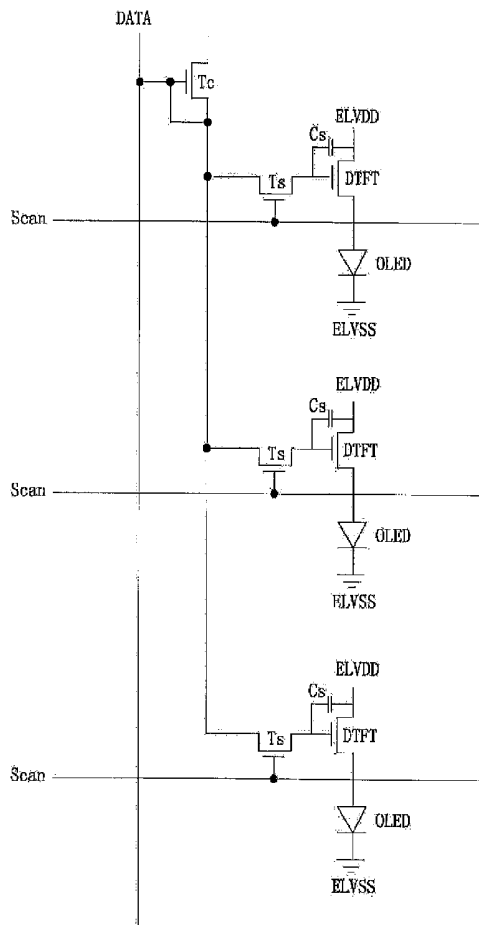


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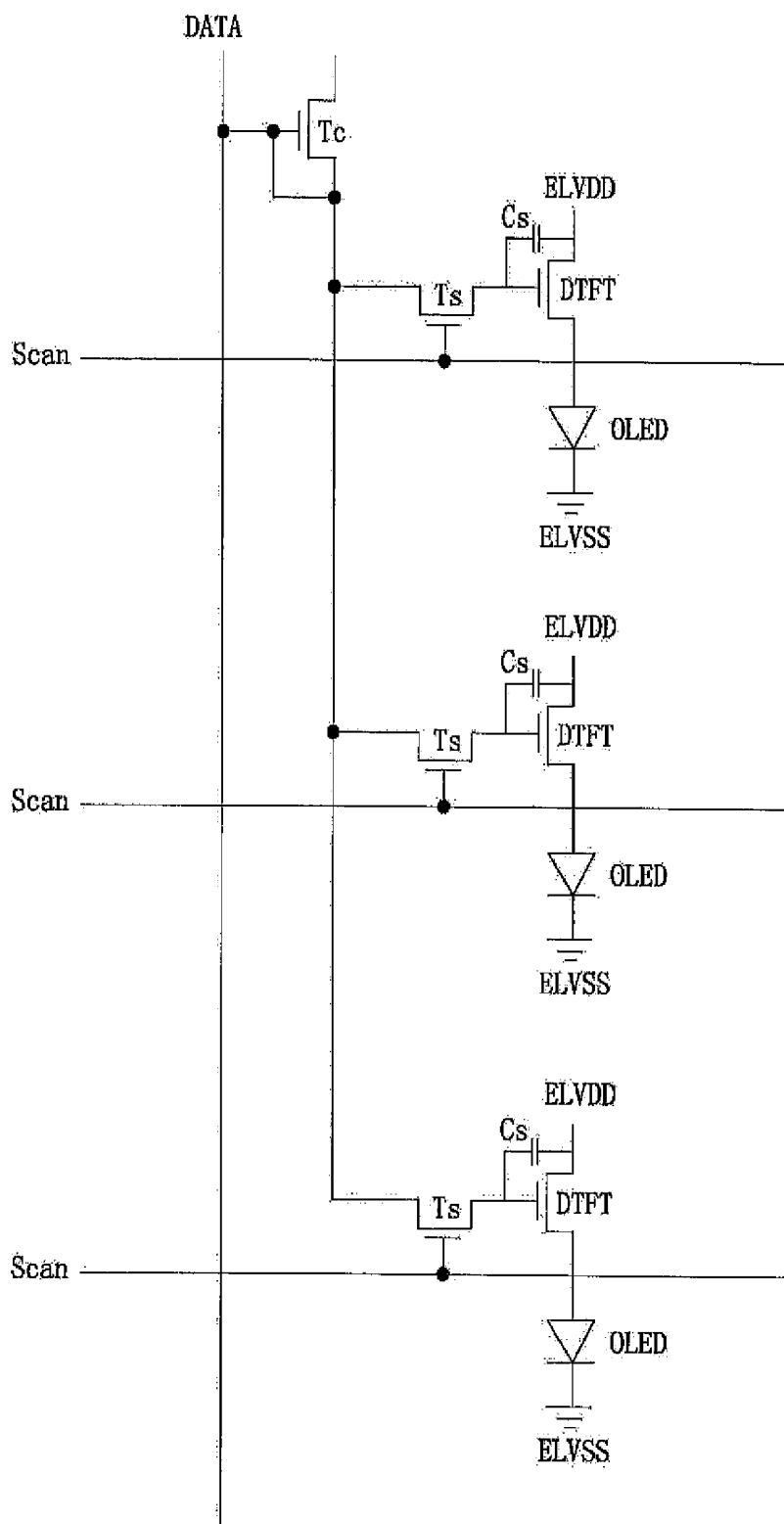


