THE BORON DOPING OF SINGLE CRYSTAL DIAMOND FOR HIGH POWER DIODE APPLICATIONS

By: Shannon Nicley
Faculty Advisor: Prof. Tim Grotjohn

Diamond has the potential to revolutionize the field of high power and high frequency electronic devices as a superlative electronic material. The realization of diamond electronics depends on the control of the growth process of both lightly and heavily boron doped diamond. This dissertation work is focused on furthering the state of the art of boron doped diamond (BDD) growth toward the realization of high power diamond Schottky barrier diodes (SBDs). The achievements of this work include the fabrication of a new dedicated reactor for lightly boron doped diamond deposition, the optimization of growth processes for both heavily and lightly boron doped single crystal diamond (SCD), and the proposal and realization of the corner architecture SBD.

Boron doped SCD is grown in microwave plasma-assisted chemical vapor deposition (MPACVD) plasma disc bell-jar reactors, with feedgas mixtures including hydrogen, methane, carbon dioxide, and diborane. Characterization methods for the analysis of BDD are described, including Fourier-transformed infrared spectroscopy (FTIR), Secondary Ion Mass Spectroscopy (SIMS) and temperature-dependent four point probe conductivity for activation energy. The effect of adding carbon dioxide to the plasma feedgas for lightly boron doped diamond is investigated. The effect of diborane levels and other growth parameters on the incorporated boron levels are reported, and the doping efficiency is calculated over a range of boron concentrations. The presence of defects is shown to affect the doping uniformity. The substrate growth temperature dependence of the plasma gas-phase to solid-phase doping efficiency in heavily boron doped SCD deposition is investigated. The substrate temperature during growth is shown to have a significant effect on the grown sample defect morphology, and a temperature dependence of the doping efficiency is also shown. The effect of the growth rate on the doping efficiency is discussed, and the ratio of the boron concentration in the gas phase to the flux of carbon incorporated into the solid diamond phase is shown to be a more predictive measure of the resulting boron concentration than the gas phase boron to carbon ratio that is more commonly reported. The corner architecture SBD structure is proposed as an alternative vertical architecture for the realization of high power, high temperature single crystal diamond diodes. The lightly doped layer of the diode is grown in a direction perpendicular to the previous epitaxial growth of the heavily doped layer, to reduce the threading type dislocations in the active region of the fabricated diodes. The first ever corner architecture SBD is fabricated and evaluated for diode performance, using the regimes identified for high quality boron doped diamond deposition at light and heavy doping levels.
JOURNAL PUBLICATIONS


JOURNAL PUBLICATIONS IN REVIEW


JOURNAL PUBLICATIONS IN PREPARATION


REFEREED CONFERENCE PUBLICATIONS


INTERNATIONAL CONFERENCE PRESENTATIONS


Crystal Boron Doped Diamond for Improving Schottky Barrier Diode Performance”
Presented at the 2014 MRS Fall Meeting, Nov 30-Dec 5 2014, Boston, MA. (Oral)


**REGIONAL CONFERENCE PRESENTATIONS**


