodes A4 and B4 similar to the electrodes A and B of the capacitor C_{st1} . As shown, the pixel circuit according to this exemplary embodiment is different from that of the first exemplary embodiment, as the pixel circuit according to the fourth exemplary embodiment further includes a capacitor C2 coupled between the power supply voltage V_{DD} and a gate of the driving transistor M31, and the select signal from the previous scan line S_{n-1} is applied to gates of transistors M33 and M34.

[0069] An operation of the pixel circuit according to this exemplary embodiment will now be described in reference to FIG. 10.

[0070] When the select signal from the previous scan line S_{n-1} becomes low level, the transistors M33 and M34 are turned on, the power supply voltage V_{DD} is applied to the first electrode A4 of the capacitor C_{st4} , and the compensation voltage V_{sus} is applied to the second electrode B4 thereof.

[0071] Next, the select signal from the present scan line S_n becomes low level, and the transistor M32 is turned on. Therefore, the voltage of the second electrode B4 of the capacitor C_{st4} is changed to the data voltage, and the voltage of the first electrode A4 of the capacitor C_{st4} is changed by a voltage variation of the second electrode B4 of the capacitor C_{st4} . The voltage of the first electrode A4 of the capacitor C_{st4} is given as Equation 11.

Equation 11

$$V_{A4} = V_{DD} + \Delta V_{B4} = V_{DD} + V_{DATA} - V_{sus}$$

[0072] Therefore, the power supply voltage V_{DD} and the voltage of the first electrode A4 of the capacitor C_{st4} are applied to both electrodes of the capacitor C2, and the capacitor C2 is charged.

[0073] In this instance, the voltage charged in the capacitor C2 is given as Equation 12, and the corresponding current flows to the OLED.

Equation 12

$$V_{C2} = V_{DD} - (V_{DD} + V_{DATA} - V_{sus}) = V_{DATA} - V_{sus}$$

[0074] The current flowing to the OLED is given as Equation 13.

Equation 13

$$I_{OLED} = \frac{\beta}{2} (V_{GS31} - V_{TH31})^2 = \frac{\beta}{2} ((V_{DATA} - V_{sus}) - V_{TH31})^2$$

[0075] As can be seen from Equation 13, the current flowing to the OLED is substantially not influenced by the power supply voltage V_{DD} .

[0076] FIG. 11 shows a case wherein the pixel circuit of the first exemplary embodiment is applied to a display panel of the light emitting display.

[0077] As shown, a plurality of pixel circuits is coupled to a line for supplying the power supply voltage V_{DD} . A voltage drop is generated in the display panel 100 because of a parasitic resistance component that exists in the line for supplying the power supply voltage V_{DD} . According to the first exemplary embodiment of the present invention, the current flowing to the OLED is substantially not influenced by the voltage drop provided on the above-noted line.

[0078] FIG. 12 is a graph that shows a relationship between the current that flows to the OLED and the voltage drop of the power supply voltage V_{DD} in pixel circuits of a light emitting display.

[0079] A curve (a) shows a current curve of the conventional pixel circuit, and a curve (b) illustrates a current curve of the pixel circuit according to the first exemplary embodiment of the present invention.

[0080] As shown in FIG. 12, the current flowing to the OLED is strongly influenced by the voltage drop of the line in the conventional pixel circuit, and the current is very little influenced by the voltage drop in the pixel circuit according to the first exemplary embodiment of the present invention.

[0081] While the present invention has been described in connection with certain exemplary embodiments, it is to be understood that the present invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims.

[0082] For example, the transistors M1 and M5 of FIG. 6A-6C as well as other transistors in other figures can be realized with the transistors having the N-type channel as well as those of the P-type channel. Further, they may also

be implemented with active elements which have first, second, and third electrodes, and control the current that flows to the third electrode from the second electrode by the voltage applied between the first and second electrodes.

[0083] Also, the transistors M12, M13, M14, and M16 of FIG. 7A as well as corresponding transistors in other figures, which are elements for switching both electrodes in response to the select signal, may be realized by using various other types of switches that perform substantially the same or similar functions.

[0084] A light emitting display suitable for application as a large screen and high brightness display is provided by controlling the current that flows to the OLED to be substantially not influenced by the power supply voltage.

[0085] Further, the current flowing to the OLED is more finely controlled by compensating for a deviation of the power supply voltage and/or a deviation of the threshold voltage of the driving transistor.

[0086] In addition, the aperture ratio of the light emitting display is enhanced by compensating for a deviation of the power supply voltage and/or a deviation of the threshold voltage of the driving transistor with lesser number of scan lines.

Claims

1. A light emitting display (100) including a plurality of data lines (D1, ..., Dm) arranged to transmit data voltages (V_{DATA}) corresponding to video signals, a plurality of scan lines (S1, ..., Sn) arranged to transmit select signals, and a plurality of pixel circuits (10), each said pixel circuit (10) coupled to a corresponding said data line (D1, ..., Dm) to receive a corresponding said data voltage (V_{DATA}) and a corresponding said scan line (S1, ..., Sn) to receive a corresponding said select signal, each said pixel circuit (10) comprising:

a transistor (M1) including a first electrode, a second electrode arranged to receive a first power supply voltage (V_{DD}), and a third electrode arranged to output a current (I_{OLED}) corresponding to a voltage between the first electrode and the second electrode;

a light emitting element (OLED) coupled to the third electrode arranged to emit light corresponding to the current (I_{OLED}) outputted by the third electrode;

a first switch (M2) arranged to transmit the corresponding said data voltage (V_{DATA}) in response to the corresponding said select signal from the corresponding said scan line (S1, ..., Sn); and

a voltage compensator (11) arranged to receive the corresponding said data voltage (V_{DATA}) transmitted by the first switch (M2) and a second power supply voltage (V_{SUS}), and to apply a compensated data voltage based on the corresponding said data voltage (V_{DATA}) and the second power supply voltage (V_{SUS}) to the first electrode of the transistor (M1),

wherein the voltage compensator (11) comprises:

a capacitor (Cst1) having a first electrode (A) coupled to the first electrode of the transistor (M1), and a second electrode (B) coupled to the first switch (M2); and

a third switch (M4) coupled between the second electrode (B) of the capacitor (Cst1) and the second power supply voltage (V_{SUS}), arranged to electrically isolate the second power supply voltage (V_{SUS}) from the second electrode (B) of the capacitor (Cst1) in response to a second control signal (Sn),

and **characterised in that** the voltage compensator (11) further comprises:

a second switch (M3) arranged to apply the first power supply voltage (VDD) to the first electrode (A) of the capacitor (Cst1) in response to a first control signal (Control signal), the second switch (M3) consisting of a transistor having a gate electrode, a first electrode and a second electrode, wherein the first electrode of the second switch (M3) is directly coupled to the first power supply voltage (VDD) and the second electrode of the second switch (M3) is directly coupled to the first electrode (A) of the capacitor (Cst1).

