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(54) **Organic electroluminescent display, driving method and pixel circuit thereof**

Organische elektrolumineszierende Anzeigevorrichtung, Ansteuerverfahren und Pixelschaltung

Dispositif d'affichage électroluminescent organique, méthode d'attaque et circuit pixel

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Description

BACKGROUND OF THE INVENTION

(a) Field of the Invention

[0001] The present invention relates to an organic electroluminescent (EL) display, a driving method of the EL display and a pixel circuit of the EL display. More specifically, the present invention relates to an organic EL display (OELD), its driving methods and a pixel circuit for compensating for deviations of the threshold voltage of a thin film transistor (TFT) and achieving high gray scale display when driving the pixels of the OELD by using the TFT.

(b) Description of the Related Art

[0002] In general, the OELD electrically excites fluorescent organic compounds to emit light, and performs voltage driving or current driving on a (N x M) number of organic luminescent cells so as to display images. As shown in FIG. 1, the organic luminescent cell comprises an anode (ITO), an organic thin film, and a cathode layer (Metal). The organic thin film comprises multi-layers including an emitting layer (EML), an electron transport layer (ETL), and a hole transport layer (HTL) so as to provide a good balance between the electron concentration and the hole concentration thereby improving emitting efficiency, and it additionally comprises an electron injecting layer (EIL) and a hole injecting layer (HIL).

[0003] Methods for driving the organic luminescent cells as described above are categorized as a passive matrix method and an active matrix method. The passive matrix method forms positive electrodes to be perpendicular to negative electrodes and selects lines and drives them, and the active matrix method connects the TFT and a capacitor to each ITO pixel electrode so that the voltage may be maintained according to capacitance.

[0004] FIG. 2 shows a conventional pixel circuit for driving an OELD using a TFT, illustrating a pixel from among a (N x M) number of the pixels. Referring to FIG. 2, a current driving transistor (Mb) is coupled to the OELD and supplies current to emit light. The current through the current driving transistor (Mb) is controlled by the data voltage supplied via a switching transistor (Ma). In this instance, a capacitor C for maintaining the supplied voltage during a predetermined frame period is coupled between the source and the gate of the current driving transistor (Mb). The gate of the switching transistor (Ma) responds to an n-th select signal line Select[n], and the source to a data line Data[m].

[0005] Referring to FIG. 3, as to an operation of the pixel having the above-described configuration, when the transistor Ma is turned on by the select signal Select[n] supplied to the gate of the switching transistor Ma, the data voltage V_{DATA} is supplied to the gate (node A) of the transistor Mb via a data line. In response to the data voltage V_{DATA} supplied to the gate, the current flows to the OELD via the transistor Mb to emit light.

[0006] In this instance, the current that flows to the OELD is expressed as follows:

Equation 1

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

where I_{OELD} represents the current flowing to the OELD, V_{GS} represents the voltage between the source and the gate of the transistor Mb, V_{TH} represents the threshold voltage of the transistor Mb, V_{DATA} represents the data voltage, and β represents a constant.

[0007] As expressed in Equation 1 and according to the pixel circuit as shown in FIG. 2, the current corresponding to the supplied data voltage V_{DATA} is supplied to the OELD, and in response to the supplied current, the OELD emits light. In this instance, the data voltage V_{DATA} has multi-step values within a predetermined range so as to show the gray.

[0008] However, it is difficult for the conventional pixel circuit to achieve high gray scale because of deviations of the threshold voltage V_{TH} of the TFT inherent from manufacturing process thereof. For example, in the case of driving the TFT pixels with data voltage in the range of 3 volts, two data voltages representing adjacent gray levels mest be apart from each other approximately by 12mV(=3V/256) so as to implement 8-bit(256) gray scale. If the deviation of threshold voltage is 100mV, it is difficult to discriminate one data voltage from another which results in decreased gray scale.

[0009] JP-A-2000/221942 discloses a drive unit for driving a corresponding one of organic EL elements including a blanking switch for blanking the video signal stored in a storage capacitor in each frame period before the start of the next frame period.

[0010] JP-A-2000/347621 discloses an active matrix OELD comprising a drive transistor for driving an OEL element and a control transistor for connecting the gate of the drive transistor to ground.

SUMMARY OF THE INVENTION

[0011] It is an object of the present invention to provide an OELD for compensating for deviations of the threshold voltage of the TFT and displaying high gray scale.

[0012] The invention is set forth in attached claim 1 and claim 16.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate an embodiment of the invention, and, together with the description, serve to explain the principles of the invention:

FIG. 1 shows a diagram of a general organic EL element;
FIG. 2 shows a conventional pixel circuit for driving the organic EL element;
FIG. 3 shows a timing diagram ef for the conventional pixel circuit;
FIG. 4 shows an OELD device according to a preferred embodiment of the present invention;
FIG. 5 shows a pixel circuit according to a preferred embodiment of the present invention;
FIG. 6 shows a pixel circuit according to a first preferred embodiment of the present invention;
FIG. 7 shows a pixel circuit according to a second preferred embodiment of the present invention;
FIGs. 8(a) and 8(b) show timing diagrams for the pixel circuit as shown in FIG. 6;
FIG. 9 shows a timing diagram for the pixel circuit as shown in FIG. 7;
FIG. 10 shows a pixel circuit according to a third preferred embodiment of the present invention;
FIGs. 11(a) and 11(b) show timing diagrams for the pixel circuit as shown in FIG. 10;
FIG. 12 shows a pixel circuit according to a fourth preferred embodiment of the present invention;
FIG. 13 shows a pixel circuit according to a fifth preferred embodiment of the present invention;
FIG. 14 shows a pixel circuit according to a sixth preferred embodiment of the present invention;
FIG. 15 shows a pixel circuit according to a seventh preferred embodiment of the present invention;
FIGs. 16 and 17 show timing diagrams for the pixel circuit as shown in FIGs. 14 and 15;
FIG. 18 shows a pixel circuit according to an eighth preferred embodiment of the present invention;
FIG. 19 shows a pixel circuit according to a ninth preferred embodiment of the present invention;
FIG. 20 shows a layout of an organic EL element according to the preferred embodiment of the present invention; and
FIG. 21 shows a cross sectional view of FIG. 20 with respect to a line A-B.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] In the following detailed description, only the preferred embodiment of the invention has been shown and described, simply by way of illustration of the best mode contemplated by the inventor(s) of carrying out the invention. As will be realized, the invention is capable of modification in various obvious respects, all without departing from the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not restrictive.

[0015] FIG. 4 shows an OELD according to a preferred embodiment of the present invention.

[0016] As shown, the OELD comprises an OELD panel 10; a data driver 30; and a scanning driver 20.

[0017] The OELD panel 10 comprises a plurality of data lines D1 to Dy for transmitting data voltages for displaying image signals; scan lines S1 to Sz for transmitting select signals; and a pixel circuit 11 formed on each of a plurality of pixels surrounded by the data lines and the scan lines.

[0018] The data driver 30 supplies the data voltage for displaying the image signals to the data lines, and the scanning driver 20 sequentially supplies the select signals to the scan lines.

[0019] FIG. 5 shows the pixel circuit 11 according to the preferred embodiment of the present invention.

[0020] As shown, the pixel circuit 11 comprises an OELD, TFTs M1 and M2, switches S1 and S2, and a capacitor C1.

[0021] The OELD emits light corresponding to the supplied current, and the current driving transistor M1 has a source coupled to the power voltage VDD and a drain coupled to the OELD, and supplies the current corresponding to the data voltage which is provided to a gate of the transistor M1 via the data line, to the OELD.

[0022] The transistor M2 has a gate coupled to the gate of the transistor M1, and the gate and a drain of the transistor M2 are coupled to function as a diode, and the transistor M2 compensates for deviations of the threshold voltage of the transistor M1 for supplying the current. According to the pixel circuit shown in FIG. 5, the current supply transistor M1 and the threshold voltage compensation transistor M2 are configured in PMOS type TFTs, but can also be configured in NMOS type TFTs to be subsequently described.

[0023] The capacitor C1, coupled between the power voltage VDD and the gate of the transistor M1, maintains the data voltage supplied to the gate of the transistor M1 during a predetermined frame period.

[0024] The switch S1 is switched responsive to the select signal Select[n] supplied by the scan line, and transmits the

data voltage supplied to the data line to the current driving transistor M1 via the transistor M2. The switch S2 initializes the gate voltage of the transistor M1 in response to a reset signal.

[0025] An operation of the pixel circuit according to the preferred embodiment as shown in FIG. 5 will now be described.

[0026] When the switch S1 is turned on according to the select signal Select[n] supplied to the switch S1, the data voltage V_{DATA} supplied to the data line is supplied to the gate (node A) of the driving transistor M1 via the transistor M2, and in response to the data voltage V_{DATA} supplied to the gate, the current flows to the OELD via the transistor M1 to emit light.

[0027] In this instance, the current flowing to the OELD is expressed as follows:

Equation 2

$$I_{OELD} = \frac{\beta}{2} \cdot (V_{GS} - V_{TH1})^2 = \frac{\beta}{2} \cdot (V_{DD} - (V_{DATA} - V_{TH2}) - V_{TH1})^2$$

where I_{OELD} represents the current flowing to the OELD, V_{GS} represents the voltage between the source and the gate of the transistor M1, V_{TH1} represents the threshold voltage of the transistor M1, V_{TH2} represents the threshold voltage of the transistor M2, and β represents a constant.

[0028] In this instance, if the threshold voltages of the transistors M1 and M2 are identical, that is, $V_{TH1} = V_{TH2}$, Equation 2 can be expressed in Equation 3. According to the preferred embodiment of the present invention, since the transistors M1 and M2 are manufactured under almost identical process conditions, the deviation of the threshold voltages of the two transistors are minimal, and accordingly, the threshold voltages become virtually identical.

