NOVEL BITS AND CUTTING STRUCTURES

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ABSTRACT

This invention provides an improved cutting element for downhole cutting tools including a support element and a beveled shearing element disposed on the support element and a drill bit including the cutting element; a cutting element including a support element and a shearing element disposed on the support element, wherein the shearing element includes TSP, a sharpened cutting edge, and at least one blended edge that forms part of an interface with the support element and a drill bit including the cutting element. Cutting inserts including an insert body and the shearing elements disclosed above are provided. Also provided are methods for forming the cutting elements and drill bit inserts and a method for drilling mixed earth formations using the improved downhole cutting tools of the present invention.
PLACING SHEAVING ELEMENT INTO MOLD

FILL MOLD

FORM CUTTING STRUCTURE

FIG. 9

FIG. 10

FIG. 11
FIG. 12
FIG. 21

FORM MOLD 2100

LOAD POWDER 2104

ADD 2ND STRUCTURE 2106

CAP HOLES 2108

PRE-PRESS 2110

FINAL PRESS 2112

FIG. 22A

FIG. 22B

FIG. 23
NOVEL BITS AND CUTTING STRUCTURES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 11/154,284 filed on Jun. 16, 2005, which is a continuation-in-part of U.S. patent application Ser. No. 10/696,535, filed on Oct. 29, 2003, which claims priority of U.S. Provisional Application Ser. No. 60/446,967, filed on Feb. 12, 2003, and U.S. patent application Ser. No. 10/967,584, filed on Oct. 18, 2004, which is a continuation of U.S. patent application Ser. No. 10/738, 629. All these parent applications are hereby incorporated by reference in their entirety.

BACKGROUND OF INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates generally to downhole cutting tools used in the oil and gas industry. More specifically, the present invention relates to improved cutting structures.

[0004] 2. Background Art

[0005] Rotary drill bits with no independently moving elements on them are typically referred to as “drag” bits in the art. Drag bits are often used to drill very hard or abrasive formations. Drag bits include those having cutting elements attached to the bit body, such as polycrystalline diamond compact insert bits, and those including abrasive material, such as diamond, impregnated into the surface of the material which forms the bit body. The latter bits are commonly referred to as “impreg” bits.

[0006] An example of a prior art diamond impregnated drill bit is shown in FIG. 1. The drill bit 10 includes a bit body 12 and a plurality of blades 14 that are formed in the bit body 12. The blades 14 are separated by channels 16 that enable drilling fluid to flow between and both clean and cool the blades 14. The blades 14 are typically arranged in groups 20 where a gap 18 between groups 20 is typically formed by removing or omitting at least a portion of a blade 14. The gaps 18, which may be referred to as “fluid courses,” are positioned to provide additional flow channels for drilling fluid and to provide a passage for formation cuttings to travel past the drill bit 10 toward the surface of a wellbore (not shown).

[0007] During abrasive drilling with a diamond impregnated bits, the diamond particles scour or abrade away the rock. As the matrix material around the impregnated diamond crystals is worn away, the diamonds at the surface eventually fall out and other diamond particles are exposed. Diamond impregnated drill bits are particularly well suited for drilling very hard and abrasive formations. The presence of abrasive particles both at and below the surface of the matrix body material ensures that the bit will substantially maintain its ability to drill a hole even after the surface particles are worn down.

[0008] Diamond impregnated bits are typically made from a solid body of matrix material formed by any one of a number of powder metallurgy processes known in the art. During the powder metallurgy process, abrasive particles and a matrix powder are infiltrated with a molten binder material. Upon cooling, the bit body includes the binder material, matrix material, and the abrasive particles suspended both near and on the surface of the drill bit. The abrasive particles typically include small particles of natural or synthetic diamond. Synthetic diamond used in diamond impregnated drill bits is typically in the form of single crystals. However, thermally stable polycrystalline diamond (TSP) tables (layers of individual diamond crystals bonded together) may also be used.

[0009] In a typical impreg bit forming process, the shank of the bit is supported in its proper position in the mold cavity along with any other necessary formers, e.g., those used to form holes to receive fluid nozzles. The remainder of the cavity is filled with a charge of tungsten carbide powder and abrasive particles such as natural or synthetic diamond. Finally, a binder, and more specifically an infiltrant, typically a nickel brass copper based alloy, is placed on top of the charge of powder. The mold is then heated sufficiently to melt the infiltrant and held at an elevated temperature for a sufficient period to allow it to flow into and bind the powder matrix or matrix and segments. For example, the bit body may be held at an elevated temperature (>1800°F) for a period on the order of 0.75 to 2.5 hours, depending on the size of the bit body, during the infiltration process.

[0010] By this process, a monolithic bit body that incorporates the desired components is formed. It has been found, however, that the life of both natural and synthetic diamond is shortened by the lifetime thermal exposure experienced in the furnace during the infiltration process. Accordingly, prior art patents disclose a technique for manufacturing bits that include imbedded diamonds that have not suffered the thermal exposure normally associated with the manufacture of such bits. Such a bit structure is disclosed in U.S. Pat. No. 6,394,202 (the '202 patent), which is assigned to the assignee of the present invention and is hereby incorporated by reference.

[0011] Referring now to FIG. 2, a drill bit 20 in accordance with the '202 patent comprises a shank 24 and a crown 26. Shank 24 is typically formed of steel or a matrix material and includes a threaded pin 28 for attachment to a drill string. Crown 26 has a cutting face 22 and outer side surface 30. According to one embodiment, crown 26 is formed by infiltrating a mass of tungsten-carbide powder impregnated with synthetic or natural diamond, as described above.

[0012] Crown 26 may include various surface features, such as raised ridges 27. Preferably, formers are included during the manufacturing process, so that the infiltrated, diamond-impregnated crown includes a plurality of holes or sockets 29 that are sized and shaped to receive a corresponding plurality of diamond-impregnated inserts 10. Once crown 26 is formed, inserts 10 are mounted in the sockets 29 and affixed by any suitable method, such as brazing, adhesive, mechanical means such as interference fit, or the like. As shown in FIG. 3, the sockets can each be substantially perpendicular to the surface of the crown. Alternatively, and as shown in FIG. 3, holes 29 can be inclined with respect to the surface of the crown 26. In this embodiment, the sockets are inclined such that inserts 10 are oriented substantially in the direction of rotation of the bit, so as to enhance cutting.

[0013] As a result of the manufacturing technique of the '202 patent, each diamond-impregnated insert is subjected
to a total thermal exposure that is significantly reduced as compared to previously known techniques for manufacturing infiltrated diamond-impregnated bits. For example, diamond imbedded according to the '202 patent have a total thermal exposure of less than 40 minutes, and more typically less than 20 minutes (and more generally about 5 minutes), above 1500°F. This limited thermal exposure is due to the hot pressing period and the brazing process. This compares very favorably with the total thermal exposure of at least about 45 minutes, and more typically about 60-120 minutes, at temperatures above 1500°F, that occur in conventional manufacturing of furnace-infiltrated, diamond-impregnated bits. When diamond-impregnated inserts are affixed to the bit body by adhesive or by mechanical means such as interference fit, the total thermal exposure of the diamonds is even less.

[0014] Another type of bit is disclosed in U.S. Pat. Nos. 4,823,892; 4,889,017; 4,991,670; and 4,718,505, in which diamond-impregnated abrasion elements are positioned behind the cutting elements in a conventional tungsten carbide (WC) matrix bit body. The abrasion elements are not the primary cutting structures during normal bit use.

[0015] A second type of fixed cutter drill bit known in the art are polycrystalline diamond compact (PDC) bits. Typical PDC bits include a bit body which is made from powdered tungsten carbide infiltrated with a binder alloy within a suitable mold form. The particular materials used to form PDC bit bodies are selected to provide adequate toughness, while providing good resistance to abrasive and erosive wear. The cutting elements used on these bits are typically formed from a cylindrical tungsten carbide “blank” or substrate. A diamond “table” made from various forms of natural and/or synthetic diamond is affixed to the substrate. The substrate is then generally brazed or otherwise bonded to the bit body in a selected position on the surface of the body.

[0016] The materials used to form PDC bit bodies, in order to be resistant to wear, are very hard and difficult to machine. Therefore, the selected positions at which the PDC cutting elements are to be affixed to the bit body are typically formed substantially to their final shape during the bit body molding process. A common practice in molding PDC bit bodies is to include in the mold at each of the to-be-formed cutter mounting positions, a shaping element called a “displacement.” A displacement is generally a small cylinder made from graphite or other heat resistant material which is affixed to the inside of the mold at each of the places where a PDC cutter is to be located on the finished drill bit. The displacement forms the shape of the cutter mounting positions during the bit body molding process. See, for example, U.S. Pat. No. 5,662,183 issued to Fang for a description of the infiltration molding process using displacements.

