A Universal Evaluation Scheme of Pixel-Level Brightness Uniformity for Micro OLED

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ABSTRACT

A universal evaluation scheme of the pixel-level brightness uniformity for Micro OLED is proposed and verified. The current Micro OLED with the best microscopic visual effect has a uniformity of 92%. And the uniformity value trend is consistent with the trend of the microscopic visual effect of the human eye.

1 Introduction

When Micro OLED is used in AR/VR, the near-eye display function is realized with the help of the picture amplification of optical systems (a virtual image of about 80 inch at 3 meters) [1, 2]. In the process of picture amplification, the user experience is affected by the pixel-level brightness difference of Micro OLED to varying degrees, which is caused by the uneven size of driving MOS transistor [3, 4]. Therefore, it is particularly urgent to quantitatively evaluate the pixel-level brightness uniformity of Micro OLED and assist to improve the user experience.

The existing evaluation standard of pixel-level brightness uniformity (3* Sigma criterion) is only applicable to the condition that the frequency distribution of pixel-level brightness is normal distribution [5, 6]. In order to universally evaluate the uniformity of pixel-level brightness (normal distribution and non-normal distribution of frequency distribution) of Micro OLED, and help improve the user experience of products.

In this work, A universal evaluation scheme for the pixel-level brightness uniformity of Micro OLED is proposed and verified, which can be used to quantitatively evaluate the pixel-level brightness uniformity of Micro OLED universally and help improve the user experience of products.

2 Evaluation scheme

The uneven size of the driving MOS transistor for Micro OLED will cause pixel-level brightness difference in the display screen [3, 4], as shown in Fig. 1.

According to the pixel-level brightness frequency distribution, the pixel-level brightness distribution trend of Micro OLED can be divided into the optimal distribution, normal distribution and abnormal distribution, as shown in Fig. 2.

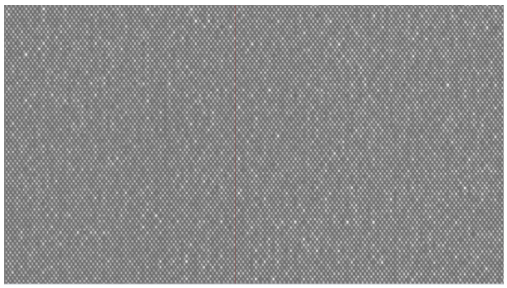


Fig. 1 Pixel-level brightness difference

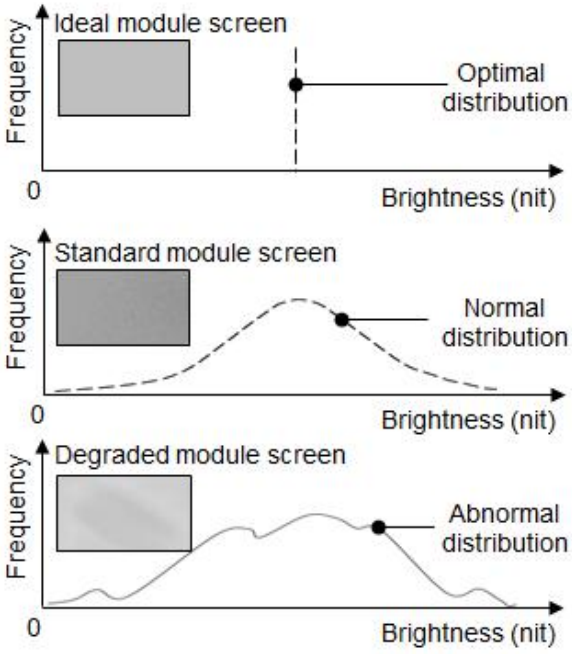


Fig. 2 Pixel-level brightness frequency distribution corresponding to different modules

The pixel-level brightness uniformity of Micro OLED with the normal distribution of pixel-level brightness frequency can be evaluated by 3*sigma evaluation scheme. In the 3*sigma evaluation scheme, the calculation expression of the brightness uniformity value of Micro OLED is as follows [5, 6].

$$\text{Uniformity}=1-(3*\text{Sigma})/(\text{Ave.})$$

$$\text{Sigma}=\sqrt{\frac{1}{N}\sum_{i=1}^{N}(L_i-\text{Ave.})^2}$$

Where, *N* is the total number of pixels in the sample's

display region, L_i is the brightness value of the *i*th pixel, and Ave. is the pixel-level brightness mean value of the sample's display region.