Equation 3

$$I_{OELD} = \frac{\beta}{2} \cdot (V_{DD} - V_{DATA})^2$$

[0029] Therefore, according to the preferred embodiment of the present invention, the OELD as expressed by Equation 3 flows the current corresponding to the data voltage supplied to the data line without relation to the threshold voltage of the current driving transistor M1. That is, since the transistor M2 compensates for the deviation of the threshold voltage of the current driving transistor M1, the transistor M1 can precisely control the current flowing to the OELD, and accordingly, the OELD with high gray scale is provided.

[0030] When the data during a previous frame period is a high level voltage and the data of a subsequent frame period is a low level voltage, no more data signal can be supplied to the node A because of diode connection characteristics of the transistor M2. Therefore, the switch S2 may be provided to initialize the node A for each time frame period with a predetermined level (e.g., a ground level). In this instance, the switch S2 can be driven by an additional reset signal or by a just previous select signal Select[n-1] to increase an aperture ratio of pixels of the OELD.

[0031] FIG. 6 shows a pixel circuit of the OELD according to a first preferred embodiment of the present invention. As shown, the pixel circuit comprises a current supplying transistor M1 and a threshold voltage compensation transistor M2 of PMOS transistors, and switches S1 and S2 of PMOS transistors M3 and M4 in the like manner of the pixel circuit of FIG. 5.

[0032] Also, an additional reset signal Reset is supplied to a gate of the transistor M4 for resetting the gate voltage of the transistor M1.

[0033] FIGs. 8(a) and 8(b) show timing diagrams for driving the pixel circuit of FIG. 6.

[0034] Referring to FIG. 8(a), the node A is initialized by the initial reset signal, a corresponding pixel is selected via the select signal Select[n], and the data signal Data[m] is supplied to the corresponding pixel. That is, according to the driving method shown in FIG. 8(a), signals are supplied to the respective transistors in order of the reset signal, the select signal and the data signal.

[0035] In detail, an external reset signal Reset is supplied to the gate of the transistor M4 to initialize the node A into a ground level, and a select signal Select[n] is supplied to the gate of the transistor M3 to activate the corresponding pixel. A data signal Data[m] is supplied to the source of the activated transistor M3 to drive the current driving transistor M1. In this instance, the current that flows to the OELD via the current driving transistor M1 is expressed in Equation 3.

[0036] The pixel circuit for using the external reset signal according to the first preferred embodiment of the present invention can be driven using the timing diagram of FIG. 8(b) as well as that of FIG. 8(a).

[0037] Referring to FIG. 8(b), the node A is initialized by the initial reset signal Reset, the data signal Data[m] is supplied to the data line, and the corresponding pixel is selected via the select signal Select[n]. That is, according to the driving method shown in FIG. 8(b), signals are supplied to the respective transistors in order of the reset signal, the data signal and the select signal.

[0038] FIG. 7 shows a pixel circuit of the OELD according to a second preferred embodiment of the present invention. The pixel circuit according to the second preferred embodiment is almost identical to the pixel circuit of FIG. 6 except that the gate of the transistor M4 is coupled to a previous scan line. That is, the pixel circuit according to the second preferred embodiment uses the select signal Select[n-1] of the previous scan line instead of an additional external reset signal Reset, and supplies the select signal Select[n-1] to the gate of the transistor M4.

[0039] As described above, when the additional external reset signal is not used, no additional wiring for transmitting the reset signal is needed, and accordingly, the aperture ratio of the pixel can be increased.

[0040] FIG. 9 shows a timing diagram for driving the OELD according to the second preferred embodiment.

[0041] As shown, according to the second preferred embodiment for resetting the node A using the scanning signal, the signals must be supplied to the respective transistors in order of the previous select signal (reset signal), the data signal and the present select signal. That is, the data voltage must be supplied to the data line before the present select signal Select[n] is supplied to the scan line.

[0042] In the case the select signal Select[n] is supplied before the present data voltage is supplied as shown in FIG. 8(a), the previous data voltage supplied to the data line is supplied to the current driving transistor M1 via the transistor M3. Therefore, the select signal must be supplied to the data line after the present data voltage is supplied to the data line.

[0043] FIG. 10 shows a pixel circuit of the OELD according to a third preferred embodiment of the present invention, and FIGs. 11 (a) and 11(b) show timing diagrams for driving the pixel circuit of FIG. 10. As shown in FIG. 10, the pixel circuit according to the third preferred embodiment of the present invention comprises NMOS type transistors M5 to M8 differing from the pixel circuits of FIGs. 6 and 7 and having a configuration totally symmetrical with the pixel circuits of FIGs. 6 and 7.

[0044] Since an operation of the pixel circuit of FIG. 10 and the timing diagrams of FIGs. 11 (a) and 11 (b) can be easily understood by a skilled person according to the descriptions of FIGs. 6 and 7, a repeated description will not be provided.

[0045] FIG. 12 shows a pixel circuit of the OELD according to a fourth preferred embodiment of the present invention.

[0046] As shown, the pixel circuit according to the fourth preferred embodiment has a configuration almost identical to those of the pixel circuits of FIGs. 6 and 7 except that a pre-charge voltage Vpre instead of the ground voltage is supplied to the drain of the switching transistor M4. As described above, when the pre-charge voltage is supplied to the drain of the transistor M4, the initial voltage of the node A can be increased to the pre-charge voltage level Vpre instead of the ground level, and hence, switching time of the transistor and power consumption can be reduced. In this instance, it is preferable to establish the pre-charge voltage to be slightly less than the minimum voltage supplied to the node A theat corresponds to the minimum voltage supplied to the data line and the maximum gray level (i.e. white level).

[0047] FIG. 13 shows a pixel circuit of OELD according to a fifth preferred embodiment of the present invention.

[0048] As shown, the pixel circuit according to the fifth preferred embodiment has a configuration almost identical to those of the pixel circuits of FIGs. 6 and 7 except that the drain and the gate of the switching transistor M4 are coupled to function as a diode and the gate of the transistor M4 (i.e., an input terminal of the diode) is coupled to an external reset signal terminal or a previous scan line.

[0049] As shown, according to the preferred embodiment, the node A can also be initialized via the transistor M4 coupled to the diode, and when the reset signal or the previous select signal is used instead of the ground voltage or the pre-charge voltage, since additional ground wiring or pre-charge wiring is not needed to be formed, the amount of wiring is reduced and the aperture ratio is increased.

[0050] FIG. 14 shows a pixel circuit of the OELD according to a sixth preferred embodiment of the present invention.

[0051] As shown, the pixel circuit according to the sixth preferred embodiment has a configuration almost identical to that of the pixel circuit of FIG. 6 except that the NMOS transistor M9 is used instead of the PMOS type transistor M4. An external reset signal is supplied to the gate of the transistor M9.

[0052] Referring to FIG. 6, when the switching transistor M4 to which the reset signal is supplied is a PMOS transistor, a predetermined voltage (e.g., the ground level) is supplied to the gate of the transistor M4 at a reset operation, and the voltage at the source (node A) of the transistor M4 continues to be decreased because of the reset operation. Therefore, the voltage V_{GS} between the gate and the source of the transistor M4 continues to be decreased and the current flowing to the ground or the pre-charge voltage from the node A via the transistor M4 continues to be reduced and substantial reset time is required. Also, since the voltage difference between the gate and the source of the transistor M4 must be greater than the absolute value of the threshold voltage Vth, when it is assumed that the reset signal supplied at the reset operation is the ground voltage, the actual lowest voltage at the node A becomes |Vth|.

[0053] Differing from this, according to the pixel circuit according to the sixth preferred embodiment, since an NMOS transistor is used for the switching transistor M9, the lowest voltage at the node A that can be achieved is almost the

ground level, and accordingly, the range of the data voltage to display gray levels can be widened. Also, since the voltage V_{GS} between the gate and the source of the transistor M9 is constant differing from FIG. 6, the current flowing to the ground or the pre-charge voltage from the node A via the transistor M4 is constant, and accordingly, the reset operation can be quickly performed.

[0054] FIG. 16 shows a timing diagram for driving the pixel circuit according to the sixth preferred embodiment. As shown, since the transistor M9 having the gate to which the reset signal is supplied is an NMOS transistor in the pixel circuit according to the sixth preferred embodiment, the reset signal has a waveform opposite to that of the reset signal of FIG. 8(a).

[0055] Since the operation of the pixel circuit of FIG. 14 and the timing diagram of FIG. 16 can be easily understood by a skilled person, a repeated description will not be provided.

[0056] FIG. 15 shows a pixel circuit of the OELD according to a seventh preferred embodiment of the present invention, and FIG. 17 shows a timing diagram of a driving waveform used in FIG. 15.

[0057] As shown by FIG. 15, the pixel circuit according to a seventh preferred embodiment has a configuration almost identical to that of the pixel circuit of FIG. 14 except that the previous scan line is coupled to the gate of the NMOS transistor M9, the previous select signal Select[n-1] is used as a reset signal, and the transistor M10 having the gate coupled to the scan line is an NMOS transistor.

[0058] When the previous select signal coupled to the gate of the NMOS transistor M9 is used as a reset signal, the transistor for switching the data voltage must be an NMOS transistor.

[0059] As shown by FIG. 17, since the pixel circuit according to the seventh preferred embodiment resets the node A using a previous select signal, the signals must be supplied to the respective transistor in order of the previous select signal (reset signal), the data signal and the present select signal.

[0060] FIGs. 18 and 19 respectively show pixel circuits of the OELD according to eighth and ninth preferred embodiments of the present invention.

[0061] The PMOS transistors and the NMOS transistors of the respective pixel circuits of FIGs. 18 and 19 are symmetrically changed with those of the pixel circuits of FIGs. 14 and 15.

[0062] Since the operation of the pixel circuits in FIGs. 18 and 19 can be easily understood by a skilled person according to the above description, a repeated description will not be provided.

[0063] A layout and a cross sectional view of the OELD according to the preferred embodiment of the present invention will now be described.

[0064] FIG. 20 shows a layout of the OELD, and more precisely, a layout of the pixel circuit of FIG. 13.