[0017] FIG. 4 shows a prior art PDC drill bit. In FIG. 4, the bit body 100 has thereon a plurality of blades 110. Each of the blades 110 has mounted thereon mounting pads (shaped according to FIG. 3) a PDC cutting element 112. Each PDC cutting element 112 includes a diamond table 113 affixed to a tungsten carbide substrate 114. The bit body 100 includes suitably positioned nozzles or “jets” 120 to discharge drilling fluid in selected directions and at selected rates of flow.

[0018] PDC cutting elements typically include a polycrystalline diamond table bonded to a substrate. The substrate is typically cylindrical in shape and is formed from a sufficiently hard and wear-resistant material such as a tungsten-carbide composite. Formation of the diamond table and its bonding to the substrate are catalyzed by a metallic binder (typically cobalt) during a high pressure, high temperature (HPHT) process. PDC cutting elements are particularly advantageous because the polycrystalline diamond table can be easily shaped to form a variety of cutter geometries suited to drill various types of earth formations. For example, the diamond table can be shaped to have a dome-shaped or curved, semi-conical geometry suited for drilling hard, highly abrasive formations, or may be shaped to have a chiseled geometry suited for drilling formations of soft or medium hardness that require more shearing action from the cutting elements.

[0019] Although PDC cutting elements offer the benefit of being able to tailor a particular cutting element to a particular formation, they are also subject to thermal degradation at the high temperatures often encountered within the wellbore during the drilling process. Thermal degradation of PDC cutting elements occurs as a result of the significant difference in the rates of thermal expansion of the metallic binder and the diamond table. At temperatures at or above 350°F (180°C), the metallic binder expands much more rapidly than the diamond, resulting in fracturing of the diamond table and degradation of the PDC cutting element.

[0020] Thermally stable polycrystalline diamond (TSP) cutting elements may be used in lieu of PDC cutting elements. TSP cutting elements are not subject to the same thermal instability of PDC as they are thermally stable up to a temperature of 1200°F (650°C). TSP is typically formed by “leaching” residual cobalt from a polycrystalline diamond table, and this process is described in further detail herein.

[0021] Similar to PDC cutting elements, the diamond table in TSP cutting elements can also be shaped to form various cutter geometries. Two common TSP cutting element shapes are the “tombstone” TSP and the “wedge” TSP. These TSP cutting elements are shown in FIGS. 4B and 4C, respectively. The tombstone and wedge TSPs include sharp edges 401, 402, 403, 404. The sharp edges that form part of cutting faces 401, 403 of the TSP cutting elements improve the ability of the cutting elements to shear formations. The TSP cutting elements also include sharp edges 402, 404 on the portion of the cutting elements that will be bonded to a support (not shown). These sharp edges 402, 404 that contact the support have been shown to create stress risers within the support, leading to cracking of the support and delamination of the TSP cutting element. Thus, TSP cutting elements that are shaped for improved cutting and retention are still needed.

[0022] Different types of bits are selected based on the primary nature of the formation to be drilled. However, many formations have mixed characteristics (i.e., the formation may include both hard and soft zones), which may reduce the rate of penetration of a bit (or, alternatively, reduces the life of a selected bit) because the selected bit is not preferred for certain zones. One type of “mixed formation” includes abrasive sands in a shale matrix. In this type of formation, if a conventional diamond-impregnated bit is used, because the diamond table exposure of this type of bit is small, the shale can fill the gap between the exposed
diamonds and the surrounding matrix, reducing the cutting effectiveness of the bit (i.e., decreasing the rate of penetration (ROP)). In contrast, if a PDC cutter is used, the PDC cutter will shear the shale, but the abrasive sand will cause rapid cutter failure (i.e., the ROP will be sufficient, but wear characteristics will be poor).

[0023] When drilling a typical well, a bit is run on the end of a bottom hole assembly (BHA) and the bit drills a wellbore with a selected diameter. However, during drilling operations, it may be desirable to increase a diameter of a drilled hole to a selected larger diameter. Moreover, increasing the diameter of the wellbore may be necessary if, for example, the formation being drilled is unstable such that the wellbore diameter decreases after being drilled by the drill bit. Accordingly, tools such as “hole openers” and “underreamers” have been designed to enlarge diameters of drilled wellbores. These types of tools also may be thought of as using fixed cutters.

[0024] In some drilling environments, it may be advantageous, from an ease of drilling standpoint, to drill a smaller diameter hole (e.g., and 8½ inch diameter hole) before opening the hole to a larger diameter (e.g., to a 17½ inch diameter hole) with a hole opener. Moreover, it is difficult to directionally drill a wellbore with a large diameter bit because, for example, larger diameter bits have an increased tendency to “torque-up” (or stick) in the wellbore. When the larger diameter bit torques-up, the bit tends to stick and drill a tortuous trajectory as it periodically sticks and then unloads torque. Therefore it is often advantageous to directionally drill a smaller diameter hole before running a hole opener in the wellbore to increase the wellbore to a desired larger diameter.

[0025] A typical prior art hole opener is disclosed in U.S. Pat. No. 4,630,694 issued to Walton et al. The hole opener includes a bull nose, a pilot section, and an elongated body adapted to be connected to a drillstring used to drill a wellbore. The hole opener also includes a triangularly arranged, hardfaced blade structure adapted to increase the diameter of a wellbore.

[0026] Another prior art hole opener is disclosed in U.S. Pat. No. 5,035,293 issued to Rives. The hole opener may be used either as a sub in a drillstring or may be run on the end of a drillstring in a manner similar to a drill bit. The hole opener includes radially spaced blades with cutting elements and shock absorbers disposed thereon. A described in detail below, embodiments of the present invention relate to hole opening technology in addition to bits, typically found at the end of a BHA.

[0027] In light of the difficulties in dealing with mixed formations by prior art tools, what is still needed, therefore, are improved cutting structures that are suited to drill various types of formations.

SUMMARY OF INVENTION

[0028] In one embodiment, the present invention relates to a cutting element for a downhole cutting tool comprising, a support element and a beveled shearing element disposed on the support element, wherein the beveled shearing element comprises thermally stable polycrystalline diamond.

[0029] In another embodiment, the present invention relates to a cutting element for a downhole cutting tool, comprising a support element, a shaped shearing element disposed on the support element, wherein the shaped shearing element is disposed proximal to a leading edge of the downhole cutting tool, and a retaining element overlaying at least a portion of the shaped shearing element.

[0030] In another embodiment, the present invention relates to a cutting element for a downhole cutting tool comprising, a support element and a shearing element disposed on the support element, wherein the shearing element comprises thermally stable polycrystalline diamond, a sharpened cutting edge proximal to a leading edge of the downhole cutting tool, and at least one blended edge, wherein the at least one blended edge forms part of an interface with the support element.

[0031] In another embodiment, the present invention relates to a cutting element for a downhole cutting tool comprising, a support element and a shearing element disposed on the support element, wherein the shearing element comprises thermally stable polycrystalline diamond, a sharpened cutting edge proximal a leading edge of the downhole cutting tool, at least one blended edge, wherein the at least one blended edge forms part of an interface with the support element, at least one tapered surface, and at least one perturbation on at least one surface of the shearing element.

[0032] In another embodiment, the present invention relates to a drill bit comprising, a bit body having at least one support element disposed thereon and a shearing element disposed on the at least one support element, wherein the shearing element comprises thermally stable polycrystalline diamond, a sharpened cutting edge proximal a leading edge of the downhole cutting tool, at least one blended edge, wherein the at least one blended edge forms part of an interface with the at least one support element.

[0033] In another embodiment, the present invention relates to a drill bit comprising, a bit body and a plurality of inserts disposed on the bit body, wherein at least one of the plurality of inserts comprises an insert body and a beveled shearing element disposed on the insert body.

[0034] In another embodiment, the present invention relates to a drill bit comprising a bit body and a plurality of inserts disposed on the bit body, wherein at one of the plurality of inserts comprises an insert body and a shearing element disposed on the insert body, wherein the shearing element comprises thermally stable polycrystalline diamond, a sharpened cutting edge proximal a leading edge of the downhole cutting tool, and at least one blended edge, wherein the at least one blended edge forms part of an interface with the insert body. Additionally, the shearing element may be tapered toward the insert body and at least one perturbation on at least one surface of the shearing element may be present.

[0035] In another embodiment, the present invention relates to a method for forming an insert comprising, forming an insert body, forming a shearing element, wherein the shearing element comprises a sharpened cutting edge proximal a leading edge of the downhole tool and at least one blended edge, and bonding the shearing portion to the diamond-impregnated insert body, wherein the bond forms an interface including at least one blended edge.

[0036] In another embodiment, the present invention relates to a method for forming a diamond-impregnated
insert comprising, forming a diamond-impregnated insert body, forming a beveled shearing element, and bonding the beveled shearing element to the diamond-impregnated insert body.

