FLEXIBLE LIGHT EMITTING CONTROLLABLE DEVICE BASED ON MEMRISTOR

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Abstract- In this paper, a novel flexible lighting circuit controllable a light emitting device (LED) through memristive switching is proposed. The proposed device is fabricated on ITO coated PET substrate through printed technique, which is able to control a light state of the LED to either ON or OFF resistance value of the memristor. In the construction of the proposed LED circuit device, a high current memristor of milli-ampere current is connected with the LED in parallel, and they are connected in series with an organic printed resistor. The most current is bypassed through the memristor with ON resistance value when LED is required to be OFF, and LED is turned on a light when the memristor is switched OFF resistance value. The operating voltage is 10 V and control voltage is ±14 V. The maximum light intensity in the ON state of LED was 0.4 lux, and light intensity in the OFF state was 0 lux. The response time of the LED is 25 seconds. We are sure the proposed light device can be used in low speed electronic display applications.

Index Terms- Memristor, light emitting device, resistance, flexible, printed technique.

I. INTRODUCTION

In recent years, there has been tremendous interest in all-printed electronics as a means of achieving ultra-low-cost electronic circuits with usage in displays and disposable electronics applications [1]. Low cost and easy to fabricate features of printed electronic displays also open doors to disposable displays and banner boards [2]. It is convenient to print very thin light emitting devices (LEDs) on a paper or plastic substrate by using printed technology, to be used in disposable lighting devices and displays including medicine packages, food packages and wrappers to show the details. This kind of display needs a memory unit for the storage of information. If the memory is within a display cell, it can reduce cost, complexity and size of the display unit [3]. In the literature relating to display, LEDs are normally controlled with transistors, that is, a separate memory unit is interfaced with display [4].

In this paper, we propose a novel approach of controlling a light emitting device (LED) with memristive switching. It is a fully printed circuit on plastic substrate through electrohydrodynamic (EHD) technique and capable to memorize the state of LED to either ON or OFF. In the construction of LED control cell, a high current memristor of milli-ampere (mA) current is connected with the LED in parallel and both are connected in series with an organic printed resistor as the schematic diagram is shown in Fig. 1(a). The LED's current is bypassed through memristor when LED is required to be OFF.

II. PROPOSED LIGHT EMITTING CIRCUIT

In Fig. 1(a), memristor is connected in parallel with light emitting device hence voltage across both the devices is the same. Organic printed resistor is connected in series to drop excessive voltage as detailed explanation shown in Fig. 1(a). The internal resistance of the light emitting device is 2500 Ω, the memristor's high state resistance (HRS) is 2100 Ω and low state resistance (LRS) is 230 Ω. Memristor is switched from HRS to LRS by applying 14 V and from LRS to HRS is switched by applying -14 V at the device input terminals. When the memristor is in HRS state the equivalent resistance of the parallel combination is 1140 Ω whereas in case of memristor's LRS state, the equivalent resistance is 210 Ω. The value of series resistor is fixed at 400 Ω. By applying the operating voltage of 10 V to the device while memristor is in HRS state, voltage across the parallel combination becomes 7.5 V hence 2.5 V is dropped across series resistor, this is the ON state of LED. The current flows through the LED, and light emission is started. When the memristor is switched from HRS to LRS state, equivalent resistance of the parallel combination of resistor and memristor (LRS) is 210 Ω, hence voltage drop across the light emitting device is 3.4 V, the LED is unable to emit light as maximum current flows through the bypass memristor due to its least resistance. By controlling the state of memristor, the light emission is controlled. This printed LED control circuit can be interface with any OLED to control switching with in a pixel of display panel, however we interfaced with a low speed light emitting single layer device in this research work.

