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Locally Ion Implantation and Annealing Effects in Diamond

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Diamond has demonstrated interesting properties for high power applications. However numerous technological obstacles make difficult the fabrication of power devices on diamond. Diamond doping in-situ gas phase is today the most efficient technique. In fact, the possibility to dope locally by ion implantation is indispensable for establishing a diamond manufacturing chain in particular to achieve the highest possible doping.

In 2014 successful incorporation of implanted phosphorus in (100) diamond donor sites show promising perspectives to process convinced implanted n-type doping [1]. However, the absence of dopant electrical activation after implantation and thermal annealing is a technological obstacle to be removed to achieve localized n-type and p-type doping.

In this work, we focus our attention on boron over-doped implanted diamond layer. We performed implantation on (100)-oriented diamond single crystals by high temperature beam line ion implantation and by beam line followed by a co-implantation plasma immersion ion implantation (PIII). The boron depth profiles in the implanted diamonds are measured by secondary ion mass spectrometry (SIMS). They confirm an almost constant concentration of implanted species at a 200 nm depth (box-profiles): 1.6×10^{20} B/cm³ for high temperature implantation. Plasma immersion ion implantation (PIII) add a boron concentration peak of $2-3 \times 10^{20}$ B/cm³ at diamond extreme surface. Transmission Electron Microscopy (TEM) images performed on as implanted samples indicate damages on diamond crystal induced by implantation, but no amorphization. After high thermal annealing at 1700°C during 30 min, SIMS analysis evidences the loss of the boron surface peak obtained by PIII while diamond recrystallization is observed by TEM together with an increase of the diamond surface roughness.

The comparison between the four-probes measurements on as implanted samples and after annealing shows a decrease of the measured sheet-resistance. This demonstrates a benefit of thermal annealing on the electrical activation of implanted boron. Hall measurements will complete these first results to evaluate the efficiency of both boron implantation and annealing conditions.

[1] Barjon et al. Physical Review B 89 (2014) 045201