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(54) **PIXEL CIRCUIT AND DRIVE METHOD THEREFOR, AND ACTIVE MATRIX ORGANIC
LIGHT-EMITTING DISPLAY**

PIXELSCHALTUNG UND ANSTEUERUNGSVERFAHREN DAFÜR SOWIE ORGANISCHE
LICHEMITTIERENDE AKTIVMATRIXANZEIGE

CIRCUIT DE PIXEL, SON PROCÉDÉ DE PILOTAGE ET DISPOSITIF D’AFFICHAGE
ÉLECTROLUMINESCENT ORGANIQUE À MATRICE ACTIVE

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Description**TECHNICAL FIELD**

5 [0001] The present invention relates to the field of flat panel display devices and, in particular, to a pixel circuit and a method for driving it, as well as to an active matrix organic light-emitting diode (AMOLED) display device.

BACKGROUND

10 [0002] Organic light-emitting diode (OLED) display devices utilize OLEDs to display images. Such display devices are active devices which differ from traditional thin-film-transistor liquid-crystal display (TFT-LCD) devices in actively emitting light and not requiring backlight. They have many advantages such as high contrast, fast response and small thickness, and are praised as display devices of the next generation that will replace the TFT-LCD devices.

15 [0003] Depending on how they are driven, OLED display devices can be categorized into passive matrix organic light-emitting diode (PMOLED) devices and active matrix organic light-emitting diode (AMOLED) devices.

[0004] An AMOLED display device comprises scan lines, data lines and an array of pixels defined by the scan lines and data lines. Each of the pixels in the array includes an OLED and a pixel circuit that drives the OLED. Reference is now made to Fig. 1, which is a diagram showing a pixel circuit in an AMOLED display device of the prior art. As shown in Fig. 1, the conventional pixel circuit 10 generally includes a switch thin-film transistor T1, a drive thin-film transistor T2 and a capacitor Cs. The switch transistor T1 is connected to a scan line S(n). When the switch transistor T1 is turned on via the scan line S(n), a data voltage V_{data} provided by a data line is stored via the switch transistor T1 in the capacitor Cs, thereby causing the drive transistor T2 to produce a current which drives the OLED to emit light.

[0005] The brightness of the pixel is determined by the current flowing through the OLED, and the current is in turn under the control of the pixel circuit. In this conventional pixel circuit, the current flowing through the OLED is affected by a threshold voltage of the drive transistor and a power supply voltage VDD applied to the pixel circuit. Upon a change occurring in the threshold voltage of the drive transistor or in the power supply voltage VDD, the current flowing through the OLED may undergo a significant variation which can lead to the OLED emitting light with a different brightness level from those of other OLEDs in response to their corresponding data signals which, however, indicate the same brightness level. Therefore, it is difficult for this conventional AMOLED display device to display an image with uniform brightness.

30 [0006] Therefore, there is an urgent need in this art for a solution to address the problem of low brightness uniformity of conventional AMOLED display devices.

[0007] EP 2 261 884 A1 discloses a pixel. The pixel includes an organic light emitting diode (OLED) having a cathode electrode coupled to a second power source (ELVSS), a first transistor (M1) for controlling an amount of current that flows from a first power source (ELVDD) to the second power source (ELVSS) via the OLED corresponding to a data signal, a second transistor (M2) coupled between a data line and a gate electrode of the first transistor, a third transistor (M3) coupled between the gate electrode of the first transistor and a reference power source (Vref), a fourth transistor (M4) coupled between the third transistor and the reference power source, a fifth transistor (M5) coupled between an anode electrode of the OLED and an initial power source (Vinit), a first capacitor (C1) coupled between the anode electrode of the OLED and a node between the third transistor and the fourth transistor, and a second capacitor (C2) coupled between the node and the gate electrode of the first transistor.

SUMMARY OF THE INVENTION

45 [0008] It is an object of the present invention to overcome the problem of low brightness uniformity arising from the use of conventional AMOLED display devices by presenting a pixel circuit and a method for driving it, as well as an active matrix organic light-emitting diode (AMOLED) display device.

[0009] This object is attained by a pixel circuit including:

- 50 a first thin-film transistor, which is connected between a second node and an anode of an organic light-emitting diode (OLED) and has a gate connected to a first node;
- a second thin-film transistor, which is connected between the first node and a third node and has a gate connected to an emission control line;
- a third thin-film transistor, which is connected between the third node and a third power source and has a gate connected to an initialization control line;
- 55 a fourth thin-film transistor, which is connected between a first power source and the second node and has a gate connected to a scan line;
- a fifth thin-film transistor, which is connected between a data line and the first node and has a gate connected to

the scan line;

a sixth thin-film transistor, which is connected between the first power source and the second node and has a gate connected to the emission control line;

a seventh thin-film transistor, which is connected between the third power source and the anode of the OLED and has a gate connected to the initialization control line;

a first capacitor connected between the first node and the third node; and

a second capacitor connected between the third node and the second node; wherein a cathode of the organic light-emitting diode is connected to a second power source, and wherein the seven thin-film transistors are all p-type thin-film transistors.

[0010] Optionally,

the first power source and the second power source are provided to drive the OLED; and the third power source is configured to provide an initialization voltage.

[0011] Optionally, the initialization voltage may be a negative voltage.

[0012] Optionally, the current provided by the first thin-film transistor to the OLED may be determined by a data voltage provided by the data line and the initialization voltage provided by the third power source and be independent of the power supply voltages provided by the first power source and the second power source, as well as of a threshold voltage of the first thin-film transistor.

[0013] Optionally, the fourth thin-film transistor and the fifth thin-film transistor may be controlled via the scan line, wherein the third thin-film transistor and the seventh thin-film transistor are controlled via the initialization control line and the second thin-film transistor and the sixth thin-film transistor are controlled via the emission control line.

[0014] Accordingly, the present invention also provides a method for driving the pixel circuit, including: a scan period including a first period of time, a second period of time and a third period of time, wherein

in the first period of time, a scan signal provided by the scan line and a control signal provided by the initialization control line both shift from a high level to a low level and a control signal provided by the emission control line jumps from the low level to the high level, leading to the third thin-film transistor, the fourth thin-film transistor, the fifth thin-film transistor and the seventh thin-film transistor being turned on, the data voltage provided by the data line being supplied to the first node via the fifth thin-film transistor, and the third node and the anode of the OLED being initialized by the third power source;

in the second period of time, the control signal provided by the initialization control line is maintained at the low level, the control signal provided by the emission control line is maintained at the high level and the scan signal provided by the scan line shifts from the low level to the high level, leading to the fourth thin-film transistor and the fifth thin-film transistor being turned off, the writing of the data voltage being ended, and a sampling of the threshold voltage of the first thin-film transistor M1 being completed; and

in the third period of time, the scan signal provided by the scan line is maintained at the high level, the control signal provided by the initialization control line jumps from the low level to the high level and the control signal provided by the emission control line drops from the high level to the low level, leading to the third thin-film transistor and the seventh thin-film transistor being turned off, the second thin-film transistor and the sixth thin-film transistor being turned on, and the first thin-film transistor outputting a current which drives the OLED to emit light.