Fig.1

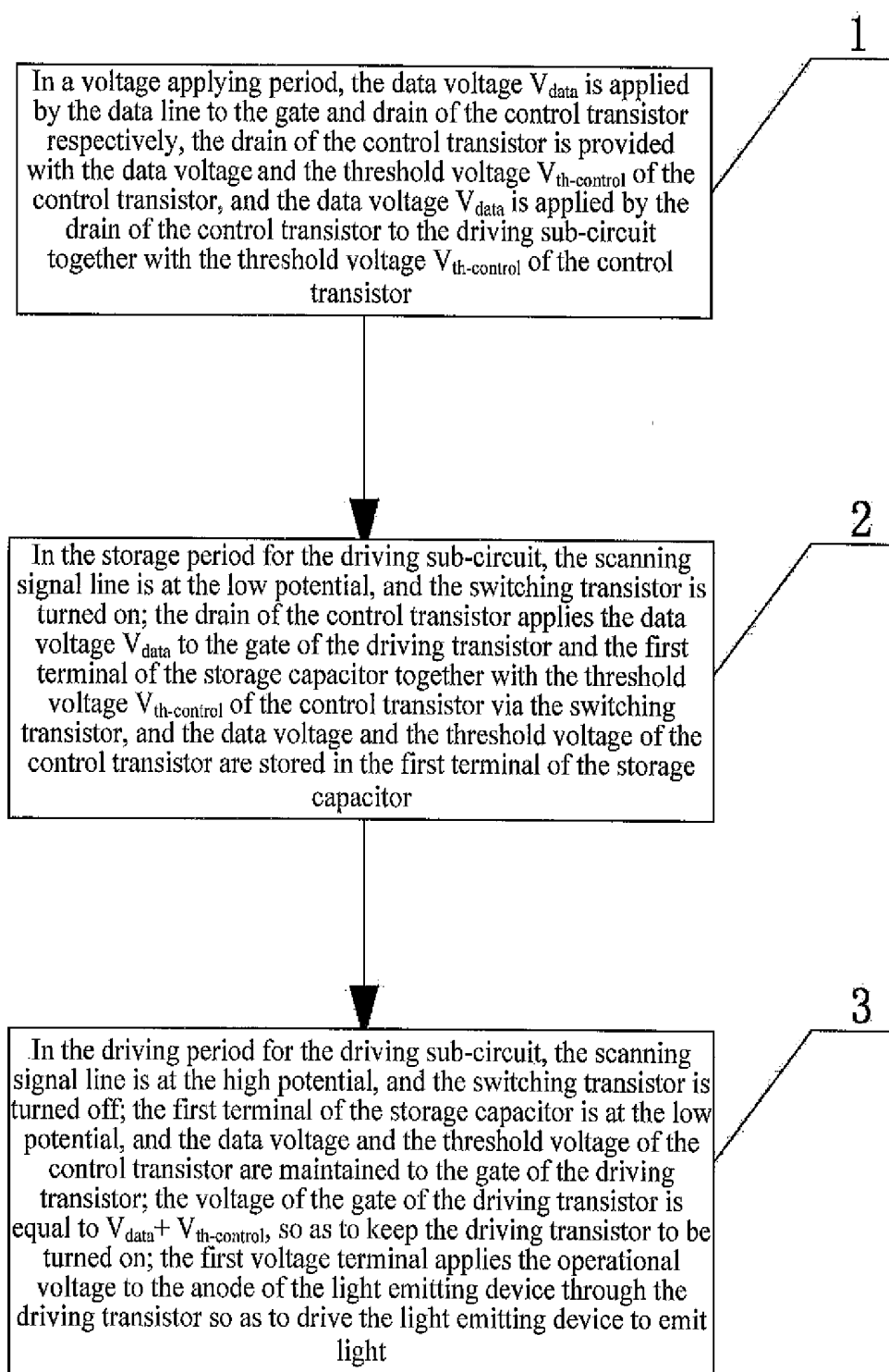


Fig.2

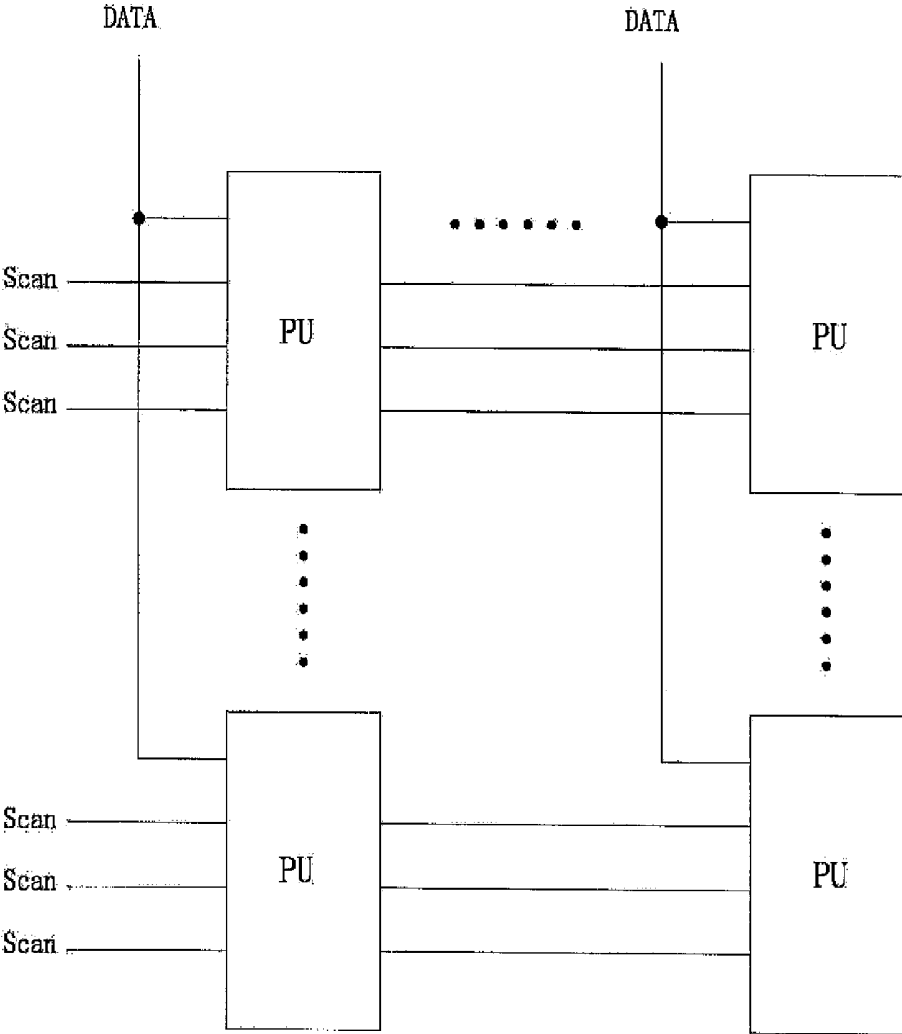


Fig.3

PIXEL DRIVING UNIT AND DRIVING METHOD THEREOF, AND PIXEL CIRCUIT

TECHNICAL FIELD

[0001] The present disclosure relates to a technical field of display, and particularly, to a pixel driving unit and a driving method thereof, as well as a pixel circuit comprising the pixel driving unit.

