

# Nova MicroLED for Next-Generation Display Applications

Kuan Yung Liao, Jing Liang Lin, Sheng Yuan Sun and Yun-Li Li

PlayNitride Inc., Miaoli, Taiwan

## Abstract

*MicroLED, a next-generation display technology, offers ultra-high brightness, a wide color gamut, superior efficiency, and high reliability. However, its integration with active-matrix (AM) backplanes has faced challenges related to power efficiency and thermal management. To address these limitations, PlayNitride introduces Tantium microLED, an advanced tandem microLED architecture. By optimizing current efficiency and minimizing power loss in LTPS-TFT backplanes, Tantium microLED enhances overall panel performance while maintaining seamless compatibility with existing mass transfer and driving technologies. This paper presents the development, evaluation, and advantages of Tantium microLED, highlighting its potential to accelerate the commercialization of microLED displays.*

## Author Keywords

MicroLED; Emissive Display; Modular; Tandem

## 1. Introduction

MicroLED technology has emerged as a leading candidate for next-generation displays due to its outstanding characteristics, including high pixel density, exceptional brightness, superior reliability, and environmental adaptability. For instance, PlayNitride has demonstrated a 5,600 PPI, 0.18" micro-display, showcasing the feasibility of ultra-high-resolution applications. The unique material properties of microLED enable exceptionally high brightness levels—exceeding one million nits in micro-displays and over 10,000 nits in automotive applications. Moreover, as gallium nitride (GaN) is a single-crystalline material, microLED displays exhibit unparalleled reliability and energy efficiency, aligning well with ESG (Environmental, Social, and Governance) sustainability principles.

Recent advancements have demonstrated the versatility of microLED technology. AUO and PlayNitride have developed rollable microLED displays, AUO and LG have introduced 3D stretchable displays, and Samsung Electronics has unveiled seamless splicing microLED panels. PlayNitride has further showcased 145" tiling microLED displays, transparent microLED panels, HDR displays, and ultra-high-resolution 5,600 PPI full-color micro-displays. These developments indicate that manufacturing challenges are being overcome, paving the way for mass production.

Despite these advances, a key challenge remains: power efficiency in LTPS-TFT-driven microLED displays. Due to the high impedance of LTPS-TFTs, significant power dissipation occurs, resulting in thermal buildup that limits device performance and longevity. This paper introduces Tantium microLED, a novel architecture designed to address these limitations by significantly enhancing current efficiency and reducing power loss.

The conventional LTPS-TFT driving architecture controls microLED brightness by modulating the TFT gate voltage, thereby regulating the current flowing into the microLED.

However, in this setup, the high-impedance TFT acts as a series resistor, leading to considerable power loss. Given that:

- The forward voltage of microLEDs is relatively low (Blue/Green: around 2.5V and Red: around 2.0V),
- The drain-source saturation voltage ( $V_{DS,sat}$ ) of LTPS-TFTs is around 3–4V,
- Approximately 60% of total power is dissipated in the TFT rather than used for light emission.

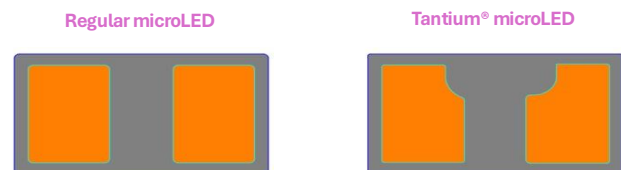
This inefficient power usage is converted into heat, significantly impacting high-brightness operation. Addressing this problem is crucial for optimizing display power consumption and efficiency.

To solve this issue, Tantium microLED employs an innovative internal tandem structure that enhances current efficiency (cd/A) while maintaining compatibility with existing display architectures. This structure reduces power loss by enabling more efficient current distribution, thus improving thermal management and overall panel performance.

## 2. Results and discussion

### 2.1. Current Efficiency Enhancement

To validate the effectiveness of Tantium microLED, we fabricated material test pieces (MT) and conducted extensive performance evaluations. Figure 1 illustrates the pad design of conventional microLED and Tantium microLED. The key objectives of these experiments were to quantify efficiency gains and assess power savings under different operating conditions.