[0065] FIG. 21 shows a cross sectional view of FIG. 20 with respect to the line A-B.

[0066] Referring to FIGs. 20 and 21, the regions I, II, III and V respectively define the regions for forming the TFTs M3, M2, M1 and M4 thereon, and the region IV for forming the OELD thereon.

[0067] As shown in FIGs. 20 and 21, a polycrystalline silicon(poly-Si) layer 200 is formed on a transparent insulation substrate 100, and a gate insulation layer 300 of SiO_2 or SiNx is formed thereon.

[0068] A scan line 400 of Al and Cr is patterned in the horizontal direction on the gate insulation layer 300 to be crossed with the polycrystalline silicon layer 200. Gate electrodes 410 are respectively formed on portions where the scan lines 400 are superimposed with the polycrystalline silicon layer 200 in the I and V regions. Also, a first capacitor electrode 450 is patterned on the same layer with the same material as the scan line 400. The gate electrodes 410 are respectively formed on the portions where the first capacitor electrode 450 is superimposed with the polycrystal silicon layer 200 of the II and III regions.

[0069] In this instance, a portion of the polycrystalline silicon layer 200 under the gate electrode 410 is not doped and forms a channel region 220. Both outer sides of the channel region 220 in polycrystalline silicon layer 200 are doped with p-type dopant and respectively form a drain region 230 and a source region 210.

[0070] An insulating interlayer layer 500 of silicon dioxide or silicon nitride is formed on the top of the gate layer such as the scan line 400 or the first capacitor electrode 450, and the gate insulation layer 300 and the interlayer layer 500 have contact holes C1 and C2 to expose the source and drain regions 210 and 230.

[0071] A data line 600 of Cr or Mo is formed in the perpendicular direction on the interlayer layer 500. A portion extended from the data line 600 and superimposed with a portion of the silicon layer 200 of the region I, that is, the source region 210, becomes a source electrode 610. In this instance, the source electrode 610 is connected to the source region 210 via the contact hole C1 formed on the interlayer layer 500.

[0072] Also, a second capacitor electrode 650 superimposed on the first capacitive line 450, for forming capacitance, is formed on a layer identical with that of the data line 600 and with a material identical with that of the data line 600. A portion where the second capacitor electrode 650 is superimposed with a portion of the silicon layer 200 of the region III, that is, the source region 210, becomes the source electrode 610. In this instance, the source electrode 610 is connected to the source region 210 via the contact hole C1.

[0073] First to fourth signal lines 640, 660, 670 and 680 are formed on the the same layer with the same material as the data line 600. A portion where the first signal line 640 is superimposed with a portion of the polycrystalline silicon

layer 200 of the region II, that is, the drain region 230, becomes the drain electrode 620, and a portion where the second signal line 660 is superimposed with the source region 210 of the region V becomes the source electrode 610. A portion where the third signal line 670 is superimposed with the drain region 230 of the region V becomes the drain electrode 620, and a portion where the fourth signal line 680 is superimposed with the drain region 230 of the region III becomes the drain electrode 620. In this instance, the source and drain electrodes 610 and 620 are respectively connected to the source and drain regions 210 and 230 via the contact holes C1 and C2.

[0074] The first and second signal lines 640 and 660 are connected to the first capacitor electrode 450 via a contact hole C3, and accordingly, as shown in FIG. 13, the drain electrode of the transistor M2 is connected to the gate electrodes of the transistors M2 and M1 and the source electrode of the transistor M4. The third signal line 670 is connected to a previous scan line Select[n-1] via the contact hole C3, and therefore, as shown by the equivalent circuit in FIG. 3, the drain electrode of the transistor M4 is connected to the previous scan line.

[0075] A passivation layer 700 of silicon oxide and silicon nitride is provided on the data wiring such as the data line 600 and the source and drain electrodes 610 and 620. A transparent pixel electrode 800 of indium-tin-oxide (ITO) is formed on the protective insulation layer 700 formed on the region IV. The pixel electrode 800 is connected to the drain electrode 620 of the TFT M1 through a via hole C4 formed on the passivation layer 700.

[0076] A flattening layer 900 is formed on the protective insulation layer 700 and the pixel electrode 800, and an organic EL element layer 1000 is formed on the flattening layer 900 and the pixel electrode 800.

[0077] According to the OELD shown in FIG. 20, the TFTs M2 and M1 are provided on one line in parallel to the data line 600. In the case of manufacturing the OELD, laser beams are scanned in parallel to the data lines. Since the TFTs M2 and M1 are located on the line in parallel to the data line 600 according to the preferred embodiment of the present invention, they are scanned with the same laser beams. Hence, since the TFTs M1 and M2 are manufactured under almost the same process condition, their threshold voltages become almost identical.

[0078] Therefore, according to the preferred embodiment of the present invention, since it is satisfied that $V_{TH1} = V_{TH2}$, Equation 3 is virtually satisfied and the OELD of high gray scale can be implemented.

[0079] The layout and the cross sectional view of the OELD shown in FIGs. 20 and 21 represents an exemplified embodiment, and diversified variations of embodiments can be implemented.

[0080] For example, in the case of manufacturing the OELD using scanned laser beams in parallel to the scan lines, the TFTs M2 and M1 may be located on the line in parallel to the scan line to be scanned with the same laser beams.

[0081] As described above, the present invention effectively compensates for the deviation of the threshold voltage of the TFT for driving the OELD and implements an OELD of higher gray scale.

[0082] While this invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the 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.

[0083] where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

Claims

1. An organic electroluminescent display pixel circuit (10) formed on a plurality of pixels defined by a plurality of data lines (D_y) and scan lines (S_z), comprising:

   an organic electroluminescent, EL, element for emitting light corresponding to a supplied current;
   a first thin film transistor, TFT, (M1) having a drain coupled to the organic EL element;
   a second TFT (M2) having a gate coupled to a gate of the first TFT (M1), and the gate and a drain of the second TFT (M2) being coupled together;
   a capacitor (C1) coupled between the gate and a source of the first TFT (M1);
   a first switch (S1) having a control terminal coupled to a scan line,
   wherein said first switch comprises a first terminal and a second terminal respectively coupled to a data line and a source of the second TFT (M2);
   and said pixel circuit (10) comprises a second switch (S2) for resetting said gate of the first TFT (M1) to a predetermined voltage which has a control terminal to which a control signal is supplied, a first terminal coupled to the drain of the second TFT (M2), and a second terminal to which said predetermined voltage is supplied.

2. An organic electroluminescent display (OELD) comprising
   a plurality of data lines (D_y) for transmitting data voltages for representing image signals;

a plurality of scan lines (S_z) for transmitting select signals; and
a plurality of organic electroluminescent display pixel circuits (10) according to claim 1, said pixel circuits being respectively formed on a plurality of pixels defined by the data lines (D_y) and the scan lines (S_z).

3. The device of claims 1 or 2, wherein the control signal is an additional external reset signal supplied to the control terminal of the second switch (S2).

4. The device of claim 1 or 2, wherein the control signal is a previous scan line select signal coupled to the control terminal of the second switch (S2).

5. The organic electroluminescent display of claims 2 and 4, wherein the data voltage is supplied to the data line before the select signal is supplied to the scan line.

6. The device of claims 1 or 2, wherein the first switch (S1) is a third TFT (M3) having a gate coupled to the scan line, a source or a drain coupled to the data line, and a drain or a source coupled to a source of the second TFT (M2), and the second switch (S2) is a fourth TFT (M4) having a gate for responding to the control signal, a source or a drain coupled to the gate of the first TFT (M1), and a drain or a source to which said predetermined voltage for a reset process is supplied.

7. The organic electroluminescent display of claims 2 and 6, wherein the predetermined voltage supplied to the drain of the fourth TFT (M4) is a ground voltage.

8. The organic electroluminescent display of claims 2 and 6, wherein the predetermined voltage supplied to the drain of the fourth TFT (M4) is a pre-charge voltage.

9. The organic electroluminescent display of claim 8, wherein the pre-charge voltage is set to be marginally less than the minimum data voltage supplied to the gate of the first TFT (M1) so as to represent the maximum gray level.

10. The device of claim 6, wherein the gate and the drain of the fourth TFT (M4) are coupled together.

11. The device of claim 6, wherein the first to fourth TFTs (M1, M2, M3, M4) have an identical conductive type.

12. The device of claim 6, wherein the first to third TFTs (M1, M2, M3) are first conductive type transistors, and the fourth TFT (M4) is a second conductive type transistor which has a polarity opposite to that of the first conductive type transistors.

13. The device of claims 6 wherein the first and second TFTs (M1, M2) are first conductive type transistors, and the third and fourth TFTs (M3, M4) are second conductive type transistors which have polarity opposite to that of the first conductive type transistors.

14. The device of claim 1 or 2, wherein the first and second TFTs (M1, M2) have almost identical threshold voltages.

15. The organic electroluminescent display of claims 2 and 3, wherein the first and second TFTs (M1, M2) are parallel to the data line or the scan line, and formed on the same line.

16. A method of driving an organic electroluminescent display pixel circuit according to claim 1, comprising the steps of:

initializing the voltage supplied to the gate of the first TFT (M1) in response to a control signal;
supplying a data voltage for representing image signals to the data lines (D_y);
sequentially supplying a select signal for selecting a pixel row to the scan lines (S_z);
switching the data voltage supplied to the data lines (D_y) in response to the select signal, and compensating the supplied data voltage to reduce a threshold voltage deviation of the first TFT (M1); and
transmitting the compensated data voltage to the gate of the first TFT (M1), and supplying the current to the organic EL element.

17. The method of claim 16, wherein the control signal is an additional external reset signal.

18. The method of claim 16, wherein the control signal is a select signal of a previous scan line.

19. The method of claim 18, wherein the data voltage is supplied to the data line before the select signal is supplied to the scan line.

