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Oxide Thickness Dependency on Threshold Voltage of GaN MOSFETs on AlGaN/GaN Heterostructure

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GaN MOSFETs on AlGaN/GaN heterostructure have attracted much attention owing to the easy fabrication of source and drain [1, 2]. However，for enhancement-mode operation, the nonideal negative threshold voltage and the low mobility are still serious problems. In this paper, we will report the performance of GaN MOSFETs with gate oxide deposited by PECVD with silane and TEOS, and the oxide thickness dependency on the threshold voltage of GaN MOSFETs on AlGaN/GaN heterostructure.

The MOSFET was fabricated on n-AlGaN/GaN HFET structure grown on a sapphire (0001) substrate (Fig.1). The first process is device isolation followed by a dry recess process with a protection mask of SiO_2 and an etching gas of $SiCl_4$. After the etching , samples were treated in HNO_3:HF=1:1 solution. Next, SiO_2 insulator with thickness of 100 nm, 60 nm, 30 nm were deposited by PECVD (SAMCO PD-220LC) with silane and 130 nm, 75 nm with TEOS as sources, respectively. Then they were given a thermal treatment under 1000 °C in N_2 for 10 min. The Ohmic contact and gate metal were finally made utilizing Ti/Al/Ti/Au and Ni/Au, respectively.

Ring-type GaN MOSFETs with inner and outer gate electrode radii of 89 μm and 183 μm (L=94μm, W_{eff}=819μm) were used for device evaluation. Drain current increase with gate voltage was confirmed up to 10 V. The transfer characteristics of GaN MOSFETs measured at V_d=0.1 V(Fig.2) show that the average field-effect mobility and interface state density are 139.4, 136.4, 144.9 cm^2/Vs and 1.44×10^{11}, 1.63×10^{11}, 1.84×10^{11} /cm^2eV for devices with silane-based oxide of 100, 60, 30 nm thick, respectively. Also, field-effect mobility of 81.5, 65.3 cm^2/Vs and interface state density of 5.14×10^{11}, 4.11×10^{11} /cm^2eV was obtained from devices with TEOS-based oxide of 130 and 75 nm thick. They did not showed obvious oxide thickness dependencies on the field-effect mobility and interface state density.

The normalized *C-V* characteristics (Fig. 3) and the transfer characteristics (Fig. 2) showed negative threshold voltages or flat band voltages for these devices. The threshold voltage of MOSFETs with silane based oxide of 100 nm, 60 nm and 30 nm are -3.2 V, -1 V and 0 V, respectively. Positive threshold voltage shift was observed when thinner oxide layer was used with both silane and TEOS-based oxide. From the oxide thickness dependency, it was estimated that positive fixed charges Q_f of around 10^{12} cm^{-2} exist near the interface. To realized enhancement-mode GaN MOSFETs, the reduction of the positive charges near the interface is necessary.

[1] J.-P. Ao, Phys. Status Solidi C **8**, 457 (2011).
[2] Q. Wang, Jpn. J. Appl. Phys **52**, (2013) (in press)..

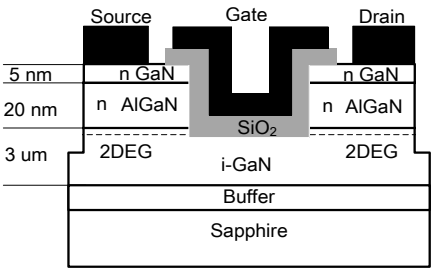

Fig.1 Device structure based on AlGaN/GaN HFET structure.

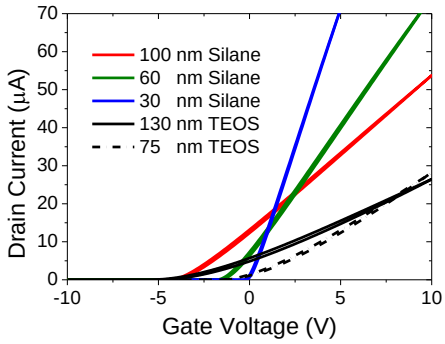

Fig. 2 Transfer Characteristics of GaN MOSFETs.(Vd=0.1V)

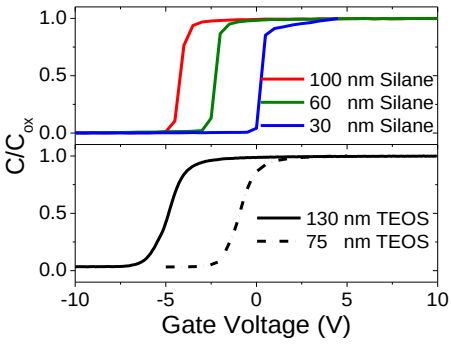

Fig. 3 Normalized Capacitance-Voltage characteristics.

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