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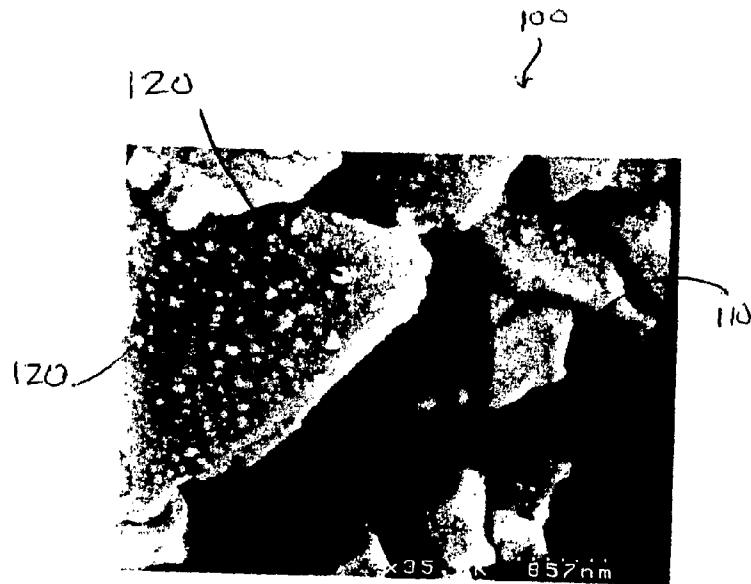
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Declarations under Rule 4.17:

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[Continued on next page]

(54) Title: SINTERED POLYCRYSTALLINE DIAMOND MATERIAL WITH EXTREMELY FINE MICROSTRUCTURES



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(57) Abstract: A sintered polycrystalline diamond material (PCD) of extremely fine grain size is manufactured by sintering a diamond powder with pre-blended catalyst metal under high pressure/high temperature (HP/HT) processing. The PCD material has an average sintered diamond grain structure of less than 1.0µm.



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A. TITLE

**SINTERED POLYCRYSTALLINE DIAMOND MATERIAL WITH EXTREMELY
FINE MICROSTRUCTURES**

B. CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application claims priority to co-pending U.S. provisional patent application no. 60/717,227, filed September 15, 2005 entitled "Sintered, Polycrystalline Diamond Compact with Extremely Fine Microstructures", the disclosure of which is incorporated herein by reference in its entirety.

C. STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

[0002] Not applicable.

D. NAMES OF PARTIES TO A JOINT RESEARCH AGREEMENT

[0003] Not applicable.

E. SEQUENCE LISTING

[0004] Not applicable.

F. BACKGROUND

1. Technical Field

[0005] The disclosed embodiments generally relate to the field of sintered diamond cutting and forming tools and more particularly to such diamond tools having extremely fine microstructures imparting improved tool properties, machinability, and an ability to impart improved surface finish to workpiece materials.

2. Description of the Related Art

[0006] Polycrystalline diamond (PCD) is used extensively in industrial applications including metal cutting, wire drawing, drilling, and as wear parts. As defined herein, PCD is a two phase polycrystalline diamond product in which the diamond crystals are sintered together to form a continuous diamond lattice. This lattice, the majority phase, comprises interparticle diamond-to-diamond bonds without interposed, non-diamond, bonding phases.

A volume of residual catalyst metal, the minor phase, may be disposed in interstices between diamond crystals.

[0007] PCD production methods were first discovered in the 1960's and are well described in patent literature. U.S. Patent Nos. 3,831,428; 4,063,909; 5,488,268, the disclosures of each of which are incorporated herein by reference, describe high pressure/high temperature (HP/HT) methods that produce cutting tools, wire drawing dies, and earth boring drilling cutters with resistance to abrasive and chemical wear. Because PCD exhibits more uniform mechanical properties than single crystal diamond and is available in larger sizes than single crystal diamond, PCD offers substantial design advantages over natural or synthetic single crystal diamond. However, PCD as currently produced, does not provide extremely smooth cut, drawn or otherwise formed workpiece surfaces. Single crystal diamond, while expensive, anisotropic, and limited in size, remains the preferred tool material for single point turning of optical materials or drawing of highly finished, fine wire. Mechanical failure, from limited strength and impact resistance, of PCD tools is also common

[0008] Available PCD components have parts having diamond grain sizes after HP/HT sintering ("as-sintered") of 1 μm to 100 μm . Finer, uniform, as-sintered diamond grain sizes, for example, of about 0.1 μm to about 1.0 μm (referred to as "submicron") have proven challenging to produce commercially using the PCD manufacturing process described above. Submicron diamond particles are difficult to produce, and have proven difficult to handle during blending and mixing due to their high surface area's ability to attract and retain contaminants that affect the sintering process and product properties.

