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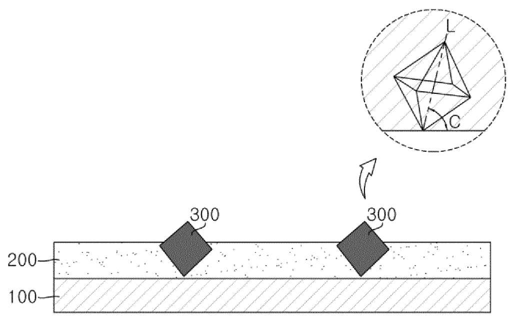
(54) DIAMOND DISC AND METHOD FOR MANUFACTURING SAME

(57) A diamond disc includes: a shank base; a bonding layer formed on a surface of the shank base; and a plurality of boron-doped diamonds (BDD) disposed in the bonding layer to be exposed. At least some of the plurality of boron-doped diamonds are disposed in the bonding layer in a posture in which an uppermost surface thereof meeting a long axis of the boron-doped diamond is inclined downward from an upper end of the major axis.

FIG.2



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a diamond disc and a method for manufacturing the same.

BACKGROUND ART

[0002] In general, a chemical mechanical polishing (CMP) process is a chemical-mechanical polishing process to obtain flatness of a semiconductor wafer by simultaneously using a polishing removal process and a dissolving action of a chemical solution.

[0003] The principle of CMP polishing processing is to supply polishing slurry in which abrasive particles and chemical solution are mixed on a polishing pad while moving the polishing pad and the wafer relative to each other in a state where the polishing pad and the wafer are pressed against each other. In this case, numerous foam pores on a surface of the polishing pad formed of polyurethane material serve to hold new polishing liquid, so that constant polishing efficiency and polishing uniformity can be obtained on the entire surface of the wafer.

[0004] However, due to the applied pressure and relative speed during polishing, the surface of the polishing pad is unevenly deformed over time, and the pores on the polishing pad are clogged with polishing residues, so that the polishing pad does not function properly. As a result, it is difficult to achieve wide-area flattening on the entire surface of the wafer and polishing uniformity between wafers during the entire processing time.

[0005] In order to solve the uneven deformation and clogging of the pores of the CMP polishing pad, a CMP pad conditioner is used to finely polish the surface of the polishing pad to form new micropores.

[0006] The CMP pad conditioning operation may be done simultaneously with the main CMP operation to increase productivity. This is called in-situ conditioning.

[0007] In this case, polishing liquid used in the CMP work includes abrasive particles such as silica, alumina, or ceria, and the CMP process is largely divided into oxide CMP and metal CMP depending on the type of polishing liquid used. The polishing liquid for oxide CMP used in the former has a pH value of 10 to 12, and the polishing liquid for metal CMP used in the latter has a pH of 4 or less and uses an acidic solution.

[0008] Typical conventional CMP pad conditioners include an electrodeposition type CMP pad conditioner made by electrodeposition and a fusion type CMP pad conditioner made by melting metal powder at a high temperature. Granular diamond particles are mainly used as an abrasive in these CMP pad conditioners. The diamond particles are fixed by a metal matrix formed by electrodeposition or fusion.

[0009] Diamond is known as a material with the highest hardness among materials existing on the earth, and due to this characteristic, diamond tools made of artificial diamond are manufactured and used.

[0010] However, in the conventional CMP process, diamond is used for polishing a wafer together with slurry in the CMP pad conditioner. When highly corrosive slurry is used, there is a problem in that additives in the slurry react with carbon in the diamond to accelerate diamond abrasion and shorten the life of the diamond disc.

(Prior Art Document)

[0011] (Patent Document) Korean Patent Application Publication No. 10-2012-0058303

DETAILED DESCRIPTION OF INVENTION

TECHNICAL PROBLEMS

[0012] Embodiments of the present disclosure provide a diamond disc with improved wear resistance and high grinding performance, and a manufacturing method thereof.

TECHNICAL SOLUTION

[0013] In accordance with one aspect of the present disclosure, there is provided a diamond disc including: a shank base; a bonding layer formed on a surface of the shank base; and a plurality of boron-doped diamonds (BDD) disposed in the bonding layer to be exposed, wherein at least some of the plurality of boron-doped diamonds are disposed in the bonding layer in a posture in which an uppermost surface thereof meeting a long axis of the boron-doped diamond is inclined downward from an upper end of the major axis.

[0014] Further, the boron-doped diamonds may be disposed in the bonding layer in a posture in which the long axes of the boron-doped diamonds have an angle more than 50° and equal to or less than 90° with respect to the shank base.

[0015] Further, a wetting angle at which a surface of the bonding layer and a surface of each of the boron-doped diamonds meet may be maintained at 0° or more and 60° or less.

[0016] Further, a ratio of a thickness of the bonding layer to an average diameter of the boron-doped diamonds may be in a range of 30% to 65%.

[0017] Further, an amount of boron doped in each of the boron-doped diamonds may range from 1 ppm to 2000 ppm.

[0018] Further, a magnetic susceptibility per unit volume of each of the boron-doped diamonds may be in a range of 20 to 800 per unit volume.

[0019] Further, a ratio of a density of the boron-doped diamonds to a density of the bonding layer may be maintained in a range of 0.4 to 0.6.

[0020] Further, each of the boron-doped diamonds may be an octahedron diamond, and a lower end of the boron-doped diamond may be in point or line contact with the surface of the shank base or is spaced apart by a predetermined distance from the surface of the shank base when the boron-doped diamond is erected on the bonding layer.

[0021] Further, in a pad cut rate (PCR) test equipment, when a CMP Pad conditioner made of the boron-doped diamonds is rotated at 100 rpm to 120 rpm and a polishing pad is rotated at 80 rpm to 95 rpm, it may take more than 13 hours until a PCR by the boron-doped diamond lowers to 2 to 10 μm/hr range for pad conditioning in a state in which the CMP Pad conditioner made of the boron-doped diamonds presses the polishing pad at 4 to 9 lbf.

[0022] In accordance with another aspect of the present disclosure, there is provided a diamond disc manufacturing method including: a bonding material application step of applying a bonding material to a surface of a shank base; a pre-sintering step of heating the bonding material applied to the surface of the shank base to a first temperature range to form a pre-sintered bonding layer; a diamond providing step of providing a plurality of boron-doped diamonds (BDD) to the surface of the pre-sintered body; and a heat treatment step of performing heat treatment in a second temperature range so that at least some of the plurality of boron-doped diamonds are disposed in the bonding layer in a posture in which an uppermost surface meeting a long axis of the boron-doped diamond is inclined downward from an upper end of the major axis.

[0023] Further, in the heat treatment step, the boron-doped diamonds may be disposed in the bonding layer, in a posture in which the long axes of the boron-doped diamonds have an angle more than 50° and equal to or less than 90° with respect to the shank base, to be exposed.

[0024] Further, in the pre-sintering step, the first temperature range may be 600°C to 900°C, and in the heat treatment step, the second temperature range may be 1000°C to 1300°C.

[0025] Further, in the heat treatment step, a wetting angle at which a surface of the bonding layer and a surface of each of the boron-doped diamonds meet may be maintained at 0° or more and 60° or less.

[0026] Further, in the heat treatment step, a ratio of a thickness of the bonding layer after the heat treatment to an average diameter of the boron-doped diamonds may be in a range of 30% to 65%.

EFFECT OF INVENTION

[0027] According to the embodiments of the present disclosure, excellent wear resistance and high grinding performance can be realized through boron-doped diamond (BDD) having an octahedral structure.

[0028] In addition, according to the embodiments of the present disclosure, the self-standing ratio of the octahedral boron-doped diamonds is higher than a certain ratio, thereby improving wear resistance and improving grinding performance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

FIG. 1 is a diagram showing a state in which boron-doped diamonds (BDD) are temporarily attached onto a bonding layer in the form of a pre-sintered body in a diamond disc according to one embodiment of the present disclosure.

