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P5-8

Improvement of AlGaN/GaN Heterostructure Field Effect Transistor Characteristics by Using Two-step Ohmic Contact Process

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1. Introduction

Since GaN-related materials, SiC, and diamond have a wide band gap, a high breakdown electric field, and a high saturation velocity, these materials are very important for electronic devices that can operate under high-temperature, high-power, and high-frequency conditions. Furthermore, the availability of heterostructures is another key advantage of a GaN-related material system for high-performance devices [1].

The performance of devices like field effect transistors (FETs) is known to depend on the contact resistance, and, hence could be substantially reduced with a high contact resistance. Development of a low resistance ohmic contact is therefore of great practical importance. Many attempts to achieve good ohmic contacts on GaN-related materials have been reported. All of these works are related with metallization structure and annealing process [2, 3].

In this study, we introduce a new structure of the contact pattern to reduce ohmic resistance.

2. Device Fabrication

The device structure was grown by radio-frequency plasma-assisted molecular beam epitaxy (rf-MBE) on a C-plane sapphire (Al_2O_3) substrate. Figure 1 shows a cross-sectional schematic diagram of the completed device structure. It was fabricated on mesa patterns that were electrically isolated using Cl_2 electron cyclotron resonance (ECR) plasma etching. The new two-step contact window patterns are fabricated on one of, or both of the source (S) and drain (D) contacts (see Fig. 1). Before ohmic metals are deposited, the wide band gap barrier layers of the inner (small) S and D window areas was etched by Cl_2-ECR plasma, leaving a relatively thin barrier layers under the ohmic metals.

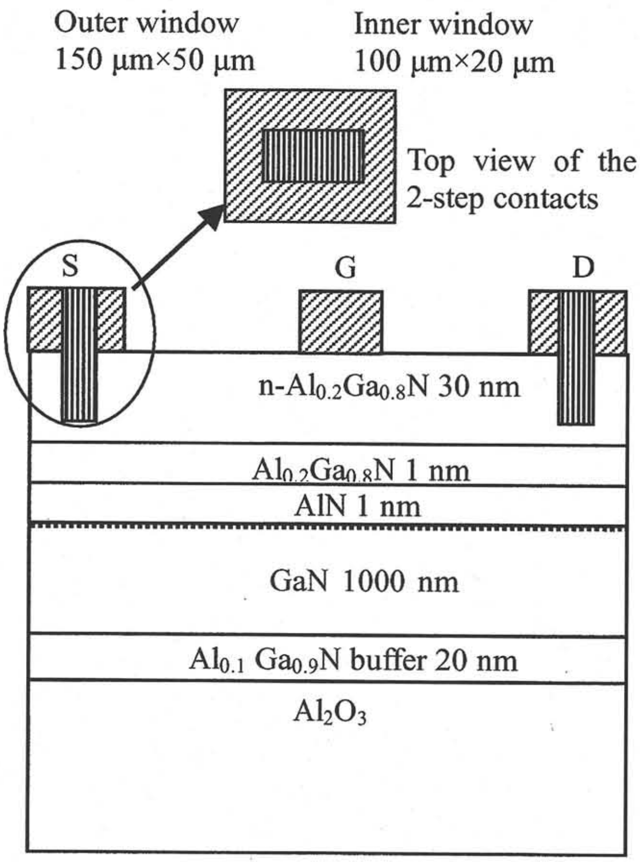

Figure 1. Cross-sectional schematic diagram of the HFET with 2-step contact patterns.

The Ti/Al/Ni/Au (300/2200/400/500 Å) ohmic metals were deposited by electron beam (e-beam) evaporation and then standard lift-off procedures were used to remove metals outside electrode patterns. The electrodes were annealed for 40 s at 900°C for inner contact and at 850°C for outer contact using rapid thermal annealing in N_2 ambient.

3. Results and Discussion

Figure 2 shows ohmic characteristics of the fabricated devices with different S and D contact patterns of the same S-D spacing. As shown, the ohmic resistance of devices with two-step contact window patterns is decreased. This result indicated that the inner small window contacts on the thinned barrier structure increase alloy effect, thus decreasing contact resistance.

