The Effect of Abrasive Grain Size on Chemical Mechanical Polishing of Single Crystalline Diamond Epitaxial Layers

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In order for single crystal diamond (SCD) to be practical as an electronic material for technical applications including solid state electronics, thin (<1 µm), precisely doped epitaxial SCD layers with very low (<1 nm) surface roughness are required. To address this, we propose a chemical mechanical polishing (CMP) process utilizing potassium permanganate as an oxidizing agent and various innovations to target uniform and repeatable material removal. A ball-joint style self-leveling sample holder is used to keep the SCD surface in flat contact with a grooved ceramic polishing wheel under the conditions of wheel rotation, sample rotation, and sample sweeping. These innovations seek to meet roughness requirements without unnecessarily affecting the epitaxial layer thickness or uniformity.

Our previous study (pending publication) investigating polishing rate and uniformity found that this CMP process yields an average polishing rate of 38.0 nm/hr and an average Sq roughness of 0.18 nm when utilizing a 1-3 µm boron carbide abrasive. Despite the low roughness result, scratches of less than 0.5 nm depth were observed in the atomic force microscope (AFM) images after CMP, indicating further opportunity for process optimization.

In this study, a series of abrasives including 45-55 nm, 300 nm, and 1-3 µm boron carbide powders are compared in order to minimize the surface roughness results of CMP processes performed on 1 µm thick heavily boron doped (p^+) epilayers grown on (100) SCDs cut to 3° off-angle. AFM analysis of the samples is used to quantify and compare outcomes of the experiments.