Impact of neutral beam etching on isolation leakage current and breakdown voltage in AlGaN/GaN HEMTs

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1. Introduction

Plasma damage is a serious concerns as a cause of excess leakage current and decrease breakdown voltage in GaN-based devices [1]. However, plasma etching is commonly used for GaN-based materials in device fabrication process. For example, the device isolation by plasma etching could cause an excess leakage current flowing through the damaged GaN surface out of the device area. In this study, we applied neutral beam etching [2] to the device isolation process to reduce such plasma damage. The neutral beam is virtually free from charged particles and UV photons. Preciously we reported that the neutral beam has an effect on reducing the leakage current and carrier traps [3]. In this report, we compared breakdown voltages of the samples processed by neutral beam and conventional plasma etching. Also, we studied the influence of etching depth on the leakage current in the neutral-beam-etched samples.

2. Experimental Method and Results

The samples 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 annealing at 780°C for 2 min. Two-terminal test element arrays with isolation distances from 10 to 110 μm, etched by neutral-beam (NB) or plasma-like beam (PL) etching with Cl_2, were prepared (Fig. 1). The etching depths were 30 nm in NB samples, and 90 nm in PL samples. After isolation, samples were passivated with SiN.

In the breakdown characterization, the voltage was increased from 0 to 1000 V until a hard breakdown occurs. To make a systematic comparison, the soft breakdown voltage (SBV), defined as the voltage at which a leakage current reaches 1 mA/mm [4], is compared among the samples. Figure 2 shows the SBV versus the isolation distance, indicating that NB samples show higher SBVs.

In previous report [3] and the above breakdown characterization, the etching depth of NB samples was 30 nm, which was smaller than we expected. In order to check the influence of the etching depth on the leakage current, NB samples with different etching depths (30, 60, 90, and 120 nm) were prepared. Results suggest that the samples with over 60 nm depths show similar leakage current (Fig. 3). Therefore, the advantage of NB on the leakage current and SBV should be enhanced if the etching depth of NB samples were more than 60 nm.

3. Conclusion

We found that the NB etching helps increase the breakdown voltage in AlGaN/GaN HEMTs. The NB etching will have an impact in enhancing the isolation breakdown voltage in GaN-based power devices.

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References

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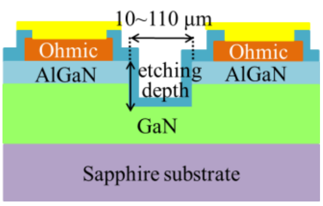

Fig.1 Device structure

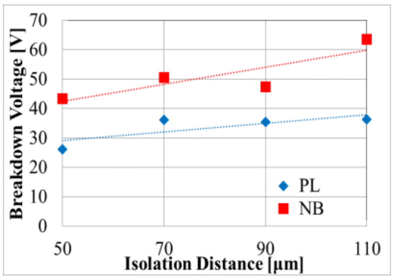

Fig.2 Correlation between isolation distance and soft breakdown voltage

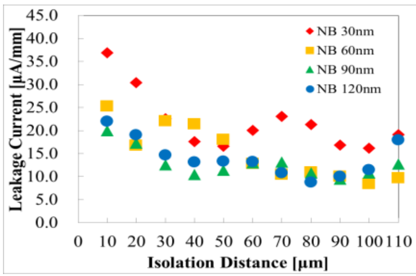

Fig.3 Leakage current in different isolation depth and distance