[0009] Submicron diamond particles have low packing densities that cause problems during loading of shielding enclosures and HP/HT processing. The very fine pores between the submicron diamond grains in the initial diamond particle mass are difficult to uniformly

penetrate with catalyst metal, leading to incomplete bonding and sintering between diamond particles. It is almost always observed that the high surface area of submicron diamond powders causes the diamond solution-reprecipitation process to occur non-uniformly. This leads to non-uniform detrimental diamond grain growth and other complications that make the production of larger parts unfeasible when final diamond grain sizes less than 1 micron are attempted.

[0010] Prior attempts to produce submicron monolithic PCD have not yielded product having any substantial uniformity, either as (i) a monolithic, free-standing body, or (ii) PCD attached to a substrate, known as supported PCD. PCD, as used herein, refers to a sintered PCD body that is comprised of a continuous diamond matrix, diamond to diamond bonds, with or without catalyst metal. PCD is generally a two-phase material (diamond and catalyst), and does not contain any significant amount of a third phase interposed between diamond grains, such as bonding carbides, nitrides, or borides.

[0011] Non PCD diamond products containing at least some submicron diamond grains are well known. U.S. Patent No. 4,505,746, the disclosure of which is incorporated herein by reference, describes the use of 3 μm and submicron diamond particles, a catalyst metal, and additional carbide, carbonitride, nitride, and boride phases to make a tougher, abrasion resistant sintered diamond compact body. U.S. Patent No. 4,303,442 to Hara et al., the disclosure of which is incorporated herein by reference, describes a method to sinter diamond materials for a cutting tool or wire die in which the grain size of the diamond is less than 1 μm . Hara et al. discusses the benefits of submicron grain structure in providing high dimensional precision and superb surface finish on workpieces. In order for Hara et al. to produce useful sintered diamond tools, it was necessary to add a third bonding phase of one or more carbides, nitrides, and borides of IVB, VB, VIB group metals (otherwise known as International Union of Pure and Applied Chemistry (IUPAC) Group 4, Group 5, and Group 6

elements, respectively) and an iron group catalyst metal to the submicron diamond particles. Additionally, Hara et al. teaches the difficulty of producing submicron PCD. Example 1 of Hara et al. shows that submicron diamond powders with less than 5% of the bonding additions undergo grain growth to over 300 μm diameters during HP/HT sintering. These non-uniform materials were not hard enough to be useful as cutting tools. Neither of the patents listed above describes the production of a submicron PCD diamond body. Both sintered products contained a third phase beyond the diamond and catalyst of true PCD.

[0012] U.S. Patent No. 6,319,460, the disclosure of which is incorporated herein by reference, describes a sintered diamond tool with improved overall toughness achieved by reducing the grain size of the diamond particles. In this case, the diamond particles were surrounded by a continuous metal matrix; no intergranular diamond bonds were formed. The product was not PCD but rather a composite with diamond grains no finer than 1 μm . The wear resistance, strength, and thermal stability of this product will be substantially inferior to true PCD.

[0013] U.S. Patent Application Publication 2005/0019114, filed by Sung, the disclosure of which is incorporated herein by reference, describes the production of nanocrystalline diamond materials, those with grain size less than 0.1 μm . This application teaches alternative methods of sintering expensive nanocrystalline diamond and specifically excluding submicron (0.1 μm to 1 μm) diamond particles and excluding the use of a liquid metal catalyst. Because no catalyst metal is present, the application does not describe a true PCD product; the product will have significant defects, and will be difficult to produce due to inherent problems of handling fine powders.

[0014] The prior art falls short of achieving a submicron particle size. U.S. Patent Nos. 5,855,996 and 5,468,268, the disclosures of which are incorporated herein by reference, describe the effect of particle size distribution (PSD) of the PCD compact on its performance

characteristics. In this case, the submicron particles are used as a portion of the diamond particle mass as a way to increase diamond concentration in the sintered PCD product. 15 volume percent is the maximum fraction of submicron diamond possible in the prior art. The micrographs in U.S. Patent No. 5,855,996 show that far less than 15 volume percent submicron diamond is actually present.

[0015] There remains a need to produce a monolithic PCD material with uniform, as-sintered, diamond grains sizes below 1 μm . Applicants have surprisingly found a method to achieve several of the advantages of submicron PCD without adding additional bonding phases or resorting to expensive nanocrystalline diamond.

[0016] The disclosure contained herein describes attempts to address one or more of the problems described above.

G. SUMMARY

[0017] In an exemplary embodiment, a polycrystalline (PCD) body has diamond crystals that have an arithmetic mean, as-sintered diamond grain size less than 1 μm . In another embodiment, the PCD body comprises grain sizes greater than about 0.1 μm and less than about 1.0 μm . In still another embodiment the as-sintered grain size of a PCD body is substantially uniform. In a further embodiment, the PCD body is monolithic; there are no added bonding phases, such as carbides, nitrides, or borides, in the PCD body. An embodiment of a PCD body may have an oxygen content less than about 0.05 weight percent. In still another embodiment of a PCD body, the nitrogen content is less than about 0.01 weight-percent. A PCD body embodied herein may have diamond crystals wherein at least 63% of the crystals have a grain size that is less than 1.0 μm . Another embodiment is a PCD body which has a mean as-sintered grain size between about 0.1 μm and 1.0 μm , with a body thickness greater than about 0.5 mm.