Patentansprüche

1. Eine organische Elektrolumineszenzanzeige-Pixelschaltung (10), die auf einer Vielzahl von Pixeln gebildet ist, die durch eine Vielzahl von Datenleitungen (D_y) und Abtastleitungen (S_z) bestimmt sind, die folgendes umfasst:

ein organisches elektrolumineszierendes, EL, Element zum Emittieren von Licht entsprechend eines zugeführten Stroms;
einen ersten Dünnschichttransistor, TFT, (M1), mit einem Drain, der an das organische EL-Element gekoppelt ist;
einen zweiten TFT (M2) mit einem Gate, das mit einem Gate des ersten TFT (M1) gekoppelt ist, und wobei das Gate und ein Drain des zweiten TFT (M2) zusammen gekoppelt sind;
einen Kondensator (C1), der zwischen das Gate und eine Source des ersten TFT (M1) gekoppelt ist;
einen ersten Schalter (S1) mit einer Steueranschlussklemme, die an eine Abtastleitung gekoppelt ist,
worin der erste Schalter eine erste Anschlussklemme und eine zweite Anschlussklemme umfasst, die jeweils mit einer Datenleitung bzw. einer Source des zweiten TFT (M2) gekoppelt sind;
und worin die Pixelschaltung (10) einen zweiten Schalter (S2) umfasst zum Zurücksetzen des Gates des ersten TFT (M1) auf eine vorherbestimmte Spannung, der eine Steueranschlussklemme hat, welcher ein Steuersignal zugeführt wird, eine erste Anschlussklemme, die an das Drain des zweiten TFT (M2) gekoppelt ist, und eine zweite Anschlussklemme, welcher die vorherbestimmte Spannung zugeführt wird.

2. Eine organische Elektrolumineszenzanzeige (OELD), die folgendes umfasst:

eine Vielzahl von Datenleitungen (D_y) zum Übertragen von Datenspannungen zum Darstellen von Bildsignalen;
eine Vielzahl von Abtastleitungen (S_z) zum Übertragen von Auswahl-Signalen; und
eine Vielzahl von organischen Elektrolumineszenzanzeige-Pixelschaltungen (10) gemäß Anspruch 1, wobei die Pixelschaltungen jeweils auf einer Vielzahl von Pixeln gebildet sind, die durch die Datenleitungen (D_y) und die Abtastleitungen (S_z) bestimmt werden.

3. Die Vorrichtung von Anspruch 1 oder 2, worin das Steuersignal ein zusätzliches externes Rücksetzsignal ist, das der Steueranschlussklemme des zweiten Schalters (S2) zugeführt wird.

4. Die Vorrichtung von Anspruch 1 oder 2, worin das Steuersignal ein vorhergehendes Abtastleitung-Auswahl-Signal ist, das an die Steueranschlussklemme des zweiten Schalters (S2) gekoppelt ist.

5. Die organische Elektrolumineszenzanzeige von Anspruch 2 und 4, worin die Datenspannung der Datenleitung zugeführt wird, bevor das Auswahl-Signal der Abtastleitung zugeführt wird.

6. Die Vorrichtung von Anspruch 1 oder 2, worin der erste Schalter (S1) ein drittes TFT (M3) ist mit einem Gate, das an die Abtastleitung gekoppelt ist, einer Source oder einem Drain, die bzw. das an die Datenleitung gekoppelt ist, und einem Drain oder einer Source, das bzw. die an eine Source des zweiten TFT (M2) gekoppelt ist, und der zweite Schalter (S2) ein viertes TFT (M4) ist mit einem Gate zum Reagieren auf das Steuersignal, einer Source oder einem Drain, die bzw. das an das Gate des ersten TFT (M1) gekoppelt ist, und einem Drain oder einer Source, dem bzw. der eine vorherbestimmte Spannung für einen Rücksetzprozess zugeführt wird.

7. Die organische Elektrolumineszenzanzeige von Anspruch 2 und 6, worin die vorherbestimmte Spannung, die dem Drain des vierten TFT (M4) zugeführt wird, eine Erde-Spannung ist.

8. Die organische Elektrolumineszenzanzeige von Anspruch 2 und 6, worin die vorherbestimmte Spannung, die dem Drain des vierten TFT (M4) zugeführt wird, eine Vorladungsspannung ist.

9. Die organische Elektrolumineszenzanzeige von Anspruch 8, worin die Vorladungsspannung so eingestellt ist, dass sie geringfügig kleiner ist als die minimale Datenspannung, die dem Gate des ersten TFT (M1) zugeführt wird, damit die maximale Graustufe dargestellt wird.

10. Die Vorrichtung von Anspruch 6, worin das Gate und das Drain des vierten TFT (M4) zusammen gekoppelt sind.

11. Die Vorrichtung von Anspruch 6, worin der erste bis vierte TFT (M1, M2, M3, M4) einen identischen Leitungstyp haben.

12. Die Vorrichtung von Anspruch 6, worin der erste bis dritte TFT (M1, M2, M3) erste Leitungstyp-Transistoren sind und der vierte TFT (M4) ein zweiter Leitungstyp-Transistor ist, der eine Polarität hat, die entgegengesetzt zu der der Transistoren vom ersten Leitungstyp ist.

13. Die Vorrichtung von Anspruch 6, worin der erste und zweite TFT (M1, M2) erste Leitungstyp-Transistoren sind, und der dritte und vierte TFT (M3, M4) zweite Leitungstyp-Transistoren sind, welche eine Polarität haben, die entgegengesetzt zu der der Transistoren vom ersten Leitungstyp ist.

14. Die Vorrichtung von Anspruch 1 oder 2, worin der erste und zweite TFT (M1, M2) nahezu identische Schwellenspannungen haben.

15. Die organische Elektrolumineszenzanzeige von Anspruch 2 und 3, worin der erste und zweite TFT (M1, M2) parallel zu der Datenleitung oder der Abtastleitung sind und auf der gleichen Leitung gebildet sind.

16. Ein Verfahren zum Betreiben einer organischen Elektrolumineszenzanzeige-Pixelschaltung gemäß Anspruch 1, das die folgenden Schritte umfasst:

Initialisieren der Spannung, die dem Gate des ersten TFT (M1) als Reaktion auf ein Steuersignal zugeführt wird;
Zuführen einer Datenspannung zum Darstellen von Bildsignalen zu den Datenleitungen (D_y);
sequenziell Zuführen eines Auswahl-Signals zum Auswählen einer Pixelreihe zu den Abtastleitungen (S_z);
Schalten der Datenspannung, die den Datenleitungen (D_y) zugeführt wird, als Reaktion auf das Auswahl-Signal, und Kompensieren der zugeführten Datenspannung, um eine Schwellenspannungsabweichung des ersten TFT (M1) zu verringern; und
Übertragen der kompensierten Datenspannung an das Gate des ersten TFT (M1) und Zuführen des Stroms an das organische EL-Element.

17. Das Verfahren von Anspruch 16, worin das Steuersignal ein zusätzliches externes Rücksetzsignal ist.

18. Das Verfahren von Anspruch 16, worin das Steuersignal ein Auswahl-Signal einer vorhergehenden Abtastleitung ist.

19. Das Verfahren von Anspruch 18, worin die Datenspannung der Datenleitung zugeführt wird, bevor das Auswahl-Signal der Abtastleitung zugeführt wird.

Revendications

1. Circuit de pixels d'afficheur électro-luminescent organique (10) formé sur une pluralité de pixels définis par une pluralité de lignes de données (D_y) et de lignes de balayage (S_z), comprenant :

un élément électro-luminescent organique, EL, pour émettre une lumière correspondant à un courant délivré ;
un premier transistor à film mince, TFT, (M1) ayant un drain couplé à l'élément électro-luminescent organique ;
un deuxième transistor à film mince (M2) ayant une grille couplée à une grille du premier transistor à film mince (M1), et la grille et un drain du deuxième transistor à film mince (M2) étant couplés l'un à l'autre ;
un condensateur (C1) couplé entre la grille et la source du premier transistor à film mince (M1) ;
un premier commutateur (S1) comportant une borne de commande couplée à une ligne de balayage,
dans lequel ledit premier commutateur comprend une première borne et une deuxième borne respectivement couplées à une ligne de données et à une source du deuxième transistor à film mince (M2) ;
et ledit circuit de pixels (10) comprend un deuxième commutateur (S2) pour remettre à zéro ladite grille du premier transistor à film mince (M1) à une tension prédéterminée, celui-ci comportant une borne de commande à laquelle est délivré un signal de commande, une première borne couplée au drain du deuxième transistor à film mince (M2), et une deuxième borne à laquelle est délivrée ladite tension prédéterminée.

2. Afficheur électro-luminescent organique (OELD), comprenant :

une pluralité de lignes de données (D_y) pour transmettre des tensions de données pour représenter des signaux d'image ;

une pluralité de lignes de balayage (S_z) pour transmettre des signaux de sélection ; et
une pluralité de circuits de pixels d'afficheur électro-luminescent organique (10) selon la revendication 1, lesdits circuits de pixels étant respectivement formés sur une pluralité de pixels définis par les lignes de données (D_y) et les lignes de balayage (S_z).

3. Dispositif selon les revendications 1 ou 2, dans lequel le signal de commande est un signal de remise à zéro externe additionnel délivré à la borne de commande du deuxième commutateur (S2).

4. Dispositif selon les revendications 1 ou 2, dans lequel le signal de commande est un signal de sélection de ligne de balayage précédent couplé à la borne de commande du deuxième commutateur (S2).

5. Afficheur électro-luminescent organique selon les revendications 2 et 4, dans lequel la tension de données est délivrée à la ligne de données avant que le signal de sélection ne soit délivré à la ligne de balayage.

6. Dispositif selon les revendications 1 ou 2, dans lequel le premier commutateur (S1) est un troisième transistor à film mince (M3) comportant une grille couplée à la ligne de balayage, une source ou un drain couplé à la ligne de données, et un drain ou une source couplé à une source du deuxième transistor à film mince (M2), et le deuxième commutateur (S2) est un quatrième transistor à film mince (M4) comportant une grille pour répondre au signal de commande, une source ou un drain couplé à la grille du premier transistor à film mince (M1), et un drain ou une source auquel est délivrée ladite tension prédéterminée pour un processus de remise à zéro.

