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Wacyk et al.

(54) **AMOLED MICRODISPLAY DEVICE WITH ACTIVE TEMPERATURE CONTROL**

(75) Inventors: **Ihor Wacyk**, Hopewell Junction, NY (US); **Olivier Prache**, Hopewell Junction, NY (US)

(73) Assignee: **eMagin Corporation**, Hopewell Junction, NY (US)

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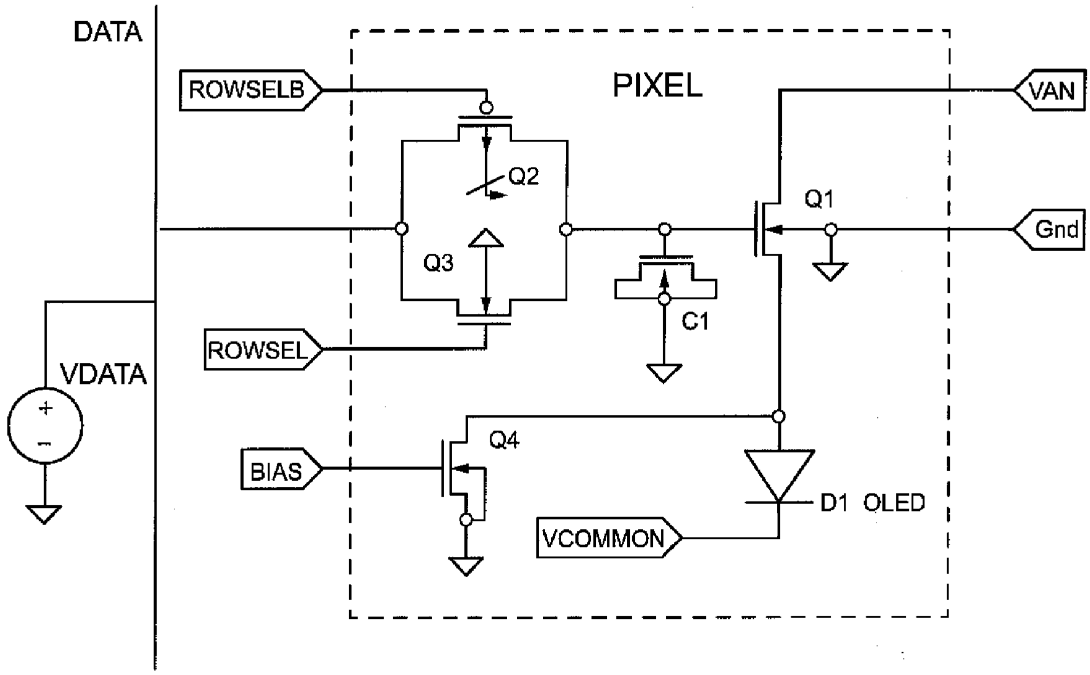
(57) **ABSTRACT**

An active-matrix organic light-emitting diode microdisplay device having a temperature control system including a temperature sensor and a control means for regulating the temperature of the OLED. The temperature is regulated by a bias transistor within the circuit, operating as a function of the temperature of the panel, such that low panel temperatures cause an increase in voltage of the bias transistor which draws a higher current through the top voltage drive transistor for self-heating the area surrounding the OLED.



