PIXEL DRIVING CIRCUIT AND OLED DISPLAY APPARATUS AND ELECTRIONIC DEVICE USING THE SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention generally relates to a pixel driving circuit for OLED display apparatus, in particular, to a pixel driving circuit using 4-terminal transistor as driving transistor, and OLED display apparatus and electronic device using the same.

[0003] 2. Description of Related Art

[0004] Being self-luminous, OLEDs eliminate the need for a backlight that is necessary in liquid crystal display devices (LCDs), and thus they are most suitable when manufacturing thinner devices. Also, the self-luminous OLEDs are high in visibility and have no limit in terms of viewing angle. These are the reasons for the attention that light emitting devices using the OLEDs are receiving in recent years as display devices to replace CRTs and LCDs.

[0005] Driving circuits for an OLED display apparatus can be categorized into two kinds, i.e., voltage driving circuits and current driving circuits. However, no matter which kind of driving circuits is used, a thin-film-transistor (TFT) is used as a driving transistor for adjusting OLED current provided to the OLED. Refer to FIG. **1**, a diagram shown connection structure of driving transistor and corresponding OLED in a conventional OLED pixel is provided. As shown in FIG. **1**, control circuit **10** provides a control signal to control the gate terminal of the driving transistor **12** for adjusting the OLED current provided to the OLED **14**. Because the driving transistor **12** is a 3-terminal device, its body is floated and the current kink effect becomes more apparent when the driving transistor **12** operates in saturation region.

[0006] Furthermore, as the driving transistor **12**, for example, an p-channel TFT, operates at high drain bias condition, holes generated by hot carrier effect will accumulate at the back channel region. These accumulated holes create extra NPN BJT current. Therefore, the TFT saturation current will increases as the drain voltage. In addition, the local electric field at the drain region may become larger because of the high defect density in the polysilicon channel. This further makes the current kink effect be more serious and the brightness uniformity of OLED display apparatus is therefore affected.

[0007] For the Active-Matrix OLED (AMOLED) panel, the brightness uniformity is influenced by three main factors, i.e. OLED reliability, OLED uniformity, and TFT characteristics variation. Refer to FIG. **2**A, a curve diagram shown the influence caused by OLED reliability is provided. As well known by those skilled in the art, the OLED current becomes degraded after a certain period. This means that larger voltage is needed to apply to the OLED device to maintain the same current. As shown in FIG. **2**A, as the OLED efficiency becomes degraded, the current flowing through OLED will be changed for a value Δ Is if the saturation current of driving TFT is not a constant value. In other words, not only pixel brightness but also panel gray scale will change with time when serious kink effect is observed for the driving TFT.

[0008] Refer to FIG. **2**B, a curve diagram shown the influence caused by OLED uniformity is provided. As shown in FIG. **2**B, even if the same Vgs value is given, the OLED current is also different because of the non-saturated TFT current (taking place due to kink effect). Thus, the non-uniform brightness of AMOLED panel will be observed. Further, refer to FIG. **2**C, a curve diagram shown the influence caused by TFT characteristics variation is provided. Due to the process variation, the degree of kink effect in TFT A, TFT B and TFT C is also different. As illustrated in FIG. **2**C, the OLED current will be dissimilar even if the turn-on characteristics of OLED devices are the same. Thus, poor brightness uniformity of AMOLED panel is obtained.

[0009] Accordingly, kink effect is an important issue for the brightness uniformity of AMOLED panel. It is therefore a necessity for reducing the kink effect taking place in the driving transistor.

SUMMARY OF THE INVENTION

[0010] Accordingly, the present invention is directed to a pixel driving circuit for OLED display apparatus, and OLED display apparatus and electronic device using the same. By using the present invention, the kink effect is reduced such that uniformity of AMOLED panel can be improved.

[0011] In one aspect, the present invention is directed to a pixel driving circuit for OLED display apparatus. The pixel driving circuit is adapted to drive an OLED having a first terminal and a second terminal, while the first terminal couples to a first voltage source. The pixel driving circuit comprises a control circuit, a driving transistor and a diode. The control circuit generates a control signal to control an OLED current supplied to the OLED. The driving transistor has a first drain/source terminal, a second drain/source terminal and a gate terminal. The gate terminal receives the control signal to control a channel between the first and second drain/source terminal for adjusting the OLED current flowing through the channel. Further, the diode couples between the channel and a second voltage source.

[0012] According to an embodiment of the present invention, the diode comprises an intrinsic region coupling to the TFT channel and a doped region coupling to the intrinsic region, wherein the TFT channel and the doped region is doped with different types of dopant.

[0013] According to an embodiment of the present invention, the diode comprises a first region, coupled to the channel that is first-type doped; and a second region, coupled to the first region and is second-type doped. The first region is an intrinsic region or a lightly-doped region doped with the second type. When the first region is lightly-doped, the second region has higher doping concentration than the first region.

[0014] According to an embodiment of the present invention, the diode comprise a first region, coupled to the channel that is first-type doped; a second region, coupled to the first region and is second-type doped; and a third region, coupled to the second region and is second-type doped. The first region is an intrinsic region or a lightly-doped region doped with the second type. When the first region is lightly-doped, the second region has higher doping concentration than the first region. The third region has higher doping concentration than the second region.

[0015] In another aspect, the present invention is directed to an OLED display apparatus, which comprises a data driver providing a data signal, a scan driver providing a scan signal and an active area. The active area comprises a plurality of OLED pixels. At least one of the OLED pixels