[0015] Optionally, in the first period of time, the first power source may be connected to the second node via the fourth thin-film transistor, wherein a voltage at the second node is equal to the voltage provided by the first power source.

[0016] Optionally, in the third period of time, the first capacitor may be shorted wherein a voltage difference between the gate and a source of the first thin-film transistor is equal to a voltage stored in the second capacitor.

[0017] Accordingly, the present invention also provides an active matrix organic light-emitting diode (AMOLED) display device including the pixel circuit as defined above.

[0018] In the pixel circuit and the method for driving it, as well as the AMOLED display device, by initializing the anode of the OLED through the seventh thin-film transistor, aging of the OLED is slowed and the service life thereof is extended. In addition, as the current output by the first thin-film transistor which serves as a drive element is determined by the data voltage provided by the data line and the initialization voltage provided by the third power source and is independent of the external power supply voltages and the threshold voltage of the first thin-film transistor, brightness non-uniformity that may arise from variations in thin-film transistor threshold voltages and power supply voltage changes can be overcome. Therefore, use of the pixel circuit and the method for driving it, as well as the AMOLED display device can result in not only service life extension but also an improvement in display quality.

BRIEF DESCRIPTION OF DRAWINGS

[0019]

Fig. 1 is a schematic diagram showing a pixel circuit in an AMOLED display device of the prior art.

Fig. 2 is a schematic illustration of a pixel circuit according to an embodiment of the present invention.

5 Fig. 3 is a timing diagram illustrating a method of driving a pixel circuit according to the present invention.

Fig. 4 schematically illustrates an AMOLED display device according to the present invention.

DETAILED DESCRIPTION

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[0020] Pixel circuits and methods for driving them, as well as active matrix organic light-emitting diode (AMOLED) display devices, according to the present invention, will be described below in greater detail with reference to specific embodiments and the accompanying drawings. The advantages and feature of the invention will become more apparent from the following description and the appended claims. It is noted that the drawings are presented in a very simplified form not precisely drawn to scale with the only purpose of facilitating the description of the embodiments of the invention.

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[0021] Reference is now made to Fig. 2, which shows a schematic illustration of a pixel circuit according to an embodiment of the present invention. As shown in Fig. 2, the pixel circuit 20 includes: a first thin-film transistor M1, which is connected between a second node N2 and an anode of an organic light-emitting diode OLED and has a gate connected to a first node N1; a second thin-film transistor M2, which is connected between the first node N1 and a third node N3 and has a gate connected to an emission control line EM_n ; a third thin-film transistor M3, which is connected between the third node N3 and a third power source and has a gate connected to an initialization control line Clk_n ; a fourth thin-film transistor M4, which is connected between a first power source and the second node N2 and has a gate connected to a scan line S_n ; a fifth thin-film transistor M5, which is connected between a data line D_m and the first node N1 and has a gate connected to the scan line S_n ; a sixth thin-film transistor M6, which is connected between the first power source and the second node N2 and has a gate connected to the emission control line EM_n ; a seventh thin-film transistor M7, which is connected between the third power source and the anode of the organic light-emitting diode OLED and has a gate connected to the initialization control line Clk_n ; a first capacitor C1 connected between the first node N1 and the third node N3; and a second capacitor C2 connected between the third node N3 and the second node N2.

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[0022] In particular, a cathode of the organic light-emitting diode OLED is connected to a second power source, and the pixel circuit 20 and the organic light-emitting diode OLED are provided with the first power source, the second power source and the third power source externally (e.g., from a power supply). The first power source and the second power source are provided to drive the organic light-emitting diode OLED, and serve to provide a first power supply voltage VDD and a second power supply voltage VSS, respectively. The third power source is configured to provide an initialization voltage V_{ref} . In general, the first power source has a high level, while the second power source and the third power source both have a low level. In this embodiment, the initialization voltage V_{ref} provided by the third power source is a negative voltage.

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[0023] As shown in Fig. 2, the pixel circuit 20 controls the fourth thin-film transistor M4 and the fifth thin-film transistor M5 via the scan line S_n , the third thin-film transistor M3 and the seventh thin-film transistor M7 via the initialization control line Clk_n , and the second thin-film transistor M2 and the sixth thin-film transistor M6 via the emission control line EM_n .

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[0024] Upon a scan signal provided by the scan line S_n transitioning to the low level, the fourth thin-film transistor M4 and the fifth thin-film transistor M5 are both turned on, leading to supply of a data voltage V_{data} provided by the data line D_m to the first node N1 via the fifth thin-film transistor M5 and application of the first power supply voltage VDD provided by the first power source to the second node N2 via the fourth thin-film transistor M4.

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[0025] When a control signal provided by the initialization control line Clk_n transitions to the low level, the third thin-film transistor M3 and the seventh thin-film transistor M7 are both turned on, leading to the initialization voltage V_{ref} provided by the third power source being supplied to the third node N3 and the anode of the organic light-emitting diode OLED via the third thin-film transistor M3 and the seventh thin-film transistor M7, respectively.

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[0026] When a control signal provided by the emission control line EM_n transitions to the low level, the second thin-film transistor M2 and the sixth thin-film transistor M6 are both turned on, causing the first thin-film transistor M1 to be turned on and provide a current which drives the organic light-emitting diode OLED to emit light having a brightness level corresponding to the magnitude of the current. This allows an image to be displayed.

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[0027] In this embodiment, the pixel circuit 20 is implemented as a 7T2C circuit including the seven thin-film transistors and the two capacitors, wherein the seven thin-film transistors are all p-type thin-film transistors, with the first thin-film transistor M1 serving as a drive transistor, the third thin-film transistor M3 and the seventh thin-film transistor M7 being controlled by the initialization control line Clk_n which is configured for initialization control, the fourth thin-film transistor M4 and the fifth thin-film transistor M5 being controlled by the scan line S_n which is configured for the control of writing of the data voltage V_{data} and sampling of the threshold voltage of the drive transistor, and the second thin-film transistor M2 and the sixth thin-film transistor M6 being controlled by the emission control line EM_n which is configuration for control

of light-emission of the organic light-emitting diode OLED.

[0028] The initialization voltage V_{ref} provided by the third power source is applied to the anode of the organic light-emitting diode OLED via the seventh thin-film transistor M7, allowing for the initialization of the anode of the organic light-emitting diode OLED and hence resulting in service life extension of the organic light-emitting diode OLED and the drive thin-film transistor M1.

