Improvement in Electrical Properties of Ga_2O_3 Schottky Barrier Diodes by Nitrogen Radical Treatment

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Vertical Ga_2O_3 power devices possess great potential for high-power electronic applications. The drain current of a vertical fin FET is modulated by a gate on a sidewall formed by etching, and the sidewall surface quality is one of the most important parameters to determine device performance. Recently, we found that nitrogen (N) radical irradiation to a Ga_2O_3 surface improves electrical properties of Ga_2O_3 Schottky barrier diodes (SBDs), which will be reported in this talk.

Vertical SBD structures were fabricated on unintentionally doped β-Ga_2O_3 (010) and (100) substrates, whose Schottky-interface orientations are the same as the primary sidewall orientations of vertical devices on Ga_2O_3 (001) and (010) substrates, respectively. For Ga_2O_3 (010) substrates, the bottom grinding surface was first planarized by lapping and chemical mechanical polishing. On the other hand, both top and bottom surfaces of Ga_2O_3 (100) substrates were prepared by cleavage, and were used as received. To fabricate ohmic contacts, the bottom surfaces of both substrates were degenerately doped by Si-ion implantation (box profile, Si = 5×10^{19} cm^{-3}), followed by activation annealing. The top surfaces were irradiated with N radicals generated by an RF-plasma cell for 2 hours in a molecular-beam epitaxy growth chamber. The RF plasma power and N_2 flow rate were 500 W and 0.6 sccm, respectively. The substrate temperature during the nitridation was kept at 700°C. Then, Ti/Au ohmic and Pt/Ti/Au Schottky electrodes were formed on the bottom and top surfaces, respectively. The same SBD structures were also fabricated without the nitridation process for comparison.

Current density–voltage (*J*–*V*) characteristics of multiple SBDs fabricated on Ga_2O_3 (010) substrates with and without the N radical treatment are shown in Figs. 1(a) and 1(b), respectively. The ideality factors (n) were estimated to be 1.06±0.01 and 1.14±0.01 for the samples with and without the nitridation process, respectively. The nitridation process provided a reduction in n.

The SBDs on Ga_2O_3 (100) substrates showed clearer differences in *J*–*V* characteristics than those on the (010) substrates. The nitridated (100) SBDs showed near-ideal and homogeneous characteristics as demonstrated in Fig. 2(a). In contrast, kinks and/or shifts of the turn-on voltage can be observed in *J*–*V* characteristics for the samples without the N radical treatment [Fig. 2(b)]. Furthermore, the characteristics varied across the devices. The n for the nitridated and non-nitridated SBDs were 1.07±0.01 and 1.18±0.04, respectively.

These results indicate that the N radical treatment is effective to remove Ga_2O_3 surface damage and improve Schottky interface properties, which should be useful for development on various types of Ga_2O_3 FETs.

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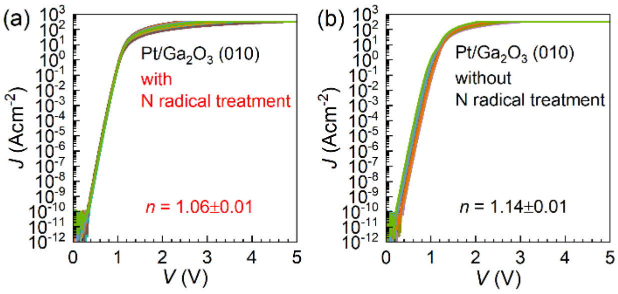

Fig. 1. *J*–*V* characteristics of Pt/Ga_2O_3 (010) SBDs: (a) with and (b) without N radical treatment.

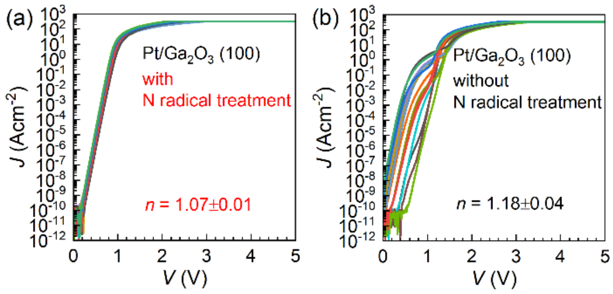

Fig. 2. *J*–*V* characteristics of Pt/Ga_2O_3 (100) SBDs: (a) with and (b) without N radical treatment.