High-Voltage and High-Frequency Operation of AlGaN/GaN Power Heterojunction FET

H. Miyamoto, Y. Ando, Y. Okamoto, T. Nakayama, T. Inoue, K. Hataya, M. Senda, K. Hirata,
M. Kosaki, N. Shibata, and M. Kuzuhara
R&D Association for Future Electron Devices
c/o NEC Corporation, 2-9-1 Seiran, Otsu 520-0833 Japan,
+81-77-537-8671, miyamoto@ fed.or.jp

Introduction: Wide bandgap AlGaN/GaN heterojunction FETs [1-5] are attracting considerable attention for high-voltage microwave power applications such as cellular phone base stations, wireless internet access system and intelligent transport system. This is due to its unique material properties, including a wide bandgap leading to high-breakdown fields, a large high-field electron drift velocity leading to high speed, and the existence of polarization effects leading to high sheet charge density that exceeds 10^{13}cm^{-2}.

In this paper, design and performance of high-voltage and high-frequency AlGaN/GaN heterojunction FETs are described.

L-Band Recessed Field-Plate FET: For high-voltage power operation of AlGaN/GaN heterojunction FETs, the trade-off relation between current collapse and breakdown characteristics was the main difficulty. To improve this trade-off relation, a recessed gate structure with a field-modulating plate (FP) [6] was introduced. In this structure, the drain side edge of the gate overlaps the SiN film by a length of 0.5 to 1.0 μm. The gate recess was also effective in compensating gain drop due to increased feed-back capacitance in the FP-FET structure. Fabricated recessed FP-FETs (*Lg* =1 μm) showed a maximum drain current (*Imax*) of 800 mA/mm and a gate-drain breakdown voltage (*BVgd*) of more than 200 V. Power measurements were performed at 2 GHz for unit-cell and multi-cell FP-FETs packaged into ceramic carriers. A 1 mm-wide unit-cell device exhibited an almost linear increase in saturated output power (*Psat*) with increasing drain bias (*Vdd*) up to 66 V without a power slump and showed a saturated output power (*Psat*) of 12W (12 W/mm) at 66 V**. A** 48 mm-wide device biased at 49 V exhibited *Psat* of 203 W (4.2 W/mm), *PAE* of 67 %, and *GL* of 10.1 dB.

Ka-Band Short Channel Power FET: For high power operation at Ka-band, a T-shaped gate planar FET with an improved layout configuration was fabricated using EB lithography [7, 8]. Fabricated FETs exhibited *Imax* of 1030 mA/mm and *BVgd* of 61 V. A 0.07 μm-long gate FET showed a unity current gain cut-off frequency of 81 GHz and a maximum frequency of oscillation of 190 GHz. On-wafer load-pull measurements were performed for multi-fingered FETs (*Lg* =0.25 μm). A 1 mm-wide device biased at 30 V exhibited *Psat* of 5.8 W (5.8 W/mm) with *PAE* of 43 % and *GL* of 9.2 dB at 30 GHz [8].

Conclusion: We have developed high power AlGaN/GaN heterojunction FETs on SiC substrates. To our knowledge, *Psat* values of 203 W and 5.8 W are the highest ever achieved at 2 GHz and 30 GHz, respectively for GaN FETs. These results indicate that GaN FET technology is promising for solid-state power devices operating at high-voltage and high-frequency.

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