GaN-based Active-matrix Micro-LED Display with improved ACR

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In recent years, displays do not restricted to the form of a flat panel. Many future applications, such as immersive stage show, AR glass and smart watch, all require good outdoor display quality and stability [1]. Ambient contrast ratio (ACR), which means the contrast ratio in the presence of ambient light, becomes a significant factor for emis-sive display [18]. ACR has already been widely applied to estimate the sunlight reada-bility of transflective liquid crystal displays (LCDs). However, the results are usually not good enough because of the low light efficiency of LCD-based products [2]. Then this concept is also extended to other flat panel displays (FPDs) like OLED. But OLED is not suitable for outdoor applications because of the relatively lower efficiency and faster degradation under high-current density, which may result in the insufficient brightness [3]. Moreover, the instability of organic material makes it undesirable to be exposed to the ambient environment like high temperature or high humidity conditions [4]. Mini-LED and micro-LED displays, with the significant advantages of high brightness and good stability, are expected to be superior for outdoor applications [5].

In this work, the fabrication and characterization of micro-LED displays with pixel pitch of 10 μm, 15 μm, 30 μm and 60 μm, were reported. The principle of ACR was il-lustrated to form the specific model for LED-based display. Micro-LED and mini-LED (provided by Refond Optics). panels were systemically analyzed and compared to eval-uate the outdoor performance. Three methods, including optical method, anti-reflection coating and structure optimization were proposed to improve the ACR of LED-based display. Besides, micro-LED technology will be introduced in detail, including the development history, the characteristic advantage, the technical key, the fabrication process, the challenge and the application. And many specific aspects such as driving mechanism, pixel miniaturization, size-dependent effect, and so on will be summarized and analyzed. Detailed characterization was carried out, including abundant factors of series resistance, ideal factor, brightness, uniformity for devices. At last, prototypes of AM driving micro-LED micro-display with 3175 PPI were achieved, and the resolutions are 1300×720 and 1000×1000. The characterization of EL spectrum, absorption spectrum, CIE coordinates and view angle for the panel were measured and investigated, as well as the reliability test under three extreme conditions, long aging, high temperature and high humidity. Protection packaging methods and heat dissipation method were also explored to avoid the demo from mechanical damage, as well as the operation aging test to show good reliability for long time working.

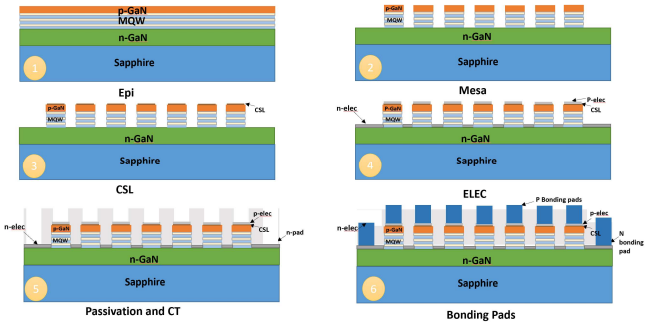

Fig. 1. Process flow of fabrication micro-LED pixel array

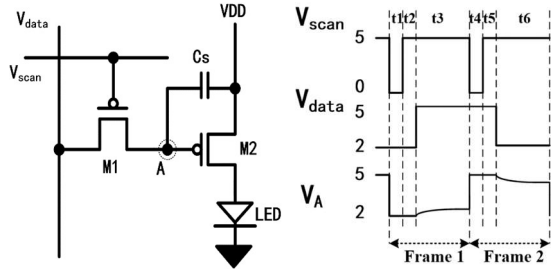

Fig 2. Schematic of a 2T1C AM pixel circuit and (b) the timing diagram of two frames. The pixel in first frame is ON and in second frame is OFF

Fig 3. photos of the display result of micro-LED display.

References

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