Suppression of isolation leakage current in AlGaN/GaN HEMTs by neutral-beam etching

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1. Introduction

GaN-based materials are usually etched by dry etching in device fabrication. However, the dry etching causes possible plasma damages at the GaN (or AlGaN) surface. This could be a serious concern as an origin of the excess leakage current flowing through the damaged GaN surface out of the device area if the plasma etching is applied in the device isolation process. Deep traps produced by plasma-induced UV photons were found to play an important role in this leakage current [1]. In this study, we applied the neutral beam etching [1] to the device isolation process to reduce such plasma damage. The neutral beam is almost electrically uncharged and has few UV photons, thus it can reduce the plasma-induced damage to the etched surface. We conducted step stress measurements [2] and compared the isolation leakage current between the samples produced by neutral beam etching and conventional plasma etching.

2. Experimental Method and Results

The samples we prepared have a standard AlGaN/GaN HEMT hetero-structure on a sapphire substrate. The thickness of the AlGaN layer is 15.6 nm. Ohmic electrodes were formed by Ti/Al/Ni/Au lift-off followed by an annealing step at 780°C for 2 min. We prepared two-terminal test element arrays with separation distances from 10 to 110 µm etched by neutral-beam (NB) or plasma-like (PL) etching by Cl_2 gas (Fig. 1). These etching depths were 30 nm and 90 nm in NB and PL samples, respectively. After isolation, these samples were passivated with a SiN film. In step stress measurements, the stress voltage (V_1) was increased from 10 to 50 V with a stress time of 10 min. for each voltage. During each voltage step (Fig. 2), the current response (I_1) was measured. The PL samples show higher leakage current and the current values were significantly decreased in each stress step in comparison to the NB samples

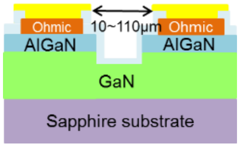

Fig.1 Device structure

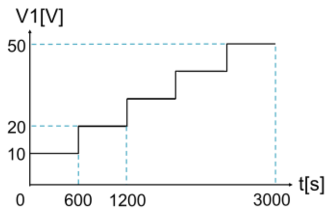

Fig. 2 Stress voltage profile

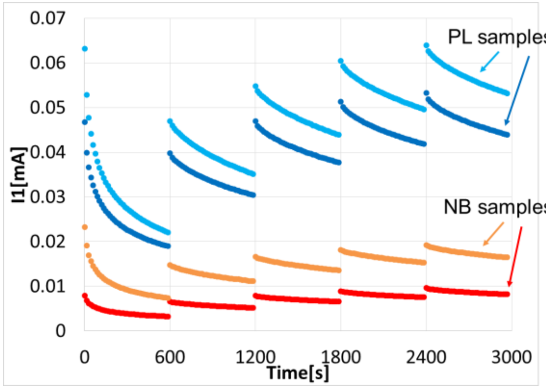

Fig. 3 Isolation current during step stress

as shown in Fig. 3. This suggests that the neutral beam etching helps reduce the plasma damage and suppress the carrier trapping by deep levels at the etched surface.

3. Conclusion

We found that the neutral beam etching helps reduce the isolation leakage current through the etched surface in AlGaN/GaN HEMTs. This will have an impact in enhancing the isolation breakdown voltage in GaN-based power devices.

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References

[1] S. Samukawa, et al., Jpn. J. Appl. Phys. **45** (2006) 2395

[2] J. Joh and J. del Alamo, IEDM (2006) p.415