

ABSTRACT

Polycrystalline diamond (PCD) materials form part of tool components used in automobile, aerospace and mining applications. These components are commonly prepared using high pressure high temperature (HPHT) techniques. The importance of PCD is due to properties such as very high hardness, toughness and wear resistance at extreme conditions in a reproducible manner. However, few studies have examined the feasibility of using liquid phase sintering aids, such as the $\text{Y}_2\text{O}_3\text{-Al}_2\text{O}_3\text{-SiO}_2$ oxide binder system to sinter PCD at low pressures using the Spark Plasma Sintering (SPS) method. In this study we aimed to produce a dense, strong, liquid phase-sintered diamond composite without undergoing the diamond phase's solution re-precipitation stage, under a low pressure of 30 – 70 MPa. Diamond composites using monomodal and bimodal diamond feedstock powders were fabricated using yttrium alumino-silicate additives, with compositions of 40wt% Y_2O_3 -25wt% Al_2O_3 -35wt% SiO_2 (yttria-rich) and 30.78wt% Y_2O_3 -13.65wt% Al_2O_3 -55.58wt% SiO_2 (silica-rich) labelled as LPI and LPII, respectively. Diamond powder and the yttria alumina silica powders were mixed using the planetary ball milling technique and the ad-mixed components were heated and pressed using the SPS furnace. This showed that the silica-rich liquid phase sintering aid produced low density composites due to amorphous grain boundary and the move of the softening point to high temperatures. However, the yttria-rich additive produced bimodal diamond composites of high relative density of ~97% and hardness of ~13GPa due to faster densification rates. All the samples were measured for density using the Archimedes' method. Characterization was performed using powder X-Ray diffraction (XRD), Scanning Electron Microscopy (SEM), Energy Dispersion Spectroscopy (EDS) and Vickers hardness measurement. Examination of fracture surfaces resulted in linking microstructural features such as intergranular cracks, crack branching and intergranular phases to the behavior of these additives under the sintering conditions used in this work. This study revealed that high densities were attainable using the yttria-rich binder under low pressures using an SPS furnace. The effect of the heating/cooling rates via the SPS were also observed to affect the microstructural behavior of the composites and consequently their properties.