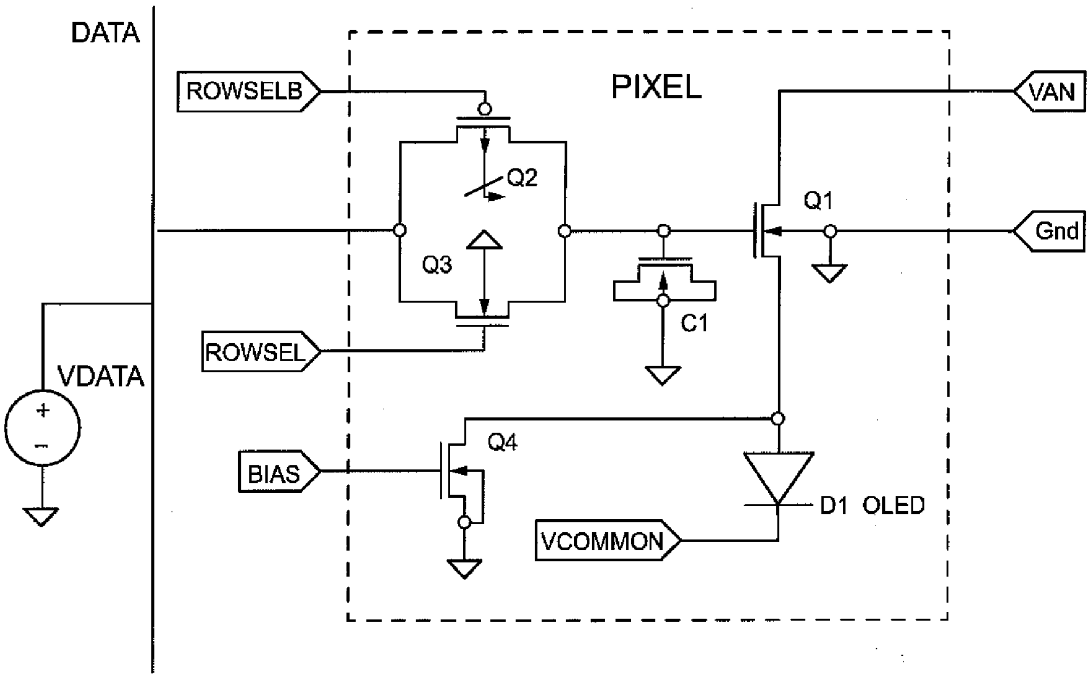

DATA
ROWSELB
PIXEL
VAN
Q2
Q1
Gnd
Q3
C1
ROWSEL
VDATA
+
−
Q4
BIAS
D1 OLED
VCOMMON

Fig. 1

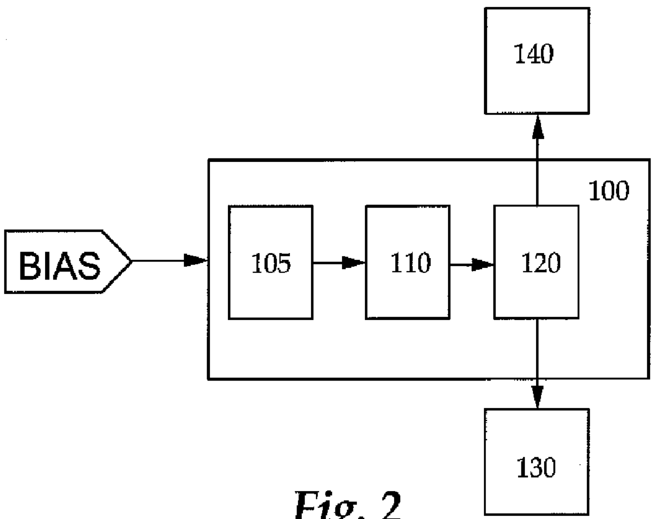

140
100
BIAS
105
110
120
130

Fig. 2

AMOLED MICRODISPLAY DEVICE WITH ACTIVE TEMPERATURE CONTROL

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of provisional patent application Ser. No. 61/470,788 filed in the U.S. Patent and Trademark Office on Apr. 1, 2011.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] This invention relates generally to pixel driver circuits for active-matrix organic light-emitting diode (AMOLED) displays and microdisplays, and more particularly, to such a circuit that includes active temperature control through the use of an on-chip heater to reduce the level of the voltage bias necessary to operate the display over a wide temperature range, especially below 0° C., and at high luminance levels.

[0004] 2. Description of the Related Art

[0005] Organic light emitting diode (OLED) devices are known to shift their current-voltage characteristics dramatically over temperature, with a large increase occurring at temperatures below 0° C. As a result, the silicon backplane must handle drive voltages that exceed the capability of typical CMOS technology. This is currently accomplished by applying a portion of the required bias voltage, namely the negative cathode supply, to all the pixels in common and tied to the silicon substrate ground potential. This approach provides the ability to operate AMOLED microdisplays over a wide temperature range (−50 to 70° C.) but at the expense of design complexity, additional external components, and limitations to the pixel size reduction.