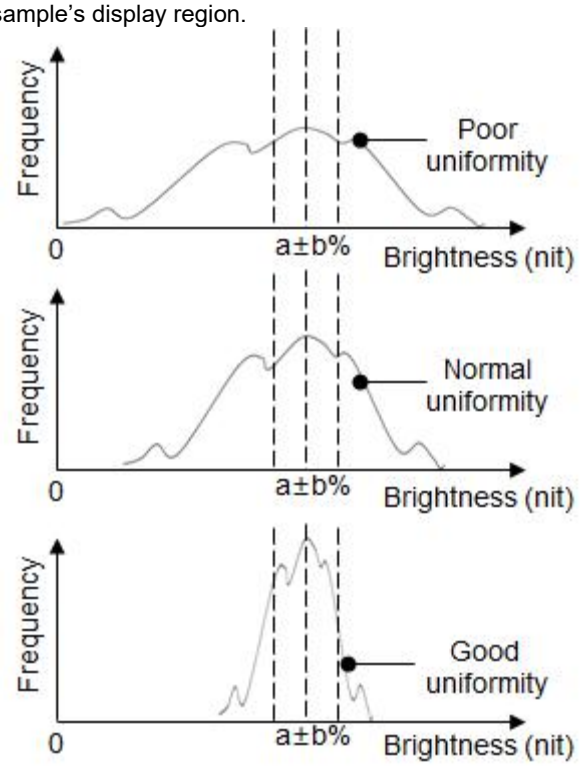


Fig. 3 Pixel-level brightness frequency distribution corresponding to different uniformity

The 3*sigma evaluation scheme will no longer be applicable for the abnormal distribution of pixel-level brightness frequency. Therefore, in order to universally and quantitatively evaluate the uniformity of pixel-level brightness (frequency distribution, normal distribution and abnormal distribution) and assist in improving the product user experience, a universal evaluation scheme of pixel-level brightness uniformity for Micro OLED is to be proposed.

As can be seen from Fig. 3, the more concentrated the brightness frequency is to the mode, the better the uniformity performance is. Therefore, the quantitative evaluation scheme of Micro OLED pixel-level brightness uniformity is proposed as follows. The ratio of the number of pixels with brightness in the range of a± b (a is the brightness mode, and b is 5% tentatively) to the number of sampling pixels is the uniformity value, so as to realize the universality evaluation scheme (as shown in Fig. 4).

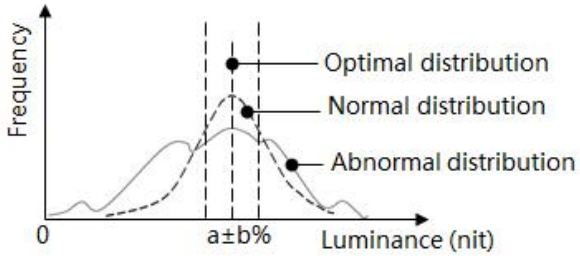


Fig. 4 Universality evaluation scheme

3 Scheme verification

The proposed evaluation scheme is verified by comparing the uniformity value trend with the microscopic visual effect trend for different modules. As shown in Table 1, the trend of the pixel-level brightness uniformity value is consistent with the trend of the microscopic visual effect of the human eye for different modules. The more concentrated the brightness frequency to the mode, the better the uniformity performance and the better the microscopic visual effect of the human eye for different modules.