[0029] In addition, the current of the organic light-emitting diode OLED provided by the first thin-film transistor M1 is determined by the data voltage V_{data} provided by the data line D_m and the initialization voltage V_{ref} provided by the third power source and is independent of the power supply voltages provided by the first power source and the second power source, as well as of the threshold voltage of the first thin-film transistor M1. Therefore, use of the pixel circuits 20 can avoid brightness non-uniformity caused by variations in threshold voltages of the thin-film transistors and changes in the power supply voltages and thus enable improved display quality of a display device in which the pixel circuits are used.

[0030] Accordingly, the present invention also provides a method for driving the pixel circuit, comprising:

a scan period including a first period of time t_1 , a second period of time t_2 and a third period of time t_3 , wherein:

in the first period of time t_1 , the scan signal provided by the scan line S_n and the control signal provided by the initialization control line Clk_n shift from the high level to the low level and the control signal provided by the emission control line EM_n jumps from the low level to the high level, leading to the third thin-film transistor M3, the fourth thin-film transistor M4, the fifth thin-film transistor M5 and the seventh thin-film transistor M7 being turned on, the data voltage V_{data} provided by the data line D_m being supplied to the first node N1 via the fifth thin-film transistor M5, and the third node N3 and the anode of the organic light-emitting diode OLED being initialized by the third power source;

in the second period of time t_2 , the control signal provided by the initialization control line Clk_n is maintained at the low level, the control signal provided by the emission control line EM_n is maintained at the high level and the scan signal provided by the scan line S_n shifts from the low level to the high level, leading to the fourth thin-film transistor M4 and the fifth thin-film transistor M5 being turned off, the writing of the data voltage V_{data} being ended, and the sampling of the threshold voltage of the first thin-film transistor M1 being completed; and

in the third period of time t_3 , the scan signal provided by the scan line S_n is maintained at the high level, the control signal provided by the initialization control line Clk_n jumps from the low level to the high level and the control signal provided by the emission control line EM_n drops from the high level to the low level, leading to the third thin-film transistor M3 and the seventh thin-film transistor M7 being turned off, the second thin-film transistor M2 and the sixth thin-film transistor M6 being turned on, and the first thin-film transistor M1 outputting a current which drives the OLED to emit light.

[0031] Specifically, in the first period of time t_1 , following the fifth thin-film transistor M5 being turned on, the data voltage V_{data} provided by the data line D_m is written to the first node N1 via the fifth thin-film transistor M5, so that a voltage V_{N1} at the first node N1 is equal to V_{data} . After the fourth thin-film transistor M4 is turned on, the first power source is connected to the second node N2 via the fourth thin-film transistor M4, so that a voltage V_{N2} at the second node N2 is equal to VDD. In this process, the third power source provides the initialization voltage V_{ref} to the anode of the organic light-emitting diode OLED via the seventh thin-film transistor M7, and thereby initializing the anode of the organic light-emitting diode OLED. This slows the aging of the organic light-emitting diode OLED and extends its service life. In addition, the third power source also provides the initialization voltage V_{ref} to the third node N3 via the third thin-film transistor M3, thereby initializing the third node N3. With the initialization being completed, a voltage at the anode of the organic light-emitting diode OLED and a voltage V_{N3} at the third node N3 are both equal to V_{ref} .

[0032] In the second period of time t_2 , following the fifth thin-film transistor being turned off, the writing of the data voltage V_{data} provided by the data line D_m to the first node N1 is terminated, so that the voltage V_{N1} at the first node N1 is equal to the data voltage V_{data} . As the fourth thin-film transistor M4 is turned off, the voltage V_{N2} at the second node N2 is pulled down to $V_{data} + |V_{th}|$, while the voltage V_{N3} at the third node N3 remains equal to V_{ref} . As the second capacitor C2 is connected between the third node N3 and the second node N2, a voltage stored in the second capacitor C2 is equal to $V_{data} + |V_{th}| - V_{ref}$, where V_{th} represents the threshold voltage of the first thin-film transistor M1. In this way, the threshold voltage of the first thin-film transistor M1 is stored in the second capacitor C2, completing the sampling of the threshold voltage of the first thin-film transistor M1.

[0033] In the third period of time t_3 , following the seventh thin-film transistor M7 being turned off, the third power source can no longer provide the initialization voltage V_{ref} to the anode of the organic light-emitting diode OLED via the seventh thin-film transistor M7, and the initialization of the anode of the organic light-emitting diode OLED is therefore terminated. At the same time, as the second thin-film transistor M2 is turned on, the first capacitor C1 is shorted. As a result, a gate-source voltage V_{sg1} of the first thin-film transistor M1, i.e., a voltage difference between the gate and source of the first

thin-film transistor M1, equals the voltage stored in the second capacitor C2. We can thus obtain the gate-source voltage V_{sg1} of the first thin-film transistor M1 as:

$$V_{sg1} = V_{data} + |V_{th}| - V_{ref} \quad \text{Eqn. 1.}$$

[0034] In this process, as the sixth thin-film transistor M6 is turned on, the first power supply voltage VDD provided by the first power source is transmitted to the first thin-film transistor M1 via the sixth thin-film transistor M6, leading to the first thin-film transistor M1 being turned on. As a result, a current follows a path leading from the first power source and passing through the sixth thin-film transistor M6, the first thin-film transistor M1 and the organic light-emitting diode OLED to reach the second power source, making the organic light-emitting diode OLED emit light. That is, in the third period of time t_3 , the pixels emit light to display an image.

[0035] The current I_{on} flowing through the organic light-emitting diode OLED is calculated as:

$$I_{on} = K \times (V_{sg1} - |V_{th}|)^2 \quad \text{Eqn. 2,}$$

wherein, K is the product of the electron mobility, aspect ratio and capacitance per unit area of the thin-film transistor.

[0036] From Eqns. 1 and 2, we can obtain:

$$I_{on} = K \times (V_{data} - V_{ref})^2 \quad \text{Eqn. 3.}$$

[0037] As indicated by Eqn. 3, the current flowing through the organic lighting emitting diode OLED is independent of the power supply voltages and the threshold voltage of the first thin-film transistor M1, and is related only to the data voltage V_{data} , the initialization voltage V_{ref} and the constant K. Therefore, even if there were changes in the power supply voltages or in the threshold voltages of the first thin-film transistors M1, the currents I_{on} in the organic lighting emitting diodes OLED would not be affected at all. Thus, the problem of non-uniform brightness arising from threshold voltage variations and power wiring impedances can be overcome by use of the pixel circuit 20 and the method for driving it. At the same time, the services lives of the organic lighting emitting diodes OLED and the first thin-film transistors M1 that serve as drive transistors can also be extended.

[0038] Accordingly, the present invention also provides an active matrix organic light-emitting diode (AMOLED) display device. As shown in Fig. 4, the AMOLED display device comprises: display unit 100, a scan driver 200 and a data driver 300. The display unit 100 includes a plurality of pixels 110 which are disposed at intersections between scan lines S_1 - S_n and data lines D_1 - D_m in a matrix. Each of the plurality of pixels 110 is connected to a corresponding one of the scan lines and a corresponding one of the data lines and comprises a pixel circuit 20 as defined above.