FIG. 2 is a view showing a state in which boron-doped diamonds (BDD) are erected in the bonding layer after heat treatment in the diamond disc according to one embodiment of the present disclosure.

FIG. 3 is a view showing a state in which boron-doped diamond (BDD) is wetted in the bonding layer after heat treatment in the diamond disc according to one embodiment of the present disclosure.

FIGS. 4 and 5 are photographs comparing wear conditions of the diamond disc according to one embodiment of the present disclosure and a regular diamond.

FIG. 6 is an enlarged comparison of the diamond disc to which boron-doped diamond (BDD) is applied according to an embodiment of the present disclosure and a diamond disc to which regular octahedral diamond not doped with boron is applied,.

FIG. 7 is a graph showing a PCR test between the diamond disc to which boron-doped diamond (BDD) is applied according to one embodiment of the present disclosure and the diamond disc to which the regular octahedral diamond is applied.

FIG. 8 is a graph showing a weight reduction rate according to heat treatment in the boron-doped diamond (BDD) according to one embodiment of the present disclosure and the regular diamond.

FIG. 9 is a block diagram illustrating a method of manufacturing a diamond disc according to one embodiment of the present disclosure.

BEST MODE FOR CARRYING OUT THE INVENTION

[0030] Hereinafter, specific embodiments for implementing a spirit of the present disclosure will be described in detail with reference to the drawings.

[0031] In describing the present disclosure, detailed descriptions of known configurations or functions may be omitted to clarify the present disclosure.

[0032] When an element is referred to as being 'connected' to, 'supported' by, 'accessed' to, 'supplied' to, 'transferred' to, or 'contacted' with another element, it should be understood that the element may be directly connected to, supported by, accessed to, supplied to, transferred to, or contacted with another element, but that other elements may exist in the middle.

[0033] The terms used in the present disclosure are only used for describing specific embodiments, and are not intended to limit the present disclosure. Singular expressions include plural expressions unless the context clearly indicates otherwise.

[0034] Further, in the present disclosure, it is to be noted that expressions, such as the upper side and the lower side, are described based on the illustration of drawings, but may be modified if directions of corresponding objects are changed. For the same reasons, some components are exaggerated, omitted, or schematically illustrated in the accompanying drawings, and the size of each component does not fully reflect the actual size.

[0035] Terms including ordinal numbers, such as first and second, may be used for describing various elements, but the corresponding elements are not limited by these terms. These terms are only used for the purpose of distinguishing one element from another element.

[0036] In the present specification, it is to be understood that the terms such as "including" are intended to indicate the existence of the certain features, areas, integers, steps, actions, elements, combinations, and/or groups thereof disclosed in the specification, and are not intended to preclude the possibility that one or more other certain features, areas, integers, steps, actions, elements, combinations, and/or groups thereof may exist or may be added.

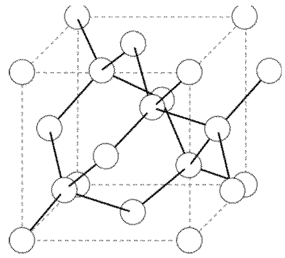
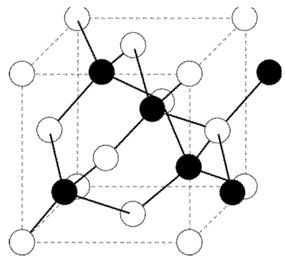
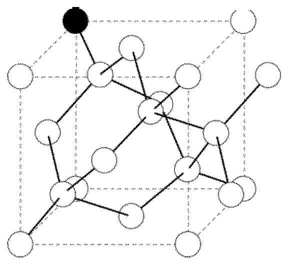
[0037] First, with regard to the chemical composition of diamond, comparing regular diamond and boron-doped diamond (BDD) according to the present disclosure, in a highly corrosive environment (e.g., W CMP or Oxide CMP process), the wear resistance of the boron-doped diamond BDD is superior to that of the regular diamond, and there is no significant difference between the wear resistance of the regular diamond and the wear resistance of the boron-doped diamond (BDD) in a less corrosive general environment.

[0038] In an electrodeposited CMP diamond disc manufacturing method, nonconductor diamond is supported using nickel electroplating as a bonding layer. However, boron-doped diamond (BDD), which conducts electricity, is covered with a nickel electrodeposition layer up to the surface of the boron-doped diamond during electroplating, so boron-doped diamond cannot be used in the electrodeposition process in a general way. Therefore, boron-doped diamond (BDD) can be applied when a diamond disc is manufactured by a welding method and a sintering method.

[0039] In addition, in the processing of general iron (Fe)-based metals, since diamond has an affinity reaction with iron-based metals, it is difficult to process the metals using the diamond. In a CMP pad conditioning operation, when slurry is supplied to a polishing pad, iron (Fe) component contained in the slurry reacts with carbon of diamond of a diamond disc to accelerate wear of the diamond. As a result, the wear of the diamond is accelerated and its life is short. However, boron-doped diamond (BDD) doped with boron according to the present disclosure suppresses the oxidation reaction of carbon ($C + O_2 \rightarrow CO_2$) (by acting as a blocking layer), so it can improve the stability of the diamond disc.

[0040] The differences in manufacturing between the boron-doped diamond (BDD) according to the present disclosure, the regular diamond, and conventional cubic boron nitride (CBN) are shown in Table 1 below.

(Table 1)

	Raw material	Catalyst	Structure	Boron content
Diamond	Graphite	Fe-Ni alloy		None
CBN	Hexagonal boron nitride	Alkali metal such as Li, Mg, Ca, etc. and nitride thereof		C:B=1:1 structure
BDD	Graphite	Fe-Ni alloy + Pure boron or Boron carbide (B_4C)		1 ppm to 2000 ppm

[0041] In the case of boron-doped diamond according to the present disclosure, Fe-Ni alloy and boron (pure boron or boron carbide) are used as catalysts, and boron may be substituted for carbon in diamond synthesis, or boron may invade the diamond structure. This boron-doped diamond can suppress the reaction between external iron (Fe) and carbon in the diamond, providing all the characteristics of diamond that is resistant to abrasion.

[0042] On the other hand, regular diamond does not contain boron while Fe-Ni alloy is used as catalyst for carbon, and cubic boron nitride (CBN) has a relatively large amount of boron added thereto to have a content ratio of carbon to boron of 1:1, so that it has very low strength compared to the boron-doped diamond although it does not react with iron (Fe), and it may be difficult to control the shape thereof.

[0043] In the present embodiment, among the diamonds applied to the diamond disc, the boron-doped diamond (BDD) may be used in an amount of 5 vol% or more of the total diamonds, depending on the purpose of use. In addition, the proportion of octahedral structure in the boron doped diamond (BDD) may be 50% or more. The proportion of boron-doped diamonds (BDDs) that are self-standing in the bonding layer may be 60% or more of the total boron doped diamonds (BDDs).

[0044] The proportion may be determined as the proportion of diamonds satisfying the above criteria among the total diamonds in a certain area by observing the total diamonds.

[0045] Hereinafter, a specific configuration of a diamond disc according to one embodiment of the present disclosure will be described with reference to FIGS. 1 to 8.

[0046] Referring to FIGS. 1 to 6, a diamond disc according to the present disclosure may be applied to a CMP pad conditioner to finely polish a surface of a polishing pad. The diamond disc may include a shank base 100, a bonding layer 200, and a plurality of boron-doped diamonds (BDD) 300.

[0047] Specifically, the shank base 100 is a backing plate of the disc, and the bonding layer 200 may be formed on a surface of the shank base 100. Since the shank base 100 corresponds to a typical shank base used as a backing plate of a disc, a detailed description of the shank base 100 will be omitted.