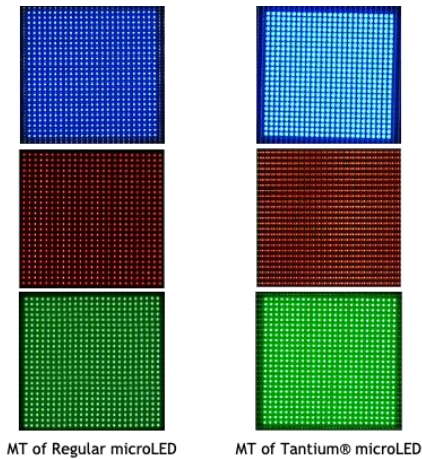


**Fig.1** Pad design of Normal microLED and Tantium microLED

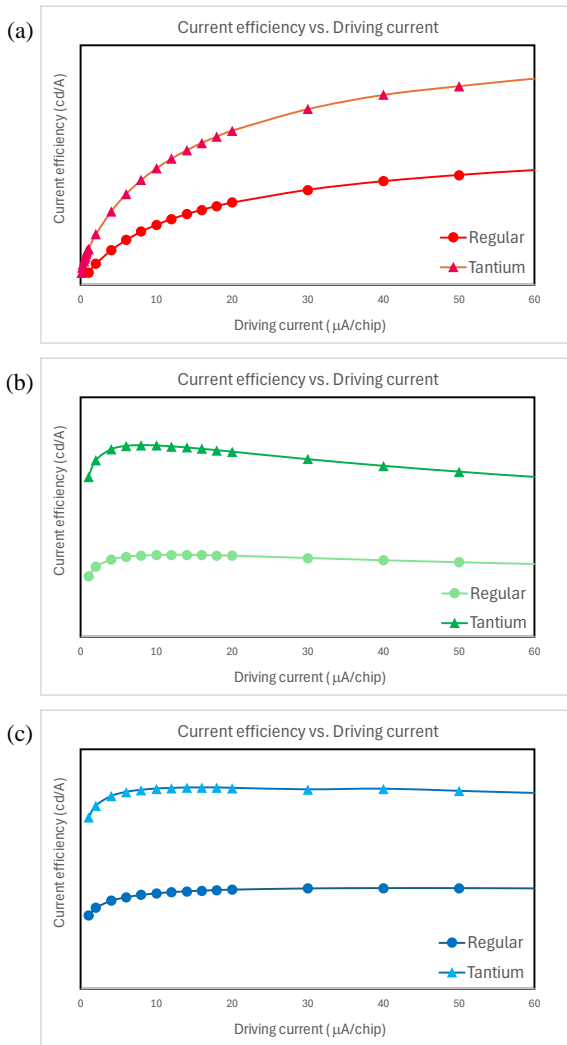
Experimental results (Figures 2 & 3) demonstrate that with a 10 $\mu$ A driving current, Tantium microLED achieves:

- 1.95 $\times$  of current efficiency improvement in red,
  - 2.35 $\times$  of current efficiency improvement in green,
  - 2.1 $\times$  of current efficiency improvement in blue
- compared to conventional microLEDs. The enhancement is contributed by not only chips in series but also the raise of current density while driving Tantium microLED.

The data indicated that Tantium microLED maintains a consistently higher efficiency across all tested conditions. This suggests that Tantium microLED offers particularly advantageous for high-brightness applications such as automotive displays.



**Fig.2** Light on results of MT with regular (left) and Tantium (right) microLED

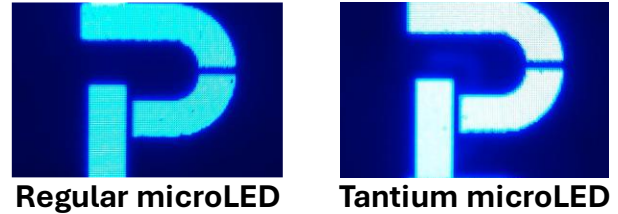


**Fig.3** The current efficiency vs. driving current with (a) red, (b) green and (c) blue MT samples

## 2.2. AM Panel Integration and Power Reduction

Tantium microLED was further evaluated on LTPS-TFT active-matrix backplanes. Figure 4 compares the brightness of conventional and Tantium microLED panels under identical data voltage conditions. Due to its enhanced current efficiency, the Tantium panel required an ELVSS adjustment of -2.0V compared to conventional microLED panels.

Power consumption measurements showed that, when driven at the same luminance, the Tantium microLED panel consumed 25.3% less power than the regular microLED panel, indicating a significant efficiency gain of 74.7% relative to conventional technology.



**Fig.4** The brightness difference between regular (left) and Tantium (right) microLED on AM backplane with the same data voltage

## 3. Conclusion

The Tantium microLED architecture significantly enhances microLED current efficiency while maintaining seamless integration with existing AM backplane designs. By improving luminous efficiency, reducing power loss, and ensuring compatibility with current mass transfer and TFT technologies, Tantium microLED represents a breakthrough in microLED display performance including:

Furthermore, the Tantium microLED architecture provides a scalable solution for microLED displays across a wide range of applications, from ultra-high-resolution micro-displays to large-format seamless video walls. Its enhanced energy efficiency contributes to sustainable display technologies, reducing environmental impact and supporting the development of next-generation energy-efficient consumer electronics.

Future research and development efforts will focus on further optimizing the Tantium structure for increased efficiency, expanding its application to wearable devices, automotive displays, and transparent display solutions. With continued advancements, Tantium microLED has the potential to become the industry standard for high-performance microLED displays, ushering in a new era of display technology with superior power efficiency, reliability, and scalability.

## 4. References

1. Liu Y, Liao K, and Li Y, "Invited Paper: Development of MicroLED Display by PixeLED Display Technology", SID Symposium Digest of Technical Papers, 51: 429-431 (2020)
2. Liu Y, Liao K, and Li Y, "Invited Paper: Toward for Ultimate Displays with MicroLED by PixeLED Display Technology", IDW 2019 Symposium Digest

**38-3 / K. Y. Liao • Invited Paper**

3. Liu Y, Liao K, Lai Y, and Li Y, “Invited Paper: High Transparency Borderless Active-Matrix MicroLED Display”, Vehicle Display Symposium 2019
4. Liu Y, Liao K, Lin C, and Li Y, “Invited Paper: PixeLED Display for Transparent Applications”, SID Symposium Digest of Technical Papers, 49: 874-875 (2018)
5. Yuto T, Masakazu S, Shota N, Tokiyoshi U, and Shinichi K, “Highly Efficient Side-by-Side Three-Stack Tandem Flexible OLED Displays with Yb-doped n-CGLs”, SID Symposium Digest of Technical papers, 71: 1070-1073
6. Yue M, Liang S, and Man K, “Hybrid Design of Light-Emitting Diodes in Tandem Structures”, Adv. Funct. Mater. 2024, 2401789
7. Jin Y, Hye I, Dong K, Ramchandra P, Jang H, “Optical performance evaluation of blue tandem top-emitting OLED device”, Organic Electronics 118 (2023) 106810