跨越“黄绿鸿沟”：三维量子阱 V 形 PN 结构助力 GaN 基 LED 实现高速波分复用可见光通信

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随着器件尺寸缩小至几十微米级别，在电流密度的限制下，micro-LED 难以实现瓦特量级的光功率，不适用于长距离通信与水下光通信等需要大功率光通信器件的情景。因此，如何提升常规尺寸 LED 的通信性能成为目前研究的重点问题。

复旦大学、南昌大学联合团队研究了一种波分复用的多色 LED 可见光通信系统。该系统使用了一种具有三维结构量子阱的硅衬底氮化镓基 LED。这种 LED 的有源层中存在一种剖面呈六角形、开口朝向 P 型氮化镓的三维结构 (“V”形坑)。通常来说，对于氮化镓基 LED，为了实现更长的自发辐射波长，需要在量子阱中添加较高的铟元素组分，因而导致严重的氮化镓、铟化镓晶格失配问题。而“V”形坑结构有助于屏蔽氮化镓基 LED 中晶格失配造成的位错，从而显著提高了长波长 (如黄绿波段) 氮化镓基 LED 的量子阱质量和光效。仿真模型表明，“V”形坑有效降低了器件的串联电阻，并增强了器件对于高频信号的响应。这意味着“V”形坑带来了更高的电光转换效率和更大的器件带宽。从而在理论上初步解释了“V”形坑结构对 LED 器件通信性能的正面作用。

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Bridging the "yellow-green gap" -- GaN-based LED achieves high rate Wavelength division multiplexing visible light communication system with three-dimensional quantum well structure

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Under the limitation of current density, micro-LED is difficult to achieve watts level optical power, which is not suitable for long-distance and underwater optical communication that requires high-power optical transmitter devices. Therefore, how to improve the communication performance of conventional-size LED is a key issue at present.

Fudan University and Nanchang University have jointly studied a wavelength division multiplexing visible light communication system based on multi-color LED. The system uses a Si substrate GaN-based LED with a 3D structured quantum well. In the active layer of this LED, there is a three-dimensional structure ("V" shaped pit, or V-pit) with a hexagonal profile, opening towards the P-type GaN layer. The V-pit structure helps to screen the dislocations caused by lattice mismatches in GaN-based LEDs, thus significantly improving the quantum well quality and optical efficiency of GaN-based LEDs with long wavelengths (such as yellow-green bands). The multicolor LED array used in this study contains eight different LED units. Up to eight independent channels for WDM can be used simultaneously. Based on the LED array, the team built a communication system and wrote advanced digital signal processing technology programs required for the system. The communication system they built achieves a 31.38 Gb/s total transmission rate.

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