[0048] The bonding layer 200 may be formed of a bonding material containing 60 wt% or more of Ni, and other elements such as Cr, Si, and the like. The bonding material may be applied to the surface of the shank base 100, and then formed into a solid phase pre-sintered body through a drying and pre-sintering process. An adhesive may be applied to a top surface of the pre-sintered body to temporarily attach the boron-doped diamond 300. On the top surface of the adhesive-coated pre-sintered body, the boron-doped diamond 300 may be temporarily attached using a drilling jig.

[0049] The pre-sintered body may be heat treated together with the boron-doped diamond 300 to form the bonding layer 200. The bonding layer 200 may be phase-changed to a liquid state during a high temperature heat treatment process, and the boron-doped diamond 300 may be disposed on the bonding layer 200 in a standing state. The bonding layer 200 with the boron-doped diamond 300 disposed in the standing state may be cooled and dried.

[0050] A density of the bonding layer 200 may range from 6 g/cm^3 to 8.3 g/cm^3. A density of the boron-doped diamond 300 may range from 3.5 g/cm^3 to 3.6 g/cm^3. In the present embodiment, the density of the bonding layer 200 is 7.6 g/cm^3 and the density of the boron-doped diamond 300 is 3.54 g/cm^3.

[0051] In addition, a ratio of the density of the boron-doped diamond 300 to the density of the bonding layer 200 may be in a range of 0.4 to 0.6. When the ratio of the density of the boron-doped diamond 300 to the density of the bonding layer 200 is higher than 0.6, the buoyancy of the boron-doped diamond 300 due to the density difference between the bonding layer 200 and the boron-doped diamond 300 may be too low, and the boron-doped diamond 300 may be immersed in the bonding layer 200. When the ratio of the density of the boron-doped diamond 300 to the density of the bonding layer 200 is less than 0.4, the buoyancy of the boron-doped diamond 300 due to the density difference between the bonding layer 200 and the boron-doped diamond 300 becomes too large, and the boron-doped diamond 300 may float on the top surface of the bonding layer 200 and tilt in a horizontal direction.

[0052] The boron-doped diamond 300 may contain Fe-Ni alloy and boron (pure boron or boron carbide) as a catalyst in carbon. As an example, the boron-doped diamond 300 may contain Fe-Ni alloy and 1 ppm to 2000 ppm of boron (pure boron or boron carbide) in carbon. In the diamond structure, boron may be substituted for carbon, or boron may invade the diamond structure. The boron-doped diamond 300 can provide wear resistance without reacting with external iron (Fe).

[0053] The boron-doped diamond 300 may have a toughness index (TI) of 20 to 50, and a temperature toughness index (TTI) of 14 to 45. The boron-doped diamond 300 may have a magnetic susceptibility (MS) per unit volume of 20 to 800, and more preferably 30 to 500.

[0054] Fe, Ni, etc. used as catalysts in the synthesis process of the boron-doped diamond 300 are included as foreign substances in the diamond. In general, as the amount of boron doping increases, the amount of foreign substances increases proportionally. When the MS value is less than 20, the amount of boron doping is very small, and the effect of corrosion resistance improvement by boron may be reduced, and when the MS value is greater than 800, the amount of boron doping is increased, but the diamond properties may be degraded due to excessive incorporation of ferromagnetic metal foreign substances such as Fe and Ni, and the diamond particles may crack during CMP pad conditioning. As the amount of metallic debris inside the boron-doped diamond 300 increases, the TI and TTI values decrease, which can also be known through the MS measurements. Diamond toughness (TI, TTI, or MS) needs to be high enough to resist fracture during prolonged use under pressure in CMP conditions.

[0055] The boron-doped diamond 300 may be an octahedron diamond. Depending on the synthesis conditions, the diamond may be prepared in an octahedral shape, wherein the octahedral diamond has sharp edges, and in the octahedral diamond, the angle formed by the faces and the line connecting the vertices and the center ranges from 35° to 45°.

[0056] The boron-doped diamond (BDD) 300 may include a plurality of boron-doped diamonds that are disposed in the bonding layer 200 to be exposed. At least some of the plurality of boron-doped diamonds 300 may be disposed in the bonding layer 200 in a posture of an angle C such that a long axis L is greater than 50° and less than or equal to 90° with respect to the shank base 100.

[0057] In the present embodiment, among a plurality of vertices of the diamond 300, an imaginary line connecting the two farthest apart vertices facing each other may be defined as an ’axis’, and the axis with the longest length among the plurality of ’axes’ may be defined as the ’long axis L’. Furthermore, the "vertex" may be defined as a point where adjacent edges meet, and when adjacent edges do not meet at a "point" (e.g., when the portion corresponding to the vertex is bluntly shaped), an imaginary point where the extended edges meet when the adjacent edges are extended may be defined as the vertex. The boron-doped diamond with the long axis of 50° or more may be defined as self-standing.

[0058] In addition, it may be understood that the boron-doped diamond 300 is self standing when the boron-doped diamond 300 is disposed on the bonding layer 200 in the posture of the angle C such that the long axis L of the boron-doped diamond 300 is greater than 50° and less than or equal to 90° with respect to the shank base 100. When the boron-doped diamond 300 is self standing on the bonding layer 200, the bottom vertex in the long axis direction of the boron-doped diamond 300 may be in point or line contact with the surface of the shank base 100, or may be spaced apart by a predetermined distance.

[0059] When the long axis L of the boron-doped diamond 300 becomes 35° with respect to the shank base 100, the boron-doped diamond 300 is in face contact with the workpiece (polishing pad), which may significantly reduce the polishing performance of the boron-doped diamond 300 on the workpiece. As the long axis L of the boron-doped diamond

300 approaches 90° with respect to the shank base 100, the boron-doped diamond 300 is in point contact with the workpiece, which may significantly increase the polishing performance of the boron-doped diamond 300 on the workpiece.

[0060] In order for the long axis L of the boron-doped diamond 300 to be disposed in the bonding layer 200 at the angle C greater than 50° and less than or equal to 90° with respect to the shank base 100, a wetting angle θ at which the surface of the boron-doped diamond 300 meets the surface of the bonding layer 200 needs to be less than 90°, and preferably, the composition of the bonding layer needs to be configured so that the wetting angle θ is less than 60°.

[0061] Referring to FIG. 3 and Equation 1 below, the wetting angle θ may be determined by an upwardly directed force Fv, a downwardly directed force F_D, and a laterally directed force F_L.

[0062]

(Equation 1)

$$F_V = F_D + F_L\cos\theta$$

[0063] When the wetting angle θ exceeds 90°, the boron-doped diamond 300 may float further because the vertical component force of F_L is directed upward, and when the wetting angle θ is less than 90°, since the direction of the vertical component force of the laterally directed force F_L may change to a lateral downward direction, the boron-doped diamond 300 may be subjected to a downward force.

[0064] For example, when the wetting angle θ is greater than 90°, the bonding layer 200 does not properly support the boron-doped diamond 300 due to buoyancy of the boron-doped diamond 300, which increases the risk of dropping the boron-doped diamond 300. Further, since chip pockets for discharging debris generated during polishing are not formed in the bonding layer, the debris cannot be discharged properly, which may cause significant deterioration of the polishing performance. Preferably, as the wetting angle θ of the octahedral boron-doped diamond 300 is smaller than 60°, the boron-doped diamond 300 makes point or line contact with the workpiece (polishing pad), and chip pockets are well formed, so that the polishing performance of the boron-doped diamond 300 for the workpiece can be remarkably increased.

[0065] However, even if the wetting angle between the boron-doped diamond 300 and the bonding layer 200 is less than 60°, when a thickness of the bonding layer is too thick, an exposure height of the boron-doped diamond 300 in the bonding layer 200 is lowered, and the boron-doped diamond 300 and the workpiece may come into surface contact by floating due to buoyancy. In addition, when chip pockets for discharge of debris generated during polishing through the boron-doped diamond 300 are shallowly formed in the bonding layer 200, discharge of debris generated during polishing may not be smooth.