2. The light emitting display (100) of claim 1, wherein the first and second switches (M2, M3) include transistors having a same channel type, and the first control signal (Control signal) is the corresponding said select signal from the corresponding said scan line (S1, ..., Sn) or another signal which has the same characteristics as the corresponding said select signal from the corresponding said scan line (S1, ..., Sn).

3. The light emitting display (100) of claim 1, wherein the third switch (M4) includes a transistor having a channel type which is different from that of the first switch (M2), and the second control signal is the corresponding said select signal from the corresponding said scan line (S1, ..., Sn) or another signal which has the same characteristics as the corresponding said select signal from the corresponding said scan line (S1, ..., Sn).

4. The light emitting display (100) of claim 1, wherein the voltage compensator (11) is adapted to provide a compensated data voltage corresponding to a voltage obtained by subtracting the corresponding said data voltage (V_{DATA}) from

a summation of the first and second power supply voltages (V_{DD} and V_{SUS}).

5. A method for driving a display panel (100) according to one of the preceding claims, the method comprising:

5 applying the first power supply voltage (V_{DD}) to the first electrode (A) of the capacitor (C_{st1}) through the second switch (M3) in response to the first control signal (Control signal);
 applying the data voltage (V_{DATA}) to the second electrode (B) of the capacitor (C_{st1}) through the first switch (M2);
 electrically isolating the first electrode (A) of the capacitor (C_{st1}) from the first power supply voltage (V_{DD}); and
 10 applying the second power supply voltage (V_{SUS}) to the second electrode (B) of the capacitor (C_{st1}).

6. The method of claim 5, wherein the transistor (M1) has a P-type channel, and the first power supply voltage (V_{DD}) applied to the second electrode of the transistor (M1) is a positive voltage.

7. The method of claim 5, wherein the second power supply voltage (V_{sus}) applied to the second electrode (B) of the capacitor (C_{st1}) is less than a summation of the data voltage (V_{DATA}) and a threshold voltage of the transistor (M1).

Patentansprüche

20 1. Lichtemittierende Anzeigevorrichtung (100), enthaltend mehrere Datenleitungen (D1, ..., Dm), die zum Übertragen von Datenspannungen (V_{DATA}), welche Videosignalen entsprechen, angeordnet sind, mehrere Scanleitungen (S1, ..., Sn), die zum Übertragen von Auswahlsignalen angeordnet sind, und mehrere Pixelschaltkreise (10), wobei jeder Pixelschaltkreis (10) an eine entsprechende Datenleitung (D1, ..., Dm) zum Empfangen einer entsprechenden Datenspannung (V_{DATA}) und an eine entsprechende Scanleitung (S1, ..., Sn) zum Empfangen eines entsprechenden Auswahlsignals gekoppelt ist, wobei jeder Pixelschaltkreis (10) umfasst:

einen Transistor (M1), der eine erste Elektrode, eine zweite Elektrode, die zum Empfangen einer ersten Stromversorgungsspannung (V_{DD}) angeordnet ist, und eine dritte Elektrode enthält, die zum Ausgeben eines Stroms (I_{OLED}) entsprechend einer Spannung zwischen der ersten Elektrode und der zweiten Elektrode angeordnet ist;
 30 ein lichtemittierendes Element (OLED), das an die dritte Elektrode gekoppelt ist und zum Aussenden von Licht entsprechend des Stroms (I_{OLED}), der durch die dritte Elektrode ausgegeben wird, angeordnet ist;
 einen ersten Schalter (M2), der zum Übertragen der entsprechenden Datenspannung (V_{DATA}) in Reaktion auf das entsprechende Auswahlsignal von der entsprechenden Scanleitung (S1, ..., Sn) angeordnet ist; und
 einen Spannungsausgleicher (11), der zum Empfangen der entsprechenden Datenspannung (V_{DATA}), die durch den ersten Schalter (M2) übertragen wird, und einer zweiten Stromversorgungsspannung (V_{SUS}) und zum Anlegen einer ausgeglichenen Datenspannung basierend auf der entsprechenden Datenspannung (V_{DATA}) und der zweiten Stromversorgungsspannung (V_{SUS}) an die erste Elektrode des Transistors (M1) angeordnet ist, wobei der Spannungsausgleicher (11) umfasst:

40 einen Kondensator (C_{st1}) mit einer ersten Elektrode (A), die an die erste Elektrode des Transistors (M1) gekoppelt ist, und einer zweiten Elektrode (B), die an den ersten Schalter (M2) gekoppelt ist; und
 einen dritten Schalter (M4), der zwischen der zweiten Elektrode (B) des Kondensators (C_{st1}) und der zweiten Stromversorgungsspannung (V_{SUS}) gekoppelt ist und zum elektrischen Isolieren der zweiten Stromversorgungsspannung (V_{SUS}) von der zweiten Elektrode (B) des Kondensators (C_{st1}) in Reaktion auf ein zweites Steuersignal (Sn) angeordnet ist, und **dadurch gekennzeichnet, dass** der Spannungsausgleicher (11) ferner umfasst:

einen zweiten Schalter (M3), der zum Anlegen der ersten Stromversorgungsspannung (V_{DD}) an die erste Elektrode (A) des Kondensators (C_{st1}) in Reaktion auf ein erstes Steuersignal (Control signal) angeordnet ist, wobei der zweite Schalter (M3) aus einem Transistor mit einer Gate-Elektrode, einer ersten Elektrode und einer zweiten Elektrode besteht, wobei die erste Elektrode des zweiten Schalters (M3) direkt an die erste Stromversorgungsspannung (V_{DD}) gekoppelt ist und die zweite Elektrode des zweiten Schalters (M3) direkt an die erste Elektrode (A) des Kondensators (C_{st1}) gekoppelt ist.

2. Lichtemittierende Anzeigevorrichtung (100) nach Anspruch 1, wobei der erste und zweite Schalter (M2, M3) Transistoren mit derselben Kanalart enthalten, und wobei das erste Steuersignal (Control signal) das entsprechende Auswahlsignal von der entsprechenden Scanleitung (S1, ..., Sn) oder ein anderes Signal ist, das dieselben Kennzeichen wie das entsprechende Auswahlsignal von der entsprechenden Scanleitung (S1, ..., Sn) aufweist.