Table 1 Verification results of different modules.

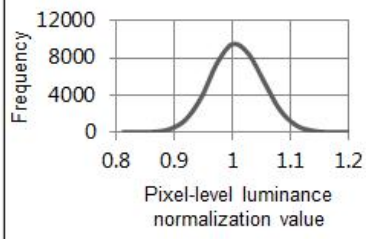
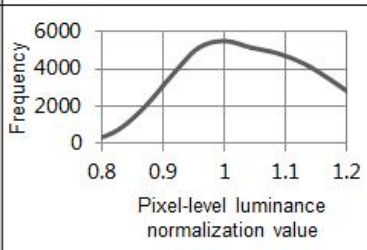
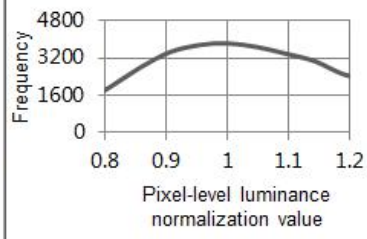
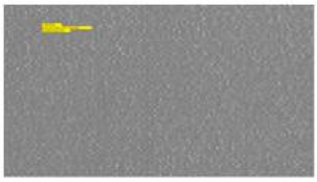
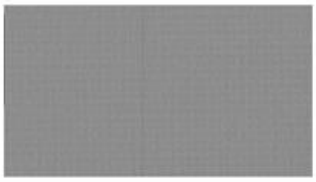
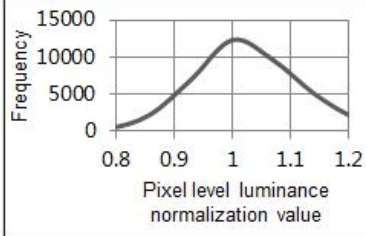
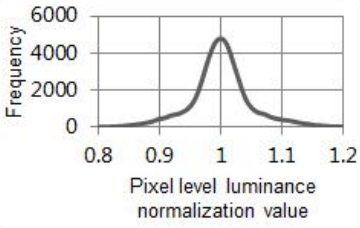
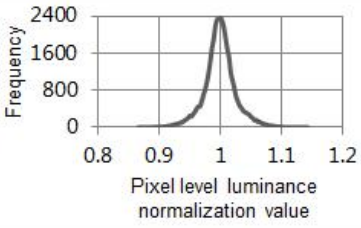
Item	Sample A	Sample B	Sample C
Microscopic visual effect of human eye			
Pixel-level brightness frequency distribution curve			
Pixel-level brightness uniformity value	64%	40%	29%

Table 2 Verification results of same module.

Item	16th gray scale of sample D	32th gray scale of sample D	64th gray scale of sample D
Microscopic visual effect of human eye			
Pixel level brightness frequency distribution curve			
Pixel level brightness uniformity value	31%	73%	92%

On the other hand, the proposed evaluation scheme is verified by comparing the uniformity value trend with the microscopic visual effect trend for the same module's different gray scales. As shown in Table 2, the trend of the pixel-level brightness uniformity value is consistent with the trend of the microscopic visual effect of the human eye for the same module's different gray scales. The more concentrated the brightness frequency to the mode, the better the uniformity performance and the better the microscopic visual effect of the human eye for the same module's different gray scales.

4 Conclusions

The existing Micro OLED pixel-level brightness uniformity evaluation scheme (3*sigma criterion) is only applicable to the case that the pixel-level brightness frequency distribution is normal distribution. A universal evaluation scheme for pixel-level brightness uniformity of Micro OLED is proposed and verified. The current micro OLED with the best visual effect has a pixel-level brightness uniformity of 92%. And the trend of the pixel-level brightness uniformity value is consistent with the trend of the microscopic visual effect of the human eye. The proposed evaluation scheme can be used to quantitatively evaluate the pixel-level brightness uniformity of Micro OLED universally and improve the user experience of products.

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