BACKGROUND

[0002] As a light emitting device of current type, organic light-emitting diodes (OLEDs) have been increasingly applied to active matrix OLED of high performance. Conventional passive matrix OLED requires a shorter driving time for a single pixel with increase of display size, and thus needs to increase transient current and increase power consumption. In the meanwhile, application of large current may cause a voltage drop on lines of nanometer ITOs (Indium Tin Oxides) to be excessively large and cause the operational voltage of the OLED to be excessively high, and hence the efficiency thereof is decreased. However, active matrix OLED (AMOLED) can address these issues fairly well through inputting OLED current by switching transistors performing progressive scanning.

[0003] In design of the pixel circuit of the AMOLED, the issue that is mainly focused on is the nonuniformity of brightness of the OLED devices driven by the respective AMOLED pixel driving units.

[0004] First of all, AMOLED employs thin film transistors (TFTs) to construct the pixel driving unit so as to provide corresponding driving current for the light emitting devices. As known, the Low Temperature Poly-silicon (LTPS) TFTs or oxide TFTs are mostly used. As compared with a general A-Si TFTs, the LTPS TFTs and the oxide TFTs have characteristics of higher mobility and stability, and more suitable for the application of AMOLED display. However, due to limitation of crystallization process, LTPS TFTs fabricated on a glass substrate with large area often have a nonuniformity in terms of electrical parameters such as threshold voltage, mobility and the like, and this nonuniformity will be converted into difference in the driving current of the OLED devices and difference in brightness and can be perceived by human's eye, that is, a phenomenon of mura. Although the oxide TFTs is pretty good in terms of the uniformity of the process, similar to the A-Si TFTs, in case of being applied a voltage for a long time and high temperature, a drift will occur in the threshold voltage thereof; and since the display pictures are different, the drift amounts of the threshold values of the respective parts of the TFTs of the panel will be different, which will cause a difference in brightness display; since this difference is associated with a previous displayed images, it is generally presented as a phenomenon of image sticking.

[0005] Since the light emitting device of the OLED is a current driven device, in the pixel driving unit for driving the light emitting device to emit light, the characteristic of the threshold value of the driving transistor thereof has a great impact on the driving current and the final displayed brightness. Drift will occur in the threshold value of the driving transistor when the driving transistor is subjected to the voltage stress and illumination, and this drift in threshold value will be embodied as nonuniformity in brightness in terms of display effect.

[0006] In addition, in the pixel circuit of the known AMOLED, in order to eliminate the impact due to the threshold voltage of the driving transistor, the structure of the pixel circuit will be generally designed to be relatively complex, and this will directly lead to decrease in yield rate of pixel circuit of the AMOLED in the manufacture.

[0007] Therefore, in order to address the above issues, the present disclosure provides a pixel driving unit, a driving method thereof, as well as a pixel circuit.

SUMMARY

[0008] Embodiments of the present disclosure provide a pixel driving unit and a driving method thereof, as well as a pixel circuit capable of addressing the issue of the drift in the threshold value of the driving transistor in the known pixel driving unit.

[0009] The technical solutions of the present disclosure are realized as follows: a pixel driving unit comprising driving sub-circuits and a control sub-circuit, wherein the control sub-circuit is connected to a data line, and the driving sub-circuits are connected to the control sub-circuit.

[0010] Further, the control sub-circuit comprises a control transistor; the gate and the drain of the control transistor are connected to the data line, and the drain of the control transistor is connected to the driving sub-circuits.

[0011] Further, at least three driving sub-circuits are included, wherein each of the driving sub-circuit includes a scanning signal line, a switching transistor, a storage capacitor, a driving transistor and a light emitting device; the gate of the switching transistor is connected to the scanning signal line, the source of the switching transistor is connected to the drain of the control transistor, and the drain of the switching transistor is connected to the gate of the driving transistor and a first terminal of the storage capacitor respectively; the source of the driving transistor is connected to a first voltage terminal and a second terminal of the storage capacitor respectively, and the drain the driving transistor is connected to the anode of the light emitting device; and the cathode of the light emitting device is connected to a second voltage terminal.

