Paper ID: T230120

DC and RF Characteristics of T-Gate AlGaN/GaN HEMTs Using a ZEP520A (1:1)/LOR5B/ZEP520A Photoresist and SiN Passivation

Hsin-Jung Lee*, Cheng-Che Lee, Shao-Yu Lo, Chieh-Hsiung Kuan

Graduate Institute of Electrics Engineering, National Taiwan University, Taipei 106, Taiwan (R.O.C.)
*** E-Mail: d04943010@ntu.edu.tw**

Abstract

The three-layer photoresist structure of ZEP520A(1:1)/LOR5B/ZEP520A was designed, and a T-shaped gate AlGaN/GaN high-electron mobility transistor was fabricated using electron-beam lithography.
The high-frequency performance was investigated using a GSG probe and exhibited a current gain cut-off frequency of 10 GHz and maximum oscillate frequency of 18 GHz.

T-gate AlGaN/GaN HEMT

- HEMT’s excellent electrical characteristics give them superior device performance and great potential in high-power and high-frequency applications compared to Si-based devices. To achieve higher cut-off frequencies (f_T) for the HEMT device, it becomes necessary to reduce the gate length (L_g) [1]. In the past few decades, compared with traditional line gates, T-shaped gates with a larger gate head length and a smaller gate foot length have been widely studied to increase the operating frequency of HEMTs while mitigating the rise in gate resistance [2,3].
- In this study, we utilized a three-layer photoresist structure composed of ZEP520A(1:1)/LOR5B/ZEP5A to fabricate a T-shaped gate and used a SiN film as the passivation layer. The DC and RF characteristics of T-shaped gate AlGaN/GaN HEMT was investigated.

Three-Layer Photoresist

- The three-layer photoresist structure was composed of ZEP520A(1:1)/ LOR5B/ZEP520A. The first ZEP520A(1:1) layer was spin-coated at 500 rpm for 5 s, then 5000 rpm for 90 s. The second LOR5B layer was spin-coated at 1000 rpm for 4 s, then 4000 rpm for 40 s. Finally, the top ZEP520A layer was spin-coated at 500 rpm for 5 s, then 5000 rpm for 90 s. After each spin-coating process of photoresist, a bake on a hot plate at 180 °C for 3 min was needed.

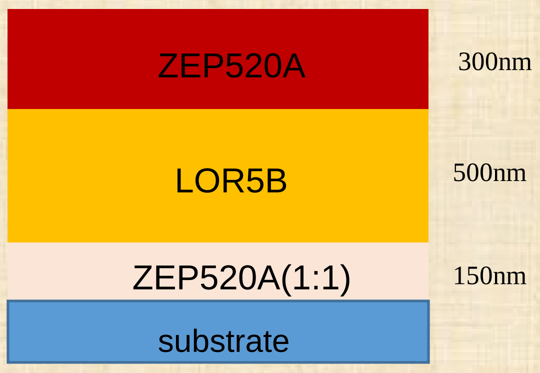

Fig. 1 Three-layer photoresist structure was composed of ZEP520A(1:1)/ LOR5B/ZEP520A.

- The thickness of ZEP520A(1:1)/ LOR5B/ZEP520A photoresists were 150 nm, 500 nm and 300 nm, respectively.
- The films were placed in the electron beam lithography system to expose the gate pattern.
- Development: using developer ZED-N50 → MF-319 → ZED-N50 in sequence.
- Finally, E-gun metal deposition was performed for the gate metal of Ni/Au with a thickness of 20/ 270 nm.
- To reduce the current collapse effect and improve the high-frequency characteristics [4], we grow a 260 nm silicon nitride (SiN) passivation layer on the device using PECVD.

SEM image of T-shaped gate

Figure 2 shows the geometry of the cross-sectional T-shaped gate. The T-shaped gate has a gate length of 300 nm and a gate head length of about 800 nm. This result verifies the feasibility of using the photoresist structure of ZEP520A(1:1)/ LOR5B/ZEP520A we presented to form a T-shaped gate with a submicron scale.

