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Characterization of electrical properties of micro-Schottky contacts on ELO GaN

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1. Introduction

GaN has attracted much attention as a material for high-voltage, high-power and high-frequency electron devices. However there are many dislocations (10^8~10^9 cm^{-2}) due to a large lattice mismatch between GaN and sapphire substrate. Then it is very important to study the effect of the dislocations on the electrical properties of GaN. It has been reported that the dislocations and/or defects affect the electrical properties of GaN [1-3]. It was reported recently on the other hand that the dislocations did not affect the Schottky I-V characteristics using micro-Schottky contacts and AFM conductive probe [4]. The epitaxial lateral overgrowth (ELO) is known as a method to reduce the dislocation density (10^6~10^7 cm^{-2}). In this report, we studied the electrical properties of the micro-Schottky contact on ELO n-GaN by using AFM conductive probe.

2. Experiments

ELO n-GaN was grown on a sapphire substrate with stripes of SiO_2 mask (window / mask = 1 μm / 1 μm) [5], as shown in Fig. 1. Carrier concentration was about 1.2×10^{17} cm^{-3}. An array of the micro-Schottky contacts (8x8, diameter = 0.6 μm) was fabricated on the ELO GaN. I-V characteristics were measured using a conductive AFM probe. Measurement in high vacuum condition was very effective to improve the electrical contact between the AFM probe and the Schottky contacts, resulting in an improvement of reproducibility.

Figure 2 shows measured I-V characteristics of the Schottky contacts. The obtained I-V characteristics are classified into two groups, good contacts with small ideality factor and poor ones with large n-value. 68% of the contacts were good ones and 32% were poor ones. Poor contacts also have large leakage current.

The obtained barrier heights and n-values for the micro-Schottky contact array are shown in Fig. 3. The average barrier height and n-value of the good contacts and poor contacts are 0.89 and 1.06, and 0.45 and 4.05, respectively. The fact that I-V characteristics are classified into two groups and no intermediate characteristics are observed suggests that the present poor I-V characteristics are caused not by fabrication process but by crystal defects. Poor I-V characteristics which were often observed in a large Schottky contact is partly due to these crystal defects. It is notable that the small n-value of 1.06 could be obtained even though the contact size was not large.

In order to confirm that fabrication process is not a cause of above results of two types of I-V characteristics, similar contact array was fabricated on n-GaAs ($n=2 \times 10^{18}$ cm^{-3}). Measured results are shown in Fig. 4. Little scatter is observed in the I-V characteristics, indicating that poor I-V characteristics of ELO GaN are caused by neither fabrication process nor measurement technique such as electrical probing on the micro-Schottky contacts.

Figure 5 shows CL image around the Schottky contact array. The dark spots around the Schottky contacts are observed suggesting the existence of dislocations. The average dislocation density was 1.8×10^8 cm^{-2}. The probability that the 0.6μm micro-Schottky contact has at least one dislocation is 51% taking into account the average dislocation density. This is comparable to the percentage of the poor contacts. Even though the correlation between the I-V characteristics and dark spots in the CL image is not clear at present, we can speculate that the poor I-V characteristics are probably due to the dislocations.

3. Summary

In summary, the I-V characteristics of the micro-Schottky contacts fabricated on the ELO GaN were classified into two groups. This suggests the effect of crystal defects on the I-V characteristics of the Schottky contacts.

References

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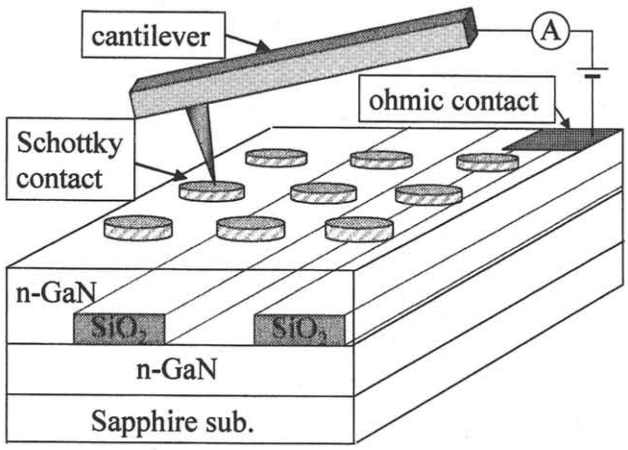

Fig. 1. Sample structure.