[0037] Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0038] FIG. 1 shows a prior art diamond impregnated bit;
[0039] FIG. 2 is a perspective view of a second type of diamond impregnated bit;
[0040] FIG. 3 shows rotated inserts;
[0041] FIG. 4 shows a prior art PDC drill bit;
[0042] FIGS. 4B-4C show various TSP cutting shapes.
[0043] FIGS. 5A-5B show a cutting structure formed in accordance with an embodiment of the present invention;
[0044] FIGS. 5C-5D show shearing elements made in accordance with embodiments of the present invention;
[0045] FIG. 6 shows a drill bit formed using cutting structures in accordance with embodiments of the present invention;
[0046] FIG. 7A shows a drill bit formed using cutting structures formed in accordance with embodiments of the present invention that further includes PDC cutting elements;
[0047] FIG. 7B shows a drill bit formed using cutting structures formed in accordance with embodiments of the present invention that further includes PDC cutting elements;
[0048] FIG. 7C shows a drill bit formed using cutting structures formed in accordance with embodiments of the present invention that further includes PDC cutting elements;
[0049] FIG. 8 shows a downhole cutting tool in accordance with one embodiment of the present invention;
[0050] FIG. 9 shows a flow chart illustrating one method of forming a cutting structure in accordance with an embodiment of the present invention
[0051] FIG. 10 shows a removable overlay that is attached to a TSP in accordance with an embodiment of the present invention;
[0052] FIG. 11 shows a coated TSP shearing element in accordance with an embodiment of the present invention;
[0053] FIG. 12 shows an insert made in accordance with an embodiment of the present invention;
[0054] FIG. 13 shows a drill bit made in accordance with embodiments of the present invention;
[0055] FIG. 14 shows an insert made in accordance with embodiments of the present invention;
[0056] FIGS. 15A-15B show inserts having shearing elements made in accordance with the present invention;
[0057] FIG. 16 shows an insert made in accordance with an embodiment of the present invention;

[0058] FIGS. 17A-17B show inserts made in accordance with embodiments of the present invention;
[0059] FIGS. 18A-18D illustrate methods for enhancing a bond between a shearing portion and a substrate in accordance with an embodiment of the present invention;
[0060] FIG. 19 shows an impregn bit formed in accordance with one embodiment of the present invention;
[0061] FIG. 20 shows a PDC bit, which includes inserts formed in accordance with one embodiment of the present invention;
[0062] FIG. 21 shows a flow chart illustrating one method of forming an insert in accordance with the present invention;
[0063] FIGS. 22A-22B show exemplary shearing portions for use in inserts in accordance with the present invention; and
[0064] FIG. 23 shows an insert in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION

[0065] One aspect of the present invention relates to a cutting structure that uses a shearing element, disposed on a support. In particular, the present invention relates to a cutting structure for use in lieu of, or in combination with, PDC cutter elements to provide a shearing action. Embodiments of the present invention are particularly useful in high speed applications, such as applications that use a mud motor and/or turbines.

[0066] In another embodiment of the present invention, at least a portion of the shearing element is overlaid by a retaining element to provide an additional retention mechanism to prevent the shearing element from dislodging from the support. The retaining element may be integrally formed with the support, or may be discretely applied to the shearing element and formed from the same composition as the support or a different composition.

[0067] In another embodiment of the present invention, diamond impregnated blades, which are used in lieu of the matrix or steel blades commonly used in PDC bits, provide the support for a TSP diamond shearing element.

[0068] The manufacturing of TSP is known in the art, but a brief description of a process for manufacturing TSP is provided herein for convenience. A diamond table is a layer of randomly oriented individual diamond “crystals” that are bonded together at bonding lines known as diamond-diamond boundaries in the art. The bonding of individual diamond crystals in the diamond table forms a lattice structure. A metallic binder, typically cobalt, serves as a catalyst in the formation of bonds between individual diamond crystals, and is often found within the interstitial spaces in the diamond table’s lattice structure. Cobalt has a significantly different coefficient of thermal expansion as compared to diamond, so upon heating of the diamond table, the cobalt will expand more rapidly than the diamond table, causing cracks to form in the lattice structure, and eventually resulting in deterioration of the diamond table.

[0069] In order to impede crack initiation and propagation in the diamond table resulting from differential thermal expansion, strong acids are used to “leach” the cobalt from
the diamond lattice structure. The removal of cobalt from the diamond table results in thermal stability of the diamond table at higher temperatures but also increases its brittleness. Accordingly, in certain cases, only a select portion (measured in any dimension) of a diamond table is leached, in order to gain thermal stability without losing impact resistance. As used herein, the term TSP includes both of the above (i.e., partially and completely leached) compounds.

[0070] As a result of these structures, embodiments of the present invention provide a “shear bit” with shearing cutting elements positioned at a leading edge of the blade that are supported by a selected material. In some embodiments, the shearing element (which may be TSP), is coated with a titanium carbide or silicon carbide coating, to enhance its retention through chemical means. Further, the shearing element may be shaped, as discussed with reference to the FIGS. below, to mimic the shapes of traditional PDC cutters or, depending on the application, to have other selected geometries.

[0071] A cutting structure in accordance with an embodiment of the present invention is now described, with reference to FIGS. 5A and 5B. In FIG. 5A, a support 502 is shown. In certain embodiments, the support 502 comprises a diamond impregnated support. In the embodiment shown in FIG. 5A, the support 502 comprises a blade, as is known for PDC bits. Shaped shearing elements 500, are disposed at selected locations on the support 502. The shaped shearing elements 500 may comprise polycrystalline diamond compact (PDC) or thermally stable polycrystalline diamond (TSP). The shearing elements 500 are placed proximal to a leading edge 508. Moreover, in this embodiment, a retaining portion 504 is provided to cover at least a portion of the shearing element 500 (as shown in FIG. 5B).

[0072] In this embodiment, the retaining portion 504 is formed from the support 502, and is created during the manufacturing process. However, in other embodiments, the retaining portion may comprise a discretely applied support, which may be formed from the same materials as the support 502 or different materials. The retaining portion 504 may be a diamond-impregnated material, a tungsten carbide composite, a cubic boron nitride composite, or any other suitable materials known in the art. By covering at least a portion of the shearing elements 500, the retaining portion 504 provides a “mechanical” retention mechanism, and decreases the likelihood of the shearing element 500 coming free from the support 502.

[0073] Moreover, in FIGS. 5A and 5B, the shearing elements 500 are shown having a “teardrop” shape, so that an exposed portion 510 (i.e., the portion of the shearing element 500 not covered by the retaining portion 504) mimics the shape of a typical PDC cutter. Because the shearing elements 500 can be so shaped, and because the support can be molded into the shape of a blade, embodiments of the present invention can be used in applications where PDC bits are typically used. Thus, embodiments of the present invention provide the advantages of PDC bits, such as shearing action and hydraulics cleaning. In some embodiments, these advantages may be realized without the limitation of high wear in abrasive formations that PDC bits typically experience, because TSP may be used as a shearing element.

[0074] The shearing elements 500 in FIG. 5B are backed by a material 506 on the drill bit (not shown). The backing material 506 provides support for the shearing element 500 during the drilling process. The backing material may comprise a diamond impregnated material. In other embodiments, the backing material may be tungsten carbide.

[0075] A shearing element having sharp edges may cause cracking or chipping of the support element at an interface between the shearing element and the support material. Thus, in an embodiment of the present invention, the shearing element may have rounded or beveled edges at the portion of the shearing element that contacts the support element.

[0076] Referring to FIG. 5c, a shearing element 516 in accordance with the present invention, comprises at least one rounded edge 520 on a portion of the shearing element 516 that is bonded to a support element (not shown). The shearing element may comprise PDC or TSP. A retaining element 524 may overlay at least a portion of the shearing element 516. The retaining element 524 may be formed integrally with the support element or discretely applied to the shearing element and may comprise a cubic boron nitride composite, a tungsten carbide composite, or a diamond-impregnated material such as a diamond-impregnated tungsten carbide composite. The retaining element 524 provides increased retention of the shearing element 516 and supplements the retention provided by the bonding of the shearing element 516 to the support element. When the shearing element 516 is disposed on the support element (not shown), which may comprise a blade or a bit body, the at least one rounded edge 520 minimizes stress risers within the support element that may cause cracks to form within the support element and separation of the shearing element 516 from the support element. Further, the shearing element 516 may comprise at least one tapered surface 528. The tapered surface 528 provides a “gripping” action of the shearing element 516 to the attached support element and increased retention of the shearing element. Additionally, the shearing element 516 may comprise a rounded edge 530 on a cutting face of the shearing element 516. The rounded edge 530 on the cutting face may improve impact resistance of the shearing element 516 during drilling. Abs. the shearing element 516 may have a non-planar contoured cutting face that may comprise various cutting geometries such as convex, concave, “saddle” shaped, chiseled, etc.