[0012] Further, the light emitting device is an organic light-emitting diode.

[0013] Further, each of the control transistor, the switching transistor and the driving transistor is a field effect transistor of P type.

[0014] A driving method for the pixel driving unit as described above comprises: applying, by the data line, a data voltage to the gate and the drain of the control transistor respectively, and providing the drain of the control transistor with the data voltage and the threshold voltage of the control transistor; and applying, by the drain of the control transistor, the data voltage to the driving sub-circuit together with the threshold voltage of the control transistor.

[0015] Further, the method further comprises the following steps of turning on, in a storage period, the switching transistor by the scanning signal line; applying, by the drain of the control transistor, the data voltage together with the threshold voltage of the control transistor, to the gate of the driving transistor and the storage capacitor through the switching transistor; and turning off, in a driving period, the switching transistor by the scanning signal line; keeping the driving transistor to be turned on by the storage capacitor, so as to drive the light emitting device to emit light.

[0016] A pixel circuit comprises a plurality of the above data lines each connected a plurality of the above pixel driving unit.

[0017] A pixel circuit comprises a plurality of the above data lines each connected a plurality of the pixel driving unit as described above, and the above driving method is performed therein.

[0018] As compared with the known technique, the embodiments of the present disclosure have the following advantages.

[0019] Firstly, with a structure in which the gate and drain of the control transistor are connected with each other, the pixel driving unit of the present disclosure allows the drain of the control transistor to apply the data voltage to the driving sub-circuit together with the threshold voltage of the control transistor, so as to cancel the threshold voltage of the driving transistor in the driving sub-circuit; in the process of driving the light emitting device, it is possible to effectively eliminate the nonuniformity due to the threshold voltage of the driving transistor and a phenomenon of image sticking due to the threshold voltage drift, avoid a problem of nonuniform brightness of the active matrix OLED due to the difference of the threshold voltages of the driving transistors thereof between the light emitting devices of different pixel driving units of the active matrix OLED, and improve the driving effect of the pixel driving unit with respect to the light emitting device, and further improve the quality of the active matrix OLED.

[0020] Secondly, the driving sub-circuit of the present disclosure has a characteristic of simple structure, and can simplify the overall structure of the pixel driving unit and the pixel circuit and reduce the difficulty in manufacturing the pixel circuit; in the meanwhile, combining the driving sub-circuit of simple structure with the control transistor, it is possible to effectively reduce the difficulty in manufacturing the pixel driving unit and the pixel circuit and manufacture cost and improve the yield rate of the pixel circuit, while the driving effect for the pixel driving circuit is ensured.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Hereinafter, the present disclosure will be further explained with reference to the appended drawings and the embodiments.

[0022] FIG. 1 is a schematic diagram of circuit connection of a pixel driving unit according to the present disclosure;

[0023] FIG. 2 is a block diagram of steps of a driving method according to the present disclosure; and

[0024] FIG. 3 is a schematic diagram of circuit connection of a pixel circuit according to the present disclosure.

DETAILED DESCRIPTION

[0025] Hereinafter, the technical solutions of the embodiments of the present disclosure will be clearly and fully described in conjunction with the appended drawings of the embodiments of the present disclosure; obviously, the described embodiments are only a part of the embodiments of the present disclosure, rather than all of the embodiments. Based on the embodiments of the present disclosure, all the other embodiments acquired by those skilled in art without paying any inventive work are within the protection scope of the present invention.

[0026] With reference to FIG. 1, the present embodiment provides a pixel driving unit comprising driving sub-circuits

and a control sub-circuit, wherein an input terminal of the control sub-circuit is connected to a data line DATA, and an input terminal of the driving sub-circuit is connected to an output terminal of the control sub-circuit.

[0027] The control sub-circuit comprises a control transistor T_c; the gate of the control transistor T_c is connected to the data line DATA and the drain of the control transistor T_c, and the drain of the control transistor T_c is connected to the gate of the control transistor T_c and respective driving sub-circuits.

