Characteristics of Ni-based Alloy Bond in Diamond Tool Using Vacuum Brazing Method

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Abstract

We found that the “”””interface reaction between Ni-based alloy bond, diamond, and steel core is very critical in bond strength of diamond tool. None element from metal bond diffuses into the steel core but the Fe element of steel core was easily diffused into the bond. This diffusion depth of Fe has a great effect on the bonding strength. The Cr in steel core accelerated the Fe diffusion and improved the bond strength, on the other hand, carbon decreased the strength. Ni-based alloy bond including Cr was chemically bonded with diamond by forming Cr carbide. However, the Cr and Fe in STS304 were largely interdiffused, the strength was very low. The Cr passivity layer formed at surface of STS304 made worse strength at commissure in brazing process.

Keywords : diamond tool, brazing, chemical reaction, bonding strength

1. Introduction

Diamond tool is generally used in polishing, cutting and detailed-drawing of various hard work pieces due to their superior hardness and wear resistance. Because the tool life is dramatically increased by using the diamond tool, the process efficiency is improved and manufacturing process can be automatized. Therefore the demands of diamond tool are increasing.

Three major parts of diamond tool manufacturing are diamond grit, bond, and the shank forming the diamond tool body. This experiment addressed the interaction behavior between diamond, Ni-based alloy bond and steel core in brazing process of diamond tool.

2. Experiments and Results

Table 1 show the chemical contents of Ni-based alloy bond used as bond and the various steel cores, respectively.

Brazing process is performed in the vacuum furnace at vacuum of $2x10^{-5}$ torr with maintaining at temperature 1000℃ for 10 minutes. Bond strength is measured by compressive strength tester using shear jig. During compression test, cross area was ϕ10 and strain rate was 5mm/min. Also the interfaces between diamond and brazed layer and between Ni brazed layer and steel core are analized by using SEM and EDS, respectively.

SEM line scanning results of Fig.1 show that Fe atom is diffusing into bond directing from steel core without regard to steel cores. We measured bond strength according to different sorts of steel during Ni-based brazing by compressed shear test because this kind of atom diffusion have effect on its bond strength as shown in the result of Fig. 2.

Table 1. Chemical contents of various steel core (Korean standard) and Ni-based alloy bond.

Ni-based alloy bond					
Wt.%	Ni	Cr	Fe	Si	B
BOND	85.5	7	3	4.5	3.1
Steel core					
Wt.%	C	Si	Mn	Cr	etc.
STS304	<0.08	<1	<2	18~20	8~10.5Ni
SCM4	0.38~0.43	0.15~0.35	0.60~0.85	0.9~1.2	0.15~0.3Mo
SK5	0.80~0.90	0.35max.	<0.50	<0.30	<0.25Ni
SK3	1.00~1.10	0.35max.	<0.50	<0.30	<0.25Ni
S45C	0.42~0.48	0.15~0.35	0.60~0.90	-	<0.2Ni

As being found out below figure, the bond strength increased with depth of Fe atom diffusion from the interface between bond and steel core. Also it had high bond strength for the fewer carbon content of steel and the higher bond strength of Cr alloy steel than Mn alloy steel. However, in case of STS304, the bond strength would rather decrease than increase in other results. This is due to the Cr_2O_3 passivity layer formed at interface.

Fig. 3 and Fig. 4 show the interface among diamond, bond and steel core by using SEM, from which we confirm the main factor which play an important role in holding diamond.

Fig. 4 shows that Cr atom leads bond and diamond to bonding as forming carbide.

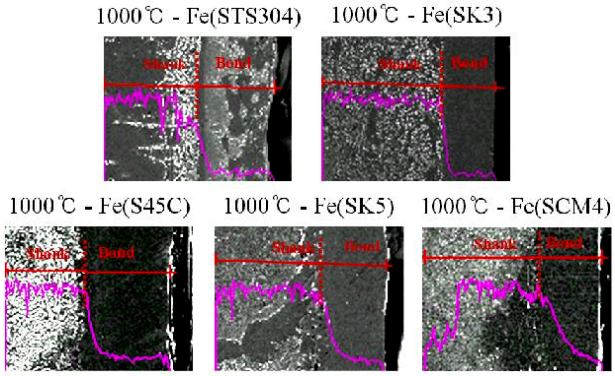


Fig. 1. SEM line scanning of the Fe diffusion in various steel cores.

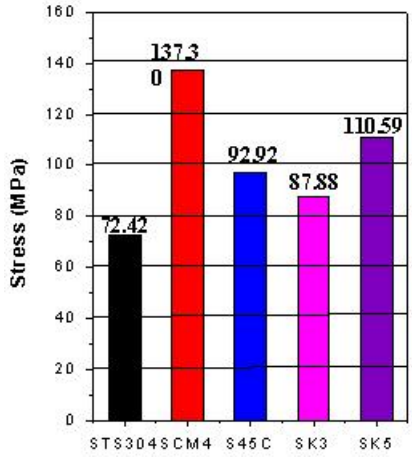


Fig. 2. Adhesion strengths between Ni-based alloy bond and various steel cores.

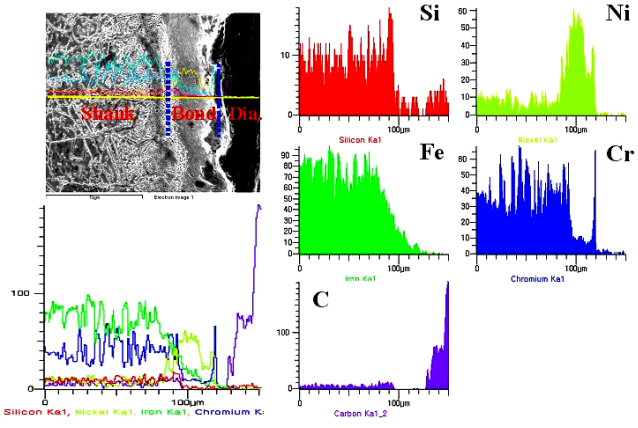
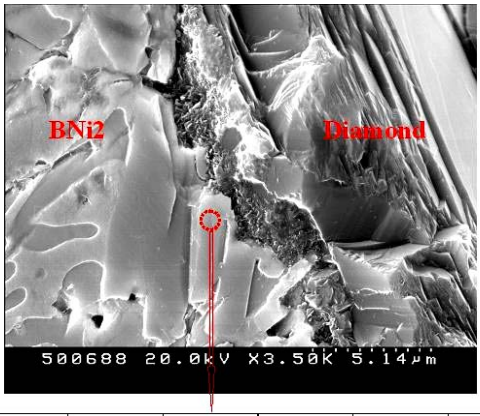


Fig. 3. SEM line scanning of the interface among diamond, Ni-based alloy bond and steel core.



	Si	Cr	Fe	Ni	total
DIA//BNi2	0.83	78.18	4.03	16.95	99.99

Fig. 4. SEM image and EDS result of BNi2 paste// diamond interface

3. Summary

The Fe diffusion has a great effect on the bond strength of Ni-based alloy bond and steel core. The diffusion was enhanced by the Cr element than the Mn (SCM4>S45C), whereas the carbon decreased the bond strength (SK5> SK3).

However, the Cr and Fe in STS304 were largely interdiffused and the strength was very low. The Cr_2O_3 passivity layer formed at surface of STS304 made worse the bond strength at interface in brazing process. Cr carbide was also formed by the chemical reaction between Ni-based alloy bond including Cr and diamond.

4. References

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