[0077] Referring to FIG. 5d, a shearing element 540 in accordance with the present invention, comprises at least one beveled edge 542 on a portion of the shearing element that is bonded to a support element (not shown). The shearing element 540 may comprise PDC or TSD. Additionally, a retaining element 544 may overlay at least a portion of the shearing element 540 and may comprise any of the materials discussed above in reference to FIG. 5c. When the shearing element 540 is disposed on the support element (not shown), which may be a blade or a bit body, the at least one beveled edge 542 minimizes stress risers within the support element that may cause cracking in the support element and separation of the shearing element 540 from the support element. Consequently, the at least one beveled edge 542 improves retention of the shearing element to the support element. Further, the shearing element 540 may comprise at least one tapered surface 546 which also provides for increased retention of the shearing element 540 to the attached support element through a “gripping” action, whereby stresses acting on the shearing element 540 are
distributed throughout the support element. Additionally, the shearing element 540 may comprise at least one beveled edge 550 on a cutting face of the shearing element. The at least one beveled edge 550 on the cutting face may improve impact resistance of the shearing element during drilling and help prevent abrasive wear of the shearing element and extend its drilling life. The shearing element 540 may have a non-planar contoured cutting face that may comprise various cutting geometries such as convex, concave, “saddle” shaped, chiseled, etc.

[0078] FIG. 6a illustrates a drill bit having cutting elements formed in accordance with an embodiment of the present invention. In FIG. 6a, a bit body 600 has a plurality of blades 610 extending from the bit body 600. In this embodiment, the blades 610 are formed from a diamond impregnated material, which may be manufactured using any technique known in the art. The bit body 600 itself may also be formed from a diamond impregnated material, or may be formed from a high strength matrix material (known to those having ordinary skill in the art), or may be steel (which may be overlaid with hardfacing).

[0079] The blades 610 have cutting elements 612 mounted at select locations. The cutting elements 612 include at least one shaped shearing element, comprising PDC or TSP supported by diamond impregnated material, that forms the blades 610. Moreover, a retaining portion 614 is disposed over at least a portion of the shearing element 612, to help prevent improve retention. The cutting elements 612 are arranged proximal to a leading edge 630 of the blades 610, such that the shearing portion (not necessarily numbered) contacts the formation to be drilled. The shearing element 612 is so disposed to provide substantially continuous shearing engagement with an earth formation during drilling. Furthermore, the bit body 600 includes suitably positioned nozzles or “jets” 620 to discharge drilling fluid in selected directions and at selected rates of flow.

[0080] Moreover, in certain embodiments, the shearing element may be coated with a material to either create or enhance a bond between the support (e.g., the blades 610 in the embodiment described above) and the shearing element (e.g., cutting element 612 in the embodiment described above). In various embodiments, the coating may comprise a titanium based coatings, tungsten based coatings, nickel coatings, silicon coatings, various carbides, nitrides, and other materials known to those skilled in the art. In particular embodiments, a TSP shearing element is provided with a titanium or silicon carbide coating. FIG. 11 illustrates a titanium carbide coating 1110 deposited on shearing element 1100, which is disposed on a support element 1120. In another embodiment, the coating comprises silicon carbide.

[0081] FIG. 7a illustrates another embodiment of the present invention. In this embodiment, shearing elements formed in accordance with an embodiment of the present invention are used in combination with standard PDC inserts. In particular, as shown in FIG. 7a, two groups of cutting elements 710, 720 are shown extending from bit body 700. The first group of cutting elements 710, which extend slightly further and, therefore, will engage the formation first, comprise PDC inserts. The PDC inserts comprise a cylindrical tungsten carbide substrate to which a diamond table made from various forms of natural and/or synthetic diamond is bonded. The substrate is brazed or otherwise bonded to the bit body 700 in a selected position. [0082] The second group of cutting elements 720 comprise a shaped shearing element having a retaining portion 724 overlaying at least a portion of the cutting elements 720 to help prevent cutting element 720 loss. The shaped shearing element 720 may comprise at least one rounded edge and at least one beveled edge.

[0083] When drilling, the first group of cutting elements 710 (which include the “standard” PDC cutters) interact with the formation first. After drilling for a period of time, the PDC cutting elements 710 will begin to wear. At some point during the drilling process, the PDC cutters will wear to the point where the cutting elements 720 begin to interact with and shear the formation.

[0084] In some embodiments, the shearing elements (which may comprise PDC or TSP) may be disposed to follow or track PDC cutters (on the same radius) to minimize PDC wear progress. In other embodiments, the shearing elements may be arranged at a different exposure than the PDC cutter where the diamond volume (assuming that the shearing element comprises diamond) increases once PDC cutters are worn beyond a certain degree (i.e., both sets of cutting elements begin to interact with the formation). Also, in some embodiments, the different cutting elements may alternate where elements having similar characteristics track. The higher wear on the PDC cutters will leave more pronounced scallops on the hole bottom to stabilize the bit and reduce vibration.

[0085] This structure for a drill bit, which uses two different types of cutters, is particularly advantageous for formations that go from “soft” to “hard.” PDC cutters wear relatively quickly in hard formations, causing a significant drop in the rate of penetration (ROP). However, by using a structure as described above, the shearing elements begin to interact with the formation as the PDC cutters wear, maintaining or even increasing ROP.

[0086] Again, it is noted that while reference has been made to particular compositions and structures in the above embodiments, the present invention is not so limited. In particular, embodiments of the present invention relate to a shearing element disposed on a support, the shearing element being disposed to provide shearing engagement with an earth formation during drilling. In certain embodiments, the shearing element may be formed from TSP, CBN, and/or polycrystalline diamond.

[0087] Further, as shown in FIG. 7b, in certain embodiments, the support 730 comprises a diamond impregnated material, but may be formed from matrix materials (any suitable material known in the art), or steel, for example. In some other embodiments, the support 730 is layered with tungsten carbide. Those having ordinary skill in the art will recognize that other materials may be used.

[0088] Still referring to FIG. 7b, in certain embodiments, the shaped shearing element 750 is formed such that the leading edge consists of essentially a single type of material. Moreover, in certain embodiments, a retaining element 754 is provided. The retaining element 754 may be formed integrally from the support element 730, or may comprise a discrete element that may or may not be formed from the same material as the support 730.

[0089] In FIG. 7b, the supports 730 include PDC cutters 740 as well as shaped shear cutters 750. The shear cutters
750 may be formed of TSP, CBN and/or polycrystalline diamond and may comprise at least one rounded edge or at least one beveled edge. In some embodiments, a retaining portion 754 covers at least a portion of the shear cutters 750 to help prevent shear cutter loss. In some embodiments, such as the one shown in FIG. 7B, the PDC cutters 740 and the shear cutters 750 are alternately positioned on the support 730. The retention portion 754 is positioned to cover at least a portion of the shear cutters 750, but not any of the PDC cutters 740. Other arrangements of a retention member such as one that also covers a portion of the PDC cutters, may be used, without departing from the scope of the invention.

[0090] The cutters 740, 750 may be arranged on the support 730 to have various positions and exposures that are advantageous for the particular formation to be drilled. In one example, a shear cutter 750a is positioned to at least partially track a PDC cutter 740. In another example, a PDC cutter element 740b may be positioned to at least partially track a shear cutter 750b.

[0091] Additionally, the exposures of the cutters 740, 750 may be varied to suit a particular application. In some embodiments, the PDC cutters 740 may have substantially the same exposure as the shear cutters 750. In other embodiments, the PDC cutters 740 and the shear cutters 750 may have different exposures. For example, the PDC cutters 740 may have a higher exposure than shear cutters 750. Alternatively, the shear cutters 750 may have a higher exposure than the PDC cutters.

[0092] In addition, some embodiments may be arranged so that a cutting element that partially tracks another cutting element has a different exposure than the cutting element that it tracks. For example, a PDC cutter 740a may have a higher exposure than a shear cutter 750a that tracks the PDC cutter 740a. Alternatively, the shear cutter 750a may have a higher exposure than the PDC cutter 740a that it tracks. The same is true for a shear cutter 750b that is tracked by a PDC cutter 740b. The shear cutter 750b may have a higher exposure than the PDC cutter 740b, or the PDC cutter 740b may have a higher exposure than the shear cutter 750b.

[0093] FIG. 7C shows another embodiment of a drill bit 760 with cutters 770, 780 positioned on a support 764. The inner profile 766, which extends from the axis of the drill bit 760 to a selected radial distance from the axis, is comprised of PDC cutters 770 that are disposed on the support 764. The outer profile 767 of the drill bit 760, which extends from the inner profile 766 to the outside radius of the drill bit 760, is comprised of shear cutters 780 that are disposed on the support 764. The shaped shear cutters 780 may be formed of TSP, CBN and/or polycrystalline diamond and may comprise at least one rounded edge, at least one beveled edge, and/or at least one tapered surface. A retaining element 774 covers at least a portion of the shear cutters 780 to help prevent shear cutter loss. In at least one other embodiment, the inner profile 766 is comprised of shear cutters 780 and the outer profile is comprised of PDC cutters 770.