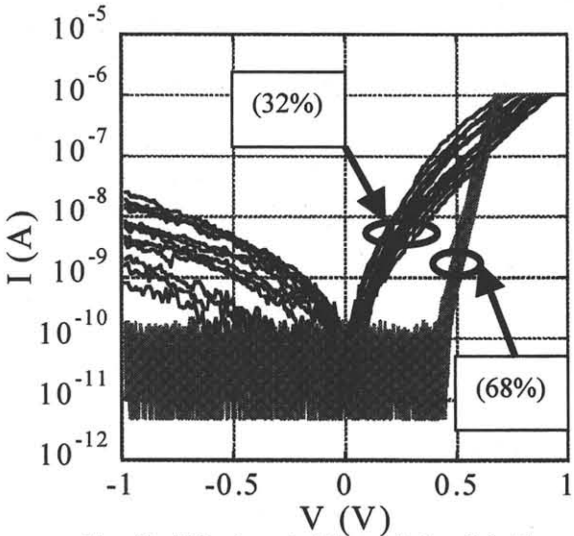

Fig. 2. I-V characteristics of the Schottky contacts on ELO GaN.

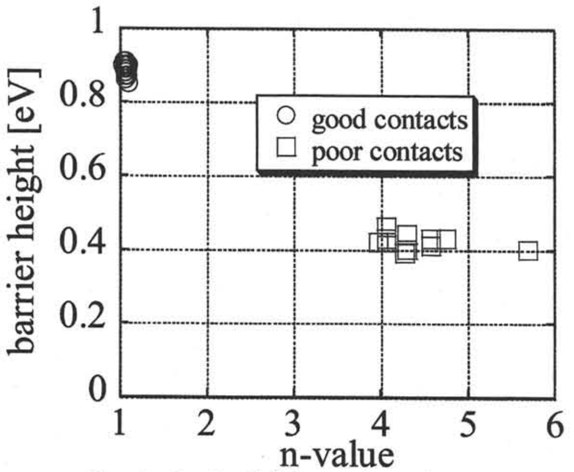

Fig. 3. Barrier heights and n-values of the micro-Schottky contacts.

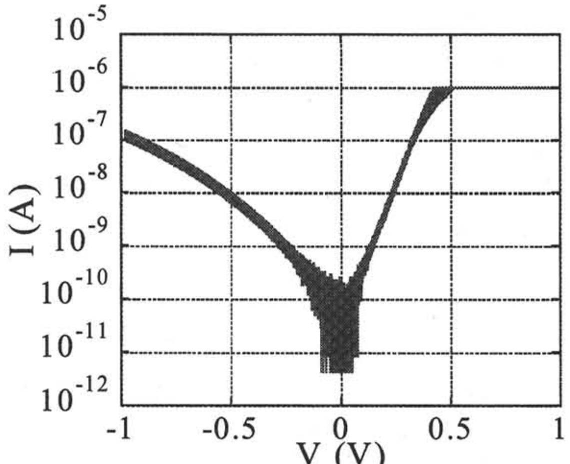

Fig. 4. I-V characteristics of the Schottky contacts on n-GaAs.

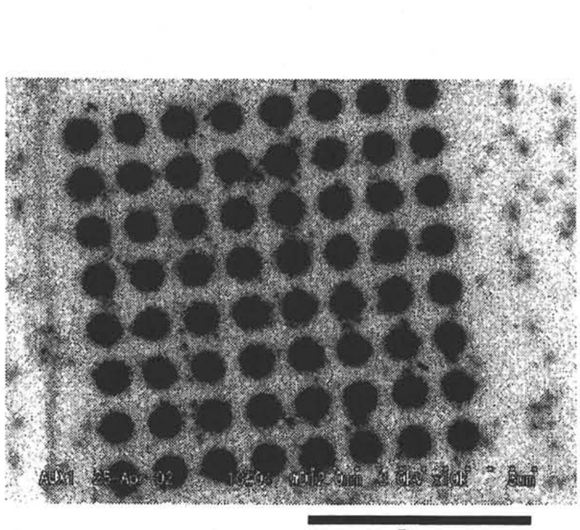

Fig. 5. CL image around the Schottky contact array.