Paper ID: T230126

Enhancement of AlGaN/GaN HEMT Device Performance Using Nano-Hole Patterns

Cheng-Che Lee, Hsin-Jung Lee*, Hong-Ru Pan, Wei-Yu Lee, 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 geometric patterns were introduced on the surface of the AlGaN layer before forming ohmic contact metal, aiming to reduce the contact resistance of AlGaN/GaN high-electron mobility transistors (HEMTs). The pattern of 0.5 μm square holes performs best, lowering contact resistance from 1.348 to 0.995 Ω·mm.

Nano-Hole Pattern

AlGaN/GaN HEMTs exhibit remarkable potential in high-power and high frequency application because of the superior high intrinsic electric field and electron saturation velocity [1].

Contact resistance is a critical factor affecting the device performance for HEMTs at high-frequency, determining key transistor characteristics such as maximum saturation current, transconductance, and on-resistance. Uneven-pattern substrate is a technique that has been reported in recent years, which fabricates patterned etching structures with different apertures of holes and aim to increase the amount of AlGaN side area effectively reduces contact resistance [2,3]. In this study, we investigate the contact resistance of geometric structures of samples with varying geometric patterns, arrangements, and sizes using transmission line model (TLM) method.

Device Fabrication

In this experiment, we fabricated AlGaN/GaN HEMTs on a c-plane sapphire substrate. The process started with a 25 nm GaN nucleation layer, followed by a 3 μm GaN buffer layer, both deposited using metal-organic chemical vapor deposition (MOCVD). An 18% Al content, 19 nm AlGaN layer, and a 2 nm GaN cap layer were subsequently grown.

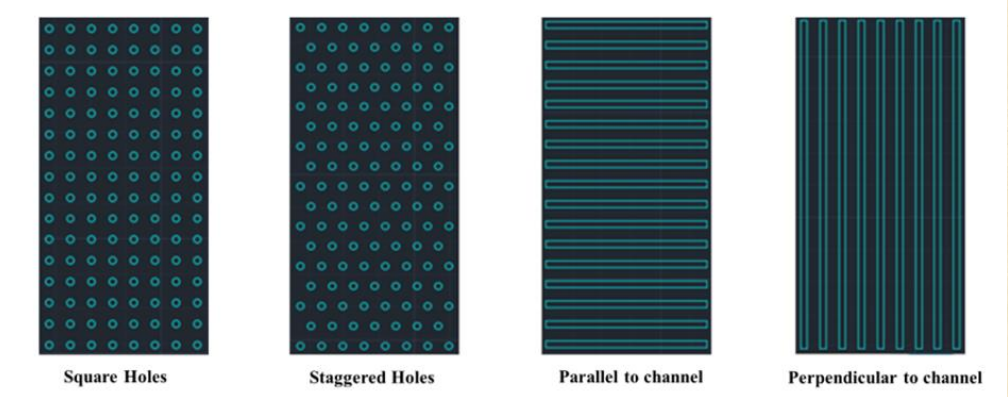

Fig. 1 Different geometric structures fabricated on the ohmic region of AlGaN layer.

Different geometric structures were fabricated on the ohmic contact area of the AlGaN layer, including symmetrically arranged and staggered holes, and stripes oriented parallel and perpendicular to the channel. These structures varied in size, with circular holes and stripe widths of **2 μm** and **0.5 μm**. The geometries, termed "**square holes**", "**staggered holes**", "**parallel to channel**", and "**perpendicular to channel**", were strategically designed to optimize the contact resistance of HEMTs,

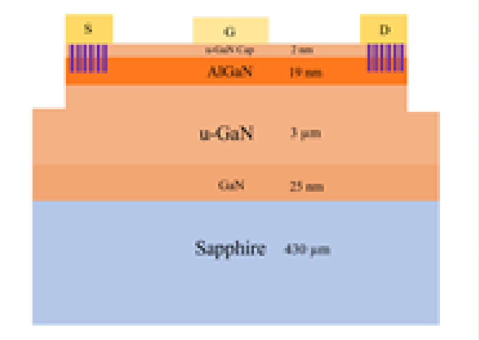

Fig. 2 Device structure of AlGaN/GaN HEMT with geometry structure under S/D regions.