Resistor was made by utilizing poly(3,4-ethylenedioxy thiophene):poly(styrenesulfonate) (PEDOT:PSS) and silver (Ag) nano particles. Memristor was prepared by mixing zirconium oxide (ZrO_2) and Poly[2-methoxy-5-(2-ethylhexy loxy)-1,4-phenylenevinylene] (MEH:PPV). The proposed LED was fabricated by using

[Ru(bpy)3]2+(PF_6)2 and poly(methyl methacrylate) which has a single layer, unlike multi layers ordinary organic light emitting diode (OLED) structure. All these components were developed through EHD fabrication facility and top electrode of memristor and LED was deposited through aluminum sputtering.

Layout and components placement diagram is shown in Figs. 1(b) and 1(c). Ligh controlable LED printed circuit through memristive switching device is fabricated on a patterned ITO coated polyethylene terephthalate (PET) substrate and encapsulated with Polydimethylsiloxane (PDMS) material as shown in Fig. 2.

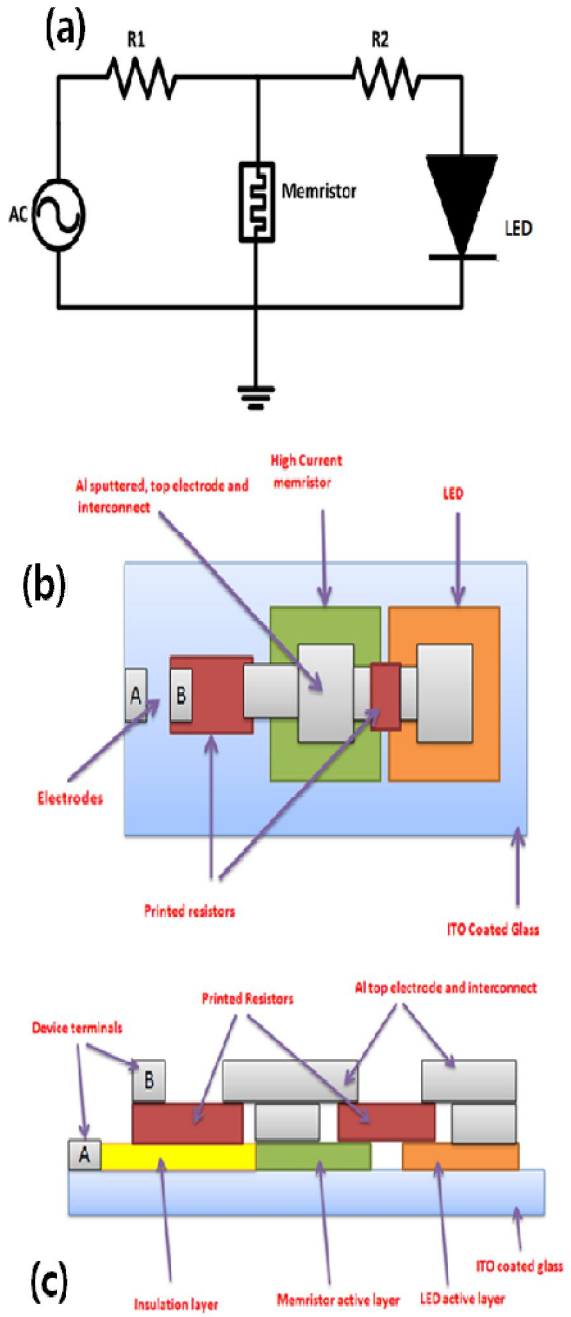


Fig. 1. (a) Schematic diagram of the proposed device. (b) Top view of components placement and layout of the circuit. (c) Cross section view of the circuit.

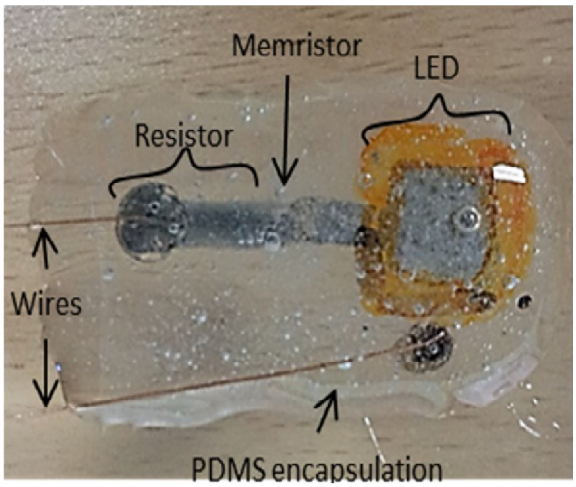


Fig. 2. Proposed device fabricated on PET substrate encapsulated with PDMS (25 mm×10 mm).