[0028] The pixel driving unit of the present disclosure comprises at least three driving sub-circuits; in the following embodiments, a case in which there are three driving sub-circuits will be exemplified, and of course, it is also possible to choose more than three driving sub-circuits as necessary in practice; here, each of the driving sub-circuits comprises a scanning signal line Scan, a switching transistor T_s, a storage capacitor C_s, a driving transistor DTFT and a light emitting device OLED.

[0029] Herein, the gate of the switching transistor T_s is connected to the scanning signal line Scan, the source of the switching transistor T_s is connected to the drain of the control transistor T_c, and the drain of the switching transistor T_s is connected to the gate of the driving transistor DTFT and a first terminal of the storage capacitor C_s; the source of the driving transistor DTFT is connected to a first voltage terminal ELVDD and a second terminal of the storage capacitor C_s, and the drain of the driving transistor DTFT is connected to the anode of the light emitting device OLED; the cathode of the light emitting device OLED is connected to a second voltage terminal ELVSS.

[0030] The first voltage terminal ELVDD of the present disclosure is externally connected to an operational power supply, and serves to provide the operational power supply for the light emitting device OLED. The second voltage terminal ELVSS of the present disclosure is connected to the cathode of the light emitting device OLED; the second voltage terminal ELVSS serves to provide a reference voltage for the cathode of the light emitting device OLED. The second voltage terminal ELVSS of the present disclosure can be generally selected in a range of -5V to 0V, and can be obtained in accordance with practical adjustment to provide a reference potential for the above elements, such as zero line, ground line for providing a zero potential, negative voltage or the like. The light emitting device OLED of the present disclosure is an organic light-emitting diode (OLED device).

[0031] Each of the driving transistors DTFTs of the present disclosure is a field effect transistor of P type; the field effect transistor of P type is an enhanced type of field effect (the threshold voltage is positive) or depletion type (the threshold voltage is negative); each of the driving transistor DTFT, the switching transistor T_s and the control transistor T_c is the field effect transistor of P type.

[0032] With a structure in which the gate and drain of the control transistor T_c are connected with each other, the pixel driving unit of the embodiment of the present disclosure allows the drain of the control transistor T_c to apply the data voltage to the driving sub-circuit together with the threshold voltage of the control transistor T_c, so as to cancel the threshold voltage of the driving transistor DTFT in the driving sub-circuit; in the process of driving the light emitting device OLED, it is possible to effectively eliminate the nonuniformity due to the threshold voltage of the driving transistor DTFT and a phenomenon of image sticking due to the thresh-

old voltage drift, avoid an issue of ununiform brightness of the active matrix OLED due to the difference of the threshold voltages of the driving transistors DTFTs therein between the light emitting devices OLEDs of different pixel driving units of the active matrix OLED, and improve the driving effect of the pixel driving unit with respect to the light emitting device OLED, and further improve the quality of the active matrix OLED.

[0033] The driving sub-circuit of this embodiment is a driving sub-circuit of 2T1C type, that is, one switching transistor Ts, one driving transistor DTFT and one storage capacitor Cs are included; it has a characteristic of simple structure, and can simplify the overall structure of the pixel driving unit and the pixel circuit and reduce the difficulty in manufacturing the pixel circuit; in the meanwhile, combining the driving sub-circuit of simple structure with the control transistor, it is possible to effectively reduce the difficulty in manufacturing the pixel driving unit and the pixel circuit and manufacture cost and improve the yield rate of the pixel circuit, while the driving effect for the pixel driving circuit is ensured.

[0034] With reference to FIG. 2, the present disclosure further provides a driving method of the pixel driving unit described above, which comprises a voltage applying period of applying, by the data line DATA, the data voltage V_{data} to the gate and drain of the control transistor Tc respectively, allowing the drain of the control transistor Tc to have the data voltage V_{data} and the threshold voltage $V_{th-control}$ of the control transistor Tc, and applying, by the drain of the control transistor Tc, the data voltage V_{data} to the driving sub-circuit together with the threshold voltage $V_{th-control}$ of the control transistor Tc.

