395a Nano-Crystalline P-Type Diamond for High Power & High Temperature Applications

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Conductive polycrystalline diamond films are desirable for a variety of high temperature and high power applications due to their high thermal conductivities, approaching the 20 W cm^{-1} K^{-1} of natural diamond. P-type diamond films may be produced by introducing boron as a dopant during growth by chemical vapor deposition (CVD). These films have properties which make them ideal for both passivation layers and ohmic contacts when a thin layer of p-type diamond is grown on top of non-conductive diamond. Applications in electronic devices that benefit from these films include passives, electromechanical devices, switches, integrated circuits, sensors and diamond heat spreaders. Nano-crystalline diamond (NCD) films were produced in a 1.5 kW ASTEX system by Microwave Plasma Enhanced Chemical Vapor Deposition (MWCVD) using precursor gas carbon concentrations from 0.5-4.0%, at 900 W power, 3.3 kPa pressure, and a substrate temperature of 680 ºC. Due to its relatively benign nature, boric acid used as the source of boron. The vapor from the saturated solution of boric acid dissolved in methanol was delivered by bubbling hydrogen through a system of two bubblers in series. Boron concentration of $1.2 – 2.4 \times 10^{19}$ cm^{-3} was measured by Secondary Ion Mass Spectroscopy (SIMS) for NCD grown with approximately 0.19% boron in the precursor gas. Film morphology was examined by Scanning electron microscopy (SEM) and grain size was found to be less than 500 nm. Sheet resistance of 260 Ω/sq. and sheet concentrations of $5.8 – 7.5 \times 10^{14}$ cm^{-2} were measured by the Van der Pauw method. Boron concentrations of $3.8 – 5.0 \times 10^{17}$ cm^{-3} were calculated from the measured sheet concentrations and film thicknesses. The nearly two order of magnitude difference in boron concentration measured by SIMS and calculated from Van der Pauw measurements indicates that not all the boron in the film is electrically active. Work is continuing to further understand this effect and to optimize this doping technique.