[0039] Specifically, the display unit 100 is provided with the first power source VDD and the second power source VSS externally (e.g., from a power supply). The first power source VDD and the second power source VSS serve as a high level voltage source and a low level voltage source, respectively, and are configured to drive the pixels 110.

[0040] As shown in Fig. 4, the display unit 100 includes the plurality of pixels 110 which are arranged in an $m \times n$ matrix, wherein m is a number of columns of the pixel 110, n is a number of rows thereof, $m \geq 1$ and $n \geq 1$. Each of the pixels 110 is connected to a corresponding one of the scan lines and a corresponding one of the data lines (each of the scan lines is connected to a correspondingly numbered one of the rows of the pixels 110, and each of the data lines is connected to a correspondingly numbered one of the columns of the pixels 110). For example, a pixel 110 in the i-th row and j-th column is connected to an i-th scan line S_i and a j-th data line D_j .

[0041] Each of the scan lines is connected to the scan driver 200 which is configured to generate scan control signals in response to external scan control signals (e.g., from timing control units). The scan control signals generated by the scan driver 200 are sequentially provided to the pixels 110 via the respective scan lines S_1 - S_n . Each of the data lines is connected to the data driver 300 which is configured to produce data signals in response to external data and data control signals (e.g., from timing control units). The data signals produced by the data driver 300 are provided to the pixels 110 via the data lines D_1 - D_m concurrently with the scan signals.

[0042] With combined reference to Figs. 3 and 4, in the first period of time t_1 , each pixel 110 is initialized and receives a data signal provided by the corresponding data line. In the second period of time t_2 , writing of the data signal is terminated, and the threshold voltage of the drive transistor is sampled. In the third period of time t_3 , the pixel 110 emits light with a brightness level corresponding to the data signal to enable the display of an image.

[0043] As the pixel 110 incorporates pixel circuits 20 as defined above which allows the threshold voltage compensation and avoidance of an impact of the first power supply voltage VDD on brightness, possible changes in the power supply

voltages or in the threshold voltages of the first thin-film transistors M1 will not affect the currents I_{on} flowing through the organic light-emitting diodes OLED, and improved brightness uniformity of the AMOLED display device can be obtained.

[0044] In summary, in the pixel circuits and the methods for driving them, as well as the AMOLED display devices, according to the present invention, by initializing the anode of the OLED through the seventh thin-film transistor, aging of the OLED is slowed and the service life thereof is extended. In addition, as the current output by the first thin-film transistor which serves as a drive element is determined by the data voltage provided by the data line and the initializing voltage provided by the third power source and is independent of the external power supply voltages and the threshold voltage of the first thin-film transistor, brightness non-uniformity that may arise from variations in thin-film transistor threshold voltages and power supply voltage changes can be overcome. Therefore, use of the pixel circuits and the methods for driving them, as well as the AMOLED display devices, according to the present invention can result in not only service life extension but also an improvement in display quality.

[0045] The foregoing description is merely preferred embodiments of the present invention and does not limit the scope of the invention in any way. All changes and modifications made in light of the foregoing disclosure by those of ordinary skill in the art fall within the scope of the appended claims.

Claims

1. A pixel circuit (20), comprising:

a first thin-film transistor (M1), which is connected between a second node (N2) and an anode of an organic light-emitting diode (OLED) and has a gate connected to a first node (N1);
 a second thin-film transistor (M2), which is connected between the first node (N1) and a third node (N3) and has a gate connected to an emission control line (EM_n);
 a third thin-film transistor (M3), which is connected between the third node (N3) and a third power source (V_{ref}) and has a gate connected to an initialization control line (Clk_n);
 a fourth thin-film transistor (M4), which is connected between a first power source (VDD) and the second node (N2) and has a gate connected to a scan line (S_n);
 a fifth thin-film transistor (M5), which is connected between a data line (D_m) and the first node (N1) and has a gate connected to the scan line (S_n);
 a sixth thin-film transistor (M6), which is connected between the first power source (VDD) and the second node (N2) and has a gate connected to the emission control line (EM_n);
 a seventh thin-film transistor (M7), which is connected between the third power source (V_{ref}) and the anode of the organic light-emitting diode (OLED) and has a gate connected to the initialization control line (Clk_n);
 a first capacitor (C1) connected between the first node (N1) and the third node (N3); and
 a second capacitor (C2) connected between the third node (N3) and the second node (N2);

wherein a cathode of the organic light-emitting diode (OLED) is connected to a second power source (VSS); and wherein

the seven thin-film transistors are all p-type thin-film transistors.

2. The pixel circuit (20) of claim 1, wherein the

first power source (VDD) and the second power source (VSS) are provided to drive the organic light-emitting diode (OLED); and the third power source (V_{ref}) is configured to provide an initialization voltage.

3. The pixel circuit (20) of claim 2, wherein the initialization voltage is a negative voltage.

4. The pixel circuit (20) of claim 1, wherein a current provided by the first thin-film transistor (M1) to the organic light-emitting diode (OLED) is determined by a data voltage provided by the data line (D_m) and an initialization voltage provided by the third power source (V_{ref}) and is independent of power supply voltages provided by the first power source (VDD) and the second power source (VSS), as well as of a threshold voltage of the first thin-film transistor (M1).

5. The pixel circuit (20) of claim 1, wherein the fourth thin-film transistor (M4) and the fifth thin-film transistor (M5) are controlled via the scan line (S_n); the third thin-film transistor (M3) and the seventh thin-film transistor (M7) are controlled via the initialization control line (Clk_n); and the second thin-film transistor (M2) and the sixth thin-film transistor (M6) are controlled via the emission control line (EM_n).

6. A method for driving a pixel circuit (20) as defined in any one of claims 1 to 5, in which a scan period includes a first period of time (t1), a second period of time (t2) and a third period of time (t3), wherein

in the first period of time (t1), a scan signal provided by the scan line (S_n) and a control signal provided by the initialization control line (Clk_n) both shift from a high level to a low level and a control signal provided by the emission control line (EM_n) jumps from the low level to the high level, leading to the third thin-film transistor (M3), the fourth thin-film transistor (M4), the fifth thin-film transistor (M5) and the seventh thin-film transistor (M7) being turned on, a data voltage provided by the data line (D_m) being supplied to the first node (N1) via the fifth thin-film transistor (M5), and the third node (N3) and the anode of the organic light-emitting diode (OLED) being initialized by the third power source (V_{ref});

in the second period of time (t2), the control signal provided by the initialization control line (Clk_n) is maintained at the low level, the control signal provided by the emission control line (EM_n) is maintained at the high level and the scan signal provided by the scan line (S_n) shifts from the low level to the high level, leading to the fourth thin-film transistor (M4) and the fifth thin-film transistor (M5) being turned off, a writing of the data voltage being ended, and a sampling of a threshold voltage of the first thin-film transistor (M1) being completed; and

in the third period of time (t3), the scan signal provided by the scan line (S_n) is maintained at the high level, the control signal provided by the initialization control line (Clk_n) jumps from the low level to the high level and the control signal provided by the emission control line (EM_n) drops from the high level to the low level, leading to the third thin-film transistor (M3) and the seventh thin-film transistor (M7) being turned off, the second thin-film transistor (M2) and the sixth thin-film transistor (M6) being turned on, and the first thin-film transistor (M1) outputting a current which drives the organic light-emitting diode (OLED) to emit light.