7. Afficheur électro-luminescent organique selon les revendications 2 et 6, dans lequel la tension prédéterminée délivrée au drain du quatrième transistor à film mince (M4) est une tension de masse.

8. Afficheur électro-luminescent organique selon les revendications 2 et 6, dans lequel la tension prédéterminée délivrée au drain du quatrième transistor à film mince (M4) est une tension de pré-charge.

9. Afficheur électro-luminescent organique selon la revendication 8, dans lequel la tension de pré-charge est établie de façon à être marginalement inférieure à la tension de données minimale délivrée à la grille du premier transistor à film mince (M1) de façon à représenter le niveau de gris maximal.

10. Dispositif selon la revendication 6, dans lequel la grille et le drain du quatrième transistor à film mince (M4) sont couplés l'un à l'autre.

11. Dispositif selon la revendication 6, dans lequel les premier à quatrième transistors à film mince (M1, M2, M3, M4) ont un type de conductivité identique.

12. Dispositif selon la revendication 6, dans lequel les premier à troisième transistors à film mince (M1, M2, M3) sont des transistors d'un premier type de conductivité, et le quatrième transistor à film mince (M4) est un transistor d'un deuxième type de conductivité qui a une polarité opposée à celle des transistors du premier type de conductivité.

13. Dispositif selon la revendication 6, dans lequel les premier et deuxième transistors à film mince (M1, M2) sont des transistors d'un premier type de conductivité, et les troisième et quatrième transistors à film mince (M3, M4) sont des transistors d'un deuxième type de conductivité qui ont une polarité opposée à celle des transistors du premier type de conductivité.

14. Dispositif selon la revendication 1 ou 2, dans lequel les premier et deuxième transistors à film mince (M1, M2) ont des tensions de seuil presque identiques.

15. Afficheur électro-luminescent organique selon les revendications 2 et 3, dans lequel les premier et deuxième transistors à film mince (M1, M2) sont parallèles à la ligne de données ou à la ligne de balayage, et sont formés sur la même ligne.

16. Procédé pour attaquer un circuit de pixels d'afficheur électro-luminescent organique selon la revendication 1, comprenant les étapes consistant à :

initialiser la tension délivrée à la grille du premier transistor à film mince (M1) en réponse à un signal de commande ;

délivrer une tension de données pour représenter des signaux d'image aux lignes de données (D_y) ;
délivrer en séquence un signal de sélection pour sélectionner une rangée de pixels aux lignes de balayage (S_z) ;
commuter la tension de données délivrée aux lignes de données (D_y) en réponse au signal de sélection, et compenser la tension de données délivrée de façon à réduire un écart de tension de seuil du premier transistor à film mince (M1) ; et
transmettre la tension de données compensée à la grille du premier transistor à film mince (M1), et délivrer le courant à l'élément électro-luminescent organique.

17. Procédé selon la revendication 16, dans lequel le signal de commande est un signal de remise à zéro externe additionnel.

18. Procédé selon la revendication 16, dans lequel le signal de commande est un signal de sélection d'une ligne de balayage précédente.

19. Procédé selon la revendication 18, dans lequel la tension de données est délivrée à la ligne de données avant que le signal de sélection ne soit délivré à la ligne de balayage.

FIG.1

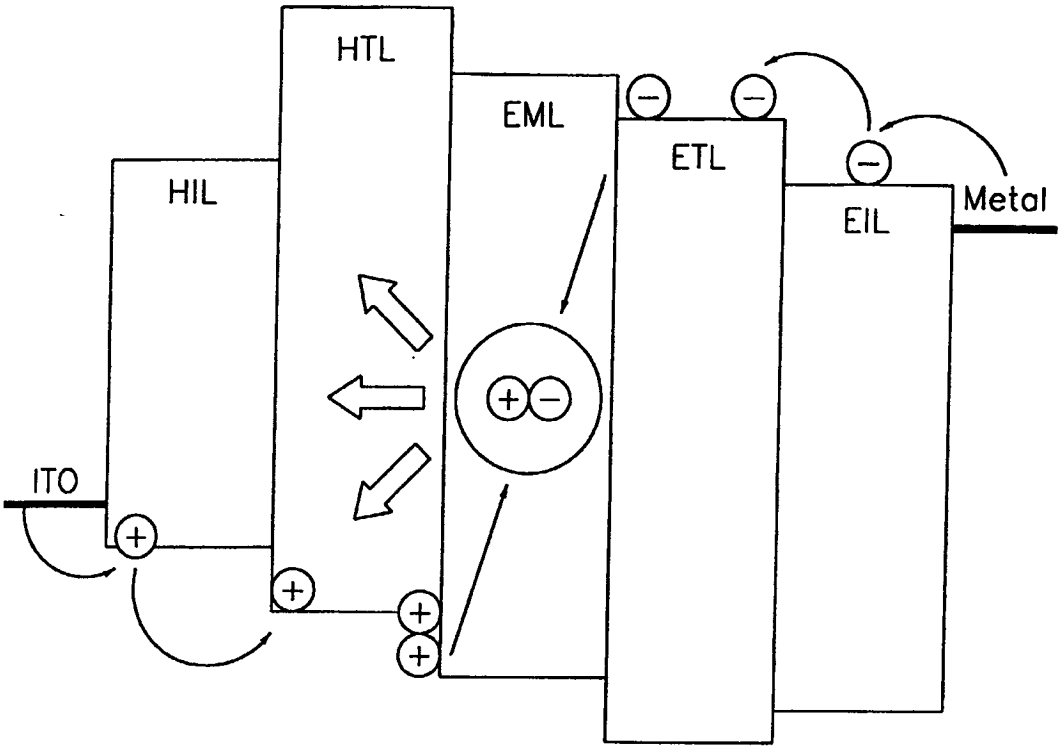


FIG.2(Prior Art)

