Growth and characterisation of doped diamond multilayers for high power electric devices

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Diamond is the ultimate semiconductor for efficient high voltage applications. Furthermore, diamond is non-toxic, safe, and its precursor, carbon, is an abundant renewable resource. Unfortunately, diamond does not have a good bulk conductivity at room temperature due the high activation energy of its dopants. Therefore, diamond power devices based on conventional structures showed limited advantages over SiC or GaN devices. So, newly designed structures, which take into account the specific properties of diamond, are required to fulfil very high voltage operation and low “on-state” resistance.

Delta-doped structures were proposed to fabricate field effect transistors (FETs). These structures required 1 nm-thick layer and very high boron levels so thereby highest carrier mobility’s are obtained due to carrier wave function delocalization out of the boron ionized impurities [1]. Alternatively, bulky diamond channels with accurate boron levels can be used in MESFETs actuated by Schottky contacts or in MOSFETs actuated by a metal gate insulated by an oxide layer. Moreover, the precise control of doping levels, localization of dopant atoms, high-quality doping junctions, and homogenous metal/diamond or oxide/diamond contacts are great challenges.

In this study, boron-doped diamond superlattices (SL) p^{++} ([B] ~ 10^{20} cm^{-3}) / p^{+} ([B] ~ 10^{18} cm^{-3}) have been grown by CVD and covered by p^{-} ([B] ~ 10^{20} cm^{-3}) drift epilayers in order to investigate the impact of crystalline defects on Schottky-barrier diodes (SBDs) leakage currents. Here, boron-doped SL served as the conductive pathway of SBDs.

The growth process was divided into the sequential addition of methane, oxygen, and boron precursor to the hydrogen carrier gas. The intensity of optically active species in the plasma has been monitored during the process by optical emission spectroscopy [2] to estimate growth rate and doping profile in-situ. Afterward, SLs were capped by a p^{-} epilayer (Fig. 1). Ti/Au and WC were employed resp. as ohmic and Schottky contact metals, as reported in ref: 2.

Reverse blocking voltages and forward currents in our new structures have been compared to conventional SBDs [3]. Statistical *I-V* measurements have been performed on the same sample. Electrical properties were very homogenous with narrow distributions (ideality factors, n~1.1, Schottky barrier height 1.7eV) indicating a reproducible Schottky interface. However, leakage currents intensities showed large variations. These results are promising to identify the source of leakage currents, and this work can be transposed to FET for improving the operation reliability.

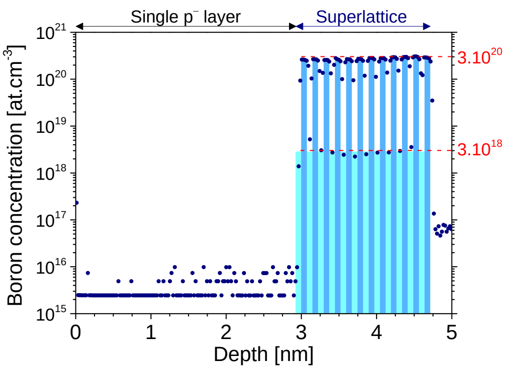

Fig. 1 – Boron concentration in a p^{-} layer capping a p^{++}/p^{+} superlattice composed of 12 alternate measured by SIMS. Blue boxes are visual guides to discriminate p^{++} and p^{+} layers.

References

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