

AlGaN/GaN HEMTs Device Degradation: Hot Carrier and Blue Defect-Related Electroluminescence

C. Hodges, N. Killat, and M. Kuball

H.H. Wills Physics Laboratory, University of Bristol, Bristol BS8 1TL, United Kingdom

AlGaN/GaN HEMTs have excellent performance, however, they still suffer from limitations in device reliability and lifetime. To date, failure and degradation mechanisms are not well understood. In pinch-off, the emergence of electroluminescence (EL) spots next to the gate edge has been shown to be proportional in density to leakage current¹, i.e. is related to degradation mechanisms. Gaining insight into the spectral response has not been attempted before, and has potential to elucidate degradation mechanisms of AlGaN/GaN HEMTs. In this work, we show that the emission spectrum from these hot spots does not only contain hot electron emission as typically observed in AlGaN/GaN HEMTs operated in forward bias, but also a distinct defect related peak at 2.9eV, where there is only a weak signal in on-state EL spectra (Fig. 1). This 2.9 eV peak only appears after device stressing (Fig. 2) when a significantly increased leakage current is measured. Such blue luminescence has been previously studied in GaN by photoluminescence and has been attributed to donor-acceptor pairs with a shallow donor level². Origins for the emergence of this defect-related peak including generation of trap states during device stress, and the injection of carriers deeper into the GaN layer will be discussed.

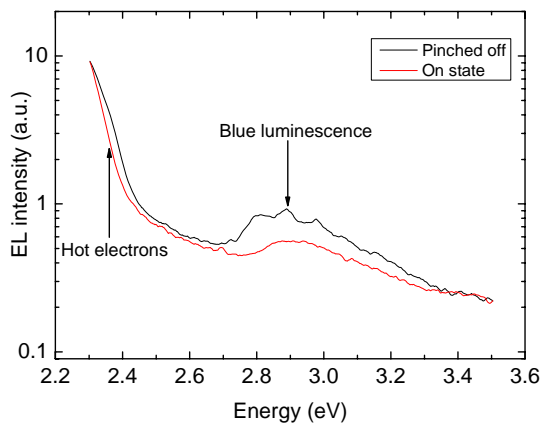


Fig 1. Electroluminescence spectrum for device 2 with $V_{DS}=60$ V, $V_{GS}=-40$ V, showing the tail of the hot-electron emission below 2.4 eV and the blue emission around 2.9 eV.

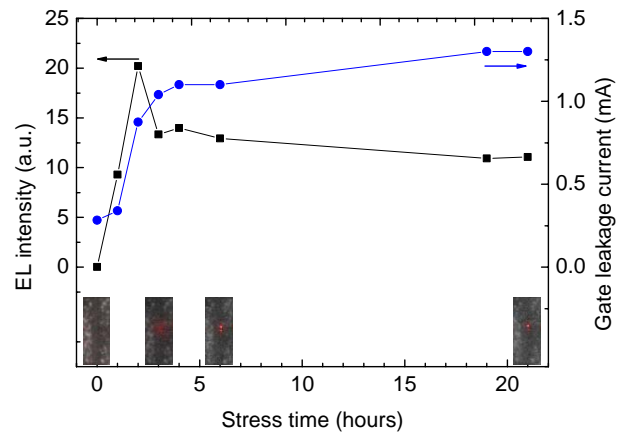


Fig 2. Increasing gate leakage current and EL intensity with stress, for device 1 with $V_{DS}=16$ V, $V_{GS}=-8$ V. The insets show EL emission before stress, and after 3, 6 and 21 hours of stressing.

References

¹ Zanoni *et al.*, *Localized damage in AlGaN/GaN HEMTs induced by reverse-bias testing*, IEEE Electron Device Letters, Vol. 30, No. 5, May 2009

² M. A. Reshchikov and H. Morkoç, *Luminescence properties of defects in GaN*, J. Appl. Phys. **97**, 061301 (2005)