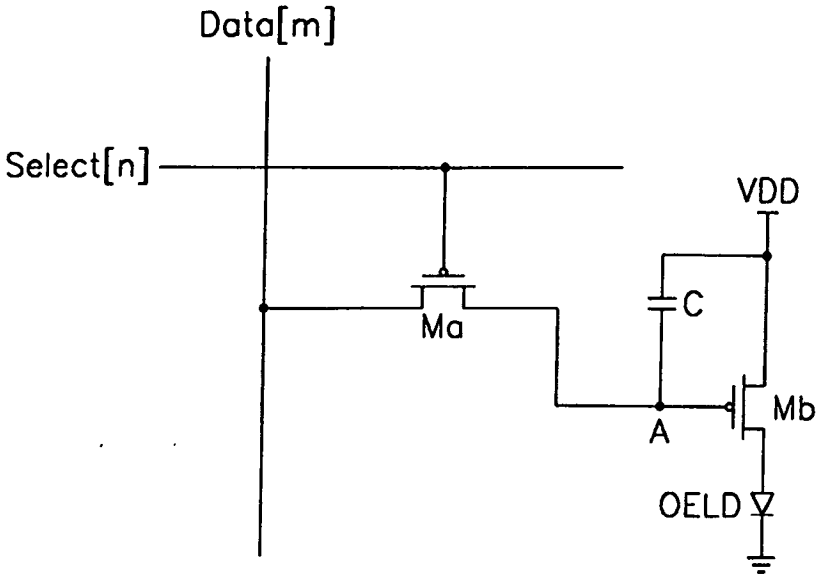


FIG.3

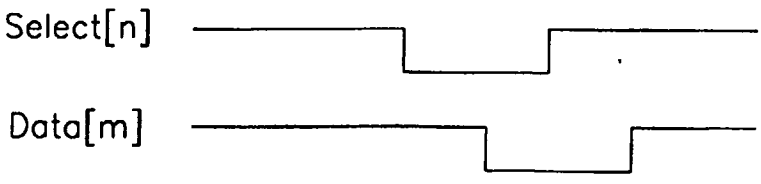


FIG.4

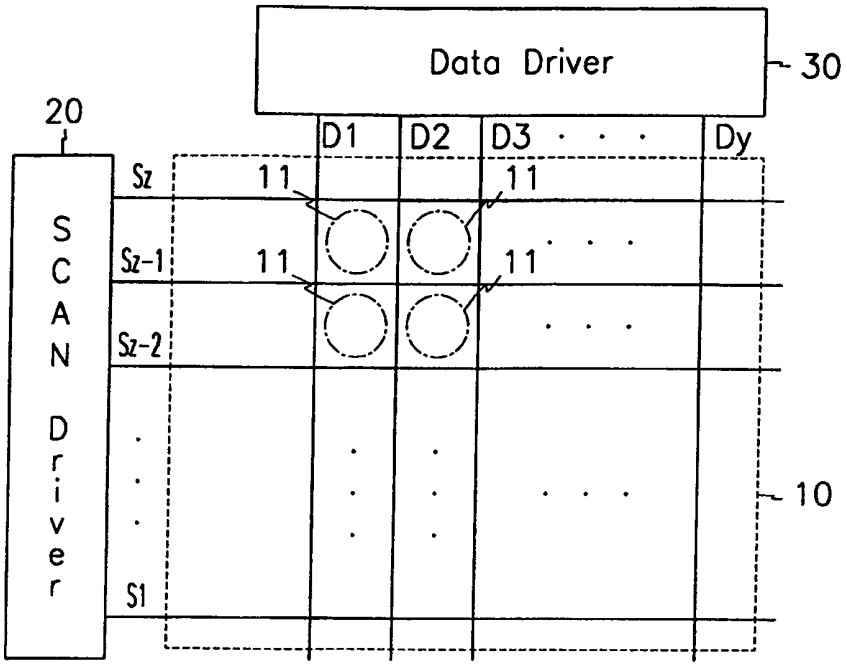

Data Driver
30
20
D1
D2
D3
Dy
Sz
Sz-1
Sz-2
S1
11
SCAN Driver
10

FIG.5

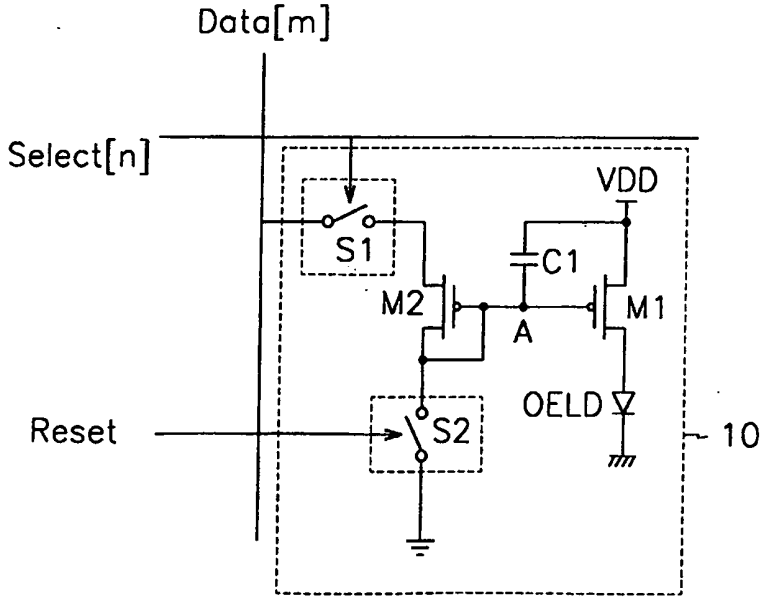

Data[m]
Select[n]
VDD
S1
C1
M2
M1
A
OELD
Reset
S2
10

FIG.6

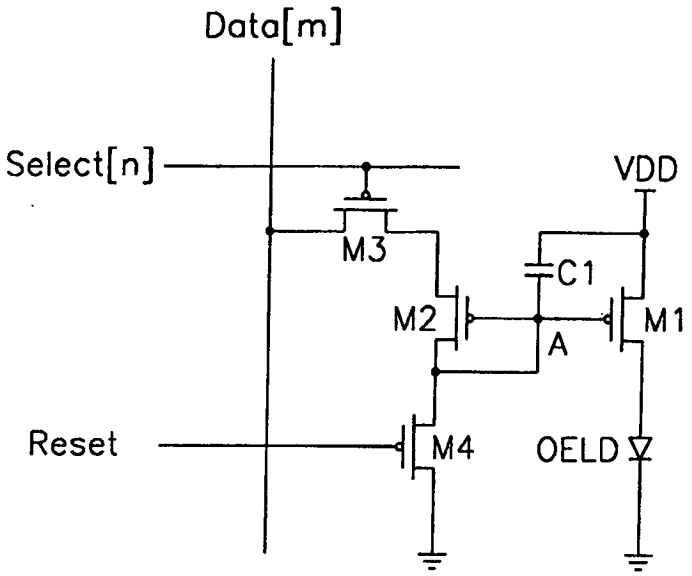


FIG.7

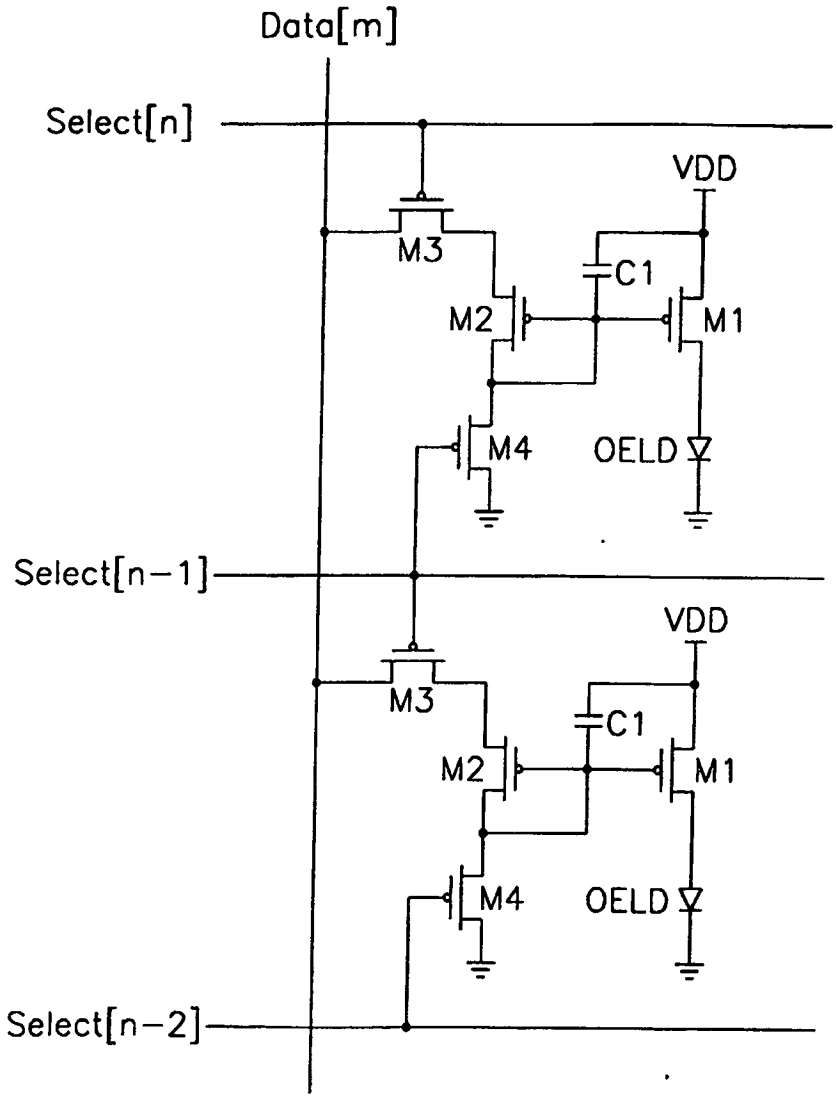

Data[m]
Select[n]
VDD
M3
C1
M2
M1
M4
OELD
Select[n-1]
VDD
M3
C1
M2
M1
M4
OELD
Select[n-2]

