[WD4-E-2]

Effects of passivation layers on carrier transport in AlGaN/GaN HFETs

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An AlGaN/GaN heterostructure field-effect transistor (HFET) as the next-generation power device has lots of advantages such as high efficiency, high frequency, and high power [1]. These advantages are enabled by the high electron mobility and density of the 2DEG layer formed intrinsically at the interface between AlGaN and GaN. It is known that the sensitive surface of AlGaN easily aggravates the electron density in 2DEG. Applying a passivation layer on the top of AlGaN can mitigate this issue, so called the passivation effect, however, the underlying physics related to the passivation effect has not been fully examined yet. In this study, we present a systematic study on the effect of passivation layers on carrier transport in AlGaN/GaN HFETs by means of various passivation materials and deposition techniques. We deposited a 100 nm-thick SiO_2 or SiN_x layer on AlGaN/GaN surface by using PECVD or rf-sputter system. After deposition of the passivation layers, a Ti/Al/Ni/Au (30/70/30/70 nm) metal stack was deposited and annealed for an ohmic contact by using an E-beam evaporator and an RTA system, respectively. For comparison purpose, a sample without any passivation layer was prepared at the same time. We observed that the sheet carrier density of the samples with a passivation layer (either SiO_2 or SiN_x) deposited by using PECVD increased, compared to the reference sample; while the sheet carrier density of the samples with a passivation layer deposited by using a rf-sputter system decreased. Through a capacitance–voltage (C–V) measurement and XPS analysis, we found that the carrier transport in 2DEG of an AlGaN/GaN HFET is significantly influenced not only by a passivation material itself but also by a deposition method. These findings will be useful for the further optimization of passivation layers for the various applications of AlGaN/GaN HFETs.

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[WD4-E-3]

Characterization of Heterojunction Interface Traps in AlGaN/GaN HEMTs through Sub-Bandgap Photonic Response and Subthreshold Ideality Factor

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AlGaN/GaN HEMTs are under active development for power devices and high-frequency applications due to high breakdown voltage and high mobility with wide bandgap and 2DEG [1]. These devices still suffer from reliability issues limiting the dynamic performance in practical applications. So it should be also considered the degradation mechanisms that affect the dynamic performance and the reliability issues of AlGaN/GaN HEMT devices [2] as well as the DC characteristics. We note that there are traps and interface states at the AlGaN/GaN heterojunction interface caused by the lattice mismatch during the fabrication process and hot carrier effect under high voltage/current operation. For a robust reliability of AlGaN/GaN HEMTs, it is very important to investigate and characterize the distribution of the interface traps over the band gap and their physical mechanism. In this work, we employed a differential ideality factor (DIF) under monochromatic sub-bandgap photonic (E_{ph}=2.8 eV) illumination, combined with capacitance-voltage (C-V) characteristics. We extracted the distribution of the interface traps over the bandgap to be $D_{it}(E) = 2.62\times10^{10} \sim 6.26\times10^{11}$ [$eV^{-1}cm^{-2}$]. This technique will be useful for characterization of the fabrication process and degradation mechanisms in AlGaN/GaN HEMTs.

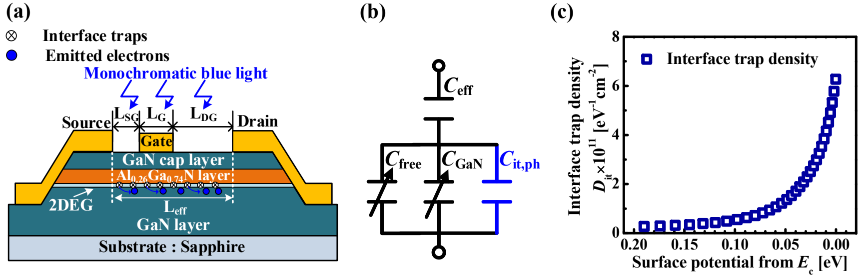

Fig. 1. (a)Schematic cross section, (b) C-V equivalent circuit of AlGaN/GaN HEMT devices and (c) extracted heterojunction interface trap density ($D_{it}(E) = 2.62\times10^{10} \sim 6.26\times10^{11}$ [$eV^{-1}cm^{-2}$]).

[1] Mishra, Umesh K., Primit Parikh, and Yi-Feng Wu., PROCEEDINGS-IEEE. **90**, 1022 (2002).
[2] Meneghesso G., et al., Semiconductor Science and Technology. **31**, 9 (2016).