The diffusion bonding of diamond to Ti by energization pulse sintering method.

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There is a need to weld diamond in order to welding it with other substrate metals in abrasion-resistant materials, cutting tools, plastic-forming tools and gears. However, diamond has a high chemical stability,[1)] and welding it with a metallic material is difficult. Accordingly, currently diamond is welded primarily by brazing.[2)] However, brazing requires a temperature of 1223 K or higher; because of the mutual warp due to the residual stress generated by differences in the thermal expansion coefficient and in the modulus of stiffness between diamond and the substrate material, the welding strength between them is insufficient.[1] Therefore, the application of the energization pulse sintering (EPS) method is comparatively made in low temperature degree and a method of effective diffusion joining between solids in a diamond and the joining of various base materials by a short time. In this study, as materials which were easy to diffuse into diamond and which obtain a bonded interface, Ti were selected. Then, each listed material was joined with diamond and the diffusion mechanism were examined.

The diamond grains were produced by a high-temperature and high-pressure method, and had a the particle size of about 150 μm. A carbon sheet was wound around the inner surface of the graphite die in order to prevent the reaction, powders (Ti) were placed in the die to 2g, and then 0.2g of diamond grains were placed in the die. The carbon sheet was inserted between the punch and the sample. The graphite die with the powder sample was placed in an spark plasma sintering (SPS) furnace, and the furnace chamber was exhausted to a vacuum (6Pa); then under held for the as welding force of 34MPa, it rapidly changed for temperature conditions of 773K, 973K and 1173K, and maintainers times of 1.2ks, 2.4ks and 3.6ks in the EPS method. To evaluate the sample after the processing, the bonded interface was observed by scanning electron microscopy (SEM) and an energy dispersion system (EDS). As a method of evaluating the bond strength of the sample, compression testing was used.

Figure 1 shows an example of the results of SEM and EDS analyses: Tight adhesion between Ti and diamond is observed in this figure. However, it is difficult to confirm the presence or absence of the generated TiC layer (diffusion layer) due to diffusion welding in EPS processing. It was impossible to confirm the presence of TiC by XRD analysis. Therefore, we analyzed the element concentrations by DBC beam analysis. The results are shown is Fig. 2.

In Fig. 2, it is possible to confirm the concentration gradient which is specific to mutual diffusion near the bonding interface for both Ti and diamond. Because this, it is assumed that mutual diffusion occurred at the bonding interface between Ti and diamond. Accordingly, it is considered that a certain bonding strength was realized between Ti and diamond due to the above-described phenomena. It was also assumed that TiC is generated as a diffusion layer at the bonding interface. These results showed that grain boundary diffusion and volume diffusion progressed with the volume transport mechanism.

The junction planes of diamond/Ti confirmed diffusion couple adhesion with all joining conditions by SEM and an EDS result after the EPS method, and grain boundary diffusion and volume diffusion progressed with the volume transport mechanism.

References

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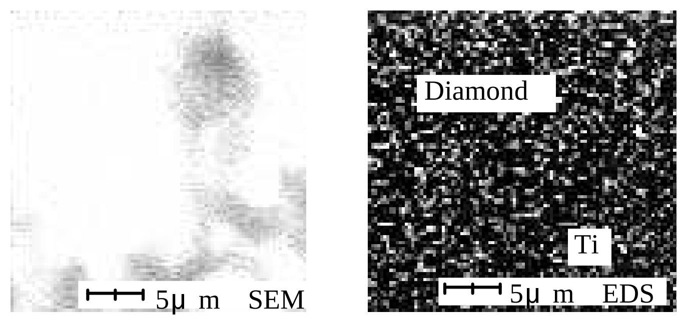

Fig. 1. Energy dispersive X-ray spectrometer analysis of Ti/diamond generated at pressure= 34MPa, temperature=1173 K, and holding time=3.6 ks.

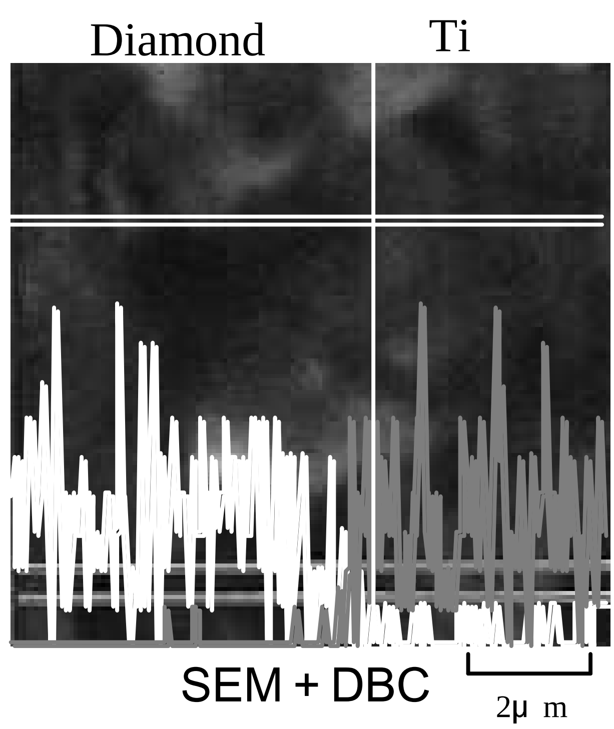

Fig.2. DBC analysis at Ti/Diamond interface area welded under conditions pressure = 34MPa, maintenance temperature = 1173K and hearting time=3.6ks.