7. The method of claim 6, wherein in the first period of time (t1), the first power source (VDD) is connected to the second node (N2) via the fourth thin-film transistor (M4), and a voltage at the second node (N2) is equal to the voltage provided by the first power source (VDD).

8. The method of claim 6, wherein in the third period of time (t3), the first capacitor (C1) is shorted and a voltage difference between the gate and a source of the first thin-film transistor (M1) is equal to a voltage stored in the second capacitor (C2).

9. An active matrix organic light-emitting diode (AMOLED) display device, comprising a pixel circuit (20) as defined in any one of claims 1 to 5.

Patentansprüche

1. Pixelschaltung (20) umfassend:

einen ersten Dünnschichttransistor (M1), welcher zwischen einem zweiten Knoten (N2) und einer Anode einer organischen Licht emittierenden Diode (OLED) verbunden ist und ein Gate aufweist, welches mit einem ersten Knoten (N1) verbunden ist;

einen zweiten Dünnschichttransistor (M2), welcher zwischen dem ersten Knoten (N1) und einem dritten Knoten (N3) verbunden ist und ein Gate aufweist, welches mit einer Emissionssteuerleitung (EM_n) verbunden ist;

einen dritten Dünnschichttransistor (M3), welcher zwischen dem dritten Knoten (N3) und einer dritten Spannungsquelle (V_{ref}) verbunden ist und ein Gate aufweist, welches mit einer Initialisierungssteuerleitung (Clk_n) verbunden ist;

einen vierten Dünnschichttransistor (M4), welcher zwischen einer ersten Spannungsquelle (VDD) und dem zweiten Knoten (N2) verbunden ist und ein Gate aufweist, welches mit einer Abtastleitung (S_n) verbunden ist;

einen fünften Dünnschichttransistor (M5), welcher zwischen einer Datenleitung (D_m) und dem ersten Knoten (N1) verbunden ist und ein Gate aufweist, welches mit der Abtastleitung (S_n) verbunden ist;

einen sechsten Dünnschichttransistor (M6), welcher zwischen der ersten Spannungsquelle (VDD) und dem zweiten Knoten (N2) verbunden ist und ein Gate aufweist, welches mit der Emissionssteuerleitung (EM_n) verbunden ist;

einen siebten Dünnschichttransistor (M7), welcher zwischen der dritten Spannungsquelle (V_{ref}) und der Anode der organischen Licht emittierenden Diode (OLED) verbunden ist und ein Gate aufweist, welches mit der Initialisierungssteuerleitung (Clk_n) verbunden ist;

eine erste Kapazität (C1), welche zwischen dem ersten Knoten (N1) und dem dritten Knoten (N3) verbunden ist; und

eine zweite Kapazität (C2), welche zwischen dem dritten Knoten (N3) und dem zweiten Knoten (N2) verbunden ist;

wobei eine Katode der organischen Licht emittierenden Diode (OLED) mit einer zweiten Spannungsquelle (VSS) verbunden ist; und wobei

die sieben Dünnschichttransistoren alle Dünnschichttransistoren vom p-Typ sind.

2. Pixelschaltung (20) nach Anspruch 1, wobei die erste Spannungsquelle (VDD) und die zweite Spannungsquelle (VSS) vorhanden sind, um die organische Licht emittierende Diode (OLED) zu betreiben; und wobei die dritte Spannungsquelle (V_{ref}) konfiguriert ist, um eine Initialisierungsspannung bereitzustellen.
3. Pixelschaltung (20) nach Anspruch 2, wobei die Initialisierungsspannung eine negative Spannung ist.
4. Pixelschaltung (20) nach Anspruch 1, wobei ein Strom, welcher durch den ersten Dünnschichttransistor (M1) der organischen Licht emittierenden Diode (OLED) bereitgestellt wird, durch eine Datenspannung, welche durch die Datenleitung (D_m) bereitgestellt wird, und eine Initialisierungsspannung, welche durch die dritte Spannungsquelle (V_{ref}) bereitgestellt wird, bestimmt wird und unabhängig von Versorgungsspannungen, welche durch die erste Spannungsquelle (VDD) und die zweite Spannungsquelle (VSS) bereitgestellt werden, wie auch von einer Schwellenspannung des ersten Dünnschichttransistors (M1) ist.
5. Pixelschaltung (20) nach Anspruch 1, wobei der vierte Dünnschichttransistor (M4) und der fünfte Dünnschichttransistor (M5) mittels der Abtastleitung (S_n) gesteuert werden; wobei der dritte Dünnschichttransistor (M3) und der siebte Dünnschichttransistor (M7) mittels der Initialisierungssteuerleitung (Clk_n) gesteuert werden; und wobei der zweite Dünnschichttransistor (M2) und der sechste Dünnschichttransistor (M6) mittels der Emissionssteuerleitung (EM_n) gesteuert werden.
6. Verfahren zum Betreiben einer Pixelschaltung (20) nach einem der Ansprüche 1 bis 5, wobei eine Abtastperiode eine erste Zeitperiode (t_1), eine zweite Zeitperiode (t_2) und eine dritte Zeitperiode (t_3) aufweist, wobei sich in der ersten Zeitperiode (t_1) ein Abtastsignal, welches durch die Abtastleitung (S_n) bereitgestellt wird, und ein Steuersignal, welches durch die Initialisierungssteuerleitung (Clk_n) bereitgestellt wird, beide von einem hohen Niveau zu einem niedrigen Niveau verschieben und ein Steuersignal, welches durch die Emissionssteuerleitung (EM_n) bereitgestellt wird, von dem niedrigen Niveau auf das hohe Niveau springt, was dazu führt, dass der dritte Dünnschichttransistor (M3), der vierte Dünnschichttransistor (M4), der fünfte Dünnschichttransistor (M5) und der siebte Dünnschichttransistor (M7) eingeschaltet werden, eine Datenspannung, welche durch die Datenleitung (D_m) bereitgestellt wird, dem ersten Knoten (N1) mittels des fünften Dünnschichttransistors (M5) zugeführt wird und der dritte Knoten (N3) und die Anode der organischen Licht emittierenden Diode (OLED) durch die dritte Spannungsquelle (V_{ref}) initialisiert werden; wobei in der zweiten Zeitperiode (t_2) das Steuersignal, welches durch die Initialisierungssteuerleitung (Clk_n) bereitgestellt wird, auf dem niedrigen Niveau gehalten wird, das Steuersignal, welches durch die Emissionssteuerleitung (EM_n) bereitgestellt wird, auf dem hohen Niveau gehalten wird und sich das Abtastsignal, welches durch die Abtastleitung (S_n) bereitgestellt wird, von dem niedrigen Niveau zu dem hohen Niveau verschiebt, was dazu führt, dass der vierte Dünnschichttransistor (M4) und der fünfte Dünnschichttransistor (M5) abgeschaltet werden, ein Schreiben der Datenspannung beendet wird und ein Abtasten einer Schwellenspannung des ersten Dünnschichttransistors (M1) abgeschlossen wird; und wobei in der dritten Zeitperiode (T_3) das Abtastsignal, welches durch die Abtastleitung (S_n) bereitgestellt wird, auf dem hohen Niveau gehalten wird, das Steuersignal, welches durch die Initialisierungssteuerleitung (Clk_n) bereitgestellt wird, von dem niedrigen Niveau auf das hohe Niveau springt und das Steuersignal, welches durch die Emissionssteuerleitung (EM_n) bereitgestellt wird, von dem hohen Niveau auf das niedrige Niveau fällt, was dazu führt, dass der dritte Dünnschichttransistor (M3) und der siebte Dünnschichttransistor (M7) abgeschaltet werden, der zweite Dünnschichttransistor (M2) und der sechste Dünnschichttransistor (M6) eingeschaltet werden und der erste Dünnschichttransistor (M1) einen Strom ausgibt, welcher die organische Licht emittierende Diode (OLED) betreibt, um Licht zu emittieren.
7. Verfahren nach Anspruch 6, wobei in der ersten Zeitperiode (t_1) die erste Spannungsquelle (VDD) mit dem zweiten Knoten (N2) mittels des vierten Dünnschichttransistors (M4) verbunden ist, und wobei eine Spannung an dem zweiten Knoten (N2) gleich der Spannung ist, welche durch die erste Spannungsquelle (VDD) bereitgestellt wird.

