Extended Abstracts of the 2008 International Conference on Solid State Devices and Materials, Tsukuba, 2008, pp. 512-513

P-6-8

A New Dual Field-Plates GaN HEMTs Structure With Improved Break Down and Noise Performance

Bing-San Hong, Chao-Wei Lin, Ming-Yang Chen, Hsien-Chin Chiu,

Department of Electronics Engineering Chang Gung University, Taoyuan, Taiwan, R.O.C

TEL:+886-3-2118800 Fax:+886-3-2118507 Email:hcchiu@mail.cgu.edu.tw

Introduction

We have systematically studied the noise, breakdown, and self-heating effect of dual field-plate (DFP) AlGaN/GaN HEMT in which the dual field-plate is connected to the source terminal(DFP-S) and the gate terminal (DFP-G). Although longer FP length promises high power density for high voltage operation, it has a disadvantage of large parasitic capacitance. By adopting DFP metal in HEMT, both DFP-S and DFP-G devices achieved higher gate bias voltage than FP device.

These experimental results indicated that the DFP-G architecture is suitable for low noise applications .

Device structures and fabrication

The HEMT structure consists of 47nm AlGaN/3μm GaN/sapphire substrate.The Al concentration in AlGaN layer is 17%. Mesa isolation was achieved by high density indenctively coupled plasma etching. Front-side ohmic contacts of Ti/Al/Ni/Au were fromed by lift-off and subsequent annealing 850℃ for 30 s under nitrogen ambient. Then 200nm SiO_2 was deposited for passivation followed by 1μm long Ni/Au-gates and field-plate were deposited.

There are illustrated in Fig.1. The gate width of HEMTs is 200μm. Structure (a) is the conventional. Structure (b) has longer drain to Source distance (L_{dg}=11μm) which was compared to DFP device. Structure (c) has FP. Structrue (d) has the 2nd-FP. Figure 2 show the SEM section of 1μm gate length HEMT with 2nd-FPs, they are connected to source and gate terminal.

Device Characterization

The DC performance of various 1 $\times$200 μm^2-gate devices were characteristized using HP4142 semicon ductor parameters analyzer. Figure 3 shows the typical DC current- voltage I_d-V_d characteristic of the DFP GaN HEMT. The DFP

Table 1 shows the current-voltage characteristics of the gate and the source of fabricated devices with L_g=1μm. The length L_{gs} between the gate and the source is 6μm. The length of the insulator film under field-plate is 200nm. We found the great improvement in the gate leakage characteristics by empolying the dual field-plate structure. The gate breakdown voltage of HEMT without FP, HEMT with FP, DFP-S, and DFP-G are 170V, 216V, 237V, and 255V, respectively. The DFP-S and DFP-G are much higher than that of the FP HEMT, which indicates the advantage of the DFP device applications.

Using a pulse system to measure the DC characteristic without thermal effect of a device that suffers from self-heating (Fig.4). We observed self-heating effect with bias conditions V_{ds}=10V and I_{ds}=320mA/mm. The DFP device has more current increase than conventional HEMT and FP device when ridded of thermal. It is explained that DFP device has great DC and RF performance if we improved the severe self-heating effect.

To further investigate the surface traps for four device, the low-frequency noise was measurd, following a method that is sensitive to the semiconductor surface. Figure 5 demonstrates that the field-plate device exhibit a lower 1/f spectra noise compared to satandard device at a Id=10mA conditions. This is due to the carriers underthe drain electrode were suppressed to flow into a deeper channel, avoiding the carriers trapped by surface states near interface, especially DFP-G.

Conclusions

In this study, low frequency noise and breakdown characterization have been done on 1μm daul-field plate GaN HEMTs to investigate the different 2nd field-plate connection. For DFP device, its lower R_g, lower 1/f noise highter breakdown voltage is suitable for low noise amplifier and voltage control oscillator applications. It has great potential for DFP device if it was improved self-heating effect.

References

[1] H.C.Chiu, et al.,IEEE TED. Semicond. Sci. Technol. **23** (2008) 035030

[3] Kouji ISHIKURA, et al., IEICE TRANS. ELECTRON., VOL.E90-C,NO5(2007)

[4] John D. Albrecht, et al, IEEE TED, VOL. 47, NO. 11, (2000)

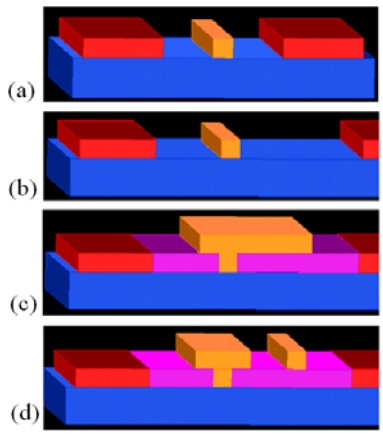

Fig.1 Four gate structure to characterize the FP operation. (a) conventional HEMT, (b) long channel device (compared with field-plate device), (c) field-plate HEMT, and (d) daul field-plate HEMT.

