Quantitative defect analysis in MOCVD GaN-on-GaN using cathodoluminescence

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Abstract

GaN-on-GaN vertical power devices can take the full advantage of excellent physical properties offered by GaN material. GaN PN diodes with breakdown voltage of 5 kV and specific on resistance of 1.25 mΩ·cm^2 has been reported [1]. To further advance the device performance of GaN-on-GaN vertical devices, high quality GaN drift layer with controllable doping at low-mid 10^{15} cm^{-3} and low compensation ratio is required. However, the unintentionally doped background impurities such as carbon from metal-organic precursors is at mid-10^{15} to low-10^{16} cm^{-3} for typical metal-organic chemical vapor deposition (MOCVD) grown GaN. In addition, Fe incorporation at the regrowth interface has recently been reported in GaN-on-GaN epitaxy, which typically has a slow decay profile and leaves residual impurities as high as mid-10^{16} cm^{-3} [2]. The incorporated impurities at the regrowth interface and beyond are detrimental to achieve controllable low doping in GaN epi-film which will inevitably affect device performance and raise reliability issues. Therefore, characterization techniques for quantitatively probing the impurity incorporation and distribution are of great importance for MOCVD GaN-on-GaN technology.

In this work, Cathodoluminescence (CL) is used as a quantitative characterization technique to probe impurities at the MOCVD grown GaN-on-GaN homoepitaxial interfaces [3]. CL intensity contrast shows a strong correlation with the interfacial impurity concentrations. Based on the analysis of recombination mechanisms of electron beam induced non-equilibrium carriers, an analytical model is proposed to quantitatively determine the impurity concentrations from CL intensity. The extracted interfacial impurity concentrations from the analytical model show a good agreement with the compensation levels obtained from capacitance-voltage measurement, signifying the potential of CL for probing the quantitative impurity levels in GaN-on-GaN structures. This approach can also be extended to be applied in other material systems.

References

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