[0094] In other embodiments of the present invention, cutting structures formed in accordance with the present invention may be used in a downhole drilling tool, which in one embodiment may be a hole opener. FIG. 8 shows a general configuration of a hole opener 830 that includes one or more aspects of the present invention. The hole opener 830 comprises a tool body 832 and a plurality of blades 838 disposed at selected azimuthal locations about a circumference thereof. The hole opener 830 generally comprises connections 834, 836 (e.g., threaded connections) so that the hole opener 830 may be coupled to adjacent drilling tools that comprise, for example, a drillstring and/or bottom hole assembly (BHA) (not shown). The tool body 832 generally includes a bore therethrough so that drilling fluid may flow through the hole opener 830 as it is pumped from the surface (e.g., from surface mud pumps (not shown)) to a bottom of the wellbore (not shown). The tool body 832 may be formed from steel or from other materials known in the art. For example, the tool body 832 may also be formed from a matrix material infiltrated with a binder alloy.

[0095] The blades 838 shown in FIG. 8 are spiral blades and are generally positioned at substantially equal angular intervals about the perimeter of the tool body, i.e., the hole opener 830. This arrangement is not a limitation on the scope of the invention, but rather is used merely for illustrative purposes. Those having ordinary skill in the art will recognize that any prior art downhole cutting tool may be used. In this embodiment, the blades 838 are formed from matrix material infiltrated with a binder alloy, and cutting elements 840 such as those described above with reference to FIG. 5 are disposed on the blades 838. Other blade arrangements may be used with the invention, and the embodiment shown in FIG. 8 is not intended to be limiting.

[0096] Moreover, in addition to downhole tool applications such as a hole opener, reamer, stabilizer, etc., a drill bit using cutting elements according to various embodiments of the invention such as disclosed herein may have improved drilling performance at high rotational speeds as compared with prior art drill bits. Such high rotational speeds are typical when a drill bit is turned by a turbine, hydraulic motor, or used in high rotary speed applications.

[0097] As known in the art, various types of hydraulically, pneumatically, or rotary operated motors can be coupled to the bit. These so-called “mud motors” are operated by pumping drilling fluid through them. Generally, there are two basic types of mud motors. One type of motor is called “positive displacement.” Positive displacement motors include a chambered stator in the interior of the motor housing which is usually lined with an elastomeric material, and a rotor which is rotationally coupled to the motor output shaft (and thence to the drill bit).

[0098] Movement of drilling fluid through chambers defined between the stator and rotor causes the rotor to turn correspondingly to the volume of fluid pumped through the motor. The other type of mud motor is called “turbine,” because the output of the motor is coupled to a turbine disposed inside the motor housing. As those having ordinary skill in the art will appreciate, the additional motors cause a higher rotational speed in the bit. By coupling cutting structures in accordance with embodiments of the present invention with motors, turbines, and the like, higher penetration rates can be achieved. The cutting structures in accordance with the present invention provide the necessary flow required, as well as providing the necessary durability, to survive under these conditions.

[0099] In one embodiment of the invention, the support (which may comprise the blades and/or the body of the bit) is made from a solid body of matrix material formed by any one of a number of powder metallurgy processes known in
the art. During the powder metallurgy process, abrasive particles and a matrix powder are infiltrated with a molten binder material. Upon cooling, the support includes the binder material, matrix material, and the abrasive particles suspended both near and on the surface of the drill bit. The abrasive particles typically include small particles of natural or synthetic diamond. As noted above, synthetic diamond used in diamond impregnated drill bits is typically in the form of single crystals. However, TSP diamond particles may also be used.

One suitable method of forming a cutting structure in accordance with an embodiment of the present invention is now described, with reference to FIG. 9. In the present invention, as illustrated in FIG. 9, a shaped shearing element is placed into a mold (step 900). Depending on the embodiments, the shearing element may comprise TSP diamond. Further, in certain embodiments, the shearing element may be coated with a chemical coating, such as titanium carbide or silicon carbide. In order to form the retaining portion that overlays the shearing element in embodiments of the present invention, a removable overlay is attached to the shearing element, prior to being placed in the mold. This structure is shown in FIG. 10.

In FIG. 10, removable overlay 1020 is shown attached to TSP diamond shearing element 1010. The removable overlay 1020 is also shown in contact with mold bottom 1030. The removable overlay 1020 is formed from a material such that during the diamond infiltration process (resulting in the diamond impregnated support) it is destroyed. In one embodiment, the removable overlay 1020 may be formed from sand.

Returning to FIG. 9, after the shearing elements (and the removable overlay) are placed into the mold, one of two steps may occur. A discrete retaining portion may be added or, a “charge” of matrix powder (which may be tungsten carbide) is added to “fill” the mold (step 910).

A binder, and more specifically an infiltrant, (which may be a nickel brass copper based alloy), along with the diamonds (in the case where the support comprises a diamond impregnated support), is placed on top of the charge of powder. The mold is then heated sufficiently to melt the infiltrant and held at an elevated temperature for a sufficient period to allow it to flow into and bind the powder matrix or matrix and segments. For example, the bit body may be held at an elevated temperature (>1800°F) for a period on the order of 0.75 to 2.5 hours, depending on the size of the bit body, during the infiltration process (step 920).

The diamond particles which are used to form the diamond impregnated support may be either natural or synthetic diamond, or a combination of both. The matrix in which the diamonds are embedded to form the diamond impregnated material should satisfy several requirements. The matrix preferably has sufficient hardness so that the diamonds exposed at the cutting face are not pushed into the matrix material under the very high pressures encountered in drilling. In addition, the matrix preferably has sufficient abrasion resistance so that the diamond particles are not prematurely released.

To satisfy these requirements, as an exemplary list, the following materials may be used for the matrix in which the diamonds are embedded: tungsten carbide (WC), tungsten alloys such as tungsten/cobalt alloys (W-Co), tungsten carbide or tungsten/cobalt alloys in combination with elemental tungsten (W) (all with an appropriate binder phase to facilitate bonding of particles and diamonds) and the like. Those of ordinary skill in the art will recognize that other materials may be used for the matrix, including titanium-based compounds, nitrides (in particular cubic boron nitride), etc.

It will be understood that the materials commonly used for construction of bit bodies can be used in the present invention. Hence, in one embodiment, the bit body may itself be diamond-impregnated. In an alternative embodiment, the bit body comprises infiltrated tungsten carbide matrix that does not include diamond. If this is the case, the blades which form the support for the shearing element may or may not be separately formed from diamond impregnated material. In an alternative embodiment, the bit body can be made of steel, according to techniques that are known in the art. The bit can optionally be provided with a layer of hardfacing. Again, if this is the case, the blades may be formed from diamond impregnated material.

Advantageously, cutting structures formed in accordance with embodiments of the present invention provide drill bits and downhole cutting tools that provide good shearing action, even in hard formations. Moreover, embodiments of the present invention provide drill bits and downhole cutting tools that may be run at high speeds (i.e., higher bit RPM’s).

In another embodiment, the present invention relates to a cutting element disposed on a downhole cutting tool comprising a support element and a shearing element, wherein the shearing element comprises thermally stable polycrystalline diamond (TSP), a sharpened cutting edge proximal to a leading edge of the downhole tool, and at least one blended edge, wherein the blended edge forms part of an interface with the support element.

FIG. 12 shows a TSP shearing element in accordance with an embodiment of the invention. The shearing element 1200 is disposed on a support element 1206. The support element 1206, in this embodiment, comprises a blade, but may also comprise a bit body or an insect body. The shearing element 1200 and the support element 1206 together form a cutting element 1210 that may be disposed on a downhole cutting tool (not shown). The shearing element 1200 comprises at least one sharpened cutting edge 1201 which is disposed proximal a leading edge of the downhole tool. Further, the shearing element 1200 may comprise a non-planar cutting face having various cutting geometries such as convex, concave, “saddle” shaped, chiseled, etc. Additionally, the shearing element 1200 comprises at least one blended edge 1202 on a portion 1205 of the shearing element 1200. The blended edge 1202 may take on any geometry whereby the intersection of the two surfaces that form the edge 1202 is not a single line. The blended edge 1202 forms part of an interface 1207 between the shearing element 1200 and the support element 1206 to which it is bonded. The blended edge 1202 minimizes stress risers in the support element 1206 that cause cracks to form and propagate within the support element 1206 and eventually lead to loss of the shearing element 1200.

Traditional TSP cutting elements include a TSP shearing element having sharp edges on the portion of the
shearing element that is bonded to a support element. Examples of such shearing elements are the “tombstone” and “wedge” TSP shearing elements discussed earlier. The sharp edges create large stresses within the support element, and more particularly, at the interface between the shearing element and the support element during drilling. The stresses lead to crack formation within the support element and eventual delamination of the shearing element from the support element. The shearing element 1200 in accordance with the invention minimizes these stresses within the support element 1206 and at the interface between the support element 1206 and the shearing element 1200.

[0111] Additionally, the shearing element 1200 may comprise at least one tapered surface 1203. The tapered surface 1203 provides for increased retention of the shearing element 1200 to the support element 1206 through a “gripping” action that distributes stresses acting on the shearing element 1200 throughout the support element 1206 rather than having them localize at the interface 1207.