3. Lichtemittierende Anzeigevorrichtung (100) nach Anspruch 1, wobei der dritte Schalter (M4) einen Transistor mit einer Kanalart enthält, die von jener des ersten Schalters (M2) abweicht, und wobei das zweite Steuersignal das entsprechende Auswahlsignal von der entsprechenden Scanleitung (S1, ..., Sn) oder ein anderes Signal ist, das dieselben Kennzeichen wie das entsprechende Auswahlsignal von der entsprechenden Scanleitung (S1, ..., Sn) aufweist.
4. Lichtemittierende Anzeigevorrichtung (100) nach Anspruch 1, wobei der Spannungsausgleicher (11) zum Vorsehen einer ausgeglichenen Datenspannung entsprechend einer Spannung geeignet ist, die durch Subtrahieren der entsprechenden Datenspannung (V_{DATA}) von einer Summierung der ersten und zweiten Stromversorgungsspannung (V_{DD} und V_{SUS}) erhalten wird.
5. Verfahren zum Ansteuern einer Anzeigevorrichtung (100) nach einem der vorhergehenden Ansprüche, das Verfahren umfassend:
 - Anlegen der ersten Stromversorgungsspannung (V_{DD}) an die erste Elektrode (A) des Kondensators (C_{st1}) durch den zweiten Schalter (M3) in Reaktion auf das erste Steuersignal (Control signal);
 - Anlegen der Datenspannung (V_{DATA}) an die zweite Elektrode (B) des Kondensators (C_{st1}) durch den ersten Schalter (M2);
 - elektrisches Isolieren der ersten Elektrode (A) des Kondensators (C_{st1}) von der ersten Stromversorgungsspannung (V_{DD}); und
 - Anlegen der zweiten Stromversorgungsspannung (V_{sus}) an die zweite Elektrode (B) des Kondensators (C_{st1}).
6. Verfahren nach Anspruch 5, wobei der Transistor (M1) einen P-Kanal aufweist und die erste Stromversorgungsspannung (V_{DD}), die an die zweite Elektrode des Transistors (M1) angelegt ist, eine positive Spannung ist.
7. Verfahren nach Anspruch 5, wobei die zweite Stromversorgungsspannung (V_{sus}), die an die zweite Elektrode (B) des Kondensators (C_{st1}) angelegt ist, weniger als eine Summierung der Datenspannung (V_{DATA}) und einer Schwellenspannung des Transistors (M1) ist.

Revendications

1. Affichage lumineux (100) comprenant une pluralité de lignes de données (D1, ..., Dm) agencées pour transmettre des tensions de données (V_{DATA}) correspondant à des signaux vidéo, une pluralité de lignes de balayage (S1, ..., Sn) agencées pour transmettre des signaux de sélection, et une pluralité de circuits de pixels (10), chaque circuit de pixels (10) étant couplé à une dite ligne de données correspondante (D1, ..., Dm) pour recevoir une dite tension de données correspondante (V_{DATA}) et une dite ligne de balayage correspondante (S1, ..., Sn) pour recevoir un dit signal de sélection correspondant, chaque dit circuit de pixels (10) comprenant :
 - un transistor (M1) comprenant une première électrode, une deuxième électrode, agencées pour recevoir une première tension d'alimentation (V_{DD}), et une troisième électrode agencée pour délivrer en sortie un courant (I_{OLED}) correspondant à une tension entre la première électrode et la deuxième électrode ;
 - un élément lumineux (OLED) couplé à la troisième électrode, agencé pour émettre une lumière correspondant au courant (I_{OLED}) délivré en sortie par la troisième électrode ;
 - un premier commutateur (M2) agencé pour transmettre ladite tension de données correspondante (V_{DATA}) en réponse audit signal de sélection correspondant provenant de ladite ligne de balayage correspondante (S1, ..., Sn) ; et
 - un compensateur de tension (11) agencé pour recevoir ladite tension de données correspondante (V_{DATA}) transmise par le premier commutateur (M2) et une deuxième tension d'alimentation (V_{SUS}), et pour appliquer une tension de données compensée basée sur ladite tension de données correspondante (V_{DATA}) et la deuxième tension d'alimentation (V_{SUS}) à la première électrode du transistor (M1),
 dans lequel le compensateur de tension (11) comprend :
 - un condensateur (Cst1) ayant une première électrode (A) couplée à la première électrode du transistor (M1), et une deuxième électrode (B) couplée au premier commutateur (M2); et
 - un troisième commutateur (M4) couplé entre la deuxième électrode (B) du condensateur (Cst1) et la deuxième tension d'alimentation (V_{SUS}), agencé pour isoler électriquement la deuxième tension d'alimentation (V_{SUS}) vis-à-vis de la deuxième électrode (B) du condensateur (Cst1) en réponse à un deuxième signal

de commande (S_n),

et **caractérisé en ce que** le compensateur de tension (11) comprend en outre :

un deuxième commutateur (M3) agencé pour appliquer la première tension d'alimentation (V_{DD}) à la première électrode (A) du condensateur (C_{st1}) en réponse à un premier signal de commande (Control signal), le deuxième commutateur (M3) consistant en un transistor ayant une électrode de grille, une première électrode et une deuxième électrode, dans lequel la première électrode du deuxième commutateur (M3) est couplée directement à la première tension d'alimentation (V_{DD}) et la deuxième électrode du deuxième commutateur (M3) est couplée directement à la première électrode (A) du condensateur (C_{st1}).

2. Affichage lumineux (100) selon la revendication 1, dans lequel les premier et deuxième commutateurs (M2, M3) comprennent des transistors ayant un même type de canal, et le premier signal de commande (Control signal) est ledit signal de sélection correspondant provenant de ladite ligne de balayage correspondante ($S_1, \dots, S_n$) ou un autre signal qui a les mêmes caractéristiques que ledit signal de sélection correspondant provenant de ladite ligne de balayage correspondante ($S_1, \dots, S_n$).

3. Affichage lumineux (100) selon la revendication 1, dans lequel le troisième commutateur (M4) comprend un transistor ayant un type de canal qui est différent de celui du premier commutateur (M2), et le deuxième signal de commande est ledit signal de sélection correspondant provenant de ladite ligne de balayage correspondante ($S_1, \dots, S_n$) ou un autre signal qui a les mêmes caractéristiques que ledit signal de sélection correspondant provenant de ladite ligne de balayage correspondante ($S_1, \dots, S_n$).

4. Affichage lumineux (100) selon la revendication 1, dans lequel le compensateur de tension (11) est adapté pour fournir une tension de données compensée correspondant à une tension obtenue par soustraction de ladite tension de données correspondante (V_{DATA}) de la somme des première et deuxième tensions d'alimentation (V_{DD} et V_{SUS}).

5. Procédé pour piloter un panneau d'affichage (100) selon l'une des revendications précédentes, le procédé comprenant :

l'application de la première tension d'alimentation (V_{DD}) à la première électrode (A) du condensateur (C_{st1}) par l'intermédiaire du deuxième commutateur (M3) en réponse au premier signal de commande (Control signal) ;
l'application de la tension de données (V_{DATA}) à la deuxième électrode (B) du condensateur (C_{st1}) par l'intermédiaire du premier commutateur (M2) ;

l'isolation électrique de la première électrode (A) du condensateur (C_{st1}) vis-à-vis de la première tension d'alimentation (V_{DD}) ; et

l'application de la deuxième tension d'alimentation (V_{SUS}) à la deuxième électrode (B) du condensateur (C_{st1}).

