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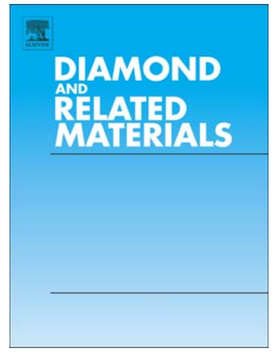

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Characterizations of etch pits formed on single crystal diamond surface using oxygen/hydrogen plasma surface treatment

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Abstract

Etch pits formed on (001)-oriented single crystal diamond surfaces by O/H plasma etching have been investigated using optical microscopy. Shapes of the formed pits are basically inverted-pyramidal hollows with the edge directions of the <110>, but central areas of these pits have two types of shapes, point-bottom and flat-bottom ones. Depth profiles of the number densities of these two-type pits showed that at an early stage of the etching, a large number of the flat-bottom pits are observed, but disappear to a depth shallower than ~10 μm. Compared with the other etching experiment using ion beam sputtering, such flat-bottom pits most likely correspond to the dislocations or microfractures introduced around the surface during surface polishing of the diamond substrates. On the other hand, point-bottom pits still continue to appear even in a deeper region. These correspond to “intrinsic” dislocations included originally inside the diamond substrate. All the tilt angles of the pit between the slope of the pit and top face of the substrate, characterizing the pit shape, were within the range of 3−7° and independent of their sizes in many pits investigated. It was found that the tilt angle and the activation energy of the etch rate obtained in this study are similar to that of an oxygen-gas related etching process.

KEYWORDS: Diamond; etch pit; point-bottom shape; flat-bottom shape; oxygen/hydrogen plasma; polishing damage; dislocation

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1. Introduction:

Diamond has a high chemical inertness unlike typical semiconductor materials, but its reactivity to oxygen is well known to be high. This allows device processing using preferential etching of oxygen to crystallographic face of diamond; for example, needle shaped diamond electron emitters have been attempted to be made by reactive ion etching using an oxygen gas [1]. Such oxygen preferential etching to diamond easily attacks to weak chemical bonding around defects and dislocations in diamond surface, leading to formation of etch pits. This is possibly useful to evaluate crystallographic imperfections like defects and dislocations in diamond. For instance, it has been reported that some etch pits formed by O/H plasma on an appropriate condition correspond to grown-in threading dislocations in CVD single crystal diamond [2]. Recent investigations have shown a large potential of diamond for high-power, high-temperature, and high frequency electronics [3], while single crystal diamond wafers are far from being free of dislocations and other structural defects [4], which would be deleterious to diamond device applications. Thus, it is