[0035] The driving method further comprises a storage period for the driving sub-circuit, during which the scanning signal line Scan is at the low potential, and the switching transistor Ts is turned on; the drain of the control transistor Tc applies the data voltage V_{data} to the gate of the driving transistor DTFT and the first terminal of the storage capacitor Cs together with the threshold voltage $V_{th-control}$ of the control transistor Tc via the switching transistor Ts, and the data voltage V_{data} and the threshold voltage $V_{th-control}$ of the control transistor Tc are stored in the first terminal of the storage capacitor Cs.

[0036] The driving method further comprises a driving period for the driving sub-circuit, during which the scanning signal line Scan is at the high potential, and the switching transistor Ts is turned off; the first terminal of the storage capacitor Cs is at the low potential, and the data voltage V_{data} and the threshold voltage $V_{th-control}$ of the control transistor Tc are maintained to the gate of the driving transistor DTFT; at this timing, the voltage of the gate of the driving transistor DTFT is equal to $V_{data} + V_{th-control}$, so as to keep the driving transistor DTFT to be turned on; the first voltage terminal ELVDD applies the operational voltage VDD to the anode of the light emitting device OLED through the driving transistor DTFT so as to drive the light emitting device OLED to emit light.

[0037] At this timing, the voltage of the gate of the driving transistor DTFT is maintained at $V_{data} + V_{th-control}$, and the voltage of the source of the driving transistor DTFT is an operational voltage of VDD; therefore, the driving voltage V_{gs} outputted from the drain of the driving transistor DTFT is calculated by a formula of $V_{gs} = V_{data} + V_{th-control} - VDD$; the driving current outputted to the light emitting device OLED via the driving transistor DTFT is calculated by a formula of

$$I_{OLED} = \frac{1}{2} K [V_{gs} - V_{th-drive}]^2$$

where, K is a current constant related to the driving transistor OLED, and $V_{th-drive}$ is the threshold voltage of the driving transistor OLED; it can be known, from substituting the V_{gs} into the formula of the driving current I_{OLED} , that the driving current I_{OLED} outputted to the light emitting device OLED via the driving transistor DTFT is expressed by a formula of

$$I_{OLED} = \frac{1}{2} K [V_{data} + V_{th-control} - VDD - V_{th-drive}]^2$$

[0038] Since an issue of short range uniformity between the threshold voltages of the control transistor Tc and the respective switching transistors Ts as well as the respective driving transistors DTFT is considered in the design of the pixel driving unit, in each of the pixel driving units, the threshold voltages of the control transistor Tc, switching transistor Ts and the driving transistor DTFT manufactured with the same design rule are approximately equal to each other; therefore, the threshold voltage of the control transistor Tc and the threshold voltage of the driving transistor DTFT described in the above formulas are cancelled with each other to obtain the following formula of

$$I_{OLED} = \frac{1}{2} K [V_{data} - VDD]^2$$

[0039] It can be known from the above calculations that the driving current I_{OLED} flowing through the driving transistor DTFT is only related to the V_{data} and the VDD, and is independent of the threshold voltage $V_{th-drive}$ of the driving transistor DTFT. Therefore, even if the $V_{th-drive}$ is lower than zero, it can be well compensated, and the impact of the nonuniformity and the drift of the threshold voltage of the driving transistor DTFT is basically eliminated. With the pixel circuit of the embodiments of the present disclosure, no matter with respect to the driving transistor of the enhanced type or depletion type, the impact of the nonuniformity of the threshold voltage can be eliminated, and thus the nonuniformity of brightness of the light emitting device can be greatly compensated and the application thereof is much wider.

[0040] With reference to FIG. 3, the present disclosure also provides a pixel circuit comprising a plurality of the above data lines DATAs, and each of the data lines is connected a plurality of the pixel driving units PUs as described above; Here, the gates of the plurality of the control transistors Tc on the same column are connected to a same data line DATA, and the driving sub-circuits on the same row are connected to a same scanning signal line Scan.

[0041] It should be explained, the source and the drain of all transistors in the embodiments of the present disclosure are not distinguished from each other; for example, the source of the driving transistor can be also referred to as the drain of the driving transistor, and correspondingly, in this case, the drain of the driving transistor is referred to as the source of the driving transistor; that is to say, for the two terminals other than the gate, one is the source, and the other is the drain.

1. A pixel driving unit comprising driving sub-circuits and a control sub-circuit, wherein the control sub-circuit is connected to a data line, and the driving sub-circuits are connected to the control sub-circuit.