[0112] The shearing element 1200 may also comprise at least one perturbation 1204 on at least one surface of the shearing element 1200. In one embodiment, the perturbation 1204 is an indentation extending along a surface of the shearing element 1200. The perturbation 1204 may be convex or concave. The perturbation 1204 may improve retention by anchoring the shearing element 1200 to the support element 1206. The increased bond area at the interface 1207 provided by the perturbation 1204 may contribute to increased retention. The at least one perturbation 1204 shall not be limited by the embodiment depicted in FIG. 12. Alternatively, the at least one perturbation 1204 may comprise at least one raised ridge on a surface of the shearing element 1200. Moreover, the perturbation 1204 may comprise any alteration of any surface of the shearing element 1200.

[0113] Referring to FIG. 13, in another embodiment, the invention relates to a drill bit 1300 including a bit body 1312 having support elements 1310 disposed thereon. The bit body 1312 may comprise tungsten carbide with a metallic binder, such as cobalt, a diamond-impregnated material, or may comprise steel that may be layer with hardfacing. In this embodiment, the support elements 1310 comprise blades arranged circumferentially around the bit body 1312 in a spiral configuration. In other embodiments, the blades 1310 may be arranged in equal angular intervals around the bit body 1312. The particular arrangement of the blades 1312 shall not limit the scope of the invention, as any arrangement known in the art may be used. The blades 1312 may comprise a matrix material such as a tungsten carbide composite or may comprise a diamond-impregnated material. The diamond-impregnated material may comprise PDC or TSD. Cutting elements 1315 are disposed on the support elements 1310. At least one of the cutting elements 1315 is a shearing element formed in accordance with the invention. The shearing element 1315 comprises TSP, a sharpened cutting edge 1318 proximal to a leading edge 1330 of the drill bit 1300, and at least one blended edge on a portion of the shearing element that is bonded to the support element 1310. As mentioned above, the blended edge minimizes stress risers that develop within the support element 1310 and at an interface between the shearing element and the support element. These stress risers lead to cracking of the support element 1310 and eventual loss of the shearing element 1315. Additionally, the shearing element 1315 may comprise a contoured, non-planar cutting face having various cutting geometries such as concave, convex, “saddle” shaped, chiseled, etc.

[0114] Still referring to FIG. 13, the shearing element 1315 may further comprise at least one tapered surface (not shown). The tapered surface provides for better retention of the shearing element 1315 to the support element 1310. Additionally, the shearing element 1315 may comprise at least one perturbation (not shown) on at least one surface of the shearing element 1315. The perturbation may be convex or concave and provides increased retention of the shearing element 1315 to the support element 1310. The perturbation may comprise an indentation, a raised surface, or any alteration of a surface of the shearing element 1315.

[0115] Further, a retaining element 1340 may partially at least a portion of the shearing element 1315. The retaining element 1340 provides an additional “mechanical” locking mechanism for retention of the shearing element 1315 to the support element 1310. The retaining element 1340 may be formed integrally from the support element 1310, or may be discrete and applied to the shearing element 1315. The retaining element 1340 may comprise a tungsten carbide matrix material, a cubic boron nitride composite, or a diamond-impregnated matrix material. Jaws or nozzles 1320 that expel drilling fluid in selected directions may also be present. The drilling fluid removes cuttings from the cutting elements 1315 and transports cuttings from the bottom of the wellbore to the surface.

[0116] In one aspect, the present invention relates to diamond-impregnated inserts that have specialized compositions. In particular, the present invention relates to inserts that provide a combination of shearing and grinding action from a single element. Accordingly, in a preferred embodiment, the present invention includes the combination of a diamond-impregnated insert with a second, shearing, “miniature” element.

[0117] According to one embodiment, diamond-impregnated inserts that will comprise the cutting structure of a bit are formed separately from the bit. Because the inserts are smaller than a bit body, they can be hot pressed or sintered for a much shorter time than is required to infiltrate a bit body. The inserts may be “braze” in sockets in order to prevent diamond degradation.

[0118] Referring to FIG. 14, a TSP insert in accordance with an embodiment of the invention comprises an insert body 1400 to which a shearing element 1401 is bonded. The insert body 1400 is typically cylindrical in shape and may comprise a diamond-impregnated material or a tungsten carbide composite. If the insert body comprises a diamond-impregnated material (which may comprise polycrystalline diamond or thermally stable polycrystalline diamond), it may further comprise a thin layer of matrix material 1406 to promote efficient brazing of the TSP insert to a bit body (not shown). Alternatively, the insert body 1400 may be sintered to the bit body or mechanically attached through interference fit.

[0119] Still referring to FIG. 14, the shearing element 1401 comprises a sharpened cutting edge 1402 and a blended edge 1403 that forms part of an interface between the shearing element 1401 and the insert body 1400. Any
number of sharpened cutting edges and blended interface edges may be present. Additionally, the shearing element 1401 may comprise at least one tapered surface 1405 and at least one perturbation 1404 on at least one surface of the shearing element 1401. The at least one perturbation 1404 may take on any of the geometries previously discussed. The tapered surface 1405 provides improved retention of the shearing element 1401 to the insert body 1400.

[0120] In another embodiment, the present invention relates to a drill bit having a bit body and a plurality of inserts disposed on the bit body, wherein at least one of the inserts is the embodiment described in FIG. 14.

[0121] In a preferred embodiment of the invention, the inserts 1500 are manufactured as individual components, as shown for example in FIG. 14A. According to one preferred embodiment, diamond particles and powdered matrix material are placed in a mold. The contents are then hot-pressed or sintered at an appropriate temperature, preferably between about 1000 and 2200°F, more preferably not higher than 1800°F, to form a composite insert. Heating of the material can be by furnace or by electric induction heating, such that the heating and cooling rates are rapid and controlled in order to prevent damage to the diamonds.

[0122] If desired, a very long cylinder having the outside diameter of the ultimate insert shape can be formed by this process and then cut into lengths to produce diamond-impregnated inserts 1500 having the desired length. The dimensions and shape of the diamond-impregnated inserts 1500 and of their positioning on the bit can be varied, depending on the nature of the formation to be drilled.

[0123] The diamond particles can be either natural or synthetic diamond, or a combination of both. The matrix in which the diamonds are embedded to form the diamond impregnated inserts 1500 must satisfy several requirements. The matrix must have sufficient hardness so that the diamonds exposed at the cutting face are not pushed into the matrix material under the very high pressures encountered in drilling. In addition, the matrix must have sufficient abrasion resistance so that the diamond particles are not prematurely released. Lastly, the heating and cooling time during sintering or hot-pressing, as well as the maximum temperature of the thermal cycle, must be sufficiently low that the diamonds embedded therein are not thermally damaged during sintering or hot-pressing.

[0124] To satisfy these requirements, as an exemplary list, the following materials may be used for the matrix in which the diamonds are embedded: tungsten carbide (WC), tungsten alloys such as tungsten/cobalt alloys (W-Co), and tungsten carbide or tungsten/cobalt alloys in combination with elemental tungsten (all with an appropriate binder phase to facilitate bonding of particles and diamonds) and the like. Those of ordinary skill in the art will recognize that other materials may be used for the matrix, including titanium-based compounds, nitrides (in particular cubic boron nitride), etc.

[0125] In the present invention, at least about 15%, more preferably about 30%, and still more preferably about 40% of the diamond volume in the entire cutting structure is present in the inserts, with the balance of the diamond being present in the bit body. However, because the diamonds in the inserts have 2-3 times the rock cutting life of the diamonds in the bit body, in a preferred embodiment the inserts provide about 57% to about 67% of the available wear life of the cutting structure. It will further be understood that the concentration of diamond in the inserts can vary from the concentration of diamond in the bit body. According to a preferred embodiment, the concentrations of diamond in the inserts and in the bit body are in the range of 50 to 100 (100=4.4 carat/cc).

[0126] It will be understood that the materials commonly used for construction of bit bodies can be used in the present invention. Hence, in the preferred embodiment, the bit body may itself be diamond-impregnated. In an alternative embodiment, the bit body comprises infiltrated tungsten carbide matrix that does not include diamond.

[0127] In an alternative embodiment, the bit body can be made of steel, according to techniques that are known in the art. Again, the final bit body includes a plurality of holes having a desired orientation, which are sized to receive and support inserts 1500. Inserts 1500 may be affixed to the steel body by brazing, mechanical means, adhesive or the like. The bit can optionally be provided with a layer of hardfacing. In another embodiment, the diamond-impregnated inserts may comprise large, coated (discussed below) natural diamonds. For example, in certain embodiments, diamonds as large as one carat per stone may be used.

[0128] In another embodiment, one or more of the diamond-impregnated inserts include embedded TSP diamond, so as to enhance shearing of the formation. The TSP can take any desired form, and is preferably formed into the insert during the insert manufacturing process.