[0018] An embodiment includes a method for producing a polycrystalline diamond (PCD) body an average as-sintered grain size less than about 1.0 μm by: starting with diamond particles having a mean volumetric particle size less than about 1.0 μm ; blending, with the diamond particles, a catalyst metal having an arithmetic mean particle size that is less than that of the diamond grain size, to form a diamond powder blend; and processing the diamond powder blend using a pressure and a temperature for a time sufficient to affect intercrystalline bonding between adjacent diamond particles. In an embodiment of the method the catalyst metal may be an iron group metal. In yet another embodiment the catalyst metal may be cobalt. The catalyst metal may be about 0.5% to about 15% by weight of the diamond powder blend. An embodiment uses the catalyst metal as nanocrystals, and a further embodiment has the catalyst metal nanocrystals adhered to the diamond particles. The processing pressure may be between about 20 Kbar and about 70 Kbar. The processing temperature may be at least about 1000°C, and the processing time may be between about 3 minutes to about 120 minutes. In an embodiment of the method, the processing further includes inclusion of a cemented metal carbide support with the diamond powder blend. A further embodiment uses a metal cemented carbide support in the shape of an annulus, with the diamond powder blend disposed within the support annulus.

[0019] Still another embodiment includes a polycrystalline diamond (PCD) wear component, such as, but not limited to, a machining tool, wear pad, punch, or die, comprising a PCD body that has a mean as-sintered diamond grain size between about 0.1 μm and about 1.0 μm . In another embodiment of the tool, the PCD body is monolithic. In yet another embodiment of the tool, the PCD body is bonded to a substrate, and the substrate may be a cemented metal carbide, such as for example, but not limited to, cemented tungsten carbide.

H. BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1 is a scanning electron microscope (“SEM”) image of an exemplary cobalt-diamond powder blend.

[0021] FIG. 2 describes a process of making a PCD body with average submicron as-sintered grain size.

[0022] FIG. 3 is an SEM image of one embodiment using 0.8 μ m diamond powder.

[0023] FIG. 4 is an SEM image of one embodiment using 0.5 μ m diamond powder.

[0024] FIG. 5 is an SEM image of a product of the prior art.

I. DETAILED DESCRIPTION

[0025] Before the present methods, systems and materials are described, it is to be understood that this disclosure is not limited to the particular methodologies, systems and materials described, as these may vary. It is also to be understood that the terminology used in the description is for the purpose of describing the particular versions or embodiments only, and is not intended to limit the scope. For example, as used herein and in the appended claims, the singular forms “a,” “an,” and “the” include plural references unless the context clearly dictates otherwise. In addition, the word “comprising” as used herein is intended to mean “including but not limited to.” Further, the word “HP/HT” refers to the processing of a material at high pressures (i.e., between 25 Kbar and 75 Kbar or higher) and high temperature (i.e., about 1000°C or higher). Unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art.

[0026] In an embodiment, a body is made of submicron polycrystalline diamond (“PCD”), that is, a liquid metal catalyzed sintered diamond product having a sintered arithmetic mean (i.e., average) diamond grain size below 1 μ m and above 0.1 μ m. Average

sintered grain size was determined using the line-intercept method. This method is based on the grain dimension determined through the intersection of randomly drawn lines on a microstructure photo, and is familiar to those skilled in the art.

[0027] Using a diamond powder with pre-blended catalyst material, such as cobalt, a method embodiment may produce high quality PCD with average as-sintered grain sizes from $0.1\mu\text{m}$ to $1.0\mu\text{m}$. In another embodiment, no bonding agents such as carbides, nitrides or borides are present in the PCD bodies. Thus, the PCD bodies described herein comprise substantially only diamond and catalyst. Prior PCD technology, as demonstrated in the art, was not capable of producing as-sintered monolithic PCD with grain sizes below $1.0\mu\text{m}$ in substantial amounts.

[0028] Diamond Powder Blend. The raw material diamond particles may be natural or HP/HT synthetic (preferably not nanocrystalline “shock” diamond) single crystal particles or polycrystalline aggregates with a submicron particle size, between about $0.1\mu\text{m}$ and about $1.0\mu\text{m}$. The raw material diamond particle size is the volumetric mean particle size measured by a particle size analyzer such as a Microtrac or any other suitable analyzer. In one embodiment, the mean volumetric particle size of the diamond particles was $0.8\mu\text{m}$. In another embodiment the mean volumetric particle size was $0.5\mu\text{m}$. In a third embodiment, particles of $0.3\mu\text{m}$ mean volumetric particle size were effectively sintered. The diamond powder blend further contained one or more pre-blended catalyst metals such as cobalt or other iron group metals. Preferably, the metal catalyst is pure metal, or substantially pure with only minor impurities. In particular, the catalyst was in the form of nanocrystalline particles adhered directly to the diamond particles made by any method known now or hereafter to one of ordinary skill in the art. In some embodiments, the metal catalyst may an average particle size that is less than that of the diamond grains.

