Characterization of thin Boron layers grown on Silicon utilizing Molecular Beam Epitaxy for ultra-shallow pn-junctions

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Given its desirable physical and electrical properties, for decades, Boron has been employed in many areas of research and industry [1]. Nowadays, used mainly in the semiconductor industry for the unique characteristics of its compounds and as a p-type dopant species by means of ionic implantation or epitaxy. In this work, the growth of nanometer thick layers of Boron on Silicon and the use of these films for ultra-shallow pn-junction formation are presented and discussed.

In this work, Molecular Beam Epitaxy is utilized for the growth of Boron layers with nanometer thicknesses on Silicon (100) epi substrates (highly n-type doped Si (100) substrates with a slightly n-type doped top layer grown by means of chemical vapor deposition with a thickness of 3 µm) targeting the formation of ultra-shallow p^+n^--junctions.

The growth properties of these films are investigated for growth temperatures ranging from 500 °C to 700 °C as well as for the variation in deposition time and consequent layer thicknesses. Resultant layers are then utilized to fabricate $p^+n^-n^+$-junction diodes for electrical characterization and evaluation. It will be shown, that the layer properties and device characteristics are mainly dependent on the temperature and duration of deposition.

Diodes fabricated with these junctions display very low saturation current densities (~ 10^{-8} A/cm^2) typical for conventional deep-junctions although at a fraction of the thickness. The diodes also display low series resistance as well as high ideality factors (Fig.1). Furthermore, diodes fabricated with these junctions display very high reverse breakdown voltages with characteristic breakdown behavior (Fig.2).

Furthermore, the use of these ultra-shallow contacts for ultra-thin emitter contacts for insulated-gate bipolar transistors (IGBTs) will be discussed.

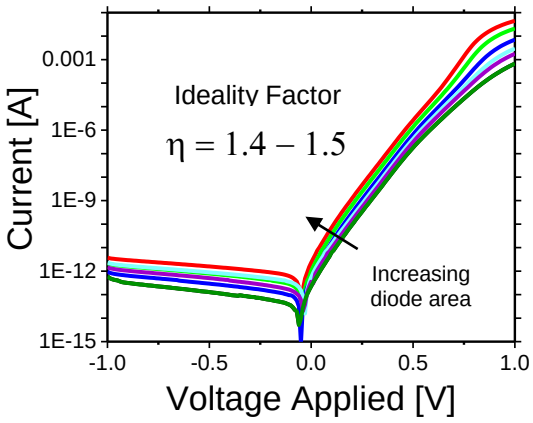

Fig. 1: I-V Characteristics for different sized diodes

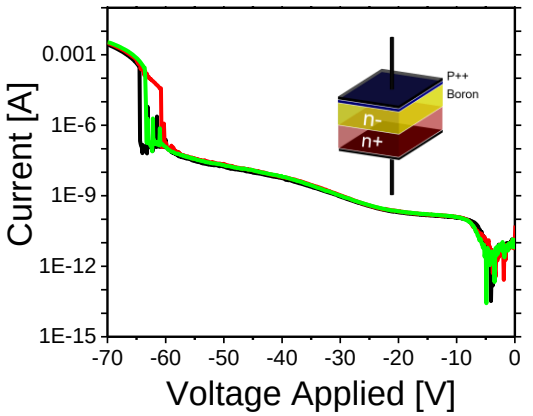

Fig. 2: Reverse Breakdown Characteristics

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