8. Verfahren nach Anspruch 6, wobei in der dritten Zeitperiode (t_3) die erste Kapazität (C1) kurzgeschlossen wird und eine Spannungsdifferenz zwischen dem Gate und einer Source des ersten Dünnschichttransistors (M1) gleich einer Spannung ist, welche in der zweiten Kapazität (C2) gespeichert ist.

9. Aktivmatrix-OLED- (AMOLED-) Anzeigegerät, welches eine Pixelschaltung nach einem der Ansprüche 1 bis 5 umfasst.

Revendications

1. Circuit de pixels (20) comprenant :

un premier transistor à couches minces (M1), qui est connecté entre un deuxième noeud (N2) et une anode d'une diode électroluminescente organique (OLED) et qui a une grille connectée à un premier noeud (N1) ;
 un deuxième transistor à couches minces (M2), qui est connecté entre le premier noeud (N1) et un troisième noeud (N3) et qui a une grille connectée à une ligne de commande d'émission (EM_n) ;
 un troisième transistor à couches minces (M3), qui est connecté entre le troisième noeud (N3) et une troisième source d'énergie (V_{ref}) et qui a une grille connectée à une ligne de commande d'initialisation (Clk_n) ;
 un quatrième transistor à couches minces (M4), qui est connecté entre une première source d'énergie (VDD) et le deuxième noeud (N2) et qui a une grille connectée à une ligne de balayage (S_n) ;
 un cinquième transistor à couches minces (M5), qui est connecté entre une ligne de données (D_m) et le premier noeud (N1) et qui a une grille connectée à la ligne de balayage (S_n) ;
 un sixième transistor à couches minces (M6), qui est connecté entre la première source d'énergie (VDD) et le deuxième noeud (N2) et qui a une grille connectée à la ligne de commande d'émission (EM_n) ;
 un septième transistor à couches minces (M7), qui est connecté entre la troisième source d'énergie (V_{ref}) et l'anode de la diode électroluminescente organique (OLED) et qui a une grille connectée à la ligne de commande d'initialisation (Clk_n) ;
 un premier condensateur (C1) connecté entre le premier noeud (N1) et le troisième noeud (N3) ; et
 un deuxième condensateur (C2) connecté entre le troisième noeud (N3) et le deuxième noeud (N2) ;
 dans lequel une cathode de la diode électroluminescente organique (OLED) est connectée à une deuxième source d'énergie (VSS) ;
 et dans lequel les sept transistors à couches minces sont tous des transistors à couches minces de type p.

2. Circuit de pixels (20) selon la revendication 1, dans lequel la première source d'énergie (VDD) et la deuxième source d'énergie (VSS) sont prévues pour entraîner la diode électroluminescente organique (OLED) ; et la troisième source d'énergie (V_{ref}) est configurée pour fournir une tension d'initialisation.

3. Circuit de pixels (20) selon la revendication 2, dans lequel la tension d'initialisation est une tension négative.

4. Circuit de pixels (20) selon la revendication 1, dans lequel le courant fourni par le premier transistor à couches minces (M1) à la diode électroluminescente organique (OLED) est déterminée par une tension de données fournie par la ligne de données (D_m) et une tension d'initialisation fournie par la troisième source d'énergie (V_{ref}) et est indépendant des tensions d'alimentation fournies par la première source d'énergie (VDD) et la deuxième source d'énergie (VSS), ainsi que de la tension de seuil du premier transistor à couches minces (M1).

5. Circuit de pixels (20) selon la revendication 1, dans lequel le quatrième transistor à couches minces (M4) et le cinquième transistor à couches minces (M5) sont commandés via la ligne de balayage (S_n) ; le troisième transistor à couches minces (M3) et le septième transistor à couches minces (M7) sont commandés via la ligne de commande d'initialisation (Clk_n) ; et le deuxième transistor à couches minces (M2) et le sixième transistor à couches minces (M6) sont commandés via la ligne de commande d'émission (EM_n).