[0029] FIG. 1 shows a Scanning Electron Micrograph of the powder raw material 100 that may be used in one embodiment. In FIG. 1, 0.8 μm mean volumetric size diamond particles 110 have 100 nanometer (nm) average size cobalt particles 120 adhered to their surfaces. Other iron group metals could also be used. In one embodiment, catalyst metals of 0.5% to up to 10% by weight were contained in the raw material blend. The catalyst may be present in varying amounts in the blend. In some embodiments, the catalyst may make up from about 1% to about 10 % of the blend by weight. In other embodiments, the catalyst may make up from about 0.5% to about 15 % by weight of the blend. In other embodiments, the catalyst may make up from about 5% to about 7% percent by weight of the blend.

[0030] FIGs. 2A and 2B represent a process of making a supported submicron PCD body. FIG. 2A refers to the system before HP/HT processing 200. FIG. 2B refers to the HP/HT processed supported submicron PCD body 250. In an embodiment of FIG. 2A, a diamond powder blend 210 (diamond particles with metal catalyst, described *supra*) and a cemented metal carbide support 220 may be disposed in a protective enclosure 230. The blended diamond particles 210 and the metal carbide support 220 may be sintered simultaneously in a single HP/HT process. In an embodiment, the metal carbide support 220 reacts only with a layer of diamond particles at the interface 240 with the metal carbide support, to adhere the resultant PCD body to the support. The resulting product 250 is a sintered PCD body 260 adhered to a metal carbide support 220. The PCD body 260, comprises diamond to diamond bonds. The product 250 is subsequently removed from the protective enclosure 230. It should be understood that the methods described herein can be used to make a monolithic (i.e., unsupported) structure. In such a case, the method shown in FIGs. 2A and 2B could be used, without the support 220.

[0031] The HP/HT processing conditions selected are sufficient to provide intercrystalline bonding between adjacent diamond grains and, optionally, the joining of

sintered diamond particles to the cemented metal carbide support. In one embodiment, the processing conditions generally involve the imposition for about 3 to about 120 minutes of a temperature of at least 1000°C and a pressure of at least 20 kilobars (kbar). In another embodiment, pressures between about 50 and about 70 kbar, and temperatures between about 1400°C and about 1600°C, may be used. Other temperatures and pressures are possible. Pressures, temperatures, and process duration are selected to minimize diamond grain growth during sintering and may be now or hereafter known to one of skill in the art. Temperatures and pressures described herein are approximate.

[0032] In yet another embodiment, the diamond and catalyst may be sintered in an HP/HT process without the metal carbide support. A subsequent HP/HT or brazing process may be used to attach a cemented metal carbide support.

[0033] In yet another embodiment, the metal carbide support may be an annulus and the mass of diamond particles with catalyst (diamond powder blend) may be disposed within the support annulus. These maybe sintered together in the HP/HT process with or without the addition of additional catalyst metal.

[0034] The disclosure contained herein relates to sintered PCD with improved strength and toughness in machining, for example, non-ferrous metals, ceramics, and wood-based composites. In addition, it relates to improved machinability during fabrication of wear components such as PCD machining tools, wear pads, punches, and dies. Finally, it relates to the ability of such tools to give an improved surface finish on workpieces, including, for example, aluminum castings or steel wire. Tools as described herein may include, for example, monolithic sintered PCD, a sintered PCD layer bonded to a substrate (such as one of a cemented metal carbide, such as cemented tungsten carbide or other material), and sintered PCD inside an annulus of cemented metal carbide such as cemented tungsten carbide or other material as would be used in wire drawing.

[0035] In the commercial production of PCD in general, it is common for the product or blank which is recovered from the reaction cell of the HP/HT apparatus to be subjected to a variety of finishing operations which include cutting, such as by electrode discharge machining or with lasers, milling, and especially grinding to remove any adherent shield metal from the outer surfaces of the compact. Such operations additionally may be employed to machine the compact into a shape which meets product specifications as to diamond layer thickness and/or carbide support thickness.

[0036] In the resulting PCD body, the average, as-sintered diamond grain size measured by the line intercept method may be less than one micron. It may also be greater than $0.1\mu\text{m}$. In various embodiments, the average grain size may be less than $0.9\mu\text{m}$, $0.8\mu\text{m}$, $0.7\mu\text{m}$, $0.6\mu\text{m}$ or $0.5\mu\text{m}$. The PCD body may be substantially uniform. These embodiments, based on symmetrical normal grain size distributions, may contain 50%, 63%, 77%, 90%, 98% and 100% of the diamond grains below 1 μm . Other embodiments may have other ranges. It may also have a low oxygen content, such as an oxygen content below 0.05%, below 0.01% or between a device detection limit and either of the above numbers. The PCD bodies contained herein may have thicknesses (i.e., top surface to substrate interface) of about 0.5 millimeters (mm) to about 1 mm, up to about 1.5 mm, greater than 1 mm, up to about 2 mm, or another size.