FIG.8A

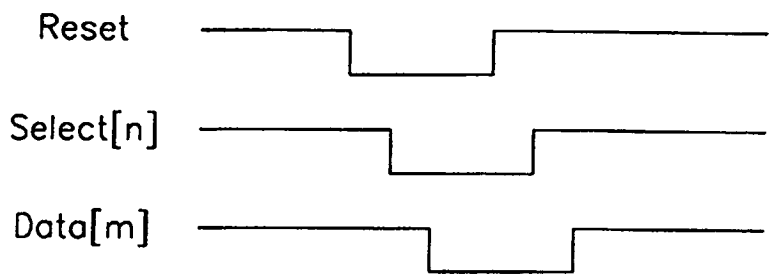


FIG.8B

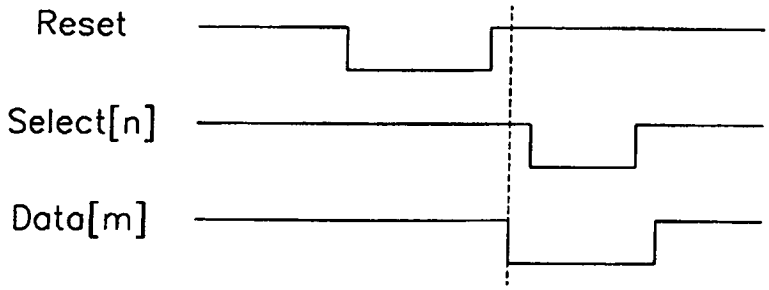


FIG.9

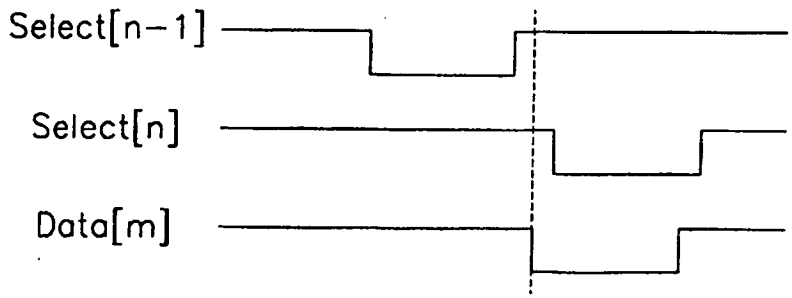


FIG.10

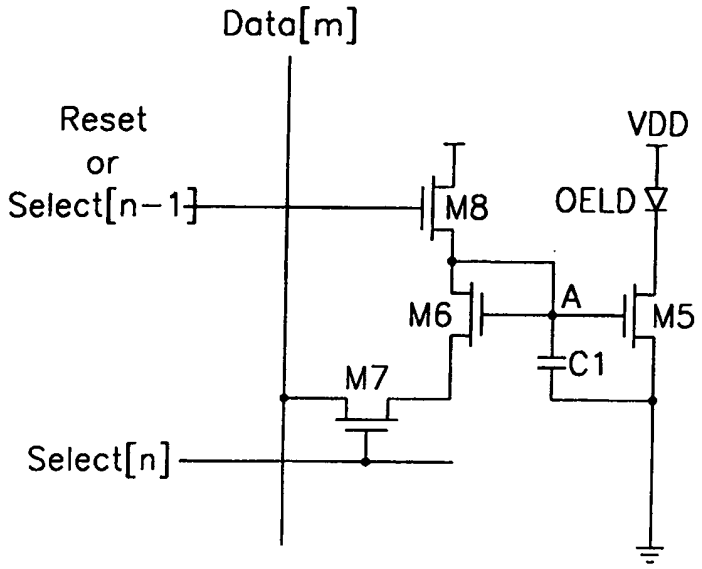


FIG.11A

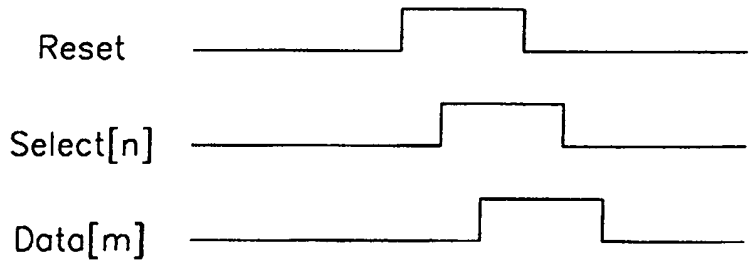


FIG.11B

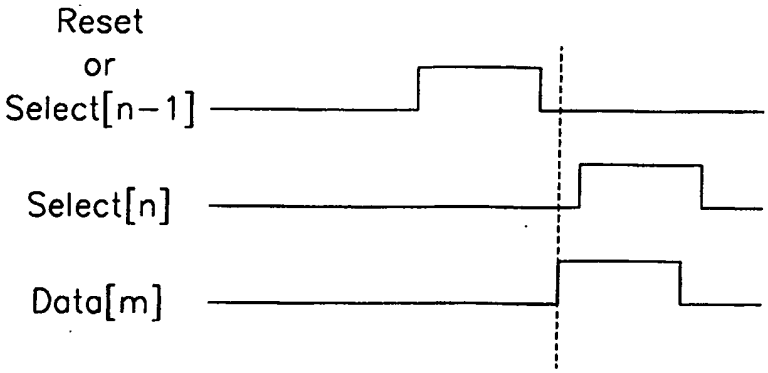


FIG.12

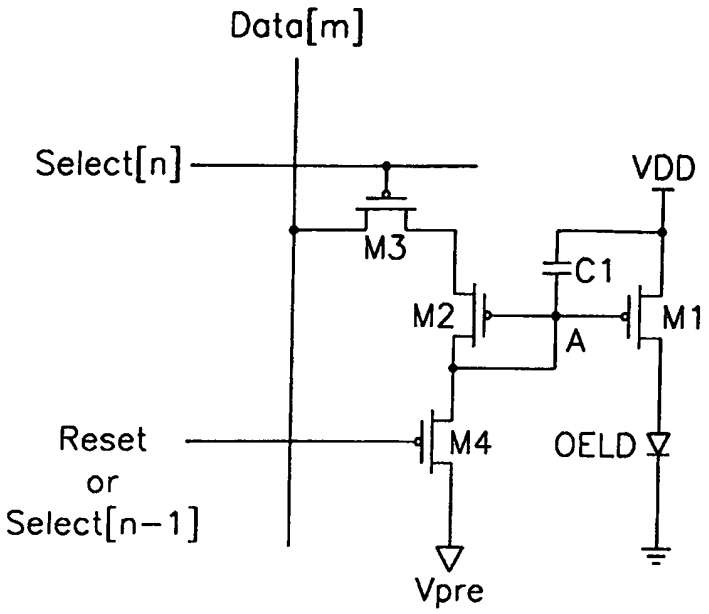

Data[m]
Select[n]
VDD
M3
C1
M2
M1
A
Reset
or
Select[n-1]
M4
OELD
Vpre

FIG.13

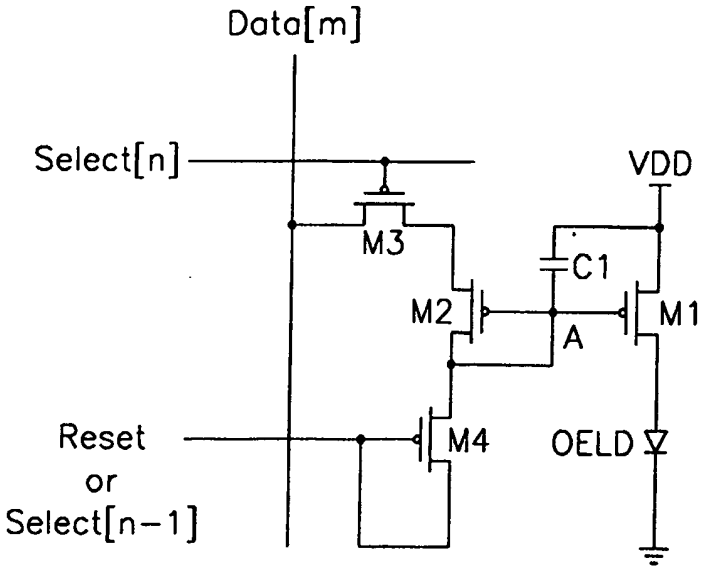

Data[m]
Select[n]
VDD
M3
C1
M2
M1
A
Reset
or
Select[n-1]
M4
OELD

FIG.14

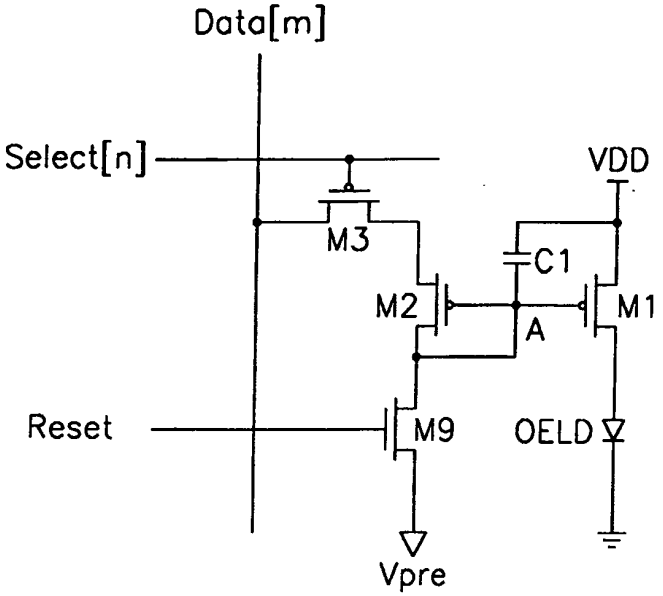

Data[m]
Select[n]
VDD
M3
C1
M2
M1
A
Reset
M9
OELD
Vpre

FIG.15

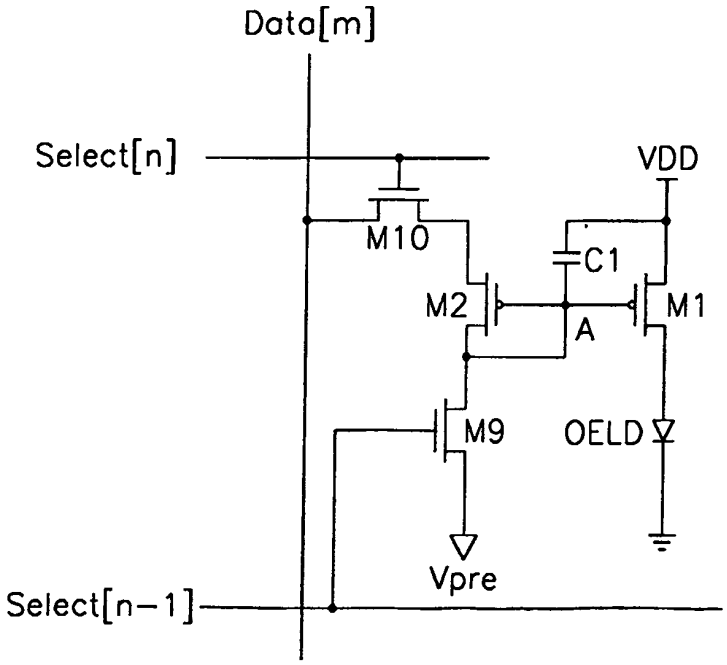

Data[m]
Select[n]
VDD
M10
C1
M2
M1
A
M9
OELD
Vpre
Select[n-1]

FIG.16

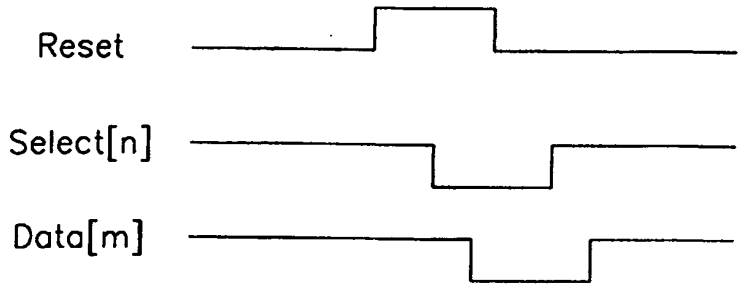


FIG.17

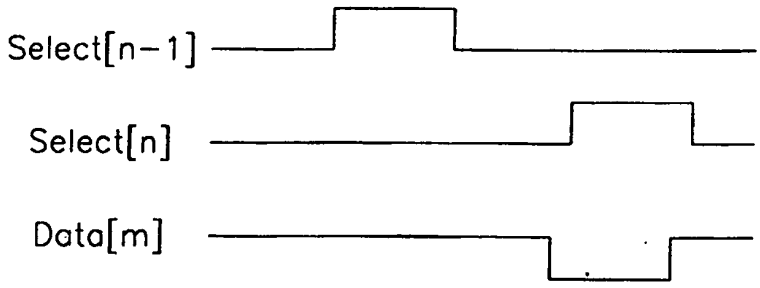


FIG.18

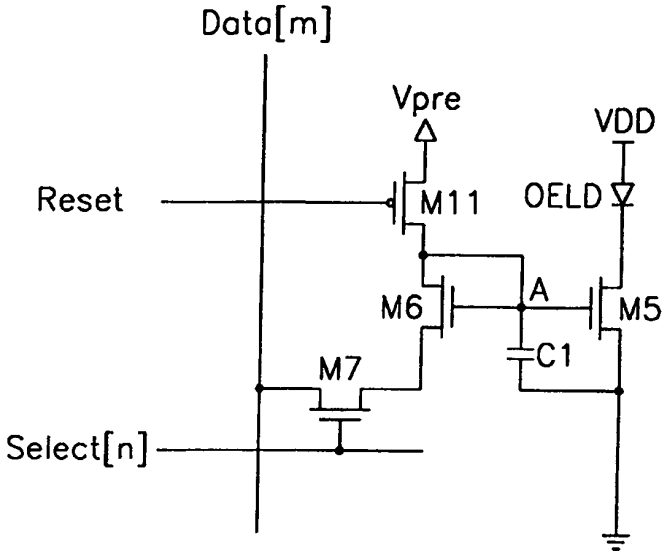

Data[m]
Vpre
VDD
Reset
M11
OELD
M6
A
M5
C1
M7
Select[n]

