Advanced Active Matrix Micro LED Driving Technology with Thin Film Transistors

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ABSTRACT

We proposed the thin-film transistor (TFT)-based pixel circuit with pulse width modulation (PWM) for the μLED displays. The PWM was applied to overcome wavelength shifts and use tens of μA current in considering EQE characteristics. The proposed circuit represented the gray level by controlling emission time using PWM data (V_{DATA_PWM}).

1 Introduction

Micro light-emitting diode (μLED) displays have been widely researched as a promising candidate due to the advantages of low power consumption, lightweight, long lifetime, and miniaturization [1]. In general, the organic light-emitting diode (OLED) pixel circuit uses a pulse amplitude modulation (PAM), which represents the gray level by the amount of current density [2]. However, gray level representations are impossible because of the wavelength shift when PAM is applied to the μLEDs [3]. Therefore, to avoid luminance distortion of μLEDs, the gray level representation should be achieved with a constant current. In addition, the μLEDs have a current region, which is maximum external quantum efficiency (EQE) [4]. Therefore, new driving technologies and circuit designs are required to utilize a high current range that can utilize the maximum EQE of μLEDs.

Meanwhile, thin-film transistor (TFT)-based backplane can be applied to both modular and mother glass types compared to the conventional PCB and silicon chip-based backplane. In addition, it is possible to implement a display of various sizes and compensate for the image quality of each pixel. Accordingly, studies on TFT-based driving circuits and new driving technologies are being variously conducted [3].

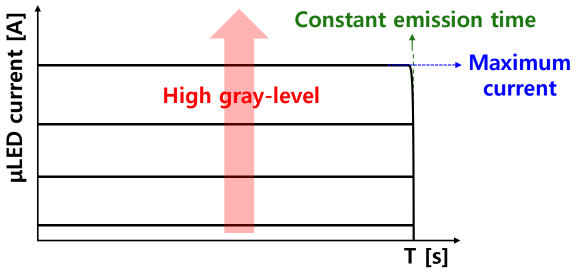
In this paper, we proposed the TFT-based μLED pixel circuit using pulse width modulation (PWM) driving to overcome the wavelength shift. The proposed pixel circuit represented the gray level by modulating the emission time using PWM data (V_{DATA_PWM}) and Sweep signal with constant tens of μA current. When the μLEDs emit light, the power consumption can be reduced using PWM and a high EQE region in the proposed pixel circuit. The pixel circuit compensated for the threshold voltage (V_{TH}) of the driving-TFTs for luminance uniformity.

2 PWM Driving Method

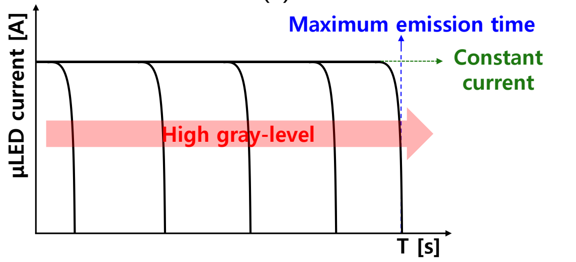
Fig 1 depicts the PAM and PWM driving methods. As mentioned earlier, the OLED usually use the PAM driving for gray level representations. The PAM is achieved by adjusting the current density of driving-TFT with constant emission time as shown in Fig. 1(a). However, in the PWM driving, the gray level is expressed by modulating the emission time, and it fixed the μLED current as shown in the Fig 1(b). In addition, the emission time can be adjusted to when it is to consider a high current range to implement maximum EQE. Therefore, the PWM driving is adopted to improve wavelength shifts and use the high EQE region.

3 TFT-Based μLED pixel Circuit

Fig. 2(a) indicates the TFT-based μLED pixel circuit with PWM. The proposed circuit consists of PWM and constant current generation (CCG) units. The PWM unit determines the gray level and the CCG unit fixes the constant current level of μLEDs. The T1 and T2 are the driving-TFTs of each unit. The internal compensation structure was applied to the proposed circuit. Fig. 2(b) shows the operations of V_{TH} compensation, PWM data and CCG data inputs, and μLED emission.

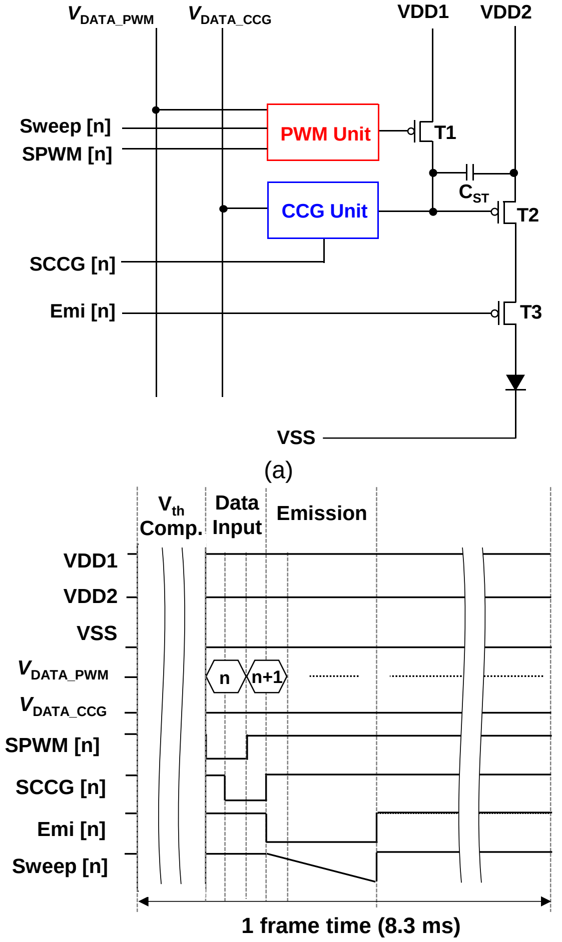


(a)



(b)

Fig. 1 (a) PAM, and (b) PWM driving methods.



(b)

Fig. 2 TFT-based μLED pixel circuit using PWM driving: (a) schematic and (b) timing diagram.

4 Conclusion

We proposed a TFT-based pixel circuit using PWM driving for the μLED displays. The PWM was applied to improve wavelength shifts and use tens of μA current in considering EQE characteristics of μLED. The proposed pixel circuit is composed of PWM and CCG units. The μLED pixel circuit represented the gray level by controlling the emission time using V_{DATA_PWM} and Sweep signal with constant μLED current. The power consumption can be decreased by using PWM and a maximum EQE when the μLEDs emit light in the proposed circuit. The internal compensation structure was applied to overcome luminance distortion by driving-TFTs in the proposed circuit.

Acknowledgement

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