[0037] As used herein, bodies having a “uniform” grain size or a “substantially uniform” grain size are intended to encompass bodies where the average grain size is less than 1 micron, meaning that more than 50% of the particles are below 1 μm after sintering.

[0038] In addition, during manufacture, various amounts of cobalt or other catalyst metal may be used. In some embodiments, some or all of the catalyst metal may remain in the finished product. In an embodiment where some or all of the catalyst metal may remain

in the material, it not present as a bonding agent phase. The metal catalyst does not form chemical bonds with the diamond carbon, and is present only as a residual contaminant.

[0039] EXAMPLES. Examples are provided herein to illustrate various embodiments but are not intended to limit the scope of the invention.

[0040] Example 1. Referring again to FIGs. 2A and 2B, this example demonstrates the ability to make PCD composites in which the sintered diamond is integrally bonded to a cemented metal carbide substrate. A diamond-cobalt powder blend with approximately 7% cobalt by weight, distributed as shown in FIG. 1 with approximately 0.8 μ m volumetric mean raw material diamond size **210**, was disposed between a tantalum (Ta) shielding enclosure **230** and a cemented tungsten carbide (WC) + 13 weight-percent cobalt disk. This assembly was subjected to HP/HT processing at about 55 Kbar at temperature of about 1400°C for about 20 minutes to form the sintered submicron PCD tool blank **260**. The PCD tool blank **250** was finished to produce a diamond layer **260** 1.5 mm thick, and the overall thickness of the blank **250** was 3.2 mm. The average as-sintered diamond grain size, assessed by direct line intercept measurement of the microstructure with a field emission scanning electron microscope, was 0.87 μ m. Several variations of this process were made using differing initial diamond powder sizes, diamond layer thicknesses, and cobalt blend amounts. These variations are summarized in Table 1.

Table 1. Average as-sintered grain size and body thickness of submicron PCD embodiments described herein.

Average Grain Size (μ m)	Amount of Cobalt in Powder Blend (weight %)	Average thickness of PCD body (millimeters)
0.5	7	0.5
0.4	7	0.5
0.25	7	0.5
0.8	1	0.5
0.8	2	0.5
0.8	5	0.5

0.8	7	0.5
0.8	7	1.0
0.8	7	1.5
0.8	7	2
0.8	10	1.5

[0041] The sintered PCD bodies in Example 1 were analyzed using the following techniques: scanning electron microscope (SEM), Oxygen and Nitrogen determination. As a comparison, PCD bodies made with prior technology and commercially available materials were also analyzed. Table 2 highlights a few of the differences seen.

Table 2. Comparison of samples with and without cobalt blending.

Analytical Technique	New PCD Material	Prior Art
LECO-Nitrogen	0.009%	0.0165%
LECO-Oxygen	0.046%	0.087%

[0042] Table 2 shows that the PCD materials of the embodiments herein have low nitrogen and oxygen concentrations, as compared with Prior Art PCD materials. Embodiments described herein may have nitrogen contents below about 0.01% (w/w). Embodiments described herein may have oxygen contents below about 0.05% (w/w).

[0043] SEM images in FIG. 3 show the submicron grain size of a PCD body embodiment described herein prepared using diamond powder with a volumetric mean size of 0.8 μ m. FIG. 4 shows the submicron grain size of a PCD body embodiment described herein prepared using diamond powder with a volumetric mean size of 0.5 μ m. FIG. 5 shows the grain size of a Sumitomo Grade DA2200 PCD body, which is a commercially available product.

[0044] Table 3 shows measurements of the sintered diamond microstructure of the same three materials as FIGs. 5-7, using the line-intercept method. This method is based on

the grain dimension determined through the intersection of randomly drawn lines on a microstructure photo.

Table 3. Comparison of measured grain sizes using line-intercept method. (sizes in microns)

Product	Average grain size (μm)	Standard Deviation (μm)
0.8 μm Starting Powder	0.87	0.41
0.5 μm Starting Powder	0.88	0.24
Sumitomo DA2200	1.46	0.79

[0045] These evaluations show that the new PCD materials described herein have a lower oxygen and nitrogen content, have much finer grain sizes, and achieve an average grain size below 1 μm , which is much finer than the finest available commercial product.

[0046] Example 2. Referring to FIG. 8, this example illustrates the ability to make carbide supported wire die blanks 800. These are materials in which the diamond portion 810 is sintered into a carbide annulus 820 using a separate metal source as the catalyst rather than sintering using the cobalt binder phase from the carbide substrate. In this example, diamond powder 810 with a volumetric mean particle size of 0.5 μm further containing 7% by weight of the fine, dispersed cobalt similar to Example 1 was used. The diamond and cobalt powder blend 810 were loaded into the center of a carbide cylinder 820 encased in a tantalum (Ta) enclosure 830. A cobalt (Co) disc 840 (shown in exploded view) was placed on top of the powder followed by a Ta shielding enclosure 850 (also in exploded view). Several of these assemblies were loaded into a HP/HT reaction cell and subjected to pressures of about 55 Kbar at temperatures between about 1300°C and about 1500°C for about 15 minutes to form the sintered PCD wire die. The PCD wire dies are recovered from the reaction cell and

finished such that the entire PCD sintered volume was about 7 mm in diameter and 6 mm thick. The overall diameter of the wire die including the carbide annulus surrounding the diamond was about 14 mm.