TLM measurements of 0.5 μm and 2 μm samples

Figure 3 shows the contact resistance of the samples with 0.5 and 2 μm symmetrically arranged holes extracted by the transmission line model (TLM) method and compared with the conventional structure.

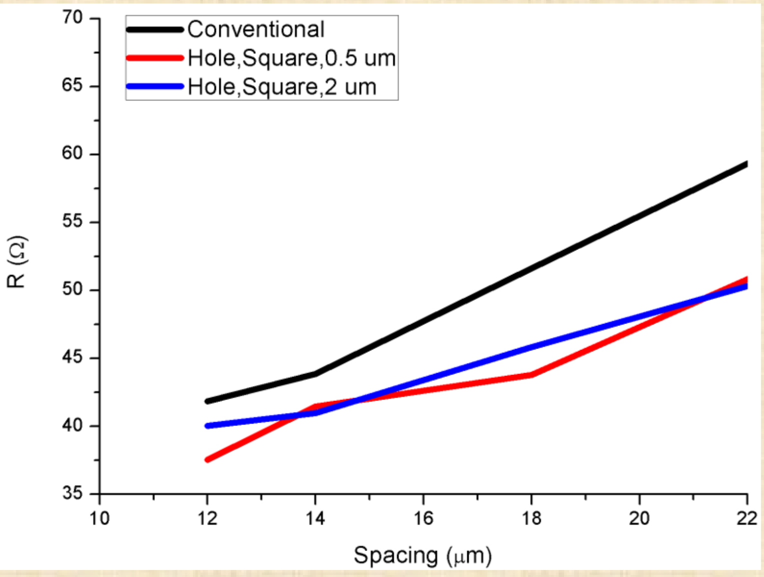

Fig. 3 The contact resistance of samples with hole structures of 2 μm and 0.5 μm compared with the conventional structure.

Comparison of contact resistances

The contact resistances of samples with different geometric patterns, arrangements, and pattern sizes were measured using the TLM method and listed in Table 1.

Pattern	R_c (Ω·mm)	ρ_c (Ω·cm^2)
Conventional	1.348	1.65×10^{-4}
Stripe, parallel, 5 μm	1.204	1.19×10^{-4}
Hole, Square, 2 μm	1.047	7.61×10^{-5}
Hole, Square, 0.5 μ	0.995	5.32×10^{-5}
Hole, Staggered, 2 μm	1.105	8.73×10^{-5}
Hole, Staggered, 0.5 μm	1.682	1.99×10^{-4}
Stripe, parallel, 2 μm	1.148	1.06×10^{-4}
Stripe, parallel, 0.5 μm	1.167	9.63×10^{-5}
Stripe, perpendicular, 0.5 μm	1.140	1.02×10^{-4}
Stripe, perpendicular, 2 μm	1.183	1.05×10^{-4}

Table 1. Extracted contact resistance and specific contact resistance of samples with different geometric patterns.

Conclusion

- We fabricated different geometry structures on the AlGaN barrier layer under source and drain regions, aiming to surmount the limitations of traditional methods in reducing contact resistance in AlGaN/GaN HEMTs.
- The geometry pattern with a size of 0.5-μm symmetrically arranged holes performs lowest contact resistance reducing from 1.348 to 0.995 Ω·mm.
- We would like to further focus on shrinking the apertures of holes to 20 nm by using the e-beam lithography to reduce the influence of threading dislocations at the interface of AlGaN and GaN.

References

1. F. Roccaforte, G. Greco, Patrick Fiorenza, et al.: 'An Overview of Normally-Off GaN-Based High Electron Mobility Transistors', 2019, 12, (10), pp. 1599
2. C. Wang, M. Zhao, Y. He, et al.: 'Optimization of ohmic contact for AlGaN/GaN HEMT by introducing patterned etching in ohmic area', Solid State Electron., 2017, 129, pp. 114–119
3. Y. Takei, M. Kamiya, K. Tsutsui et al.: 'Reduction of contact resistance on AlGaN/GaN HEMT structures introducing uneven AlGaN layers',2015, Phys. Status Solidi A, 212, (5), pp, 1104–1109

printed by MegaPrint Inc. www.postersession.com