

Chemical state analysis of Ultraviolet-Ray Aided Machining diamond surface

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Diamond has attracted attention for future material of semiconductor devices in the electric field due to its extraordinary physical properties. In order to use diamond for the semiconductor substrate, it needs to make the surfaces flat at an atomic scale. However, since a diamond is known as one of the hardest materials, a general mechanical polishing method takes a long polishing time to flatten a diamond surface. To overcome this problem, alternative polishing methods have been investigated over recent years. Ultraviolet-ray aided machining (U-RAM) is one of them. U-RAM is a chemical-mechanical polishing which uses chemical reaction on a surface by radicals from solution with photocatalyst and ultraviolet-ray [1, 2]. Although the polishing efficiency of the diamond was improved, details of chemical and mechanical processing on the surface is unknown. In order to elucidate a mechanism of U-RAM, we have analyzed the chemical state of U-RAM diamond (U-RAM Dia) and a commercial diamond (Scaif Dia) by X-ray absorption fine structure (XAFS) measurement.

The experiments were performed at BL-8 of SR center in Ritsumeikan University. We used two diamonds produced by high-pressure and high-temperature method. Only one diamond was processed by U-RAM. U-RAM used anatase TiO₂ powder (7 nm, 5 wt%) as photocatalyst, Cathilon (5 wt%), diamond powder (0-2 μm, 5 wt%), and Ti powder (40 μm, 20 wt%) under 253.7 nm wavelengths ultraviolet irradiation. U-RAM rotation speed is 150 rpm and polishing time is 90 minutes.

Figure 1 shows C *K*-edge XAFS spectra of the samples. N≡C, C-H and C=O bonds appear around 286.4 eV, 287.2 eV and 288.2 eV, respectively [3]. Diamond surface is chemically stable with hydrogen and oxygen termination. Since the intensity of C-H bond decreases after U-RAM treatment, the surface termination atom could be changed. Figure 2 shows O *K*-edge XAFS spectra of two diamond samples. C=O and C-O-C bond appear around 531.1 eV and 533.8 eV, respectively [3]. The peak intensity of C-O-C bond for Scaif Dia is smaller than that for U-RAM Dia. It indicates that U-RAM makes oxygen-carbon bonds on the surface due to

actions of scratching with diamond powder and radicals of decomposed water and Cathilon. Combined with C *K*-edge results showing that U-RAM changed hydrogen surface termination to other chemical bonds, the polishing efficiency of U-RAM is improved by composing carbon-oxygen bonds on the surface.

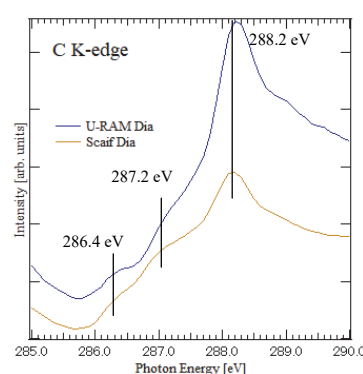


Fig. 1 C *K*-edge XAFS spectra of diamond samples with or without U-RAM.

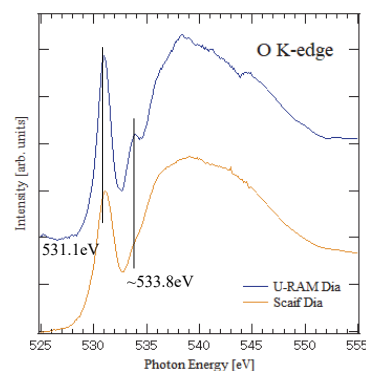


Fig. 2 O *K*-edge XAFS spectra of diamond samples with or without U-RAM.

References

- [1] Y. CHIWAYA and T. TANAKA, *J. Jpn. Soc. Abr. Tech.*, **2007**, 51, 232
- [2] T. TANAKA, M. TAKIZAWA and A. HATA, *J. Jpn. Soc. Abr. Tech.*, **2019**, 63, 630
- [3] C. WALTER, K. KUMMER, D. VYALIKH, V. BRUSER and K.D. WELTMANNA, *J. Elec. Soc.*, **2013**, 160, 1088