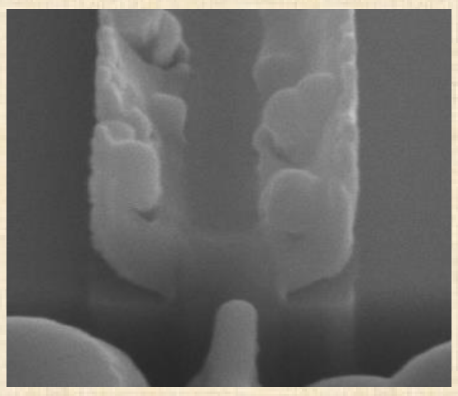

Fig. 2 The cross-sectional T-shaped gate with a gate length of 300 nm.

RF measurement - f_T and f_{max}

- The RF characteristics of the T-gate AlGaN/GaN HEMT were measured using an N5225A PNA microwave network analyzer, Keysight Technologies, Inc. The metal pads were fabricated on the device, and the high-frequency signals were extracted using the GSG probe.
- The high-frequency performance of the 300 nm T-gate AlGaN/GaN HEMT exhibited a current gain cut-off frequency (f_T) of 10 GHz and a maximum oscillate frequency (f_{max}) of 18 GHz when the V_{GS} is -3.5 V, and the V_{DS} is 6 V.

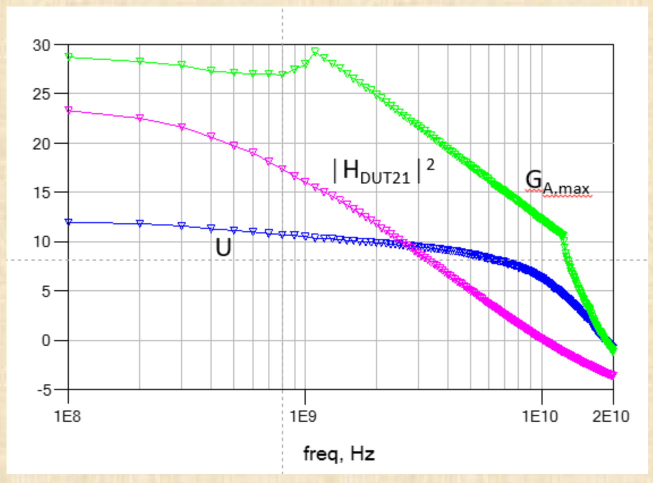

Fig. 3 The RF characteristics of the T-gate AlGaN/GaN HEMT .

Conclusion

We have developed a T-gate process using a triple-layer photoresist composed of, **ZEP520A (1:1)/LOR5B/ZEP520A** achieving T-gates with **300 nm** linewidths. The fabricated HEMT devices exhibited a cut-off frequency (f_t) of **10 GHz** and a maximum oscillation frequency (f_{max}) of **18 GHz** at a bias of V_{GS} = -3.5 V and V_{DS} = 6 V.

References

1. A. Danielraj, Sanjoy Deb, A. Mohanbabu et al.: 'Impact of Recessed Δ-shaped Gate Vertical CAVET AlGaN/GaN MIS-HEMT for High-power, low-loss switching applications', Journal of Computational Electronics, 2021, 21, pp. 169–180.
2. Zhang, Y., Wei, K., Huang, S. et al.: 'High-Temperature-Recessed Millimeter-Wave AlGaN/GaN HEMTs With 42.8% Power-Added-Efficiency at 35 GHz', IEEE ELECTRON DEVICE LETTERS, 2018, 39, (5).
3. Zhu, M., Xie, Y., Shao, J., et al.: 'Nanofabrications of T shape gates for high electron mobility transistors in microwaves and THz waves, a review', Micro and Nano Engineering, 2021, 13, pp. 100091.
4. Lee, B., Kim, R., Lim, B., et al., 'High RF performance improvement using surface passivation technique of AlGaN/GaN HEMTs at K-band application', in Electronics Letters, 2013, 49, (16), pp. 1013-1015.

www.postersession.com