Influence of bulk defects on the Schottky barrier height of β-Ga_2O_3 diodes

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Schottky contacts are widely used for power rectification, voltage clamping, high-speed switching circuits and solar photodetectors. Interface defects between metal and semiconductor are known to reduce the barrier height, thus degrading the rectifying behavior of the junction. In this work, we demonstrate that bulk defects can also contribute to Schottky contact degradation.
Vertical Schottky barrier diodes have been performed using Ti/Au for the Ohmic contact on the back side and Ni/Au for the Schottky contact on the top. The first set of diodes was carried out with a commercial β-Ga_2O_3 (-201) substrate grown by Edge defined Film fed Growth (EFG) from Novel Crystal Technology with a doping level at 4.3×10^{17} cm^{-3}. The second set of diodes was realized with an 11 µm epitaxial layer grown by Hydride Vapor-Phase Epitaxy (HVPE) on a Sn-doped β-Ga_2O_3 (001) substrate. The doping levels of the epitaxial layer and Sn-doped substrate are 2.1×10^{16} cm^{-3} and 7×10^{18} cm^{-3}, respectively.
Deep Level Transient Spectroscopy has allowed the detection of bulk deep traps in both sets of diodes. Three main traps E2, E2* and E3 were identified with a concentration of the order of 10^{15} cm^{-3} in the EFG commercial substrate, whereas traps E1, E2 and E2* were detected in the HVPE epitaxial layer with a concentration of the order of 10^{13} cm^{-3}.

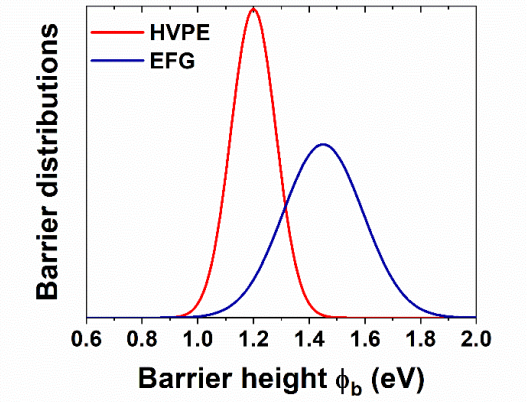

Figure 1: Distribution of Schottky barrier heights at 0 V for diodes performed on EFG substrate and HVPE epitaxial layer.

Barrier heights and ideality factors extracted from current-voltage measurements are temperature dependent. Assuming barrier inhomogeneities at the Schottky contacts [1-2], we were able to fit the experimental data by considering a Gaussian distribution of barrier heights. We found a correlation between Gaussian barrier height distributions (see Figure 1) and the concentrations of deep traps. In diodes performed on the EFG substrate, the higher concentration of traps is associated with a broader Gaussian distribution of Schottky barrier heights. Furthermore, the standard deviation is more sensitive to voltage variation for diodes fabricated on the EFG substrate than for those performed on the HVPE layer. Barrier height inhomogeneities are therefore greater for diodes realized on the EFG substrate. This result can be explained by the higher concentration of defects observed from the bulk to the surface.

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