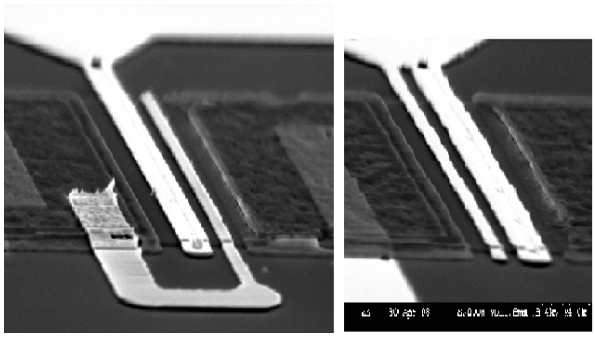

Fig.2 SEM cross-section of daul field-plate

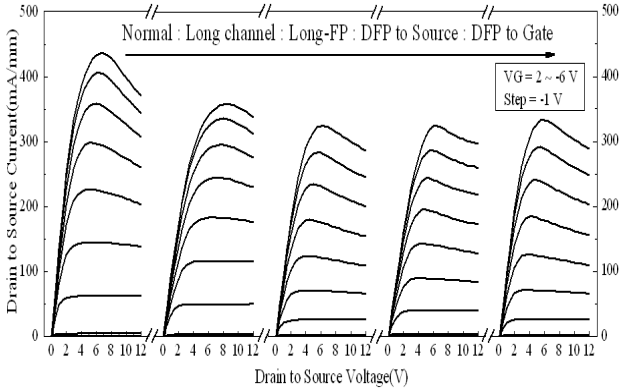

Fig.3 The measured results of nomalized Id-Vd characteristics for standard and DFP GaN HEMTs.

	Conventional	L-Channel	FP	DFP-S	DFP-G
Breakdown Voltage	153 V	170 V	216	237 V	255 V

Table.1 The gate breakdown voltage.

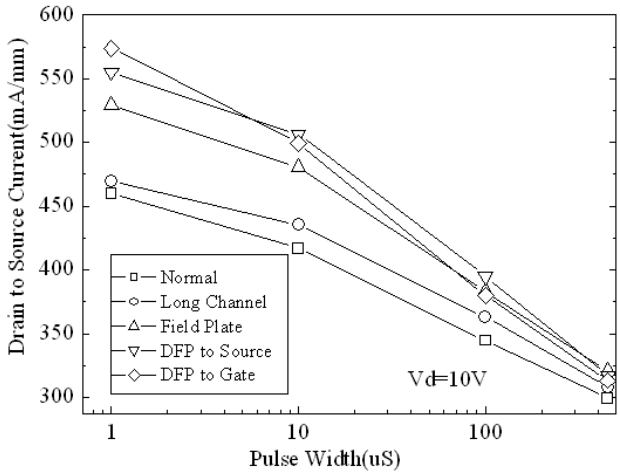

Fig.4 Compared the same order current of pulse measurement.

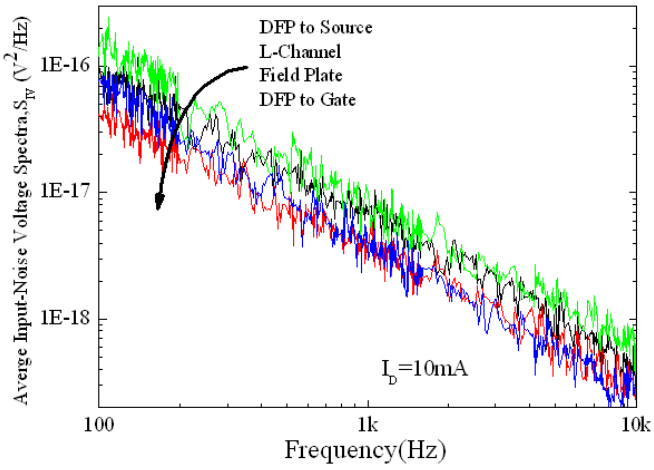

Fig.5 The low-frequency noise spectra for four device.