[0066] In addition, when the wetting angle of the boron-doped diamond 300 (BDD) is less than 60°, the boron-doped diamond 300 is more deeply embedded in the bonding layer 200 by surface tension, so that the height of the boron-doped diamond 300 protruding from the bonding layer 200 may be lowered. Therefore, the thickness of the bonding layer 200 needs to be strictly controlled so that a discharge passage of debris generated during polishing of the diamond disc can be secured.

[0067] Further, when the thickness of the bonding layer 200 is thinner than an appropriate thickness, self-standing may occur due to buoyancy (difference in density between the boron-doped diamond and the bonding layer) and wetting. In this case, the chip pocket is well formed in the bonding layer 200, but if the thickness of the bonding layer 200 is too thin, the boron-doped diamond 300 may come into contact with the shank base 100 and the boron-doped diamond 300 may be further forced downward by surface tension, and the boron-doped diamond 300 lies at an angle, so that the exposure height of the boron-doped diamond 300 in the bonding layer 200 is lowered, and the boron-doped diamond 300 may come into surface contact with the workpiece. For example, when the diamond lies down and is placed on the bonding layer 200 in a posture at an angle C where an angle of the long axis of the boron-doped diamond 300 with respect to the shank base 100 is about 35° to 45°, the self-standing ratio of the boron-doped diamond 300 may be lowered.

[0068] The thickness of the bonding layer 200 according to the present disclosure has a certain ratio to an average diamond particle size (diameter). For example, the ratio of the thickness of the bonding layer 200 to the average diameter of the boron-doped diamond 300 according to the present disclosure may be in a range of 30% to 65%. Table 2 is a table showing an angle-good diamond ratio (self-standing ratio) for each height of the bonding layer 200 and a pad cut rate (PCR). The particle size of diamonds has a certain range of mesh size, and the average size of diamonds conforms to the ANSI standards. For example, the diamonds used in Table 2 are #80 to #100 with an average size of 150 μm and a size range of 127 to 181 μm. Diamonds are deposited at a density of 400 pieces/cm^2 onto a disc of an approximately 4" diameter. Depending on the average diamond size, the number of diamonds attached per unit area may vary.

(Table 2)

Classification	Pre-sintered body thickness (μm)	diamond average size (μm)	Bond thickness (with diamonds) (μm)	Bond thickness/ diamond average size	diamond exposure height (μm)	self-standing diamond (%)	PCR (μm/hr) after 15 minutes
BDD Octa	150	150	52	36%	91	70%	291
BDD Octa	190	150	68	46%	92	77%	302
BDD Octa	220	150	79	53%	88	86%	345
BDD Octa	260	150	94	62%	85	60%	275
BDD Octa	300	150	106	70%	39	30%	195
Regular Octa	220	150	79	53%	88	85%	240
BDD blocky	220	150	79	53%	83	-	<100
Regular blocky	220	150	79	53%	83	-	<100

[0069] Referring to Table 2, when the bonding layer thickness is 68 μm, 79 μm, and 94 μm, the diamond exposure height is relatively high compared to the bonding layer thickness, and the angle-good diamond ratio, for example, the self-standing ratio, is the highest, PCR is also the highest. When the thickness of the bonding layer is 106 μm, the diamond exposure height is relatively low compared to the thickness of the bonding layer, the good-angle diamond ratio (self-standing ratio) is low, and the PCR is also low. When the bonding layer thickness is 52 μm, the diamond exposure height is relatively high compared to the bonding layer thickness, but the angle-good diamond ratio (self-standing ratio) is somewhat lowered and the PCR is slightly reduced.

[0070] That is, since the PCR is very low when the ratio of the thickness of the bonding layer 200 to the average diameter of the boron-doped diamonds 300 is 70% or more, the thickness ratio of the bonding layer 200 to the average diameter of the boron-doped diamonds 300 needs to be managed at less than 70%. In addition, when the thickness of the bonding layer 200 is too thin, even if the PCR value is maintained to some extent, there is a risk of diamond falling off, so the thickness of the bonding layer 200 needs to be at least 30% or more of the average diamond size. Therefore, the ratio of the thickness of the bonding layer 200 to the average diameter of the boron-doped diamond 300 is preferably in the range of 30% to 65%.

[0071] FIG. 6 shows cross-sectional photographs of the boron-doped octahedral diamond 300 and the regular octahedral diamond after heat treatment. Even if the regular diamond not doped with boron has an octahedron shape, when the PCR test is performed in PCR test equipment for 15 minutes, the PCR value of the regular diamond is lower than that of the boron-doped diamond (BDD) 300 under the same condition. Blocky type, that is, cube-octahedral shaped diamond shows a very low PCR value in the PCR test under the same conditions as the boron-doped diamond disc, regardless of whether it is boron-doped or not.

[0072] Referring to FIG. 7, in order to measure the pad cut rate (PCR) of discs made of boron-doped diamond 300 and the regular octahedral diamond over a long period of time, the PCR test equipment, the polishing pad, the CMP pad conditioner, and slurry are prepared. For example, CMP polisher of CTS Inc. may be used as the PCR test equipment, IC1010 ((DuPont) product with a diameter of 20" may be used as the polishing pad, and slurry W7000 (Cabot microelectronics) may be used. Further, the CMP pad conditioner may be equipped with the regular octahedral diamond and the boron-doped octahedral diamond 300 with a diameter of 4".

[0073] After the PCR test equipment, the polishing pad, the CMP pad conditioner, and the slurry are prepared, when the polishing pad is rotated at 80 to 95 rpm and the CMP pad conditioner is rotated at 100 to 120 rpm, the time taken until PCR is lowered below the minimum PCR value for pad conditioning is measured in a state in which the boron-doped diamond 300 or the regular octahedral diamond of the CMP pad conditioner is applied to the polishing pad at a pressure of 4 to 9 lbf. If the PCR value is lower than a set value, it is considered that the role as the CMP pad conditioner is insufficient. In this case, the CMP pad conditioner can polish the polishing pad while reciprocating 18 to 20 times per minute from the center to the edge of the polishing pad, and can provide 300 ml of slurry per minute to the polishing pad.

[0074] As a result of the long-term PCR test, it has been confirmed that in the CMP pad conditioner equipped with the regular octahedral diamond, for example, it took 8 hours for PCR to reach 10 μm/hr, whereas in the CMP pad conditioner equipped with boron-doped diamond 300, it took 13 hours for PCR to reach 10 μm/hr. In the PCR test described herein, in the CMP pad conditioner, it took 13 hours for the PCR to reach, for example, 10 μm/hr, but taking more than 13 hours may also be included in the idea of the present disclosure. In the CMP pad conditioner, the longer the time required for PCR to reach 10 μm/hr, the more advantageous it is, so in the present specification, there is no need to specify an upper limit for the time required for PCR to reach 10 μm/hr, but the time required for PCR to reach 10 μm/hr in the CMP pad conditioner may be 100 hours. In addition, even when the set value is set to, for example, 5 μm/hr or 2 μm/hr, it has been confirmed that the boron-doped diamond 300 maintains the pad polishing characteristics for a longer period of time by 30% or more than the regular octahedral diamond.

[0075] FIGS. 4 and 5 are SEM photographs of individual diamonds on a disc observed over time under the above experimental conditions. The Comparative Example is a regular octahedral diamond, and a sharp edge is observed before use, but it is observed that the edge is almost worn after 10 hours and 15 hours. On the other hand, it can be seen that the edges of the boron-doped octahedral diamond, which is Test Example, are less worn even after 10 hours and 26 hours of use.

[0076] Referring to FIG. 8, only the diamond was subjected to heat treatment at 750°C for 3 hours in an air atmosphere to confirm the weight change. A weight reduction of 2.5% is achieved in the case of the boron-doped diamond (300, BDD) according to the present disclosure, whereas the weight of a regular diamond is reduced by 24.8%. For example, the boron-doped diamond exhibited a significantly lower weight change rate than the normal diamond. That is, it can be confirmed that the diamond is chemically very stable by suppressing the reaction with oxygen in the air by boron doping.