[0129] In various embodiments of the invention, TSP may be embedded in a diamond impregnated support, embedded in a body (substrate) of an insert, or may form a shearing element of a cutting element. In accordance with the invention, TSP may be formed by leaching residual cobalt from a polycrystalline diamond table that is formed by sintering diamond, a metal carbide (typically tungsten carbide), and a metallic binder (typically cobalt) at high temperature and high pressure. Alternatively, a TSP or PDC composite may be used to form cutting elements in accordance with the present invention. The TSP or PDC composite may comprise TSP or PDC combined with silicon carbide (or other materials) and may be formed by a hot press process, a hot isostatic press process, or any other powder metallurgy process known in the art.

[0130] Referring to FIGS. 15A-15B, a novel cutting element in accordance with an embodiment of the present invention is shown. In this embodiment, the insert 1500 includes a leading edge 1502 having a given thickness. In a particular embodiment, the leading edge 1502 comprises a diamond table having a selected thickness, which is formed in a manner similar to conventional PDC diamond tables with a tungsten carbide substrate. In the embodiment shown, the leading edge 1502 has a thickness of about 0.080 inches to about 0.120 inches. The thickness and nature of this leading edge may be varied, depending on a user's requirements.

[0131] In particular, the leading edge 1502 may be formed from a number of compounds, such as cubic boron nitride (CBN), PDC, or TSP.

[0132] Returning to FIGS. 15A and 15B, the remainder of the insert 1500 comprises a body 1504, which may be
formed in the manner described above. In a preferred embodiment, the body 1504 is an impregnated substrate comprising tungsten carbide impregnated with diamond. In an alternative embodiment, the body 1504 may comprise tungsten carbide impregnated with TSP or PDC.

[0133] Furthermore, in certain embodiments, the insert 1500 is provided with an outer layer 1506, which provides a brazing surface. In a preferred embodiment, the outer layer 1506 comprises a thin "virgin" (i.e., not impregnated) tungsten carbide layer, in order to promote effective brazing (i.e., maintain the braze strength) of the insert 1500 into a socket (not shown) on a drill bit (not shown).

[0134] By brazing the insert 1500 into a socket, which occurs at significantly lower temperature than diamond impregnation, thermal degradation of the leading edge 1502 may be avoided. Advantageously, therefore, the integrity of the leading edge 1502 is maintained. During drilling, the leading edge 1502 provides shearing cutting action similar to that of a PDC cutter. As wear progresses, the body 1504 of the insert 1500 introduces impregnated diamonds to the formation, increasing drilling efficiency and limiting the progression of wear. Thus, an insert formed in this manner includes both a shearing portion (1502) and an abrasive portion (1504).

[0135] While FIGS. 15A and 15B illustrate an insert 1500 having a "post" shape, no limitation on the present invention is intended by the shown geometry. For example, FIG. 16 shows an insert 1600 having a "saddle" shaped top portion. Additionally, an insert in accordance with the present invention may have any non-planar top cutting portion geometry such as a convex or concave geometry.

[0136] FIGS. 17A and 17B show alternative embodiments of the present invention. In FIG. 17A, an insert 1700 having a shearing portion 1710 and an abrasive portion 1712 is shown. In this embodiment, the shearing portion 1710 has a "V" shape. Again, other geometries for the shearing portion are possible and are expressly within the scope of the present invention. In particular, the shearing portion 1710 may comprise at least one beveled edge or at least one blended edge at an interface with the abrasive portion 1712. In FIG. 17A, the shearing portion 1710 may comprise TSP or PDC deposited on a diamond-impregnated substrate (the abrasive portion 1212).

[0137] In FIG. 17B, a bonding portion 1720 is disposed between the shearing portion 1710 and the abrasive portion 1712. In one embodiment, the shearing portion 1710 comprises TSP, the abrasive portion 1712 comprises diamond-impregnated tungsten carbide, and the bonding portion 1720 comprises "virgin" (i.e., non-impregnated) tungsten carbide. The bonding portion is provided to increase the bond strength between the shearing and abrasive portion. For certain combinations of the compounds described herein, such as PDC, TSP, CBN, or ceramic materials, the bond between the shearing portion and abrasive portion may be too weak to survive sustained drilling. In this case, a bonding portion may be provided.

[0138] Accordingly, in certain embodiments, such as those where there is no tungsten carbide bonding portion, and the shearing portion comprises TSP, the shearing portion may be coated with a material to either create or enhance a bond between the diamond-impregnated body and the shearing portion. Typically, in preferred embodiments, this occurs in one of two ways, which are described with reference to FIGS. 18A-18D below.

[0139] In FIGS. 18A and 18B, a coating 1850 is applied to the shearing portion 1852 to strengthen a bond between the shearing portion 1852 and the diamond-impregnated body 1854. In a preferred embodiment, the coating 1850 comprises a layer of virgin tungsten carbide, applied to a TSP shearing portion, to enhance the metallurgical bond between the body 1854 and the shearing portion 1852. FIG. 18B shows the same technique, but shows an insert having a different geometry than that depicted in FIG. 18B. In various embodiments, the coating may comprise a titanium based coatings, tungsten based coatings, nickel coatings, various carbides, nitrides, and other materials known to those skilled in the art.

[0140] FIGS. 18C and 18D, in contrast, illustrate a case in which a shearing portion having a substrate is used. In FIG. 18C, a shearing portion 1860 includes a cap 1861 and a substrate 1862. In one embodiment, the shearing portion 1860 is a TSP shearing element. In one embodiment, the substrate 1862 includes a binder metal, such as cobalt, which can migrate into the diamond-impregnated body 1864. According to one embodiment, the substrate 1862 may migrate into diamond-impregnated body 1864, and vice versa, enhancing the bond between the diamond-impregnated body 1864 and the substrate 1862.

[0141] Further, in certain embodiments, such as those in which the abrasive portion comprises diamond impregnated tungsten carbide, the bonding portion is virgin tungsten carbide, and the shearing portion comprises PDC or TSP, the bonding layer wears faster than the abrasive or shearing portions. This has the effect of "sharpening" the shearing portion (which is the leading edge of the insert). As the bonding portion wears, new surfaces of the shearing portion are constantly being exposed, which assists in maintaining good shearing action.

[0142] The present invention allows bits to be easily constructed having inserts in which the size, shape, and/or concentration of diamond in the cutting structure is controlled in a desired manner. Likewise, the inserts can be created to have different lengths, or mounted in the bit body at different heights or angles, so as to produce a bit having a multiple height cutting structure. This may provide advantages in drilling efficiency. For example, a bit having extended diamond-impregnated inserts as a cutting structure will be able to cut through downhole float equipment that could not be cut by a standard diamond-impregnated bit, thereby eliminating the need to trip out of the hole to change bits.

[0143] Additionally, a bit having such extended diamond-impregnated inserts will be able to drill sections of softer formations that cannot be efficiently drilled with conventional diamond-impregnated bits. In contrast, embodiments of the present invention makes efficient drilling of softer formations possible due to shearing action of inserts that extend beyond the surface of the bit body.

[0144] Referring now to FIG. 19, a drill bit head 1900 according to one embodiment of the present invention is shown. According to one preferred embodiment, the drill bit head 1900 is formed by infiltrating a mass of tungsten-
carbide powder impregnated with synthetic or natural diamond, as described above. Preferably, formers are included during the manufacturing process, so that the infiltrated, diamond-impregnated drill bit head 1900 includes a plurality of holes or sockets 1922 that are sized and shaped to receive a corresponding plurality of diamond-impregnated inserts 1900. Once the sockets 1922 are formed, inserts 1900 are mounted in the sockets and affixed by any suitable method, such as brazing, adhesive, mechanical means such as interference fit, or the like.

[0145] While reference has been made to impreg bits, inserts formed in accordance with the present invention may also be adapted to be used in “conventional” PDC cutting structures. In particular, inserts in accordance with the present invention may replace some or all of the polycrystalline diamond inserts used in PDC bits. FIG. 20 illustrates one such embodiment.

[0146] In FIG. 20, a drill bit 2090 having at least one insert 2000 in place of a PDC cutter is depicted. As shown in FIG. 8, the drill bit 2090 is formed with at least one blade 2091, which extends generally outwardly away from a central longitudinal axis 2095 of the drill bit 2090. The at least one insert 2000 is disposed on the at least one blade 2091. The number of blades 2091 and/or inserts 2000 is related to the type of rock to be drilled, and can thus be varied to meet particular rock drilling requirements.

[0147] The at least one insert 2000 in the present example comprises an impregnated diamond base and a shearing element comprising a sharpened cutting edge and at least one blended edge that forms part of an interface between the base and the shearing element mounted thereon. The at least one blade 2091 has at least one socket or mounting pad (not numbered separately), which is adapted to receive the at least one insert 2000. In the present embodiment, the at least one insert 2000 is brazed onto the at least one socket. Accordingly, in a preferred embodiment, the at least one insert 2000 may be provided with an outer layer of virgin tungsten carbide to improve braze strength.

[0148] It should be noted that references to the use of specific substrate compositions are for illustrative purposes only, and no limitation on the type of substrate used is intended. As an example, it is well known that various metal carbide compositions, in addition to tungsten carbide, may be used.