2. The pixel driving unit according to claim 1, wherein the control sub-circuit comprises a control transistor; a gate and a drain of the control transistor are connected to the data line, and a drain of the control transistor is connected to the driving sub-circuits.

3. The pixel driving unit according to claim 2, comprising at least three driving sub-circuits, wherein

each of the driving sub-circuits includes a scanning signal line, a switching transistor, a storage capacitor, a driving transistor and a light emitting device;

a gate of the switching transistor is connected to the scanning signal line, a source of the switching transistor is connected to the drain of the control transistor, and a drain of the switching transistor is connected to the gate of the driving transistor and a first terminal of the storage capacitor respectively;

a source of the driving transistor is connected to a first voltage terminal and a second terminal of the storage capacitor respectively, and the drain of the driving transistor is connected to an anode of the light emitting device; and

a cathode of the light emitting device is connected to a second voltage terminal.

4. The pixel driving unit according to claim 3, wherein the light emitting device is an organic light-emitting diode.

5. The pixel driving unit according to claim 9, wherein each of the control transistor, the switching transistor and the driving transistor is a field effect transistor of P type.

6. A driving method for the pixel driving unit according to claim 2, comprising:

applying, by the data line, a data voltage to the gate and the drain of the control transistor respectively, and providing the drain of the control transistor with the data voltage and a threshold voltage of the control transistor; and applying, by the drain of the control transistor, the data voltage together with the threshold voltage of the control transistor to the driving sub-circuit.

7. The driving method according to claim 6, further comprising:

turning on, in a storage period, the switching transistor by the scanning signal line; applying by the drain of the control transistor, together with the threshold voltage of the control transistor, the data voltage to the gate of the driving transistor and the storage capacitor via the switching transistor; and

turning off, in a driving period, the switching transistor by the scanning signal line; keeping the driving transistor to be turned on by the storage capacitor, so as to drive the light emitting device to emit light.

8. A pixel circuit comprising a plurality of data lines, wherein each of the data lines is connected to a plurality of the pixel driving units according to claim 1.

9. The pixel circuit according to claim 8, wherein the pixel circuit is driven with the driving method according to claim 6.

10. The pixel circuit according to claim 8, wherein the control sub-circuit comprises a control transistor; a gate and a drain of the control transistor are connected to the data line, and a drain of the control transistor is connected to the driving sub-circuits.

11. The pixel circuit according to claim 10, wherein each of the plurality of pixel driving units comprises at least three driving sub-circuits, wherein

each of the driving sub-circuits includes a scanning signal line, a switching transistor, a storage capacitor, a driving transistor and a light emitting device;

a gate of the switching transistor is connected to the scanning signal line, a source of the switching transistor is connected to the drain of the control transistor, and a drain of the switching transistor is connected to the gate of the driving transistor and a first terminal of the storage capacitor respectively;

a source of the driving transistor is connected to a first voltage terminal and a second terminal of the storage capacitor respectively, and the drain of the driving transistor is connected to an anode of the light emitting device; and

a cathode of the light emitting device is connected to a second voltage terminal.

12. The pixel circuit according to claim 11, wherein the light emitting device is an organic light-emitting diode.

13. The pixel circuit according to claim 12, wherein each of the control transistor, the switching transistor and the driving transistor is a field effect transistor of P type.

* * * * *

专利名称(译)	像素驱动单元及其驱动方法和像素电路		
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摘要(译)

本发明涉及显示技术领域，尤其涉及一种像素驱动单元及其驱动方法，以及包括该像素驱动单元的像素电路；像素驱动单元包括驱动子电路和控制子电路，其中控制子电路连接到数据线，驱动子电路连接到控制子电路。在驱动发光器件的过程中，像素驱动单元可以有效消除由于驱动晶体管的阈值电压引起的不均匀性和由于阈值电压漂移引起的图像残留现象，避免了有源亮度不均匀的问题；矩阵OLED由于有源矩阵OLED的不同像素驱动单元的发光器件之间的驱动晶体管的阈值电压的差异，并且改善了像素驱动单元相对于发光器件的驱动效果，以及进一步提高有源矩阵OLED的质量。

