Thermal and statistical analysis of various AlN/GaN HEMT geometries for millimeter Wave applications

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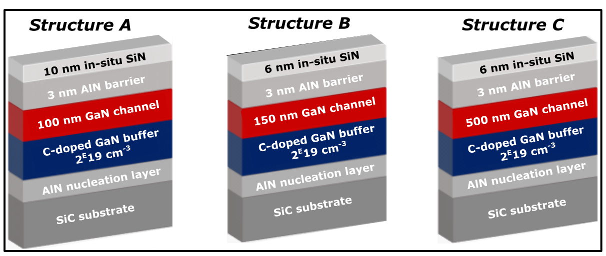
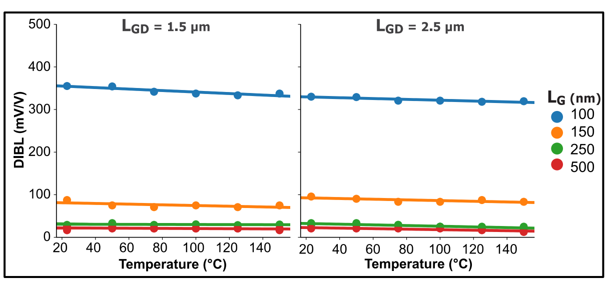
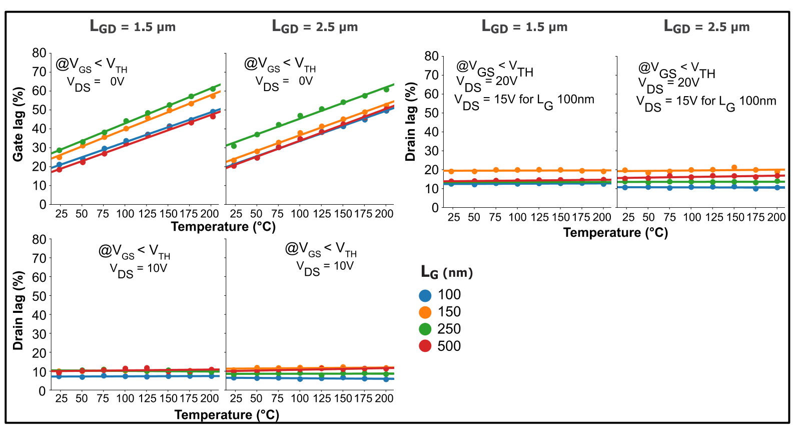
Modern telecommunication systems such as 5G, military wireless communication and radar amplifiers are applications that imply high power, high temperature and high frequency operation, with high level of confidence on the reliability. GaN technology is the optimal candidate to fulfill these requirements [1]. In order to increase the frequency range to mmWave and maintain a high power-added / output power density combination, downscaling HEMT devices is crucial. The ultrathin AlN barrier on GaN channel meets these criteria [2-3]. However, a trade-off must be implemented to ensure high reliability of the active device considering the high junction temperature sensitivity, which could lead to transistor degradation, especially under high current and high voltage biasing. In this work, a statistical analysis of relevant electrical parameters of 3 different AlN/GaN structures featuring various t_{ch} for 2×100µm gate width transistors was conducted in a safe operating area using DC and pulsed DC measurement setup. Thermal characterization was also carried out to monitor the main electrical parameters variation with temperature (T°).
After a DC stabilization procedure, 96 HEMT devices under test exhibit a minor dispersion in DIBL and lag rates, which reflects an undeniable technological mastering and maturity. Evaluation of the sensitivity of devices with different geometries at temperatures of up to 200°C revealed that the gate-drain distance impacts Ron variation and not Idss variation with temperature. We also showed that DIBL at moderate electrical field and the drain lags exhibit athermal behavior ; unlike gate lag delays which can be thermally activated and exhibit a linear temperature dependence regardless of the size of the gate length.

Keywords- GaN, HEMT, on-resistance Ron, DIBL, traps, Idss







[1] U.K.Mishra, P.Parikh and Yi-Feng Wu, "AlGaN/GaN HEMTs-an overview of device operation and applications," *Proceedings of the IEEE*, vol.90, no.6, pp.1022-1031.

[2] T. Zimmermann *et al.*, "AlN/GaN insulated-Gate HEMTs with 2.3 A/mm output current and 480 mS/mm transconductance," *IEEE Electron Device Letters*, vol.29, no.7, pp.661-664, July 2008.

[3] F.Medjdoub, M.Zegaoui, D.Ducatteau, N.Rolland and P.A.Rolland, "High-performance Low-Leakage-Current AlN/GaN HEMTs grown on silicon substrate," *IEEE Electron Device Letters*, vol.32, no.7, pp.874-876, July 2011.