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(54) Title: THRESHOLD VOLTAGE COMPENSATION METHOD FOR ELECTROLUMINESCENT DISPLAY DEVICES
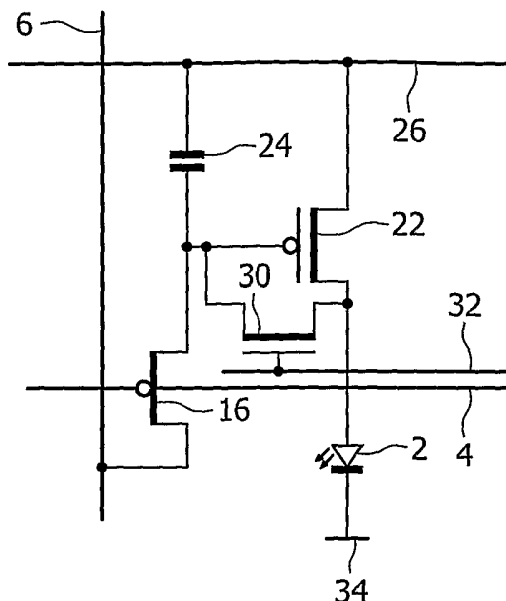
(57) Abstract: An active matrix electroluminescent display device has a shorting transistor (30) connected between the gate and drain of the drive transistor (22). Means (42) is provided for measuring a voltage on the data line (6). The shorting transistor (30) can be used to discharge the voltage on the gate of the drive transistor (22) until it switches off. By storing the resultant voltage on the data line (6) through an address transistor (16), the data line is used as one of the control/measurement lines for the threshold measurement.

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1

THRESHOLD VOLTAGE COMPENSATION METHOD FOR ELECTROLUMINESCENT DISPLAY DEVICES

5   This invention relates to electroluminescent display devices, particularly active matrix display devices having thin film switching transistors associated with each pixel.

Matrix display devices employing electroluminescent, light-emitting, display elements are well known. The display elements may comprise organic thin film electroluminescent elements, for example using polymer materials, or else light emitting diodes (LEDs) using traditional III-V semiconductor compounds. Recent developments in organic electroluminescent materials, particularly polymer materials, have demonstrated their ability to be used practically for video display devices. These materials typically comprise one or more layers of a semiconducting conjugated polymer sandwiched between a pair of electrodes, one of which is transparent and the other of which is of a material suitable for injecting holes or electrons into the polymer layer.

The polymer material can be fabricated using a CVD process, or simply by a spin coating technique using a solution of a soluble conjugated polymer. Ink-jet printing may also be used. Organic electroluminescent materials exhibit diode-like I-V properties, so that they are capable of providing both a display function and a switching function, and can therefore be used in passive type displays. Alternatively, these materials may be used for active matrix display devices, with each pixel comprising a display element and a switching device for controlling the current through the display element.

Display devices of this type have current-driven display elements, so that a conventional, analogue drive scheme involves supplying a controllable current to the display element. It is known to provide a current source transistor as part of the pixel configuration, with the gate voltage supplied to the current source transistor determining the current through the display

2

element.   A storage capacitor holds the gate voltage after the addressing phase.

Figure 1 shows a known pixel circuit for an active matrix addressed electroluminescent display device.   The display device comprises a panel having a row and column matrix array of regularly-spaced pixels, denoted by the blocks 1 and comprising electroluminescent display elements 2 together with associated switching means, located at the intersections between crossing sets of row (selection) and column (data) address conductors 4 and 6. Only a few pixels are shown in the Figure for simplicity.   In practice there may be several hundred rows and columns of pixels. The pixels 1 are addressed via the sets of row and column address conductors by a peripheral drive circuit comprising a row, scanning, driver circuit 8 and a column, data, driver circuit 9 connected to the ends of the respective sets of conductors.

The electroluminescent display element 2 comprises an organic light emitting diode, represented here as a diode element (LED) and comprising a pair of electrodes between which one or more active layers of organic electroluminescent material is sandwiched. The display elements of the array are carried together with the associated active matrix circuitry on one side of an insulating support.   Either the cathodes or the anodes of the display elements are formed of transparent conductive material.   The support is of transparent material such as glass and the electrodes of the display elements 2 closest to the substrate may consist of a transparent conductive material such as ITO so that light generated by the electroluminescent layer is transmitted through these electrodes and the support so as to be visible to a viewer at the other side of the support. Typically, the thickness of the organic electroluminescent material layer is between 100 nm and 200nm.   Typical examples of suitable organic electroluminescent materials which can be used for the elements 2 are known and described in EP-A-0 717446.   Conjugated polymer materials as described in WO96/36959 can also be used.

Figure 2 shows in simplified schematic form a known pixel and drive circuitry arrangement for providing voltage-programmed operation. Each pixel 1 comprises the EL display element 2 and associated driver circuitry.   The

driver circuitry has an address transistor 16 which is turned on by a row address pulse on the row conductor 4. When the address transistor 16 is turned on, a voltage on the column conductor 6 can pass to the remainder of the pixel. In particular, the address transistor 16 supplies the column

5   conductor voltage to a current source 20, which comprises a drive transistor 22 and a storage capacitor 24. The column voltage is provided to the gate of the drive transistor 22, and the gate is held at this voltage by the storage capacitor 24 even after the row address pulse has ended. The drive transistor 22 draws a current from the power supply line 26.

10   The drive transistor 22 in this circuit is implemented as a PMOS TFT, so that the storage capacitor 24 holds the gate-source voltage fixed. This results in a fixed source-drain current through the transistor, which therefore provides the desired current source operation of the pixel.

One problem with voltage-programmed pixels, particularly using

15   polysilicon thin film transistors, is that different transistor characteristics across the substrate (particularly the threshold voltage) give rise to different relationships between the gate voltage and the source-drain current, and artefacts in the displayed image result.

Various techniques have been proposed for compensating for these

20   threshold voltage variations. Some techniques perform in-pixel measurement of the drive transistor threshold voltage, and add this threshold voltage to the pixel drive signal, so that the combined drive voltage takes account of the threshold voltage. A pixel circuit to perform this requires two storage capacitors, one for the threshold voltage and one for the pixel drive voltage.

25   Additional switching transistors are also required to enable the threshold voltage to be measured, for example by discharging a capacitance across the gate-source of the drive transistor until it turns off.

Other proposed techniques perform measurement of the threshold voltage externally of the pixel array, and then compensate for the threshold

30   voltage by adjusting the pixel drive signals. These pixel circuits again require additional elements in order to enable signals to be provided to the external circuitry to enable the threshold voltage to be determined. For example, it has

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