6. Procédé pour entraîner un circuit de pixels (20) tel que défini dans l'une quelconque des revendications 1 à 5, dans lequel une période de balayage comprend une première période de temps (t_1), une deuxième période de temps (t_2) et une troisième période de temps (t_3), et dans lequel dans la première période de temps (t_1), un signal de balayage fourni par la ligne de balayage (S_n) et un signal de commande fourni par la ligne de commande d'initialisation (Clk_n) passent tous deux d'un niveau haut à un niveau bas et un signal de commande fourni par la ligne de commande d'émission (EM_n) saute du niveau bas au niveau

haut, conduisant à la mise en service du troisième transistor à couches minces (M3), du quatrième transistor à couches minces (M4), du cinquième transistor à couches minces (M5) et du septième transistor à couches minces (M7), une tension de données fournie par la ligne de données (D_m) étant fournie au premier noeud (N1) via le cinquième transistor à couches minces (M5), et le troisième noeud (N3) et l'anode de la diode électroluminescente organique (OLED) étant initialisés par la troisième source d'énergie (V_{ref}) ;

dans la deuxième période de temps (t_2), le signal de commande fourni par la ligne de commande d'initialisation (Clk_n) est maintenu au niveau bas, le signal de commande fourni par la ligne de commande d'émission (EM_n) est maintenu au niveau haut et le signal de balayage fourni par la ligne de balayage (S_n) passe du niveau bas au niveau haut, conduisant à la mise hors service du quatrième transistor à couches minces (M4) et du cinquième transistor à couches minces (M5), l'écriture de la tension de données étant terminée, et un échantillonnage d'une tension de seuil du premier transistor à couches minces (M1) étant terminé ; et

dans la troisième période de temps (t_3), le signal de balayage fourni par la ligne de balayage (S_n) est maintenu au niveau haut, le signal de commande fourni par la ligne de commande d'initialisation (Clk_n) saute du niveau bas au niveau haut et le signal de commande fourni par la ligne de commande d'émission (EM_n) chute du niveau haut au niveau bas, conduisant à la mise hors service du troisième transistor à couches minces (M3) et du septième transistor à couches minces (M7), à la mise en service du deuxième transistor à couches minces (M2) et du sixième transistor à couches minces (M6), et à la délivrance en sortie, par le premier transistor à couches minces (M1), d'un courant qui entraîne la diode électroluminescente organique (OLED) afin qu'elle émette une lumière.

7. Procédé selon la revendication 6, dans lequel, dans la première période de temps (t_1), la première source d'énergie (VDD) est connectée au deuxième noeud (N2) via le quatrième transistor à couches minces (M4), et la tension au niveau du deuxième noeud (N2) est égale à la tension fournie par la première source d'énergie (VDD).

8. Procédé selon la revendication 6, dans lequel, dans la troisième période de temps (t_3), le premier condensateur (C1) est court-circuité et la différence de tension entre la grille et une source du premier transistor à couches minces (M1) est égale à la tension stockée dans le deuxième condensateur (C2).

9. Dispositif d'affichage à diodes électroluminescentes organiques à matrice active (AMOLED) comprenant un circuit de pixels (20) tel que défini dans l'une quelconque des revendications 1 à 5.