6. Procédé selon la revendication 5, dans lequel le transistor (M1) a un canal de type P, et la première tension d'alimentation (V_{DD}) appliquée à la deuxième électrode du transistor (M1) est une tension positive.

7. Procédé selon la revendication 5, dans lequel la deuxième tension d'alimentation (V_{SUS}) appliquée à la deuxième électrode (B) du condensateur (C_{st1}) est inférieure à la somme de la tension de données (V_{DATA}) et d'une tension de seuil du transistor (M1).

FIG.1

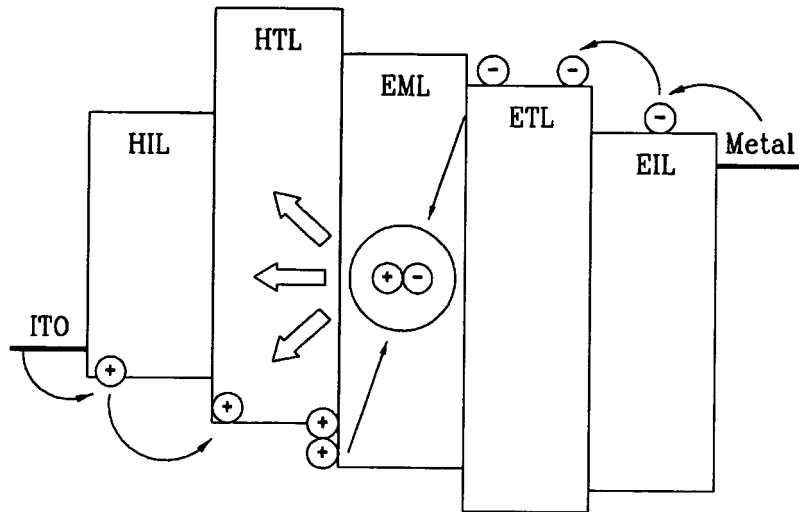


FIG.2

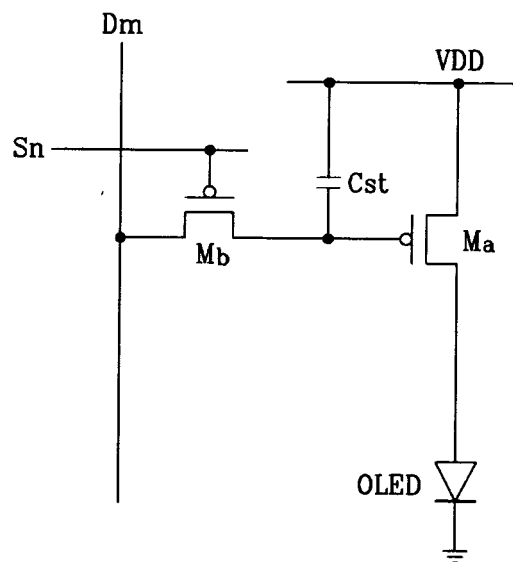


FIG.3

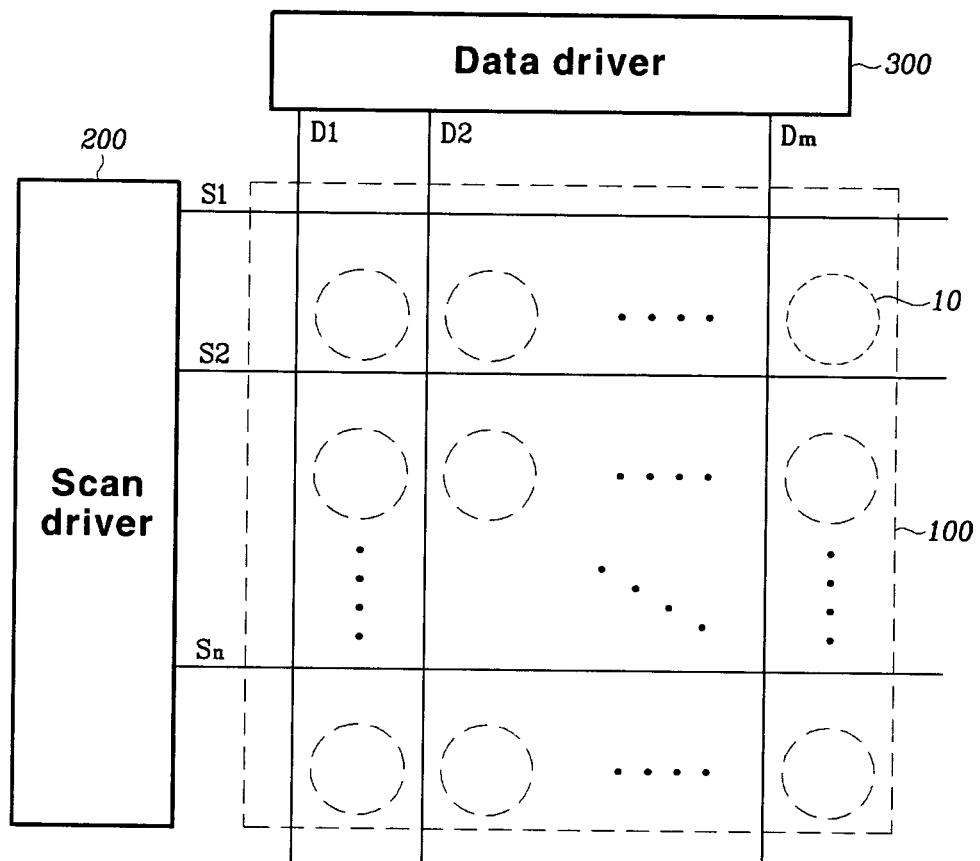


FIG.4

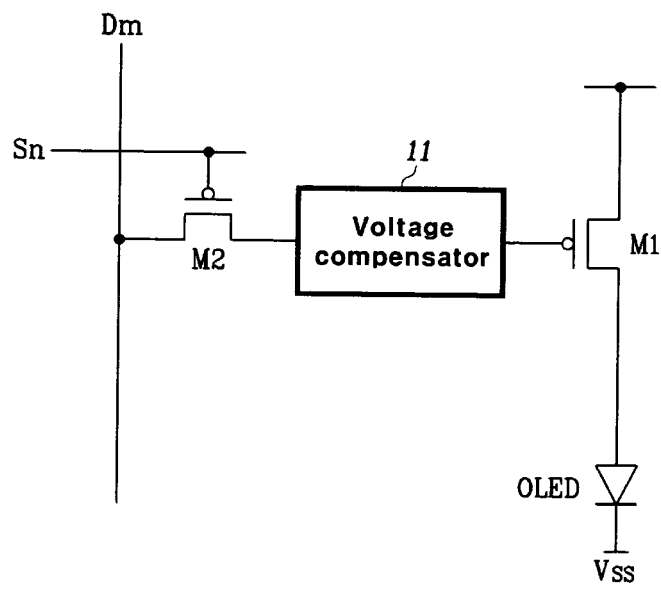


FIG.5

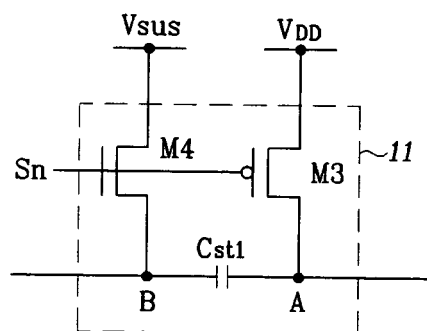


FIG.6A

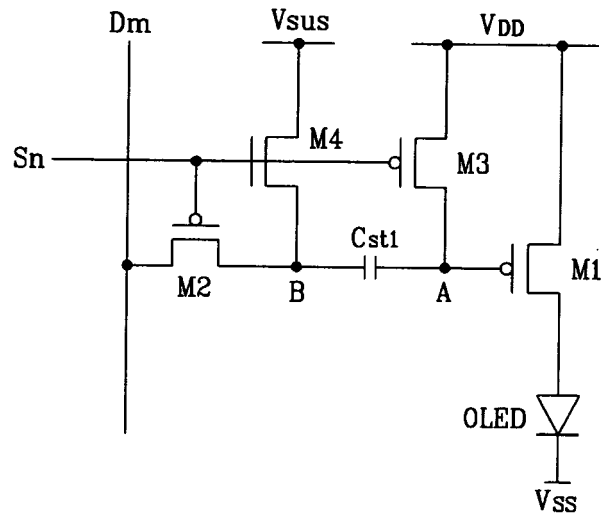


FIG.6B

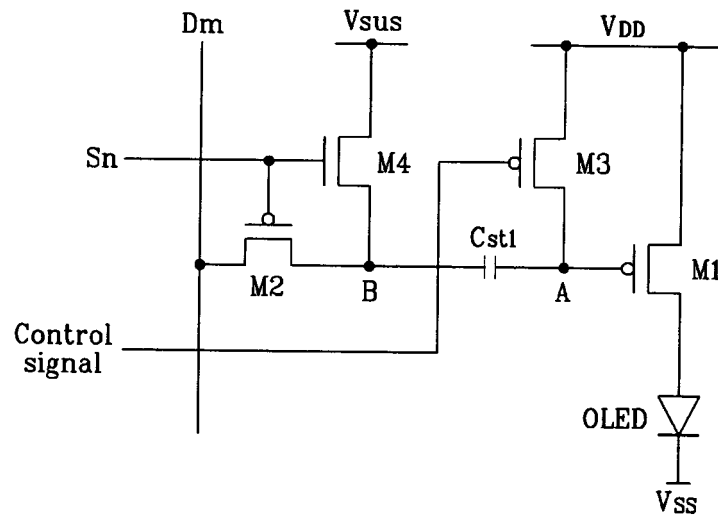


FIG.6C

