Technical-Report

Breakthrough for the Next Generation Power Devices

Next-generation power devices composed of wide band-gap semiconductors such as Gallium Nitride (GaN) and Silicon Carbide (SiC) possess advantages in terms of power consumption and miniaturization; and are expected to be utilized in wind power generators, solar cell power plants, and hybrid/electric vehicles, trains, etc.

In the article below, SAMCO introduces recent breakthroughs in the manufacturing process for these next generation devices.

AlGaN Thickness Control (Recess Etching)

Recess etching for gate electrodes (15nm deep) requires low-damage, low-rate, highly accurate and uniform etching with smooth bottoms. SAMCO meets these requirements and has now achieved processing at a BIAS RF power of 5W (V_{dc} = −10V) and stable low etch rate of 0.8nm/min. No micro trenches, pits, or pillars were observed and etching depth non-uniformity across the 6" wafer was 1nm.

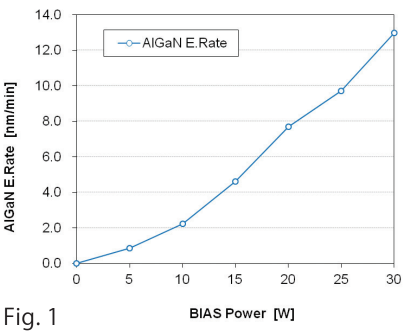

Fig. 1

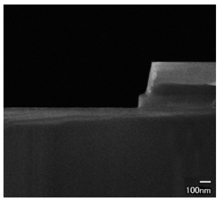

Fig. 2

Gate Formation Using Highly Selective GaN/AlGaN Etching

In GaN power devices, for some structures GaN is etched to expose AlGaN and form the gate. This process requires GaN/AlGaN selectivity of greater than 50:1 and a smooth AlGaN surface. SAMCO overcame this challenge by utilizing an additive gas. By precisely controlling the flow rate of this gas, high selectivity was achieved (Fig.3). Following this, by further optimizing the reaction chamber and gas composition, selectivity of >100:1 has now been achieved.

As well as the HFET(HEMT) devices mentioned above, SAMCO is conducting research on MOSFET devices where the gate AlGaN is completely etched. For both the HFET(HEMT) and MOSFET processes, we can accurately detect the interface, as well as precisely control the etch depth with automated optical endpoint detection systems.

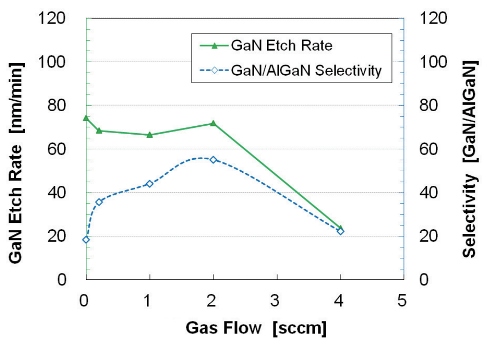

Fig. 3

Insulation Layer Deposition Using PECVD

For AlGaN/GaN HFET devices possess a problem called "current collapse". Here, the train current flow stops due to increased resistance caused by an electron trap on the AlGaN interface.

To rectify this, SiN and other dielectric films are deposited on the AlGaN surface to lessen the electric field on the gate edges. Normally SiN and SiO_2 insulation films are deposited using SiH_4. However, research has shown that TEOS-SiO_2 insulation films deposited on SAMCO' s PD-220 series systems provide further reduction in gate leakage. (Fig. 4)[1] We have also worked on oxidization films on MOFSET gates and have achieved mobility of 136cm^2/Vs or more.

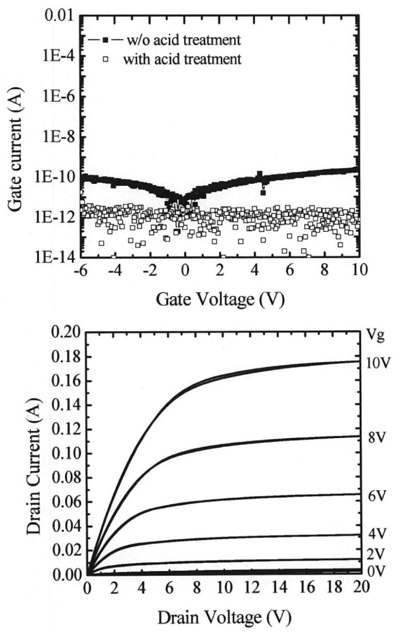

Fig. 4

New Approaches for 4H-SiC Device Fabrication

For SiC VIA hole etching, etching rates of 2 - 3 μm/min have been achieved on a SAMCO high speed etching system currently under development.

SAMCO is also strongly focused on gate oxide films to enable high mobility trench MOS devices. Please refer to the previous technical report, "High-speed Etching of SiO_2 and SiC".

Reference

1) K. Nakatani, J. –P. Ao, K. Ohmuro, M. Sugimoto, C. –Y. Hu, Y. Sogawa, and Y. Ohno : Evaluation of GaN MOSFET with TEOS-SiO_2 Gate Insulator, The 2009 International Conference on Solid State Devices and Materials, Sendai, Oct. 2009.