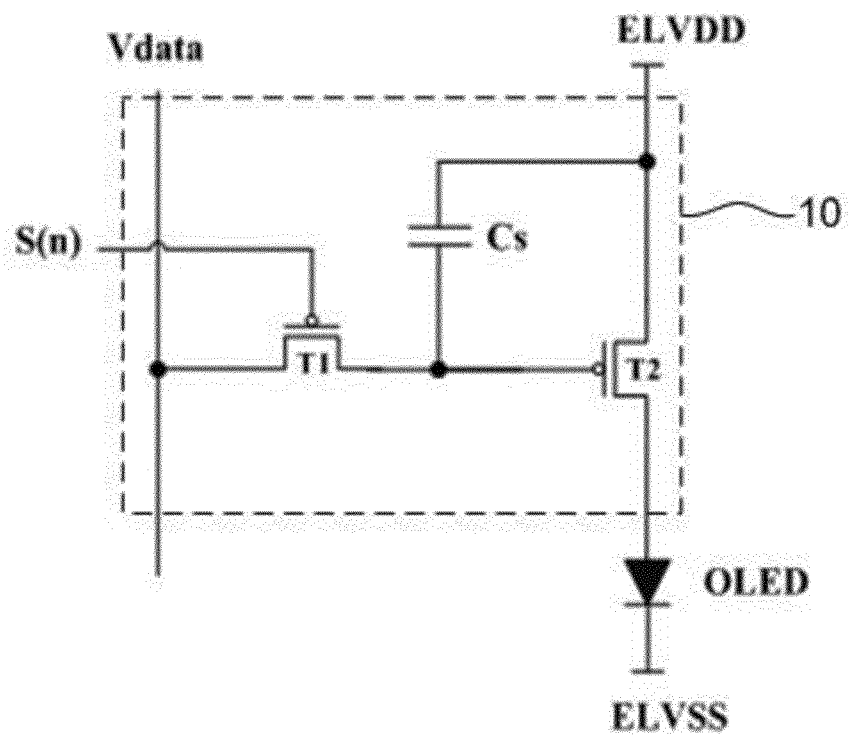


FIG. 1

20

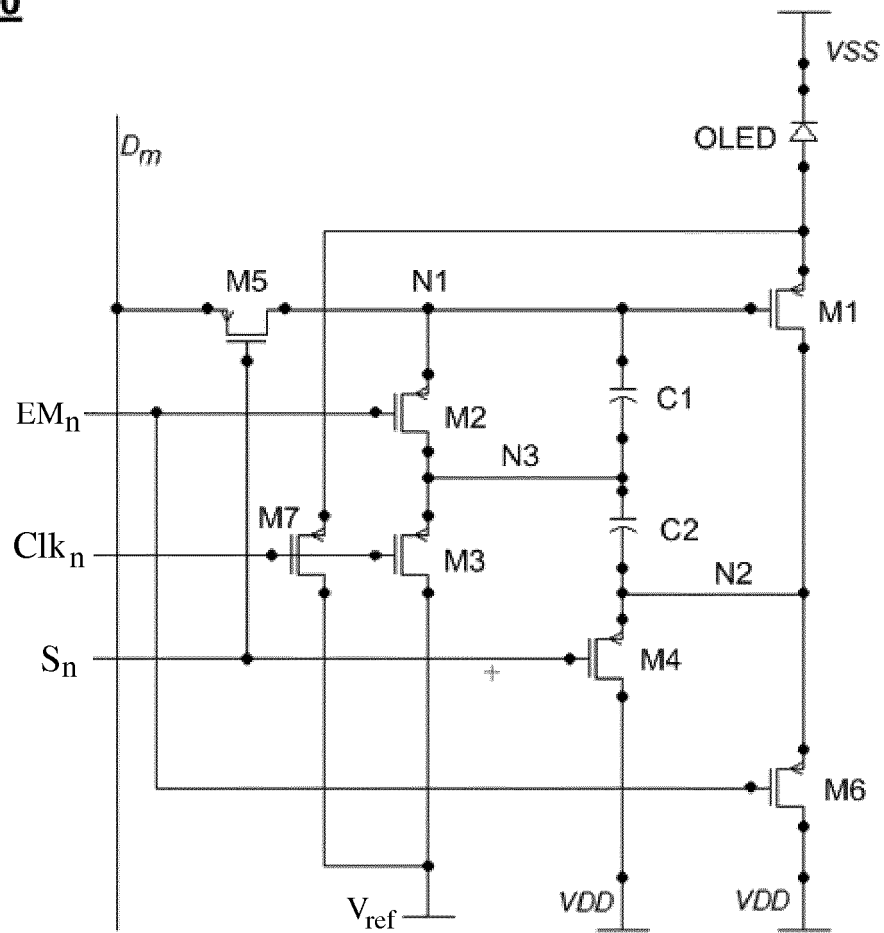


FIG.2

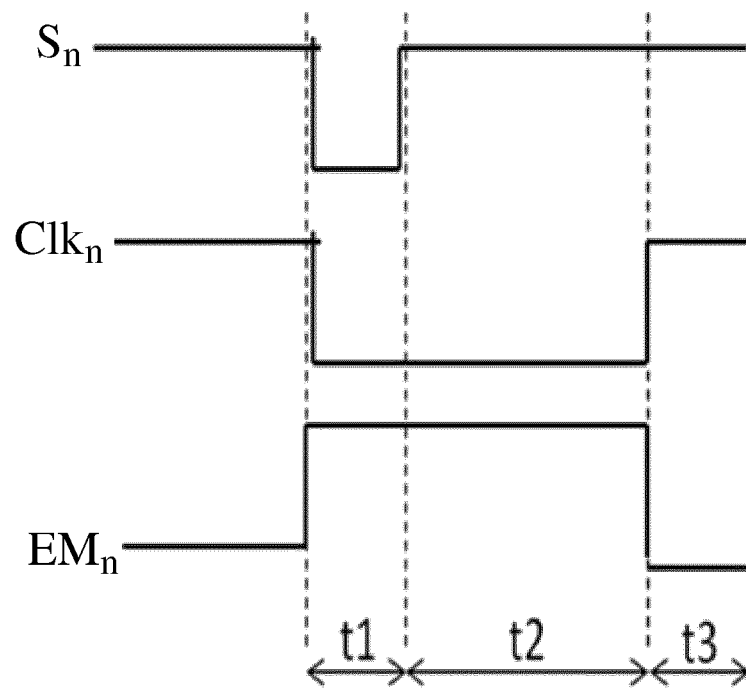


FIG. 3

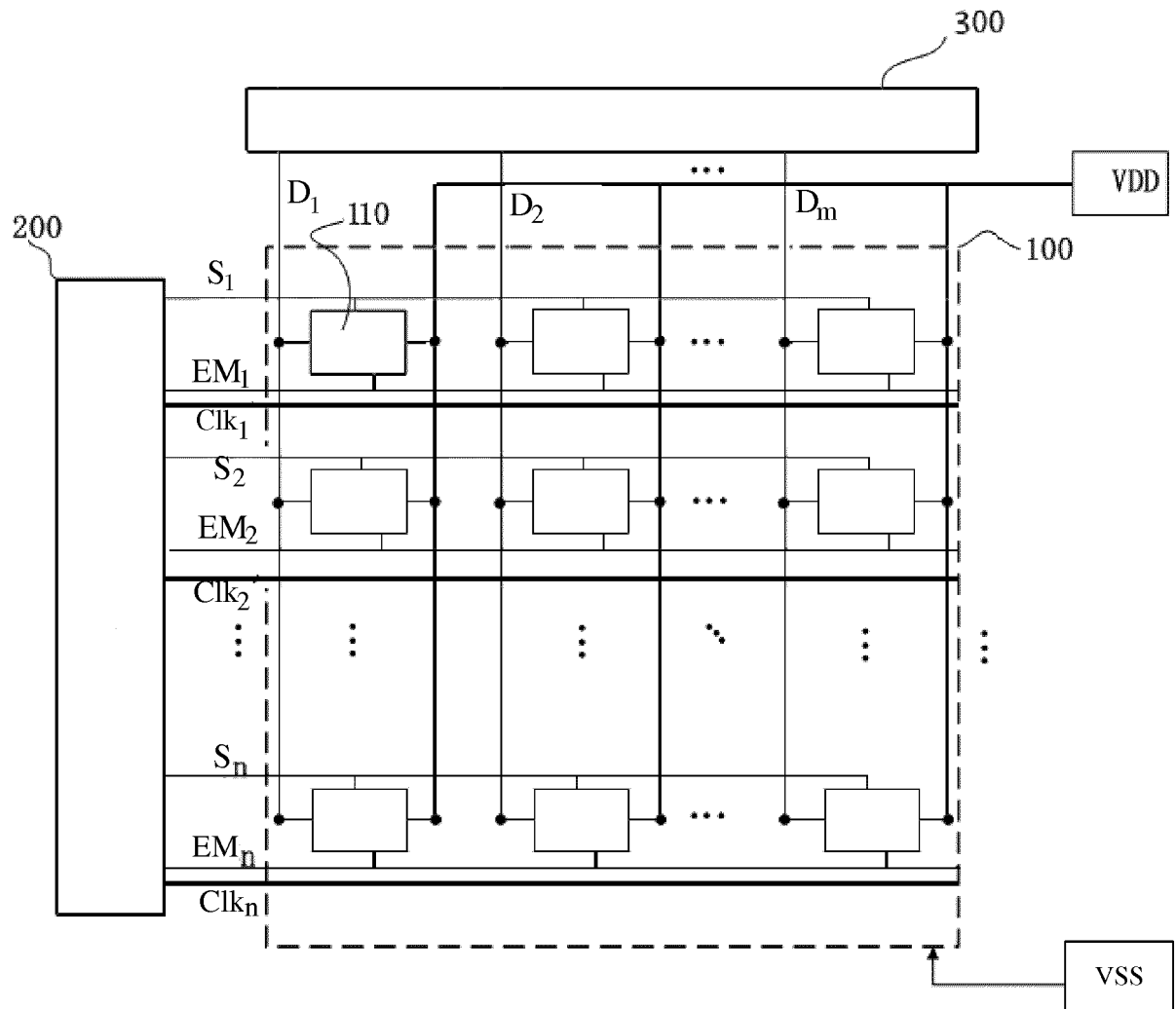


FIG.4

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 2261884 A1 [0007]

专利名称(译)	像素电路及其驱动方法，以及有源矩阵有机发光显示器		
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外部链接	Espacenet		

摘要(译)

像素电路 (20) 及其驱动方法，以及有源矩阵有机发光显示器。像素电路 (20) 通过第七薄膜晶体管 (M7) 初始化有机发光二极管 (OLED) 的阳极，从而减慢有机发光二极管 (OLED) 的老化和服务有机发光二极管 (OLED) 的寿命延长。用作驱动元件的第一薄膜晶体管 (M1) 的电流输出由数据线 (D m) 提供的数据电压和由第三电源提供的初始化电压 (V ref) 确定与外部电源电压和第一薄膜晶体管 (M1) 的阈值电压有关，因此由薄膜晶体管的阈值电压的偏差和电源电压的变化引起的亮度不均匀性可以避免。因此，使用像素电路 (20) 的有源矩阵有机发光显示器及其驱动方法延长了使用寿命，并提高了显示质量。