[0077] Accordingly, the diamond disc according to the present disclosure can provide all of the characteristics of diamond that is resistant to abrasion while having the same characteristics as boron nitride (CBN) that does not react with iron (Fe), thereby improving the lifespan of the diamond disc.

[0078] Hereinafter, a method for manufacturing a diamond disc according to one embodiment of the present disclosure will be described with reference to FIG. 9.

[0079] Referring to FIG. 9, the method for manufacturing a diamond disc according to one embodiment of the present disclosure may include a bonding material application step (S100), a pre-sintering step (S200), a diamond providing step (S300), and a heat treatment step (S400).

[0080] In the bonding material applying step (S100), a bonding material may be applied to the surface of the shank base. The bonding material may contain 60 wt% or more of Ni, and other elements such as Cr, Si, etc.

[0081] In the pre-sintering step (S200), a solid phase pre-sintered body may be formed through a pre-sintering process in which the bonding material applied to the surface of the shank base is heated and dried in a first temperature range. In this case, the first temperature range may be a temperature range of 600°C to 900°C. In the pre-sintering step (S200), the ratio of the thickness of the bonding layer after the final heat treatment to the average diameter of the boron-doped diamond may be in a range of 30% to 65%.

[0082] In the diamond providing step (S300), a plurality of boron-doped diamonds (BDD) may be provided on the surface of the pre-sintered body. In this case, the plurality of boron-doped diamonds may be temporarily attached on the pre-sintered body through an adhesive using a punching jig.

[0083] In the heat treatment step (S400), heat treatment may be performed in a second temperature range so that the plurality of boron-doped diamonds are disposed on the pre-sintered body in a standing state to be exposed. At least some of the plurality of boron-doped diamonds may be self-standing in a posture at an angle C in which the long axis L is greater than 60° and less than or equal to 90° with respect to the shank base. In this case, the second temperature range may be a temperature range of 1000°C to 1300°C.

[0084] In the heat treatment step (S400), the solid phase pre-sintered body is phase-changed to a liquid phase bonding layer. Accordingly, some (about 50 vol%) of the individual boron-doped diamonds may be exposed on the upper surface of the bonding layer 200 due to buoyancy by the density difference, and the remaining part (about 50 vol%) of the individual boron-doped diamonds may descend below the surface of the bonding layer.

[0085] In this case, the boron-doped diamond having the shape of an octahedron is the most stable when the lower vertex of the boron-doped diamond is directed downward. Although it may vary depending on the viscosity of the bonding layer and the heat treatment time at the high heat treatment temperature, when the boron-doped diamond is maintained under this condition for a long time, rotation of the boron-doped diamond may occur, resulting in a self-standing phenomenon.

[0086] In the heat treatment step (S400), the wetting angle at which the surface of the pre-sintered body and the surface of the boron-doped diamond meet may be maintained at 0° or more and 60° or less. The octahedral boron-doped diamond has better chip pocket formation when the wetting angle is smaller than 60°, and since the boron-doped diamond makes point or line contact with the workpiece (polishing pad), the polishing performance of the boron-doped diamond for the workpiece can be remarkably increased.

[0087] As described above, the present disclosure can implement excellent wear resistance and high grinding performance through the boron-doped diamond having an octahedral structure, and since the self-standing ratio of the boron-doped diamond exceeds a certain ratio, wear resistance can be improved and grinding performance can be improved.

[0088] The examples of the present disclosure have been described above as specific embodiments, but these are only examples, and the present disclosure is not limited thereto, and should be construed as having the widest scope according to the technical spirit disclosed in the present specification. A person skilled in the art may combine/substitute the disclosed embodiments to implement a pattern of a shape that is not disclosed, but it also does not depart from the scope of the present disclosure. In addition, those skilled in the art can easily change or modify the disclosed embodiments based on the present specification, and it is clear that such changes or modifications also belong to the scope of the present disclosure.

Claims

1. A diamond disc comprising:

a shank base;
a bonding layer formed on a surface of the shank base; and
a plurality of boron-doped diamonds (BDD) disposed in the bonding layer to be exposed,
wherein at least some of the plurality of boron-doped diamonds are disposed in the bonding layer in a posture in which an uppermost surface thereof meeting a long axis of the boron-doped diamond is inclined downward from an upper end of the major axis.

2. The diamond disc of claim 1, wherein the boron-doped diamonds are disposed in the bonding layer in a posture in which the long axes of the boron-doped diamonds have an angle more than 50° and equal to or less than 90° with respect to the shank base.

3. The diamond disc of claim 1, wherein a wetting angle at which a surface of the bonding layer and a surface of each of the boron-doped diamonds meet is maintained at 0° or more and 60° or less.

4. The diamond disc of claim 1, wherein a ratio of a thickness of the bonding layer to an average diameter of the boron-doped diamonds is in a range of 30% to 65%.

5. The diamond disc of claim 1, wherein an amount of boron doped in each of the boron-doped diamonds ranges from 1 ppm to 2000 ppm.

6. The diamond disc of claim 1, wherein a magnetic susceptibility per unit volume of each of the boron-doped diamonds is in a range of 20 to 800 per unit volume.

7. The diamond disc of claim 1, wherein a ratio of a density of the boron-doped diamonds to a density of the bonding layer is maintained in a range of 0.4 to 0.6.

8. The diamond disc of claim 5, wherein each of the boron-doped diamonds is an octahedron diamond, and
a lower end of the boron-doped diamond is in point or line contact with the surface of the shank base or is spaced apart by a predetermined distance from the surface of the shank base when the boron-doped diamond is erected on the bonding layer.

9. The diamond disc of claim 1, wherein in a pad cut rate (PCR) test equipment, when a CMP Pad conditioner made of the boron-doped diamonds is rotated at 100 rpm to 120 rpm and a polishing pad is rotated at 80 rpm to 95 rpm, it takes more than 13 hours until a PCR by the boron-doped diamond lowers to 2 to 10 μm/hr range for pad conditioning in a state in which the CMP Pad conditioner made of the boron-doped diamonds presses the polishing pad at 4 to 9 lbf.

10. A diamond disc manufacturing method, comprising:

a bonding material application step of applying a bonding material to a surface of a shank base;
a pre-sintering step of heating the bonding material applied to the surface of the shank base to a first temperature range to form a pre-sintered bonding layer;
a diamond providing step of providing a plurality of boron-doped diamonds (BDD) to the surface of the pre-sintered body; and
a heat treatment step of performing heat treatment in a second temperature range so that at least some of the plurality of boron-doped diamonds are disposed in the bonding layer in a posture in which an uppermost surface meeting a long axis of the boron-doped diamond is inclined downward from an upper end of the major axis.

11. The diamond disc manufacturing method of claim 10, wherein in the heat treatment step, the boron-doped diamonds are disposed in the bonding layer, in a posture in which the long axes of the boron-doped diamonds have an angle more than 50° and equal to or less than 90° with respect to the shank base, to be exposed.

12. The diamond disc manufacturing method of claim 10, wherein in the pre-sintering step, the first temperature range is 600°C to 900°C, and in the heat treatment step, the second temperature range is 1000°C to 1300°C.

13. The diamond disc manufacturing method of claim 10, wherein in the heat treatment step, a wetting angle at which a surface of the bonding layer and a surface of each of the boron-doped diamonds meet is maintained at 0° or more and 60° or less.

14. The diamond disc manufacturing method of claim 10, wherein in the heat treatment step, a ratio of a thickness of the bonding layer after the heat treatment to an average diameter of the boron-doped diamonds is in a range of 30% to 65%.