[0047] It will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Also that various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

J. CLAIMS

What is claimed is:

1. A polycrystalline diamond (PCD) body comprising diamond crystals having an arithmetic mean, as-sintered, diamond grain size less than 1 μm .

2. The PCD body of claim 1 wherein the grain size is greater than 0.1 μm .

3. The PCD body of claim 1 wherein the body has an oxygen content below about 0.05 weight-percent.

4. The PCD body of claim 1 wherein the body has a nitrogen content below about 0.01 weight-percent.

5. The polycrystalline diamond (PCD) body of claim 1 comprising diamond crystals, wherein at least 63% of the crystals have a grain size that is less than 1.0 μm .

6. The polycrystalline diamond (PCD) body of claim 1, wherein the thickness of the sintered diamond body is greater than about 0.5 mm.

7. The PCD body of claim 1 further comprising a cemented metal carbide support.

8. A method for producing a polycrystalline diamond (PCD) body with an arithmetic mean as-sintered grain size less than 1 μm , comprising:

providing diamond particles having a volumetric mean particle size of less than about 1.0 μm and greater than about 0.1 μm ;
blending, with the diamond particles, a catalyst metal having an average particle size that is less than that of the diamond grain size, to form a diamond powder blend;
and
processing the diamond powder blend using a pressure and a temperature for a time sufficient to cause intercrystalline bonding between adjacent diamond grains.

9. The method of claim 8 wherein the catalyst metal comprises an iron group metal.
10. The method of claim 8 wherein the metal catalyst comprises cobalt.
11. The method of claim 8 wherein the metal catalyst comprises about 0.5% to about 15% by weight of the diamond powder blend.
12. The method of claim 8 wherein the metal catalyst comprises nanocrystalline particles.
13. The method of claim 12 wherein the nanocrystalline particles are directly adhered to the diamond particles.
14. The method of claim 8 wherein the pressure is between about 20 Kbar and 70 Kbar, and wherein the temperature is at least about 1000°C, and wherein the time is between about 3 minutes to about 120 minutes.

15. The method of claim 8 further comprising processing the diamond powder blend together with a cemented metal carbide support.
16. The method of claim 8 wherein the metal carbide support comprises a support annulus and the diamond powder blend is disposed within the support annulus.
17. A polycrystalline diamond (PCD) wear component comprising a PCD body comprising diamond crystals having an arithmetic mean, as-sintered, diamond grain size between about 0.1 μm and about 1.0 μm .
18. The component of claim 17 wherein the PCD body is monolithic.
19. The component of claim 17 wherein the PCD body is bonded to a substrate.
20. The component of claim 17 wherein the substrate comprises a cemented metal carbide.
21. The component of claim 17 wherein the cemented metal carbide comprises cemented tungsten carbide.

