# Blue Superluminescent Diode on *c*-Plane GaN Beyond Gigahertz Modulation Bandwidth for Visible Light Communication

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## Introduction

Recently, GaN light-emitting diode (LED) and laser-diode (LD) have recently been developed for solid-state lighting (SSL) and visible light communication (VLC) [1, 2]. Superluminescent diode (SLD), which operates in the amplified spontaneous emission (ASE) mode offers further niche in SSL and VLC applications. The ASE (superluminescent) occurs when the optical feedback is suppressed, and thus inhibiting the onset of lasing. SLD offers speckles-free emission that is associated with LD, as well as exhibits shorter carrier lifetime since it operates in the ASE regime. The ASE results in a high modulation bandwidth and high data rate [3], as compared to LED, which operates in the spontaneous emission regime. In our previous work, we have demonstrated 560 MHz [4] and 800 MHz [3] of modulation bandwidth for semipolar-based SLDs. However, the expensive production cost of those substrates prevents them from wide-availability. Thus, here, we demonstrate a *c*-plane GaN-based SLD emitting at 442 nm with beyond GHz of bandwidth for simultaneous dual SSL-VLC technology.

## Experiments and Results

At one of the laser facet, a 12-degree tilted waveguide structure was utilized to supress the lasing action. Figure 1(a) shows the electroluminescence (EL) of the SLD at different continuous (CW) injection currents ($I_0$). EL confirms the superluminescent characteristic of our SLD as evident in the decreasing FWHM (from 26 nm to 7 nm) as $I_0$ increased. Inset of Fig.1a shows the light-output – current – voltage (L-I-V) characteristics of the superluminescent behaviour characterized by the superlinear dependency of output power on injection currents, with a peak power of 25 mW at 1A. Figure 1(b) shows the frequency response of the SLD at different $I_0$ resulting in the achievement of 1 GHz of modulation bandwidth at -3dB (limited by the maximum bandwidth of the Thorlabs APD210 avalanche photodetector). The modulation bandwidth increases with increasing $I_0$, which results in a increasing ASE around 442 nm with a reduced linewidth of ~7 nm, leading to significantly shorter carrier lifetime [5].

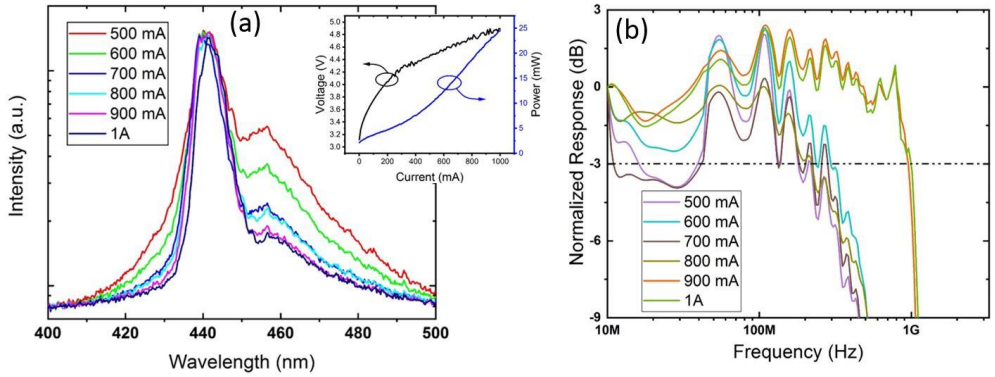


**Figure 1:** (a) Electroluminescence of the SLD at different $I_0$ with peak emission at ~442 nm. Inset: L-I-V characteristics of SLD with an optical power of 25 mW at 1A. (b) The frequency response curves from 500 mA to 1A, with the highest bandwidth of 1GHz at 1A.

## Conclusion

In conclusion, we have demonstrated a high modulation bandwidth of 1GHz at 1A of injection current for a 442-nm SLD at 25 mW. The 12°- tilted facet is utilized to supress the onset of lasing. The ASE regime of SLD results in a shorter carrier lifetime, and has led to a high modulation bandwidth, which expands the plethora of devices for applications in SSL-VLC.

## References

[1] G. R. Goldberg *et al.*, *IEEE Journal of Selected Topics in Quantum Electronics*, vol. 23, no. 6, pp. 1-11, 2017.
[2] A. A. Alatawi *et al.*, *Optics Express*, vol. 26, no. 20, p. 26355, 2018.
[3] C. Shen *et al.*, *Optics Express*, vol. 24, no. 18, pp. 20281-20286, Sep 5 2016.
[4] C. Shen *et al.*, *Optics Letters*, vol. 41, no. 11, pp. 2608-2611, 2016/06/01 2016.
[5] R. Hui and M. O'Sullivan, *Fiber optic measurement techniques*. Academic Press, 2009.