[0006] The use of an on-chip heater to raise the OLED temperature rapidly above 0° C. at very low ambient temperatures will eliminate the need for a negative cathode supply. The heating can be supplied by applying power to a resistive thin-film located above the OLED layer, such as an indium-tin-oxide (ITO) layer, and regulating the power according to the ambient temperature.

[0007] While these units may be suitable for the particular purpose employed, or for general use, they would not be as suitable for the purposes of the present invention as disclosed hereafter. Specifically, the present invention raises the OLED temperature by dissipating power in actively controlled devices found in the silicon drive circuitry located below the OLED layer, such as the BIAS transistor used in the voltage pixel driver of the preferred embodiment.

[0008] It is, therefore, a primary object of the present invention to operate an AMOLED microdisplay over a wide temperature range (−50 to 70° C.) using the present and advantageous circuit design architecture without compromising design complexity, adding external components or limiting the pixel size reduction.

[0009] It is, therefore, a primary object of the present invention to provide a pixel circuit that reduces the voltage bias over a wide temperature range, especially below 0° C., and at high luminance levels.

[0010] It is, therefore, another object of the present invention to reduce the complexity and cost of the silicon backplane and external electronics used for the AMOLED microdisplay.

[0011] It is, therefore, another object of the present invention to provide a path to further miniaturization of the pixel drive circuit.

[0012] It is, therefore, another object of the present invention to operate the circuit over a more limited temperature range for the OLED, such that the optical performance of the AMOLED microdisplay is significantly improved.

BRIEF SUMMARY OF THE INVENTION

[0013] In accordance with one aspect of the present invention, a self-heating drive circuit for an active-matrix organic light-emitting diode (AMOLED) microdisplay device for use with a reference voltage source is disclosed. The OLED is operably connected to the reference voltage source through a NMOS drive transistor configured as a voltage follower.

[0014] The circuit includes a means for detecting the temperature of the microdisplay device and a means for reducing the voltage bias by controlling the forward bias of the drive transistor, thus heating the AMOLED as a function of the temperature of the microdisplay.

[0015] In accordance with an additional embodiment an active matrix organic light-emitting diode (AMOLED) microdisplay device is provided that includes a panel having a top voltage drive transistor, a bias transistor and an organic light-emitting diode. The device further includes a temperature control system in communication with the bias transistor.

[0016] The temperature control system has a temperature sensor for detecting the temperature of the panel and is capable of heating the organic light emitting diode when the temperature of the panel falls below a predetermined threshold temperature.

[0017] The temperature control system has a means for reducing the voltage bias by regulating the voltage of the bias transistor as a function of the temperature of the panel. Hence, low panel temperatures actuate an increased voltage of the bias transistor and draw a higher current through the top voltage drive transistor for self-heating the panel.

[0018] In accordance with an additional embodiment an active matrix organic light-emitting diode (AMOLED) microdisplay device is implemented with a temperature control means and management means.

[0019] The device includes a temperature sensor built into the silicon backplane of an AMOLED microdisplay device for measuring the temperature of the device and generating an output by a voltage control oscillator (VCO) as a temperature measurement signal.

[0020] The device further includes a temperature control system for controlling the voltages of the microdisplay device and receiving the temperature signal for transmitting a digital signal to a system processor. The system processor processes the digital signal corresponding to the temperature of the microdisplay device and generates temperature dependent reference signals for inputting to the control means. The control means is able to control the voltages of the microdisplay device in response to the temperature measurement signal.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0021] To these and to such other objects that may hereinafter appear, the present invention relates to an AMOLED microdisplay with active temperature control as described in detail in the following specification and recited in the annexed claims, taken together with the accompanying drawings, in which like numerals refer to like parts in which:

[0022] FIG. **1** is a schematic diagram of the NMOS source follower implementation of a pixel voltage drive circuit of the present invention having active temperature control within the drive circuitry.

