Growth and Characterization of Conductive Diamond Multilayers for Schottky Diodes

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Introduction – Recent progresses in diamond Schottky-barrier diodes (SBD) aimed to increase breakdown voltage and to minimize serial resistance. Therefore, serial resistance has been reduced by working on diode structures containing heavily boron-doped (p^+) layers or conductive (p-type) substrates [1]. However, highest breakdown voltages are still obtained on resistive conventional SBDs structures, based on insulating substrate without a p^+-layer. We suppose that crystalline defects located inside p^+-layer and at its interfaces initiate dislocations, which propagate throughout SBDs, and worsen breakdown voltage ability [2].

In this study, we fabricated highly crystalline conductive diamond multilayers by alternating thin boron-doped films with [B] ~ 10^{20} cm^{-3} (p^+) and [B] ~ 10^{18} cm^{-3} (p^-). These p^+p^- multilayers were used to build the conductive pathway of SBDs, and their properties on serial resistance and breakdown voltage have been characterized.

Experimental details – p^+ and p^- layers have been deposited consecutively in the same plasma-enhanced CVD reactor. The growth process comported the sequential addition of methane, oxygen, and TMB to the hydrogen feed gas. Typically, the process was divided into six steps in a loop: p^- deposition, gas purge, boron shot, p^+ deposition, oxygen shot, and gas purge. The intensity of hydrogen Balmer's emission lines, OH* (~308 nm), CH* (~431 nm), BH* (~433 nm), and C_2* (~515 nm) emission peaks have been monitored during the process by optical emission spectroscopy. [3].

Results and discussions – Different B/C gas ratios have been employed to determine the effect of boron doping level on the crystallinity. Figure 1 shows the SIMS boron concentration profile measured in sample "ML6". ML6 was composed of four p^--layers spaced by p^+-layers deposited with the same period, but with different B/C gas ratios (0.7%, 1%, 1.2%, and 1.5%). Despite the variation of B/C gas ratios, doping levels in p^+-layers remained unchanged. This experiment highlights the phenomenon of boron incorporation that saturates near the metal-semiconductor transition (~ 3×10^{20} cm^{-3}). We made the hypothesis that incorporation saturation is correlated to a low density of dislocations in the layer. Therefore, we assume to increase charge carrier density in p^+p^- multilayers, while maintaining dislocation density low. That property of p^+p^- multilayer in SBDs has been appraised from reverse blocking voltage and forward current (not shown here) with respect to our previous results obtained on conventional SBDs.

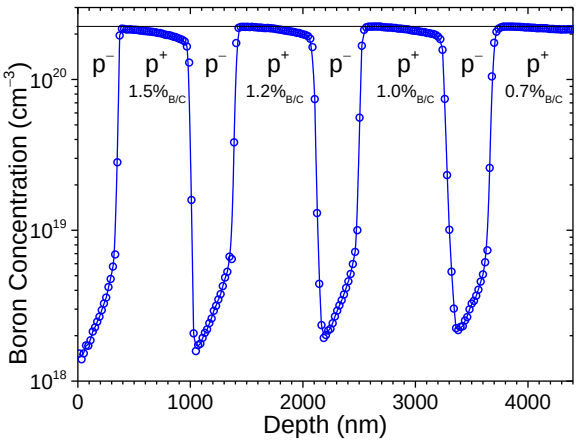

Fig. 1 – SIMS boron concentration profile of a p^+p^- multilayer. Molar fractions of CH_4 used in p^- and p^+ layers were 1% and 6% respectively.

References
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