High-efficiency smoothing of polycrystalline diamond via plasma-based atom-selective etching

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Abstract. Due to the extreme mechanical hardness and chemical inertness, the smoothing of polycrystalline diamond (PCD) poses various challenges, such as a low material removal rate, excessive damage introduction, and difficulty in achieving sub-nanometer roughness. These issues greatly impede the further industrial applications of PCD. Herein, we propose using atmospheric inductively coupled plasma for smoothing PCD based on plasma-based atom-selective etching. This method has been proven to achieve high-efficiency smoothing of PCD without introducing new damage. During the etching process, oxygen is added to argon plasma to generate highly reactive oxygen radicals. These radicals can etch the carbon atoms on diamond surface with different rates according to their atomic bonding states. The etching process can be controlled by adjusting the flow rate of oxygen, radio frequency power, and torch-wafer distance, reducing the *S*a roughness of PCD from 338.0 nm to 22.2 nm in only 20 minutes. The material removal rate of PCD can be as high as tens of micrometers per minute, thousands of times higher than conventional mechanical/chemical mechanical polishing methods. Furthermore, X-ray diffraction spectra and Raman spectra results indicate that no amorphous carbon or new stress is introduced, and the crystal structure remains consistent before and after smoothing. Hence, combined with chemical mechanical polishing and other fine polishing methods, plasma-based atom-selective etching is believed to serve as an efficient pre-polishing approach to significantly increase the overall polishing efficiency of PCD.