FIG.1

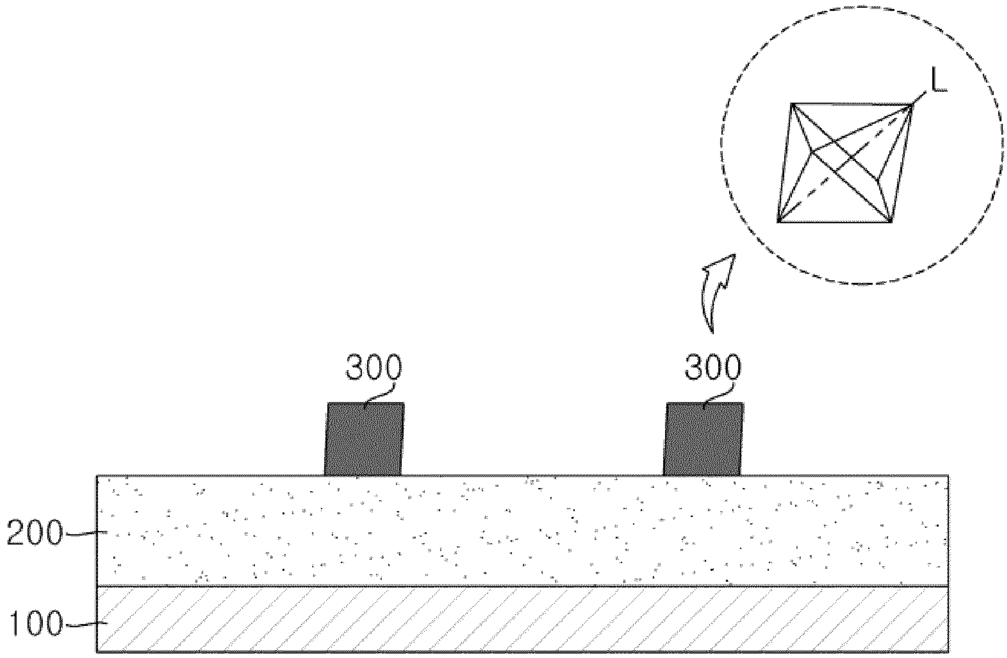


FIG.2

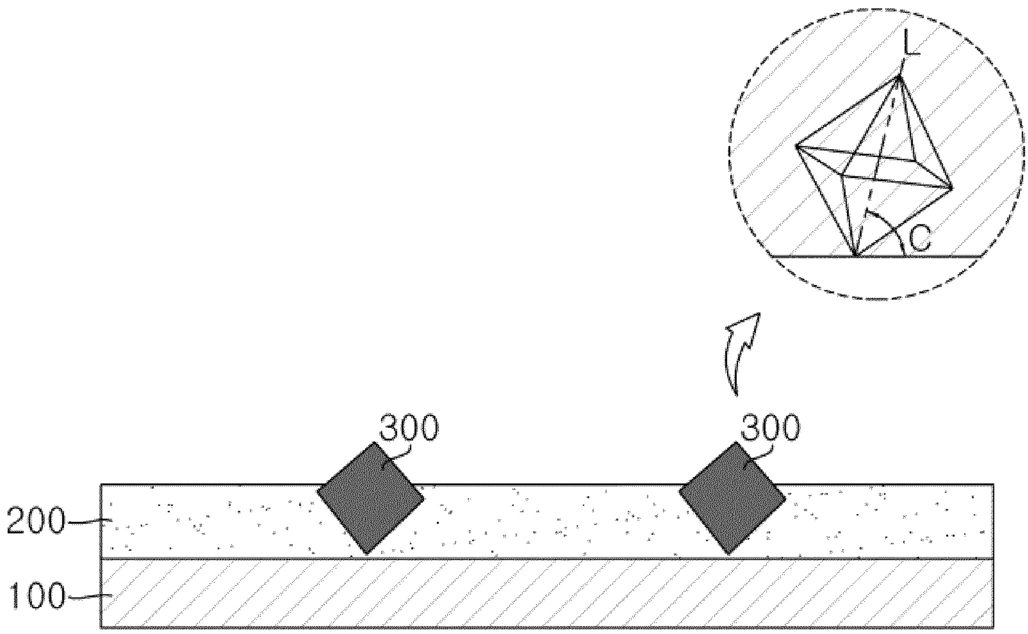


FIG.3

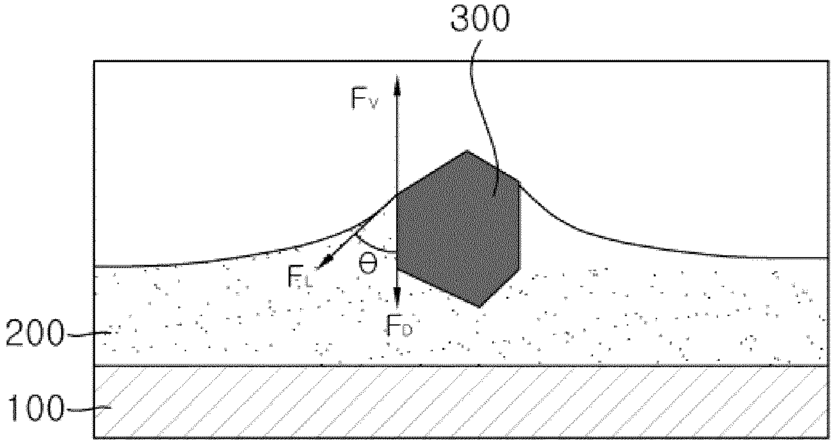
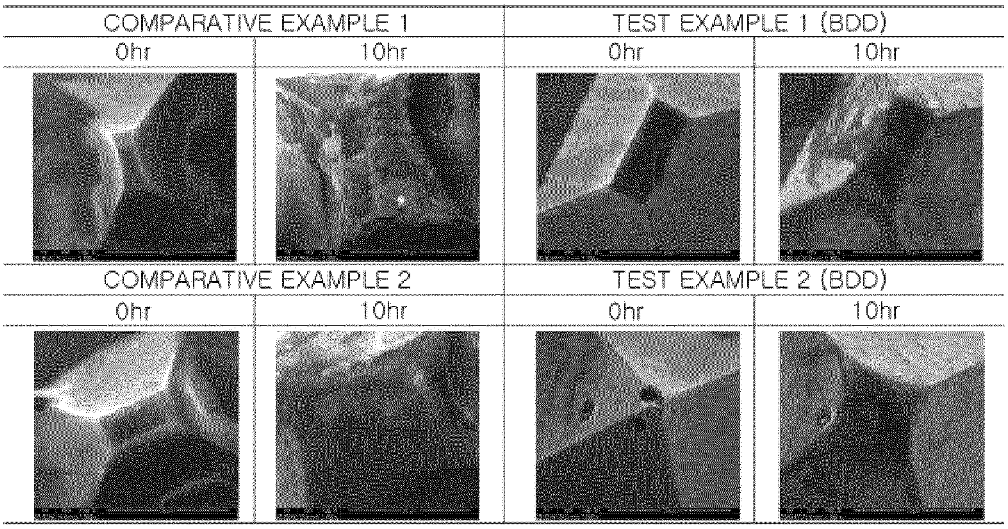


FIG. 4


COMPARATIVE EXAMPLE 1
TEST EXAMPLE 1 (BDD)
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10hr
0hr
10hr
COMPARATIVE EXAMPLE 2
TEST EXAMPLE 2 (BDD)
0hr
10hr
0hr
10hr

