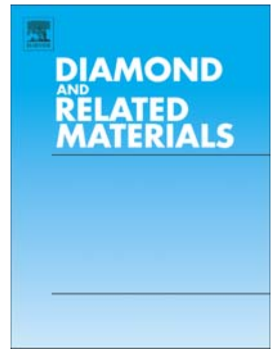

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PII: S0925-9635(16)30332-6
DOI: doi: 10.1016/j.diamond.2016.07.006
Reference: DIAMAT 6668

To appear in: *Diamond & Related Materials*

Received date: 15 April 2016
Revised date: 13 July 2016
Accepted date: 13 July 2016

Optimal drift region for diamond power devices

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Abstract

In power devices such as Schottky Barrier Diodes or Field Effect Transistors, the breakdown voltage is linked to the design of the drift layer but also to the physical properties of the material used. Diamond, with its high critical electric field due to its large band gap, opens the way to power components able to withstand very high voltage with outstanding figures of merit. Nevertheless, a particular attention has to be paid to the design of the drift layer to take benefit of these outstanding properties. Indeed, the drift region thickness, doping level and consequently the punch through or non-punch through designs must be well designed to reach the desired breakdown value and to minimize the ON state resistance at the same time. Here, a focus on the optimization of the specific ON state resistance as function of the breakdown voltage figure of merit has been carried out, while optimizing the drift layer and calculating the specific ON state resistance of unipolar high voltage diamond power devices. Based on the ionization integral calculation with impact ionization coefficients adapted to diamond, we performed an accurate analysis to find the best punch through design of the drift layer offering the lowest ON state resistance at a given breakdown voltage value. This theoretical study has been first applied in a one dimensional approach of the breakdown voltage. An additional 2D cylindrical coordinate analysis was performed to quantify the radius effect on the breakdown voltage value, and to compare the 2D breakdown voltage with the 1D breakdown voltage, for different drift region designs. These results offer preliminary design rules to fabricate more efficient unipolar diamond power devices. At the material level, this analysis also points out that thicknesses and doping levels required to achieve such structures are quite challenging for crystal growth in the context of high voltage power devices.

Key word

Numerical design of experiences, drift layer, breakdown voltage, punch through design, diamond, unipolar component, figure of merit.

Introduction

As the demand in high power and high frequency electronics keep increasing, standard semiconductors show their limits. Indeed, components able to operate at high voltage, high frequency and high temperature are crucial to go beyond the classical design trade off in power devices. Diamond, thanks to its outstanding properties, is the ultimate semiconductor to meet these requirements [1]. In power electronics, Schottky Barrier Diode (SBD) rectifier and Field Effect Transistor (FET) switch are two complementary devices in the commutation cell of