Figure 3 shows dc characteristics of the heterojunction field effect transistors (HFET) with a D-S spacing (L_{ds}) of 2.2 μm, a gate length (L_g) of 1.0 μm, and a gate width (W_g) of 50 μm. Transconductance and total drain current were increased by using 2-setp ohmic contact process.

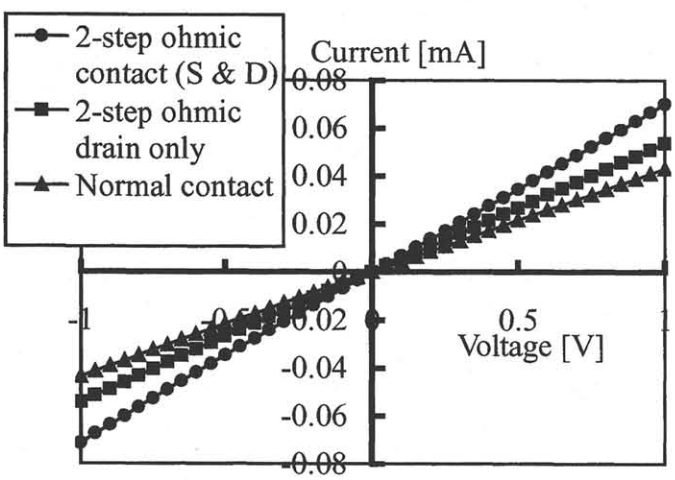

Figure 2. Ohmic characteristics of the different contact patterns

4. Conclusions

We fabricated a new ohmic contact structure of the 2-step contact process, and demonstrated improvement of the ohmic resistance and device characteristics.

References

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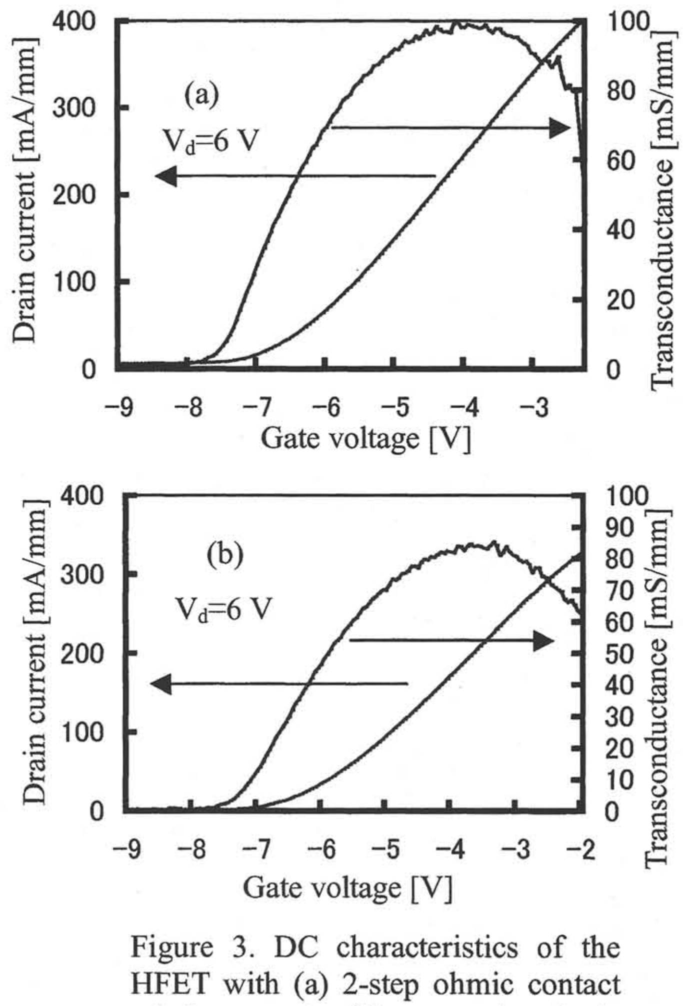

Figure 3. DC characteristics of the HFET with (a) 2-step ohmic contact window and (b) normal ohmic contact process.