[0023] FIG. **2** is a functional block diagram for showing the interface between the bias transistor of the drive circuit and the active temperature control system for controlling the voltages of the microdisplay of the present invention.

[0024] To the accomplishment of the above and related objects the invention may be embodied in the form illustrated in the accompanying drawings. Attention is called to the fact, however, that the drawings are illustrative only. Variations are contemplated as being part of the invention, limited only by the scope of the claims.

DETAILED DESCRIPTION OF THE INVENTION

[0025] The present invention is directed to an AMOLED microdisplay device with active temperature control.

[0026] FIG. **1** illustrates a pixel driver that is based on a voltage source consisting of a transistor Q1 and a storage capacitor C1. Transistor Q1 is preferably configured as an MOS transistor, and most likely an NMOS transistor. The voltage on the NMOS transistor sets the current in the organic light-emitting diode OLED D**1**. In its broadest context, the microdisplay includes a pixel area or panel having the top voltage drive transistor Q**1**, a bias transistor Q**4** and an OLED D**1**.

[0027] A transmission gate consisting of a transistor Q**2** and a transistor Q**3** acting as switches forms the data line access switch for the pixel. Both switches are closed by control signals ROWSELB and ROWSEL, respectively, during the programming phase in order to write data into the pixel. Both are opened at the end of the programming phase. In addition, the drain to substrate junction of transistor Q**4** forms a clamp diode that protects the rest of the pixel circuitry from short circuits across the OLED D**1**.

[0028] The microdisplay device is susceptible to a variety of disadvantages and drawbacks in functionality when the ambient temperature is low and most specifically below 0° C. The present invention includes a temperature control system **100** which self heats the OLED and panel thus providing the ability to operate AMOLED microdisplays over a wide temperature range (−50 to 70° C.) but without the expense of design complexity, additional external components, and limitations to the pixel size reduction. Specifically, the temperature control system **100** is a means for reducing voltage bias by controlling the forward bias of said drive transistor for heating the AMOLED as a function of the temperature of the microdisplay.

[0029] The temperature control system **100** (shown in FIG. **2**) is tied to the bias transistor Q**4** or bias pin. The circuit block is tied to the bias pin. The temperature control system includes a temperature sensor **105**, preferably on a backplane of the silicon wafer, for detecting the temperature of the panel. The temperature control system heats the OLED D**1** when the temperature of the panel is below a predetermined threshold temperature, generally in the range of 0° C. to −50° C.

[0030] The temperature control system **100** includes a control means **120** for regulating the temperature of the OLED D**1**, in order to keep temperature relatively constant and maximize performance. Specifically, the control means **120** is capable of reducing voltage bias by controlling the forward bias of said drive transistor for heating the AMOLED as a function of the temperature of the microdisplay. The temperature is regulated by the bias transistor Q**4** as a function of the temperature of the panel, such that low panel temperatures cause an increase in voltage of the bias transistor Q**4** which draws a higher current through the top voltage drive transistor Q1 for self-heating the area surrounding the OLED D1 and the panel. Thus, also heating the OLED D**1**.

[0031] Preferably, the control means **120** receives temperature data from the temperature sensor and in conjunction with a management means **130** processes when the temperature falls below a predetermined threshold temperature and increases the output voltage of the bias transistor Q**4**. The increase in voltage from the bias transistor Q**4** draws a higher current through the top voltage drive transistor Q1 and self heats the pixel area, thus raising the temperature of the OLED D**1**. When the control means **120** receives the temperature from the temperature sensor and the temperature is high, the management means **130** processes a decrease in the output voltage of the bias transistor Q**4**, thus lowering the current through transistor Q1.