FIG.19

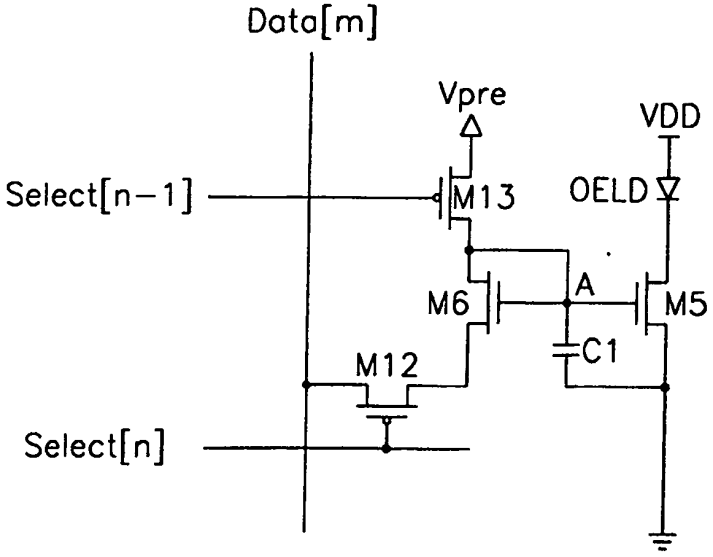

Data[m]
Vpre
VDD
Select[n-1]
M13
OELD
M6
A
M5
C1
M12
Select[n]

FIG.20

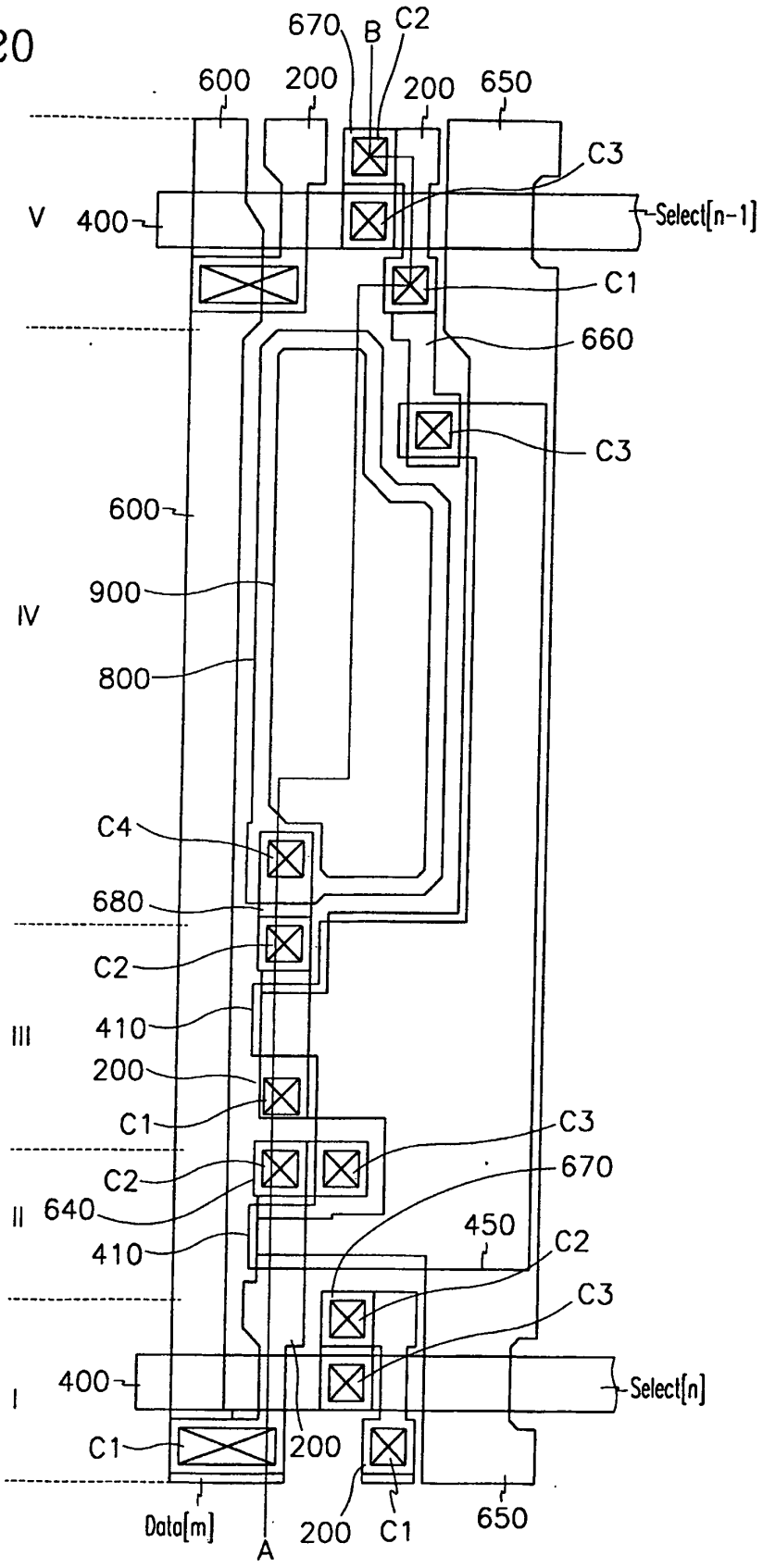
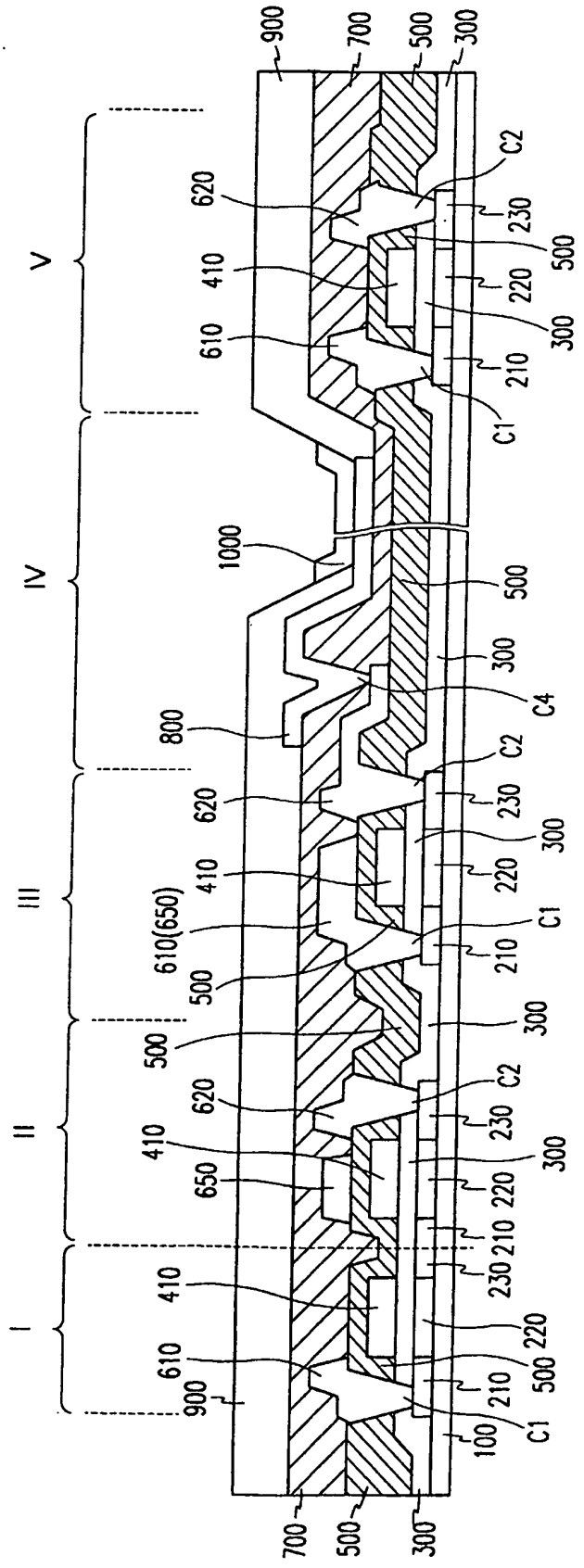

670
B
C2
600
200
200
650
C3
V
400
Select[n-1]
C1
660
C3
600
900
IV
800
C4
680
C2
III
410
200
C1
C3
C2
670
II
640
450
410
C2
C3
I
400
Select[n]
C1
200
Data[m]
A
200
C1
650

FIG.21


I
II
III
IV
V
900
700
500
300
620
410
610
1000
800
610(650)
650
C1
C2
C4
230
220
210
100

专利名称(译)	有机电致发光显示器，其驱动方法和像素电路		
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摘要(译)

公开了一种OELD和像素电路，包括：用于根据提供的电流发光的有机EL元件;第一开关，用于响应于提供给扫描线的选择信号，切换提供给数据线的数据电压;第一TFT，用于响应于经由第一开关提供给第一TFT的栅极的数据电压而向有机EL元件提供电流;第二TFT，具有耦合到第一TFT的栅极的栅极，并且补偿第一TFT的阈值电压的偏差;以及用于在预定时间期间维持提供给第一TFT的栅极的数据电压的电容器。

Equation 1

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