Basic study on modification of GaN surface by atmospheric microplasma

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INTRODUCTION

GaN is usually formed by nitriding GaAs and grown on the sapphire substrate with a high dislocation density as shown in Fig. 1 (1). For this dislocation, microchannel epitaxy (MCE) or regrowth of GaN is required to reduce dislocations. Recently, plasma treatment is used for interface treatment, regrowth of GaN and nitridation process of GaAs. Microplasma is a atmospheric pressure nonthermal plasma and a type of dielectric barrier discharge which has small discharge gap under 100 μm which requires relatively low discharge voltage of only about 1 kV. The effect of surface treatment of GaN by atmospheric microplasma was experimentally investigated.

METHODS

(1) Microplasma Electrodes

Microplasma was generated with a pair of electrodes which covered with dielectric layer and faced each other at small discharge gap under 100 μm with a spacer. Due to small discharge gap (0.100 μm) and to the assumed specific dielectric constant of ε = 10, a high intensity electric field (10^7 - 10^8 V/m) could be obtained with relatively low discharge voltage of only about 1 kV.

(2) Experimental setup

Fig. 5 shows the experimental setup for surface treatment of GaN substrate. In this study, a negative pulse power supply was used to generate microplasma. Streamers were generated between electrodes that could generate various radicals and ions. These active species could affect a target surface (2).

Fig. 5 Experimental setup for surface treatment of GaN substrate.

Table 1 Experimental conditions.

<table>
<thead>
<tr>
<th>Atmosphere gas</th>
<th>Carrier gas</th>
<th>Carrier gas flow rate [m/s]</th>
<th>Discharge voltage [kV]</th>
<th>Discharge gap [μm]</th>
<th>From GaN surface to electrode [mm]</th>
<th>Treatment time [s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ar</td>
<td>N2</td>
<td>5</td>
<td>-1.3</td>
<td>100</td>
<td>1</td>
<td>5 ~ 30</td>
</tr>
</tbody>
</table>

RESULT

(1) SEM Image of GaN surface

Images of GaN surface were taken by FE-SEM to check a damage of GaN surface by microplasma treatment and confirm a effect of reducing dislocations of a GaN surface on a substrate (Fig. 6). All of following GaN sample surface were treated for 10 s with Ar microplasma and N2 microplasma.

CONCLUSIONS

In this study, the following conclusions were obtained.

1. The possibility of the GaN surface modification by atmospheric microplasma had confirmed.
2. It could be considered that physical damage for GaN surface can be controlled by choosing appropriate process gas, power supply and treatment time.
3. Different changes of N 1s and Ga 3d peaks was observed in Ar microplasma treatment and N2 microplasma treatment.

REFERENCE


Fig. 3 Image of microplasma.