Abs. 932, 206th Meeting, © 2004 The Electrochemical Society, Inc.

Influence of substrate roughness on the adherent of BDD film on Ti-based substrates

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Conductive diamond electrode comprises of Boron doped diamond thin films (Fig. 1)were deposited on the Ti substrates by using the hot filament microwave plasma CVD method. The effect of microstructural morphology of substrate was examined on the BDD diamond/Ti substrate adhesion strength. Two types of substrate were prepared, one with Ti annealed at elevated temperature and subsequent chemically etched to provide rough surface relief and the other with polished smooth surface finish. The roughening of substrate surface significantly reduces the stress in diamond film and improves its adherence to the Ti substrate.

The BDD films were assessed for adhesion using the Vickers indentation test [1-2]. Figure 2 reveals that the film on polished substrate fractured after indentation at the load as low as 200 g leading to the initiation and propagation of long radial cracks. The ratio of crack's length (C) to the imprint size (a) is high, about 10. On the contrary, no delamination appeared on the film deposited on the roughened substrates at the load as high as 1 kg, while only short lateral cracks were found at higher loads. Thus, the adhesion strength has been significantly improved by using Ti substrate with roughened surface.

We prepared undoped films on polished and roughened titanium plates at the same deposition conditions as the B-doped films to evaluate the stress from Raman spectra, which are shown in the narrow frequency range in Fig. 3. For the undoped film on polished Ti the Raman peak is strongly shifted to 1340.4 cm^{-1} and broadened (peak width $\Delta\nu$=14.4 cm^{-1} FWHM) This shift is caused by the thermal compressive stress generated due to mismatch between the thermal expansion coefficients of diamond and Ti [3]. On the roughened Ti the diamond films shows practically no stress, the peak centered at 1331.1 cm^{-1} narrows to 9.0 cm^{-1}. Depending on the sampling spot size and location on that film surface the peak position varied typically between 1330 and 1335 cm^{-1} Due to the Fano effect[4, 5] the particular B-doped film on the similarly roughened substrate exhibits the further shift in the peak position down to 1327.2 cm^{-1}. The thermal stress in film on the rough surface is strongly reduced, because the film thickness is comparable with the characteristic size of surface relief features, so the diamond resists the protrusion contraction upon cooling after deposition.

Fig. 1

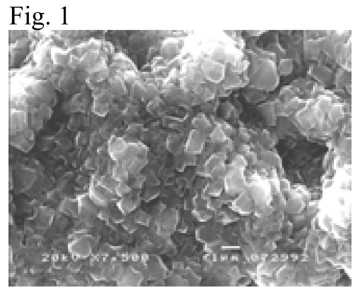


Fig. 2

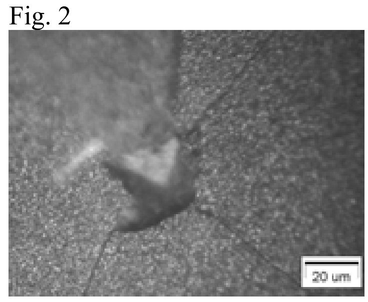
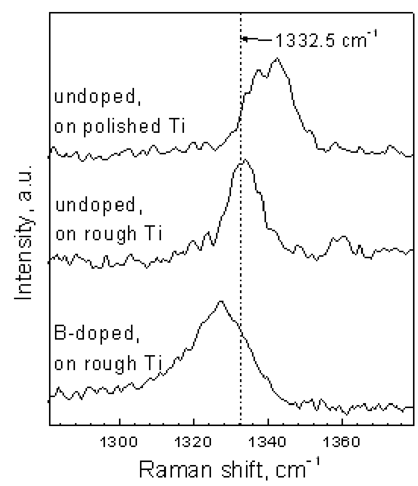


Fig. 3



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