III. CHARACTERIZATION

Each component was characterized for their functionality by using Agilent B1500A Semiconductor Device Analyzer. At first, probes were connected to high current memristor, a voltage sweep from -8 V to 8 V with 20 mA current compliance (cc) was applied, and the device showed good state memorizable memristive behavior with R_{OFF}/R_{ON} > 10. This measurement process was repeated for 20 endurance cycles as shown in Fig. 3(a). Organic printed resistor was characterized by using the same probe station, and applied voltages from 0 V to 15 V are swept with current compliance of 100mA. The resistor has a linear relationship between current and voltage with ohmic value of 395 Ω as shown in Fig. 3(b). The fabricated LED was analyzed by applying a variable voltage source and a lux meter inside a black box to characterize the light intensity of the device as shown in Fig. 3(c). The LED emits light from 4 V, and light intensity is safely increased till 0.96 lux on 12 V. The response time of the LED was analyzed by applying fixed 10 V and recording light intensity along the time as shown in Fig. 3(d).

After confirmation of individual components characterization, the proposed circuit in Fig. 1(a) was verified for its functionality. A variable voltage source was applied across the device and light intensity was recorded with lux meter in a dark box. When the memristor was kept in HRS state to allow maximum current through LED, light intensity was increasingly observed along the input voltage increments. The light intensity was 0.4 lux till this value the memristor was in HRS state (OFF) as the input voltage crossed 10 V, the memristor transition from HRS to LRS started and light intensity was decreased as shown in Fig. 4(a). At input of 14 V, the memristor was fully switched into LRS state (ON) and allowed maximum current through it, hence the current flow through LED was minimum and light intensity approached 0 lux. Voltage across the memristor and LED was recorded along the input voltage sweeps as shown in Fig. 4(b).

