4H-SiC Planar MESFETs with F_{max} of 40 GHz without Trapping Effect

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The superior electrical, thermal and chemical properties made SiC as a promising material for the application of high-frequency and high-power devices. SiC MESFETs have received increased attention for a microwave power device. Recent progress verifies the superiority of SiC MESFETs [1],[2]. However, in spite of these promising results, some improvements are required in the processing and performance to commercialize. In this study, we fabricated 4H-SiC planar MESFETs using ion-implantation without gate recess and the DC and RF performances were characterized.

A semi-insulating 4H-SiC wafer with a p-type buffer layer and an n-type active layer was used to fabricate MESFET. High-temperature phosphorous ion-implantation was performed to form highly doped source and drain regions. Thin thermal oxide was grown on the substrate followed by deposition of thick field oxide using CVD to passivate the surface. Ohmic contact was formed using Ni after annealing at 1000ºC for 2 min in Ar atmosphere. Gate contact was formed using Ni/Pt followed by patterning of pad metal using Au. E-beam lithography was used to define the gate. The gate lengths were from 0.3 µm to 1.0 µm. The gate-to-source spacing and gate-to-drain spacing were from 1.0 µm to 2.0 µm.

Fig. 1 shows the DC characteristics of the fabricated MESFET with a gate length of 0.5 µm and a gate width of 100 µm. The saturation drain current was 500 mA/mm and the transconductance was 27 mS/mm. The pinch-off voltage was about -24 V.

Fig. 2 shows the small-signal properties calculated from measured s-parameter. The cut-off frequency and maximum oscillation frequency were 8.2 GHz and 40 GHz, respectively, at V_{ds}=40 V and V_{gs}=-5 V. The large-signal properties were shown in Fig. 3. Load-pull power measurement was performed at 2 GHz and V_{ds}=40 V due to the power-limitation of our measurement system. The associated gain, P_{1dB} and PAE were 6 dB, 21.7 dBm and 15 %, respectively. The output power density was 1.7 W/mm.

Instability in drain current due to the trapping effect is a problem of MESFETs. The drain and gate current measurements as a function of the input power confirm the suppression of the trapping effect (Fig. 4) [3].

Acknowledgements

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References

[1] R. C. Clarke and J. W. Palmour, Proceedings of the IEEE, 90(6), 987, 2002.

[2] R. J. Trew, Proceedings of the IEEE, 90(6), 1032, 2002.

[3] F. Villard, J.-P. Prigent, E. Morvan, C. Dua, C. Brylinski, F. Temcamani and P. Pouvil, IEEE Trans. Microwave Theory Tech., 51(4), 1129, 2003.

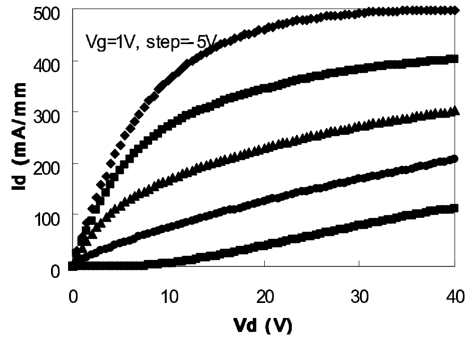

Fig. 1. DC characteristics of MESFETs with a gate length of 0.5 µm.

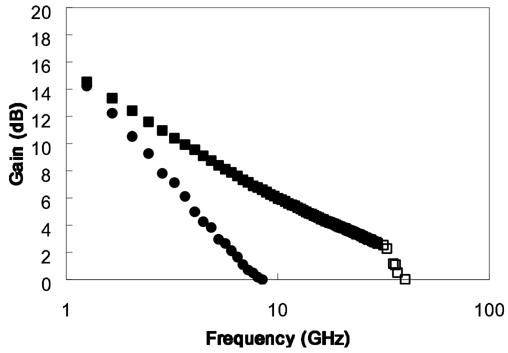

Fig. 2. Small-signal characteristics with F_t and F_{max} of 8.2 GHz and 40 GHz, respectively.

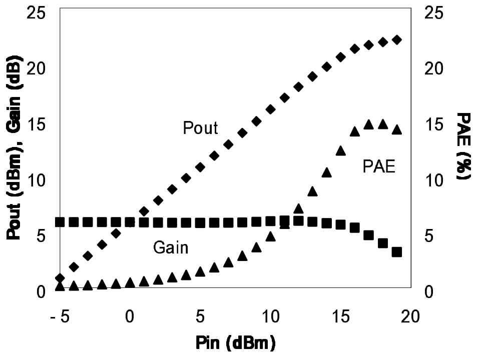

Fig. 3. Large-signal characteristics with a gate length of 0.5 µm and a gate width of 100 µm.

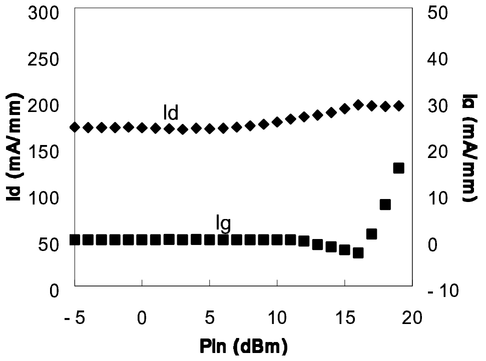

Fig. 4. Drain and gate current under RF operation without the trapping effect.