Improved current collapse phenomenon in AlGaN/GaN HEMTs on Si substrate by using SiNx re-deposition process

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AlGaN/GaN HEMTs have great potential in high power microwave applications [1]. Despite the remarkable improvement in GaN-device technology, the “current collapse” issue has not been completely solved yet, which plays an important role in RF performance. It has been reported that optimizing a surface passivation process can diminish the current collapse phenomenon [2]. In this study, we developed a SiNx re-deposition process to further improve the current collapse phenomenon. A pre-passivation process started with SiNx deposition at 350°C using a remote ICP-CVD system in order to protect the surface during device fabrication. The key difference in the re-deposition process was that the SiNx pre-passivation layer was removed after high-temperature ohmic annealing by using a CF4/O2-based dry etching method and a new SiNx film was re-deposited on the entire surface before continuing the process. No significant difference in drain current density was observed between re-deposited and control devices whereas great improvement in pulse characteristics was observed for the re-deposited device. The SiNx pre-passivation layer was not removed for the control devices. The current collapse in pulse characteristics (VDS,Q = 30 V and VGS,Q = -5 V) decreased from ~33% to less than 8% when the re-deposition process was employed. It is speculated that the surface, even with the pre-passivation layer, was damaged during high-temperature ohmic annealing (800 °C, in N2 ambient). Removing the pre-passivation layer and re-depositing the fresh SiNx film turned out to be a very effective way to recover the damaged surface. As a result of the improved pulse characteristics, the re-deposited device exhibited superior characteristics to the control device; an output power density of 6.3 W/mm and PAE of 53.5% with the drain bias of 15V at 9.3 GHz.