Electronic Grade 100 mm Diameter Single Crystal Ultra-Wide Bandgap (UWBG) Diamond Substrates: MPCVD Growth and Processing

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Abstract: Single crystal diamond, with its exceptionally high thermal conductivity, is gaining significant interest as an ultra-wide bandgap (UWBG) semiconductor material for RF and power electronics as the substrate diameter scales to 50 mm and 100 mm. We have developed a method of 'seed tiling' to assemble and overgrow arrays of smaller seed crystals into large diameter single crystals using Microwave Plasma Chemical Vapor Deposition (MPCVD). This method results in large domains of device-quality material which increase in size as the tiles are scaled up.

Crystal quality is further improved when our MPCVD growth method is paired with modulated N_2 doping to promote Lateral Epitaxial Overgrowth (LEO) for (100) step-flow growth across the tile seams. Seed tile 'cloning' is used to ensure consistent seed tile orientation. Additionally, we have implemented structural defect reduction strategies, including tungsten (W) pulsed doping. This allows for suppression of defects near the tile seams, resulting in large-area substrates with the lowest densities of structural defects. The W doping concentration and defect concentration have been characterized using electrochemical etching, Raman, secondary ion mass spectrometry (SIMS), and photoluminescence (PL).

Our poster will show our recent progress under the DARPA-LADDIS and DARPA-UWBGS programs with the goal of increasing (100) diamond substrate sizes to 100 mm, reducing defects, chemical-mechanical polishing, and manufacturing technology for cost-effective production of large area epi-ready substrates.