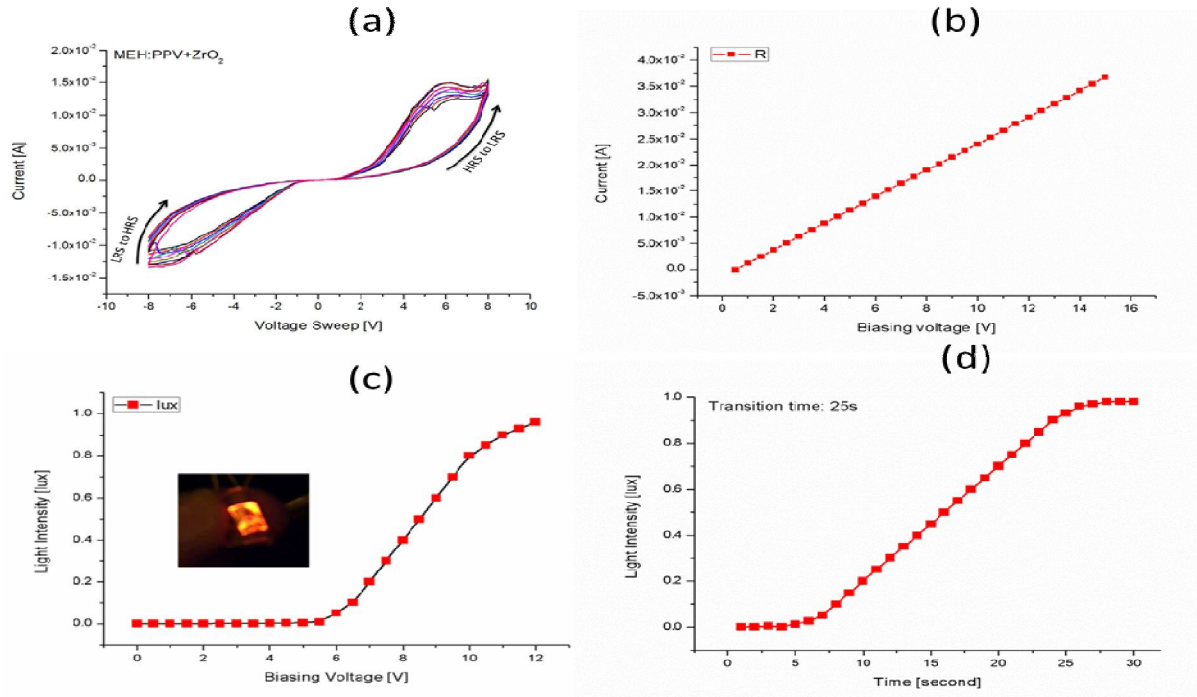


Fig. 3. (a) Current-voltage (I-V) curves of the fabricated memristor. (b) Current-voltage (I-V) curve of the organic printed resistor. (c) Light intensity curve of the LED. (d) Response time analysis of the LED.

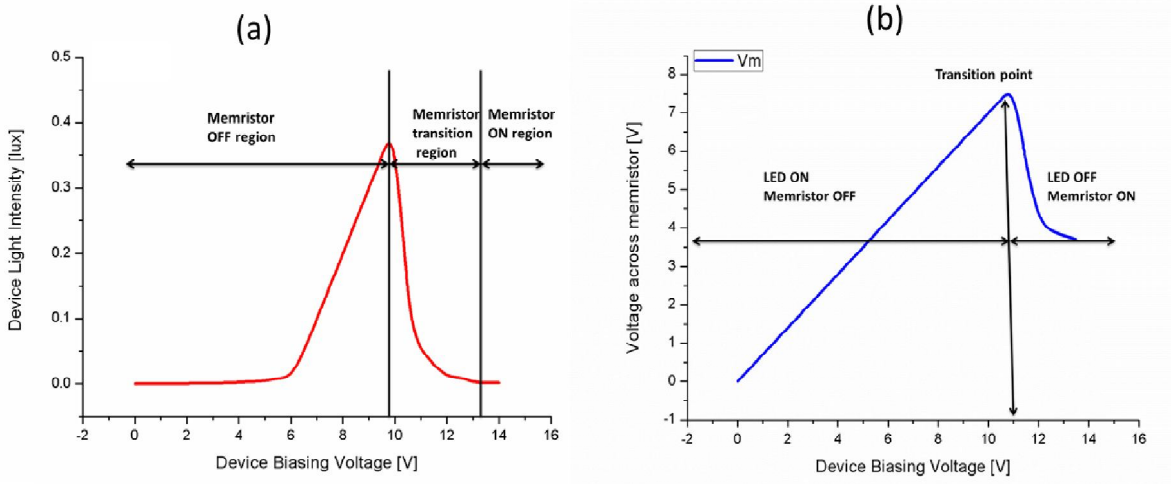


Fig. 2. (a) Device functionality diagram for analysis of light intensity by biasing voltage. (b) Voltage across the memristor along biasing voltage.

Once the device is switched in either state ON or OFF by applying ±14 V, it will retain its last state even if the input voltage is not connected. Applying 10 V to the circuit, it will give output according to the previous state. The proposed device can be fabricated as dot matrix LED on plastic or paper substrate.

CONCLUSION

We have proposed a novel light controllable LED circuit with memristive switching. The device was fabricated with EHD technique on a patterned ITO coated PET substrate. The device dimensions were 25 mm×12 mm. The operating voltage is 10 V and control voltage is ±14 V. The maximum light intensity in the ON state of LED was 0.4 lux, and light intensity in the OFF state was 0lux. The response time of the LED is 25 seconds, it can be used in low speed electronic display applications.

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