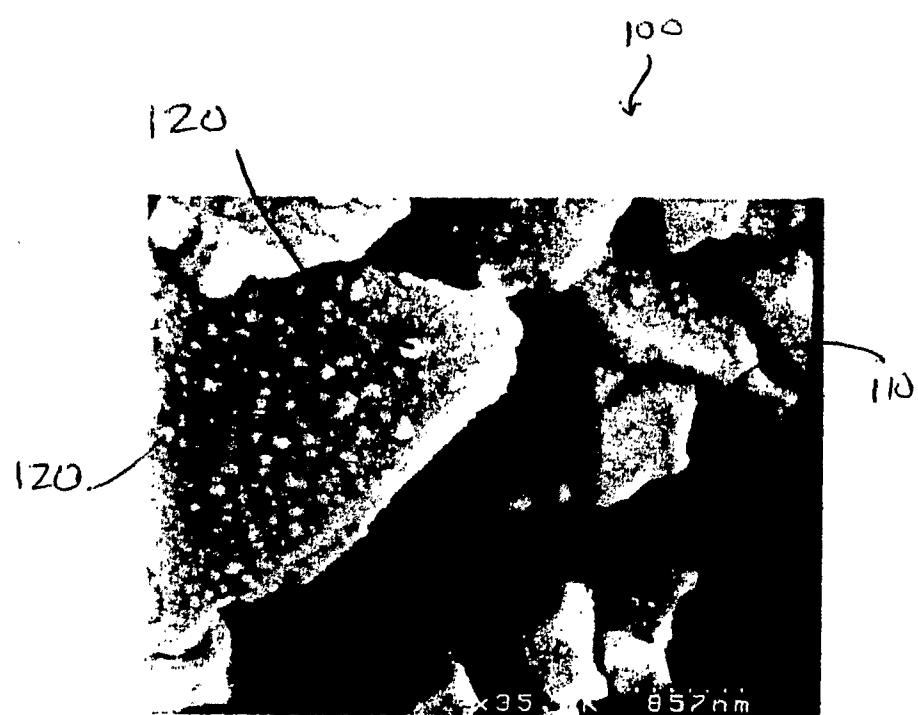
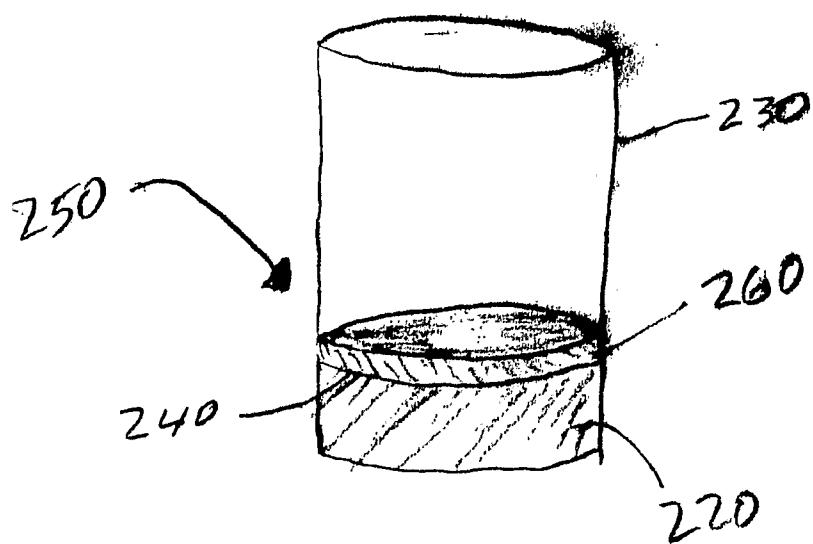
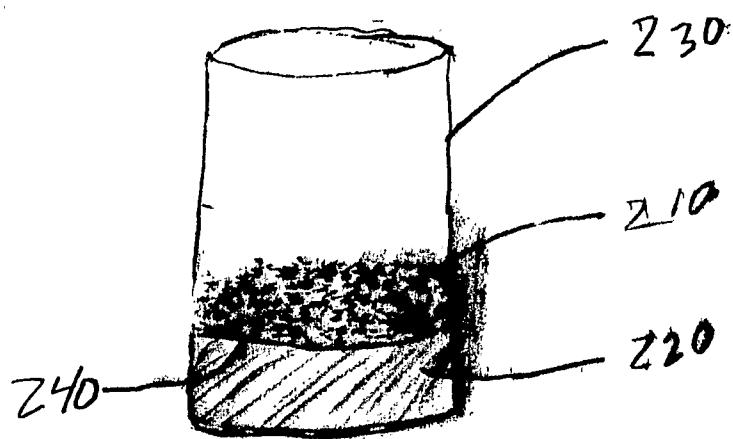


FIG. 1



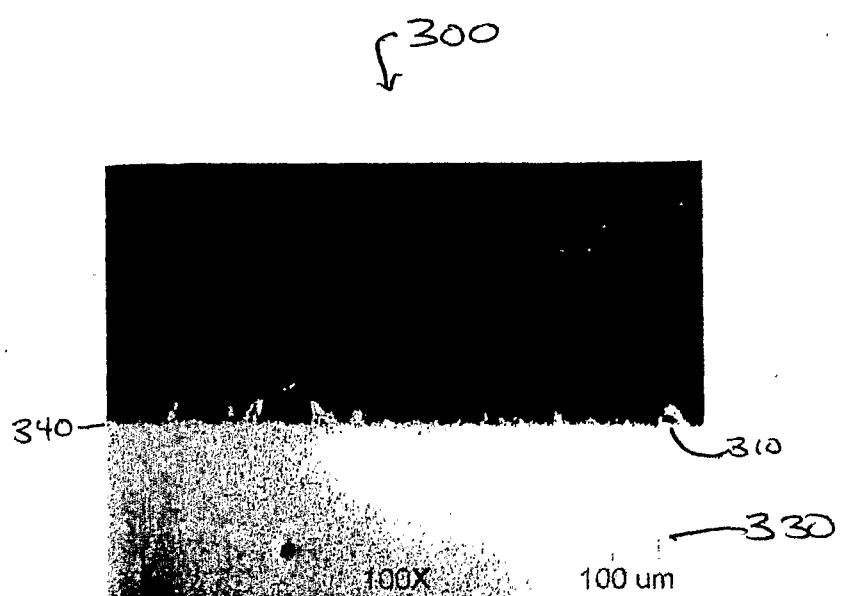


FIG. 3

(PRIOR ART)