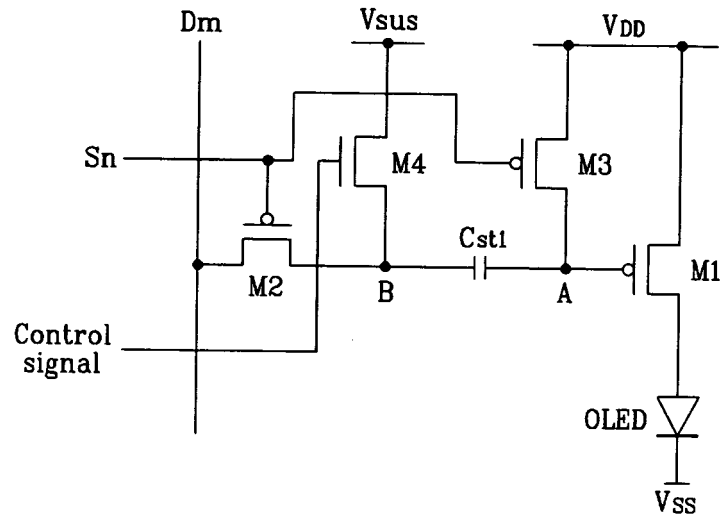


FIG.7A

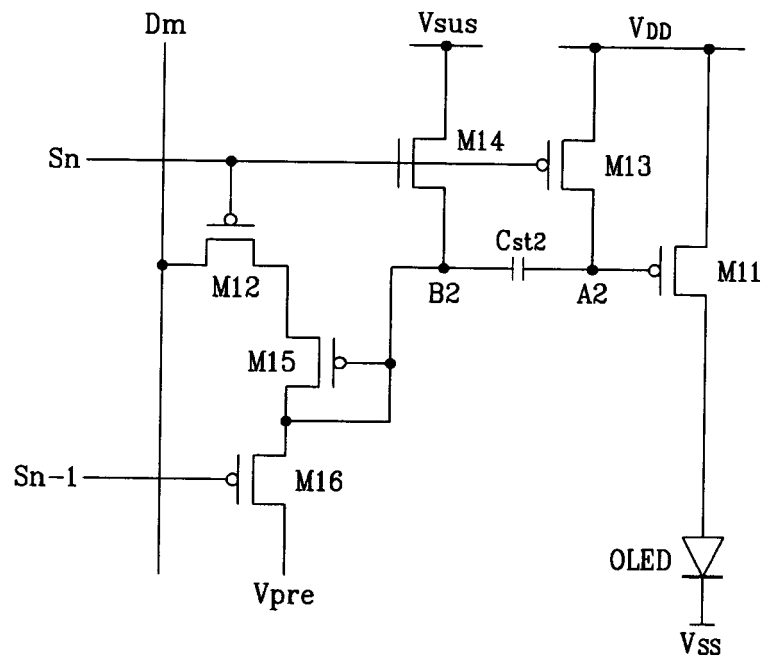


FIG.7B

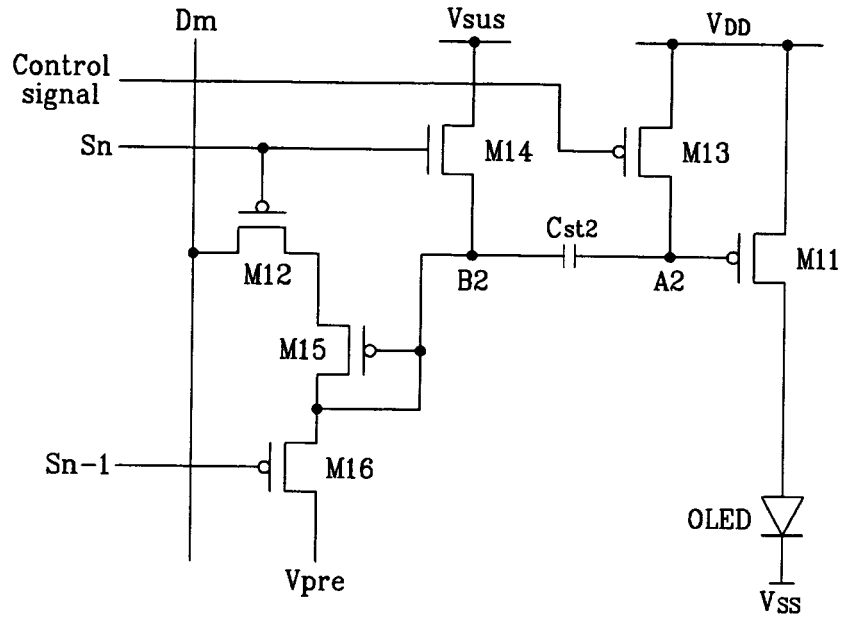


FIG.7C

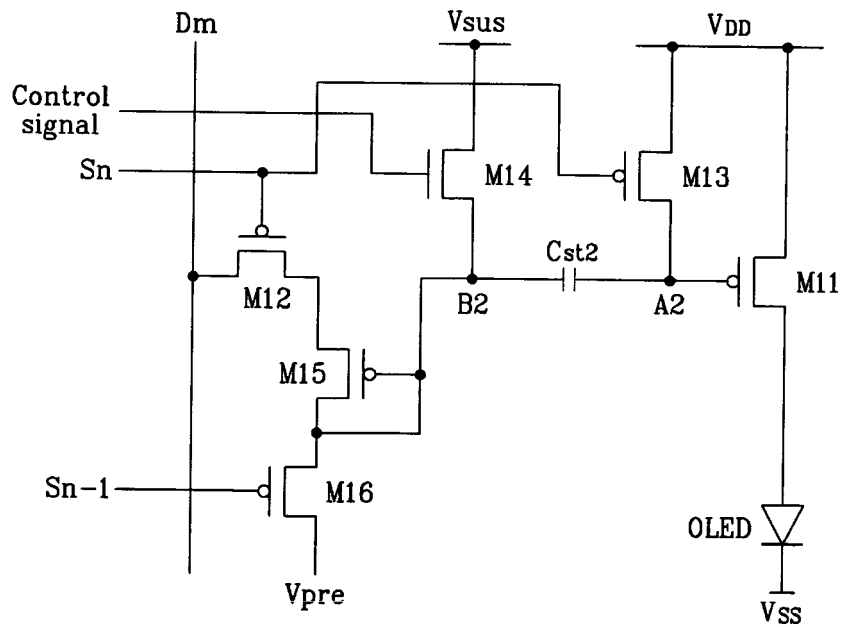


FIG.7D

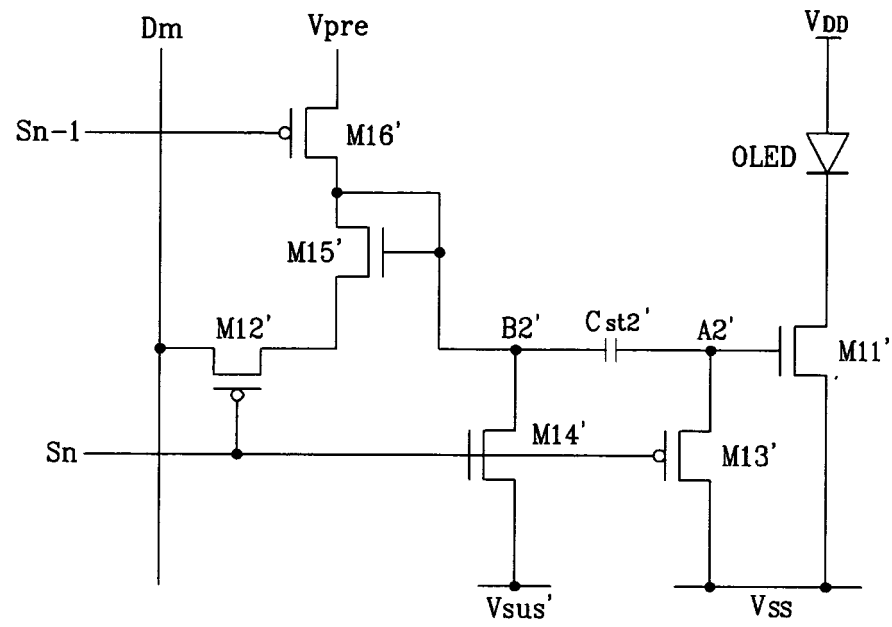


FIG.8

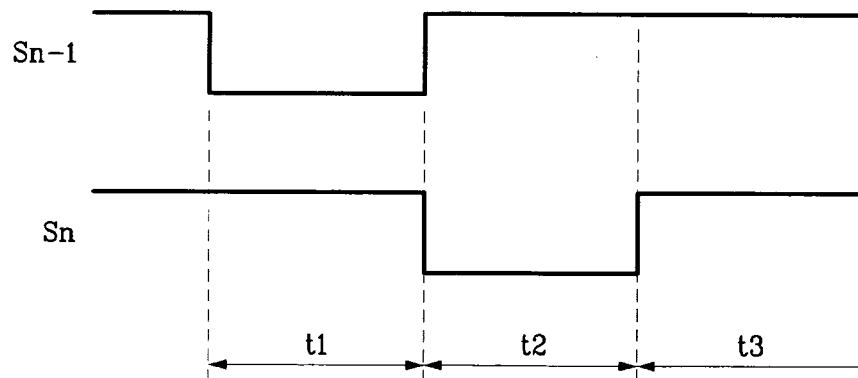


FIG.9A

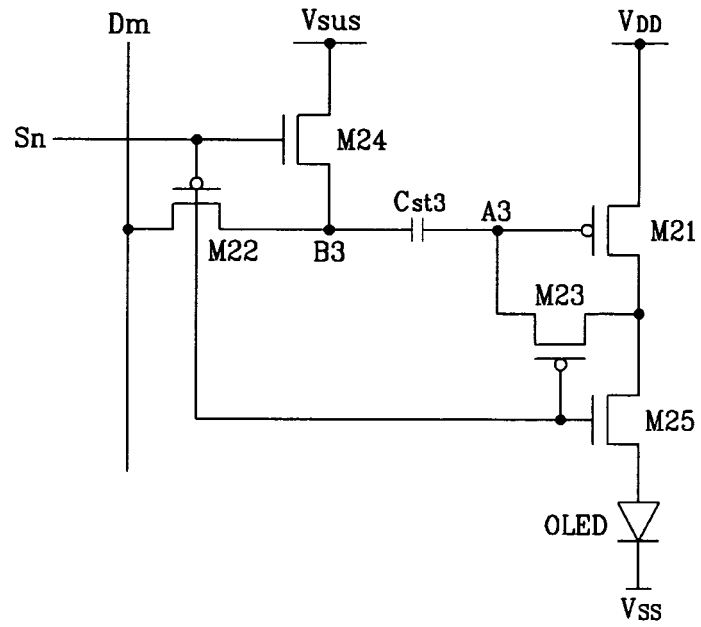


FIG.9B

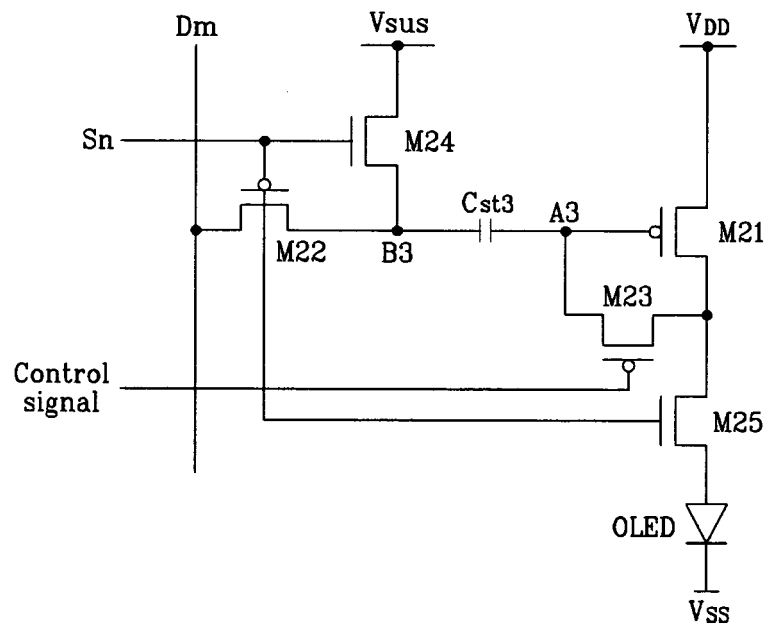


FIG.9C

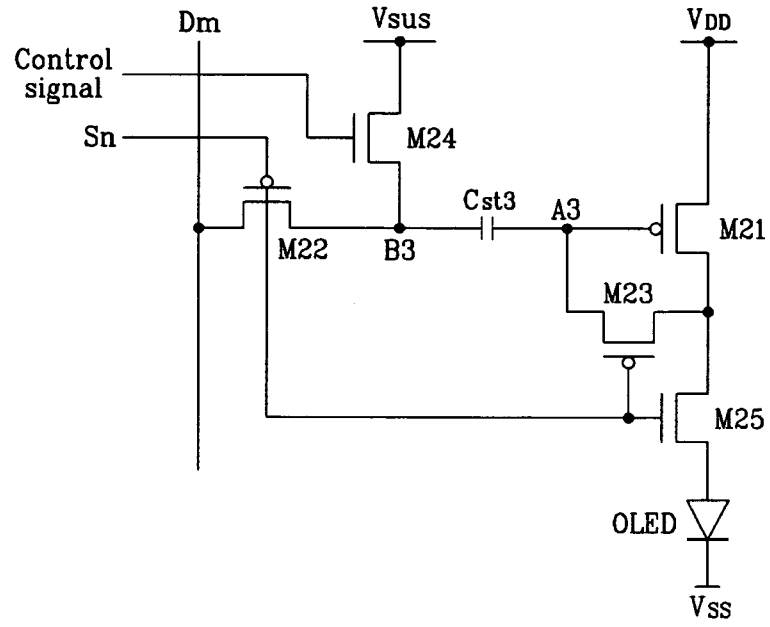