FIG.5

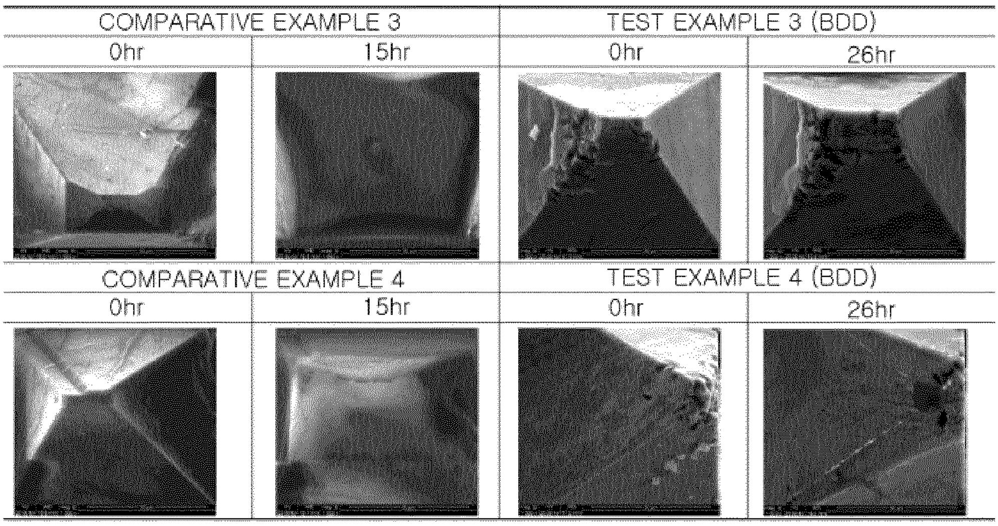

COMPARATIVE EXAMPLE 3
0hr
15hr
TEST EXAMPLE 3 (BDD)
0hr
26hr
COMPARATIVE EXAMPLE 4
0hr
15hr
TEST EXAMPLE 4 (BDD)
0hr
26hr

FIG. 6

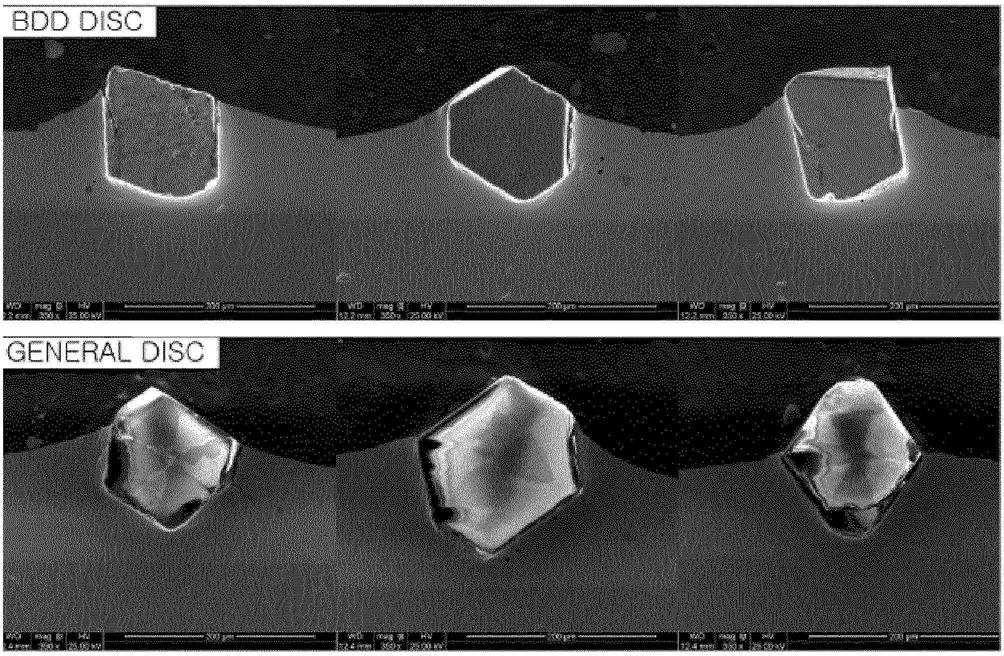


FIG. 7

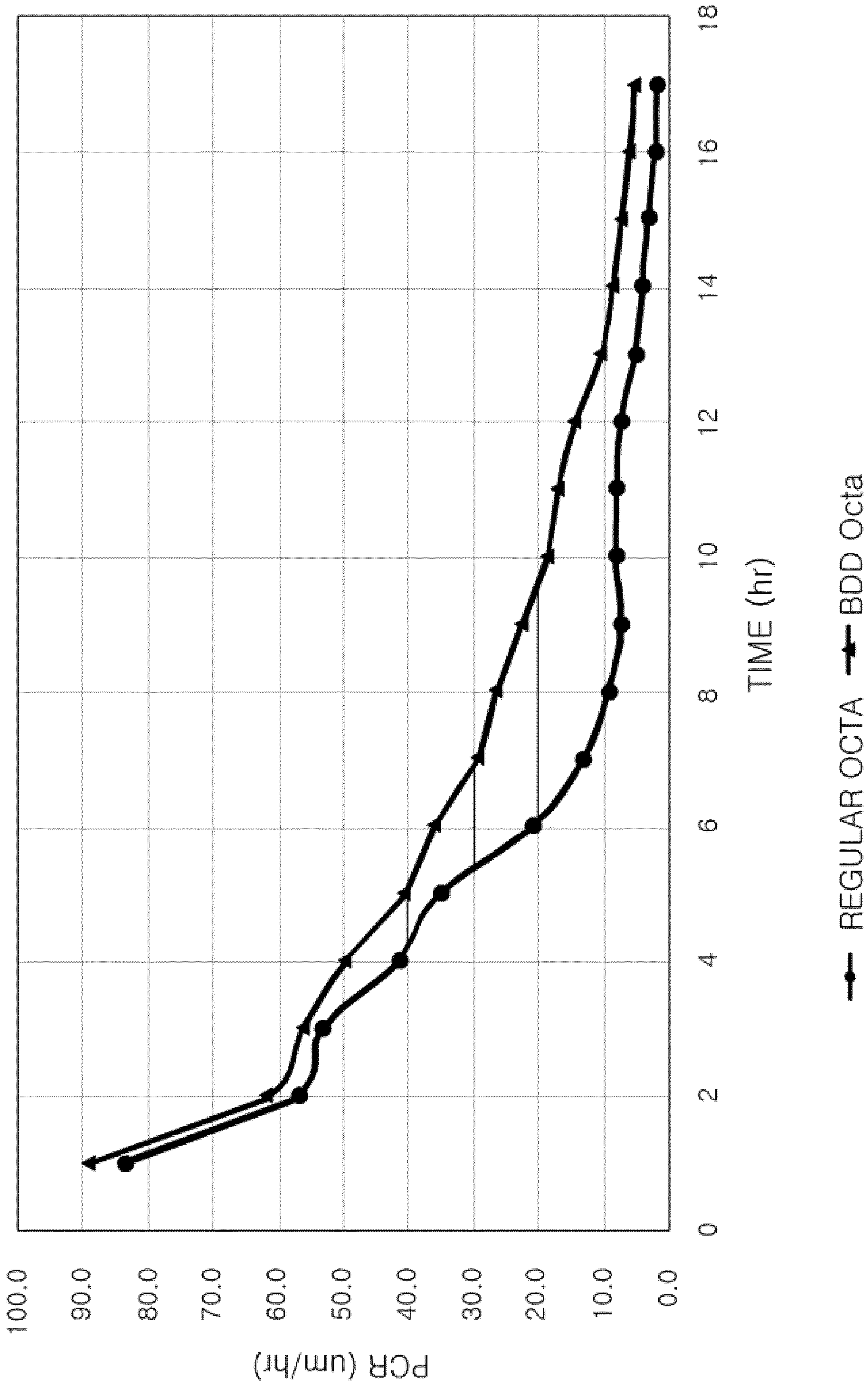

PCR (um/hr)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
2
4
6
8
10
12
14
16
18
TIME (hr)
REGULAR OCTA
BDD Octa