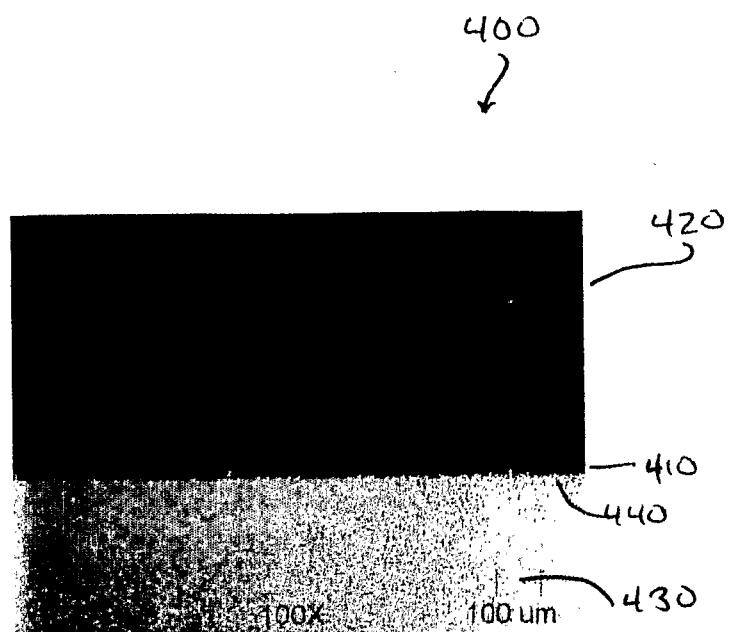


FIG. 4



FIG. 5

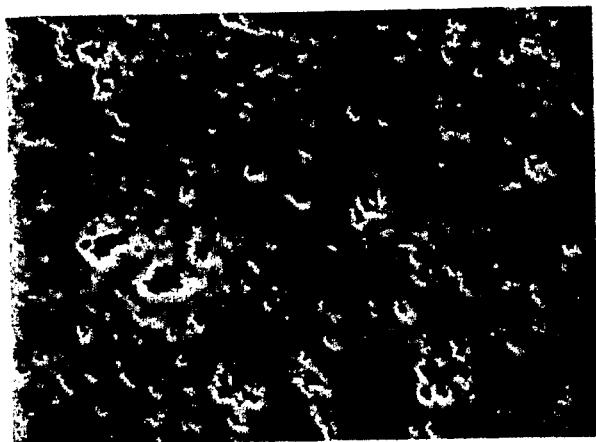


FIG. 6



FIG. 7

(PRIOR ART)

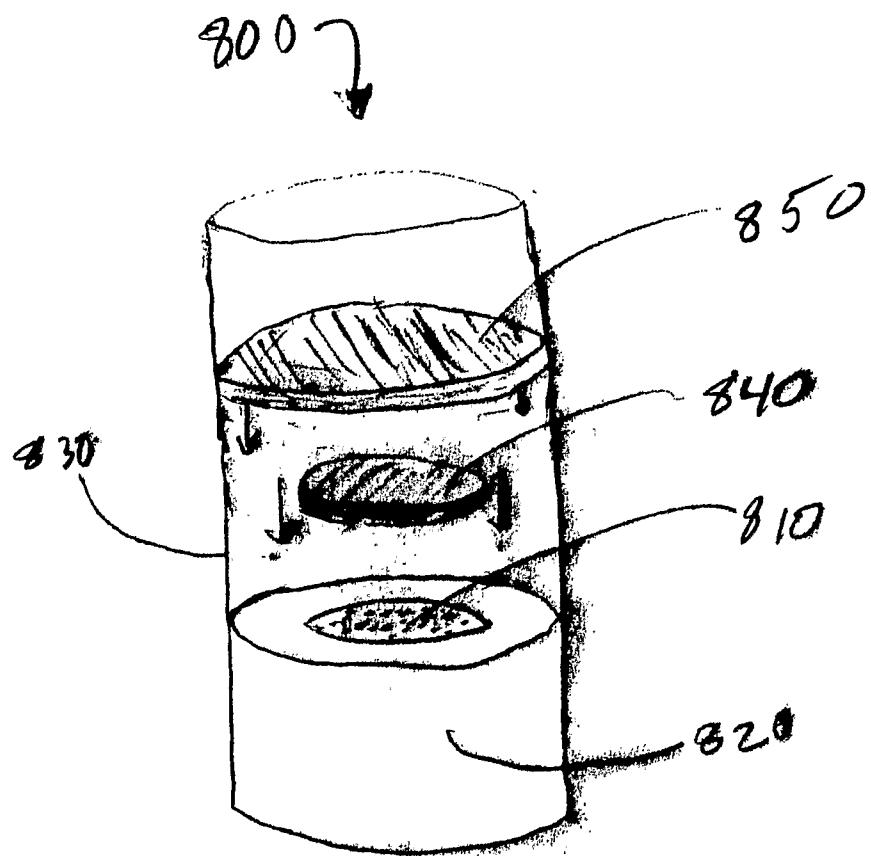


FIG. 8