FIG.9D

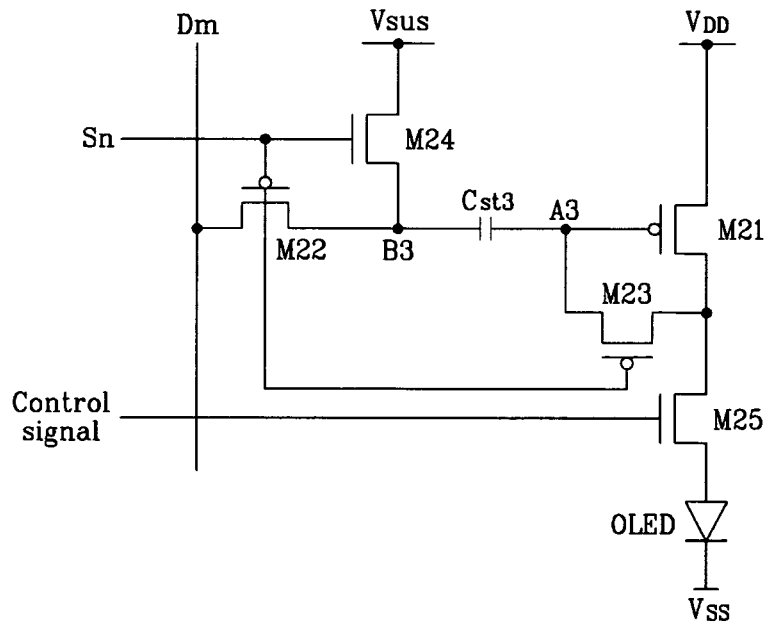


FIG.10

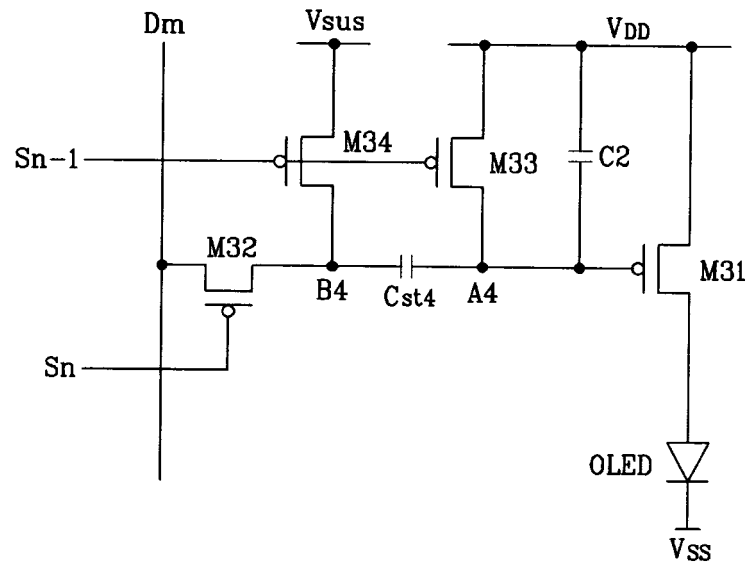


FIG.11

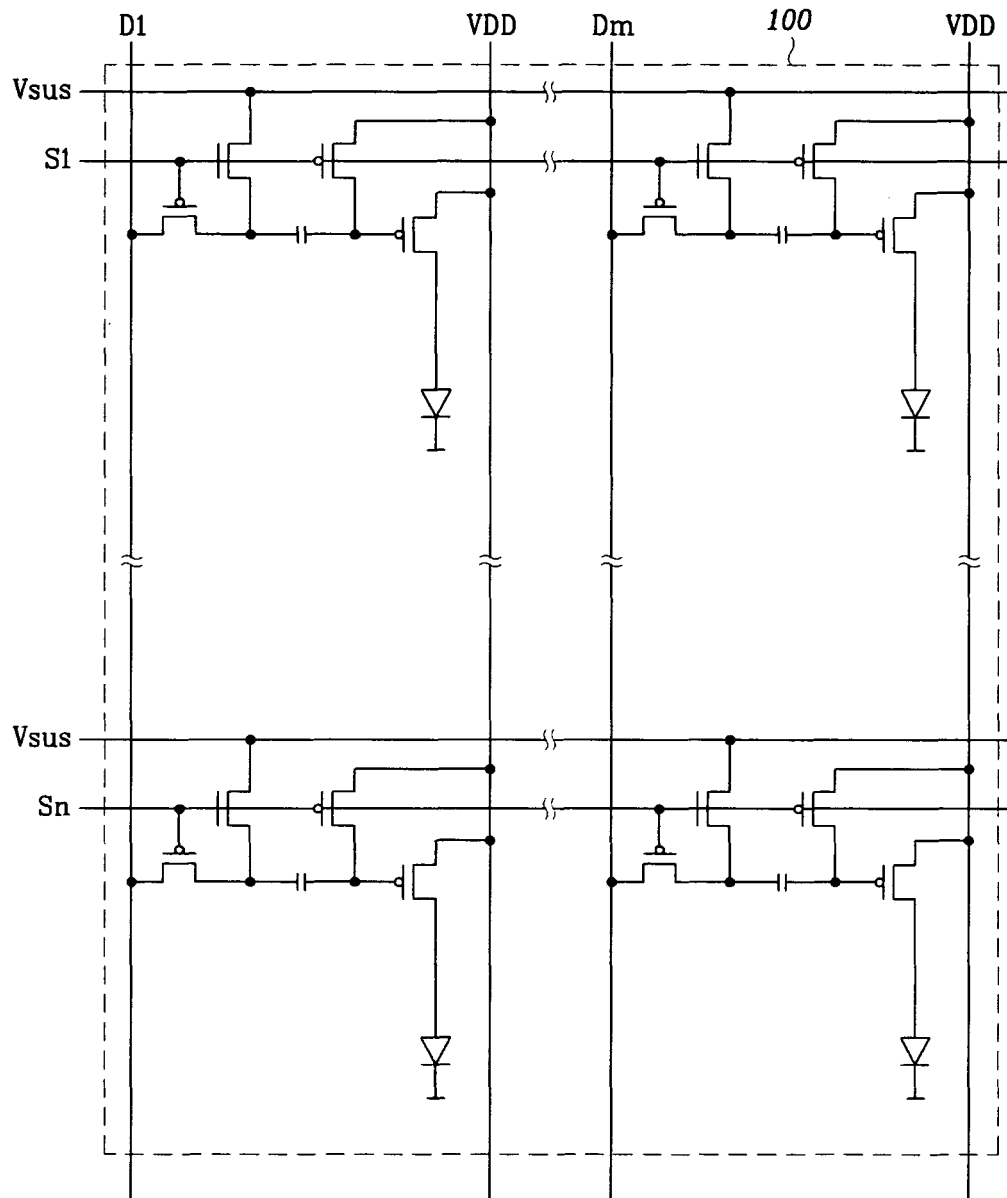
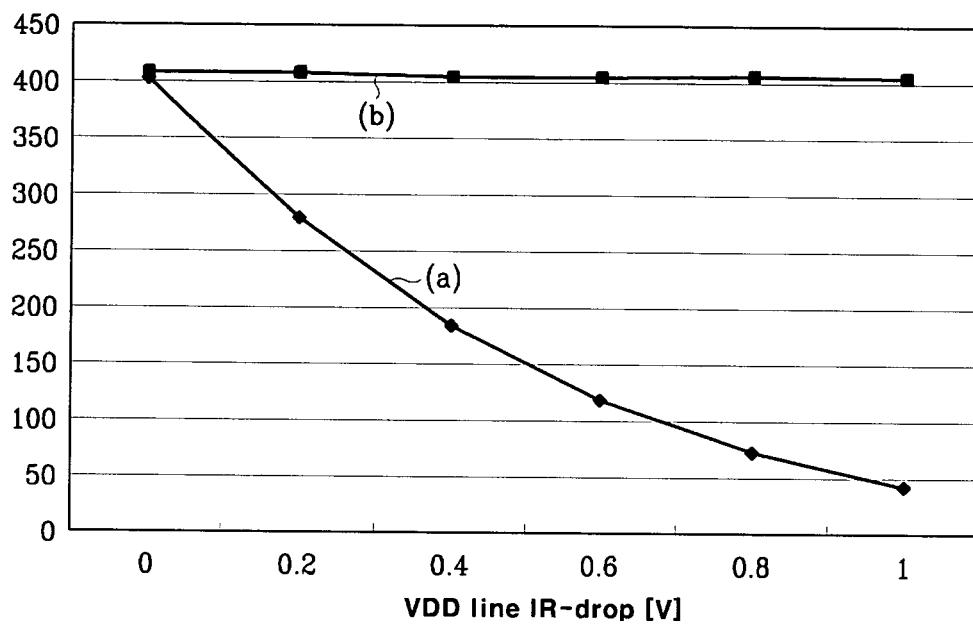


FIG.12



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003173165 B [0009]

专利名称(译)	发光显示器，显示面板及其驱动方法		
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申请号	EP2004090384	申请日	2004-10-06
[标]申请(专利权)人(译)	三星斯笛爱股份有限公司		
申请(专利权)人(译)	三星SDI CO. , LTD.		
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摘要(译)

一种发光显示器，包括用于传输数据电压的数据线，用于选择选择信号的扫描线和像素电路。像素电路耦合到数据线和扫描线。像素电路包括晶体管，该晶体管包括第一，第二和第三电极，其中第三电极输出与第一和第二电极之间的电压对应的电流。耦合到第三电极的发光元件发射对应于第三电极输出的电流的光。第一开关响应于来自扫描线的选择信号发送数据电压。电压补偿器接收由第一开关传输的数据电压和第二电源电压，并将基于数据电压，第一电源电压和第二电源电压的补偿数据电压施加到晶体管的第一电极。

Equation 1

$$I_{OLED} = \frac{\beta}{2} (V_{GS} - V_{TH})^2 = \frac{\beta}{2} (V_{DD} - V_{DATA} - |V_{TH}|)^2$$