FIG.8

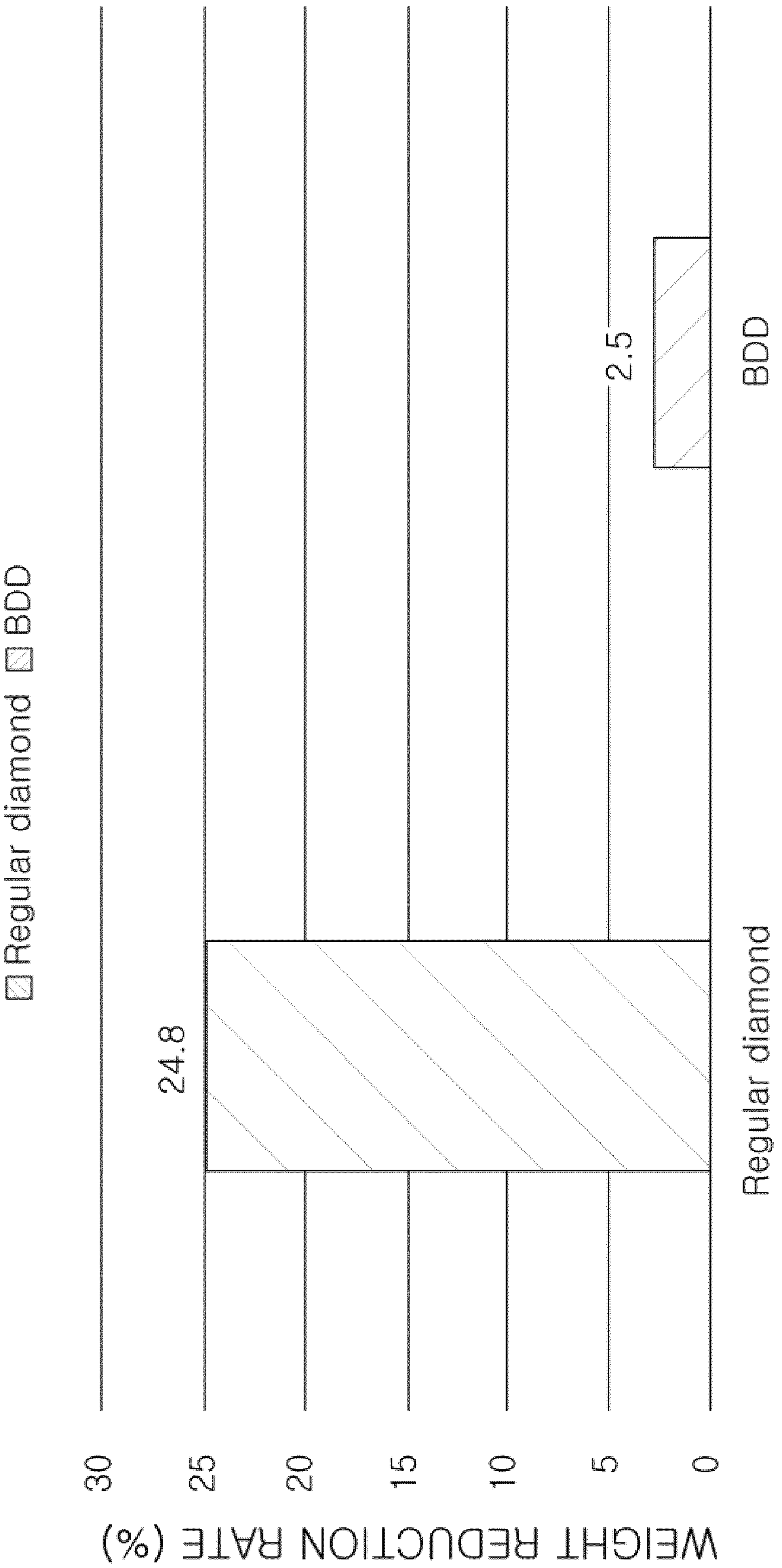
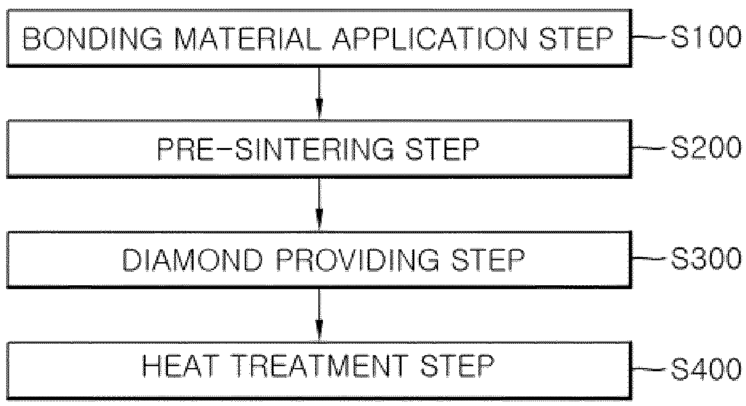

Regular diamond
BDD
WEIGHT REDUCTION RATE (%)
30
25
20
15
10
5
0
24.8
2.5
Regular diamond
BDD

FIG. 9


BONDING MATERIAL APPLICATION STEP
S100
PRE-SINTERING STEP
S200
DIAMOND PROVIDING STEP
S300
HEAT TREATMENT STEP
S400

INTERNATIONAL SEARCH REPORT

International application No. **PCT/KR2022/003778**

A. CLASSIFICATION OF SUBJECT MATTER

B24D 3/10(2006.01)i; **B24D 18/00**(2006.01)i; **B24B 37/30**(2012.01)i; **B24B 37/10**(2012.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B24D 3/10(2006.01); B24B 37/20(2012.01); B24B 37/24(2012.01); B24B 53/017(2012.01); B24B 53/02(2006.01); B24B 53/12(2006.01); B24D 3/00(2006.01); B24D 5/12(2006.01); C09K 3/14(2006.01); C23C 18/18(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models: IPC as above
Japanese utility models and applications for utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS (KIPO internal) & keywords: 베이스(base), 본딩층(bonding layer), 보론 도핑 다이아몬드(boron doping diamond), 기울기(slope), 소결(sintering), 디스크(disk)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009-0325471 A1 (CHOU et al.) 31 December 2009 (2009-12-31) See paragraphs [0025]-[0027]; and figures 3 and 4A-4B.	1-14
Y	JP 2012-086291 A (DISCO CORP.) 10 May 2012 (2012-05-10) See paragraphs [0011] and [0031]; and claim 3.	1-14
Y	KR 10-2010-0030475 A (EHWA DIAMOND INDUSTRIAL COMPANY LIMITED) 18 March 2010 (2010-03-18) See claim 4; and figure 5.	8
A	JP 2006-176698 A (UTSUNOMIYA UNIV.) 06 July 2006 (2006-07-06) See paragraphs [0004] and [0013].	1-14
A	KR 10-2007-0032067 A (INTEL CORPORATION) 20 March 2007 (2007-03-20) See claims 1-5; and figures 4a-4b.	1-14

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 June 2022	**16 June 2022**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office **Government Complex-Daejeon Building 4, 189 Cheongsa-ro, Seo-gu, Daejeon 35208**	
Facsimile No. **+82-42-481-8578**	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2019)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2022/003778

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		KR 10-2012-0040107 A	26 April 2012
KR 10-2010-0030475 A	18 March 2010	KR 10-1118537 B1	24 February 2012
JP 2006-176698 A	06 July 2006	JP 4143727 B2	03 September 2008
KR 10-2007-0032067 A	20 March 2007	CN 101022921 A	22 August 2007
		CN 101022921 B	30 November 2011
		JP 2008-507855 A	13 March 2008
		KR 10-0876990 B1	07 January 2009
		US 2006-0019583 A1	26 January 2006
		US 2006-0019584 A1	26 January 2006
		US 7097542 B2	29 August 2006
		US 7175510 B2	13 February 2007
		WO 2006-019839 A1	23 February 2006

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- KR 1020120058303 **[0011]**