[0032] In one embodiment, the control system **100** works in conjunction with a management means **130**. Specifically, in this embodiment, the temperature sensor measures the temperature of the microdisplay and generates an output by a voltage control oscillator **110** (VCO) as a temperature measurement signal. Here, the temperature control system, controls voltages of the microdisplay device and receives the temperature signal for transmitting a digital signal to a system processor **140**. The system processor processes the digital signal corresponding to the temperature of the microdisplay device to generate temperature dependent reference signals for inputting to the control means **120** for controlling the voltages of the microdisplay device in response to the temperature measurement signal.

[0033] The present microdisplay device therefore utilizes the advantages present with the increased current drawn from the top voltage drive transistor Q**1** to self-heat the OLED D**1** without affecting the signal to the OLED D**1**. This is unique and uncharted in the industry where it is uncommon to increase the current through transistor Q**1** and bias transistor Q**4**, which is commonly fixed by the VCOMMON pin. However as discovered, the current prior art creates a plurality of disadvantages including use of specific silicon technologies to provide a means through the VCOMMON pin. In the present invention, rather than utilize VCOMMON tied to the ground or another small voltage, the present invention regulates the existing voltage through transistor Q**1** and bias transistor Q**4**, thus taking advantage of current circuit design architecture.

[0034] In conclusion, herein is presented an AMOLED microdisplay device having active temperature control. The invention is illustrated by example in the drawing figures, and throughout the written description. It should be understood that numerous variations are possible, while adhering to the inventive concept. Such variations are contemplated as being a part of the present invention. while only a limited number of preferred embodiments of the present invention have been disclosed for purposes of illustration, it is obvious that many modifications and variations could be made thereto. It is intended to cover all of those modifications and variations, which fall within the scope of the present invention as defined by the following claims.

We claim:

1. A self-heating drive circuit for an active-matrix organic light-emitting diode (AMOLED) microdisplay device for use with a reference voltage source, said OLED being operably connected to said reference voltage source through a NMOS drive transistor configured as a diode, said circuit comprising:

a means for detecting temperature of said microdisplay device and means for reducing voltage bias by controlling the forward bias of said drive transistor for heating the AMOLED as a function of the temperature of the microdisplay.

2. An active matrix organic light-emitting diode (AMOLED) microdisplay device, comprising:

a panel having a top voltage drive transistor, a bias transistor and an organic light-emitting diode; and

a temperature control system in communication with said bias transistor;

wherein said temperature control system comprises a temperature sensor for detecting the temperature of said panel;

wherein said temperature control system heats the organic light emitting diode when the temperature of said panel is below a predetermined threshold temperature;

wherein said temperature control system includes a means for reducing the voltage bias by regulating the voltage of said bias transistor as a function of said temperature of said panel, such that low panel temperatures actuate an increased voltage of said bias transistor and draw a higher current through said top voltage drive transistor for self-heating said panel.

3. An active matrix organic light-emitting diode (AMOLED) microdisplay device implemented with a temperature control means and management means, comprising:

a temperature sensor disposed directly on a backplane of a silicon wafer of an AMOLED microdisplay device for measuring a temperature of said microdisplay device and generating an output by a voltage control oscillator (VCO) as a temperature measurement signal;

a temperature control system for controlling voltages of said microdisplay device and receiving said temperature signal for transmitting a digital signal to a system processor; and

said system processor processing said digital signal corresponding to said temperature of said microdisplay device to generate temperature dependent reference signals for inputting to a said control means for controlling said voltages of said microdisplay device in response to said temperature measurement signal.

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专利名称(译)	具有主动温度控制的Amoled微显示器件		
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当前申请(专利权)人(译)	eMagin公司		
[标]发明人	WACYK IHOR PRACHE OLIVIER		
发明人	WACYK, IHOR PRACHE, OLIVIER		
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其他公开文献	US9489887		
外部链接	Espacenet USPTO		

摘要(译)

一种有源矩阵有机发光二极管微显示器件，具有温度控制系统，该温度控制系统包括温度传感器和用于调节OLED温度的控制装置。温度由电路内的偏置晶体管调节，作为面板温度的函数运行，使得低面板温度导致偏置晶体管的电压增加，从而通过顶部电压驱动晶体管吸收更高的电流 - 加热OLED周围的区域。