Study of Premature Breakdown Failure Mechanisms in Diamond Schottky Barrier Diodes with TCAD

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The extreme material properties of single crystalline diamond (SCD) make it desirable for a variety of electronic applications, especially power electronics. Recently, power electronic systems are expected to deliver and control more power, all while being smaller in size [1]. Diamond has several unique qualities that make it a suitable material for the next generation of more powerful and smaller power electronic systems. One notable quality for the development of future power electronic systems is its exceptionally large reverse breakdown electric field, which has been reported to be 13 MV/cm [2]. However, reaching the theoretical limit of reverse breakdown electric field for Schottky barrier diodes (SBDs) has largely been a question of the presence of defects [3]-[5]. In this study, heavily and lightly boron doped diamond layers are epitaxially grown onto diamond substrates having a 3-degree offcut from the (100) orientation and are then processed into pseudo-vertical SBDs. The SBDs will be analyzed experimentally to obtain temperature dependent I-V characteristics and breakdown voltages (BVs). The experimental BVs are then compared to both the theoretically expected values of the BVs and TCAD simulations of the SBD geometry. Finally, cross sections of the SBDs will be created using focused ion beam processing, and analyzed using transmission electron microscopy (TEM) to obtain atomistic level resolution of the active device region. The C-V characteristics and TEM cross sections of the SBDs will then be analyzed to identify existence and type of defects, and gauge their effect on the observed BVs compared to the theoretical breakdown predictions.

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