[0149] Further, embodiments of the present invention may include non-planar geometry to form a non-planar interface between the abrasive portion and shearing portion to reduce the inherent stresses present at the interface. The use of non-planar interfaces is known in the art. For example, U.S. Pat. No. 5,494,477 discloses one such non-planar interface and is hereby incorporated by reference.

[0150] A second system using a non-planar interface is disclosed in U.S. Pat. No. 5,662,720. In this system, the surface topography of the substrate system is altered to create an “egg-carton” appearance. The use of an “egg-carton” shape allows the stress associated with the cutting to be distributed over a larger surface area, thereby reducing the probability of delamination of the shearing portion from the substrate.

[0151] One suitable method of forming an insert in accordance with the present invention is now described, with reference to FIG. 21. First, a mold, which defines dimensions of an insert, is formed (2100). The mold may be made of any suitable material known in the art, such as graphite. In one embodiment, the mold comprises a block having one or more holes and at least an upper and a lower plunger for each hole (not shown). Alternatively, a series of upper and lower plungers may be used. The upper and lower plungers are used to define the height of the insert. Alternatively, the hole may have a fixed bottom and only an upper plunger is required for defining the height of the insert. After forming the mold, powder of a suitable material, as noted above, that forms the diamond-impregnated body of the insert upon heating and pressure is loaded into the holes, with the lower plungers in place (2104). Then, the upper plunger is placed into the hole, “capping” the hole shut (2108). In a preferred embodiment, the mold assembly is then pre-pressed in a hand operated press (2110). Finally, the mold assembly is placed in the hot press furnace (2112) for the production of a diamond-impregnated insert body. In one embodiment, a second cutting structure (e.g., the shearing portion) is added after the formation of the diamond-impregnated insert body.

[0152] In a preferred embodiment, however, the second cutting structure is placed into the hole (2106) on top of the powder material that is to form the diamond-impregnated insert body, before or at the time the upper plunger is placed into the hole to cap this hole (2108). No specific geometry of cutting structure is required by this invention. With this embodiment, the bonding between the diamond-impregnated insert body and the second cutting structure (the shearing portion) is formed during hot press.

[0153] In a preferred embodiment, the second cutting structure is physically attached to a surface of the upper plunger, prior to placing the upper plunger in the hole. Because the upper plunger is designed and manufactured based on the shape of the diamond-impregnated body and second cutting structure, the second cutting structure “mates” with the upper plunger. Accordingly, the orientation and position of the second cutting element may be set at this stage. Additionally, the surface of the upper plunger to which the second cutting structure is attached may be “scoured” or marked to aid in proper positioning of the second cutting element. The upper plunger/second cutting element may then be placed into the hole, “capping” the hole shut (2108). In a preferred embodiment, the mold assembly is then pre-pressed in a hand operated press (2110). Finally, the mold assembly is then placed in the hot press furnace (2112) for the production of an insert having a diamond-impregnated body with a shearing portion disposed thereon.

[0154] Accordingly, based on this method, diamond-impregnated inserts having a specified geometry may be formed. Further, based on this method, a shearing portion having a specified geometry may be used in conjunction with the diamond-impregnated insert. The resulting insert, therefore, can have a specific geometry, which is adapted to more effectively drill a formation.

[0155] Alternate methods of forming an insert may be used. For example, a high pressure, high temperature (HPHT) process for sintering diamond or cubic boron nitride may be used. Such a process has been described in U.S. Pat. Nos. 5,676,496 and 5,598,621, and their teachings are incorporated by reference herein. Another suitable method for hot-compacting pre-pressed diamond/metal powder mix-
tures is hot isostatic pressing, which is known in the art. See Peter E. Price and Steven P. Kohler, “Hot Isostatic Pressing of Metal Powders”, Metals Handbook, Vol. 7, pp. 419-443 (9th ed. 1984). As noted above, the HPHT process can be done with both the powder and the shearing portion present, or the diamond-impregnated body can be formed prior to attachment of a shearing portion.

[0156] FIGS. 22A and 22B show particular shearing portions for use in embodiments of the present invention. FIG. 22A shows a circular TSP cutter that may be used as a shearing portion in accordance with embodiments of the present invention. The TSP shearing element includes a sharpened cutting edge 2200 and at least one blended edge 2201 that forms part of an interface with a support element. In FIG. 22A, the TSP cutter having a diameter φ (which, in certain embodiments, ranges from 6-9 mm) and a thickness ω (which, in certain embodiments, ranges from 2-4 mm). In FIG. 22B, a triangular CBN shearing portion is shown. In FIG. 22B, the CBN shearing portion is shown having a length B (which, in certain embodiments, is 6-9 mm) and a thickness ω (which, in certain embodiments, ranges from 2-4 mm).

[0157] FIG. 23 illustrates another aspect of the present invention. In FIG. 23, an insert 2300 is shown having a varying composition from a center portion 2302 to an exterior portion 2304. By varying the composition (such as the diamond content) of the insert 2300, the relative hardness of the insert can be tailored to a given formation. Also, wear characteristics may be better controlled by such control. The composition may vary in either a uniform or non-uniform manner. In particular, while FIG. 20 illustrates the insert 2300 having similar compositions on either side of the center portion 2302 (i.e., exterior portion 2304 has the same composition) this is not necessarily required. Depending on the requirements of the user, the composition may be altered around the location where the shearing portion is to be placed.

[0158] Further, while embodiments of the present invention have disclosed various matrix materials, it should be noted that other suitable materials will be apparent to those of ordinary skill in the art. In particular, the matrix material may be a CBN composite, rather than a tungsten carbide composite. CBN composites have the advantage of being more thermally stable than tungsten carbides. In addition, materials may be selected in order to improve certain manufacturing processes. For example, by judiciously selecting compositions, frictional heat generation during abrasion of the composite may be reduced. This can be achieved by selecting matrix material with abrasion resistance lower than diamond and with lower friction coefficient. For example, CBN instead of WC may be used in the matrix with ceramic binder.

[0159] Further, mixtures of any of the materials disclosed herein, or those known to one of ordinary skill in the art may be used. For example, it is expressly within the scope of the present invention that an insert body may be formed that comprises diamond, CBN, TiC (or TiN), or cobalt aluminate pressed using the HPHT or other processes described above.

[0160] While reference to particular diameters, lengths, and thicknesses are discussed, no limitation on the scope of the present invention is intended thereby. In particular, the size of the insert, and the shearing portion will vary depending on the nature of the formation to be drilled and/or other criteria selected by the user.

[0161] Further, other structures known in the art may be used in conjunction with the shearing portion disposed on a diamond-impregnated body disclosed above. For example, in certain embodiments, a “wear” portion may be present on the insert. Specifically, a wear portion may comprise a bearing surface used in gauge pads.

[0162] Advantageously, embodiments of the present invention provide cutting elements that can “grind” a formation as well as “shear” a formation, to increase the overall rate of penetration and/or wear resistance of a bit. Furthermore, advantageously, embodiments of the present invention provide better drilling results when drilling mixed formations (i.e., formations having both hard and soft characteristics such as sand/shale formations). Furthermore, embodiments of the invention advantageously minimize stresses acting on support elements to which shearing elements are bonded that can lead to cracking of the support elements, thereby improving retention of the shearing elements.

[0163] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

What is claimed is:

1. A cutting element disposed on a downhole cutting tool, comprising:
   a support element; and
   a beveled shearing element disposed on the support element, wherein the beveled shearing element comprises thermally stable polycrystalline diamond.

2. A cutting element disposed on a downhole cutting tool, comprising:
   a support element;
   a shaped shearing element disposed on the support element, wherein the shaped shearing element is disposed proximal to a leading edge of the downhole cutting tool; and
   a retaining element overlaying at least a portion of the shaped shearing element.

3. The cutting element of claim 2, wherein the shaped shearing element comprises at least one beveled edge.

4. The cutting element of claim 2, wherein the shaped shearing element comprises at least one rounded edge.

5. The cutting element of claim 2, wherein the shaped shearing element comprises at least one tapered surface.

6. The cutting element of claim 2, wherein the shaped shearing element comprises at least one rounded cutting edge.

7. The cutting element of claim 2, wherein the shaped shearing element comprises at least one beveled cutting edge.

8. The cutting element of claim 2, wherein the shaped shearing element comprises at least one non-planar cutting
face geometry selected from the group consisting of concave, convex, saddle shaped, chiseled, and beveled.

9. The cutting element of claim 2, wherein the shaped shearing element comprises at least one selected from the group consisting of polycrystalline diamond, thermally stable polycrystalline diamond, a silicon carbide polycrystalline diamond composite, and a silicon carbide thermally stable polycrystalline diamond composite.

10. The cutting element of claim 2, wherein the retaining element is formed integrally with the support element.

11. The cutting element of claim 2, wherein the retaining element is at least one selected from the group consisting of a cubic boron nitride composite, a tungsten carbide composite and a diamond-impregnated material.

12. A cutting element disposed on a downhole cutting tool, comprising:

- a support element;
- a shearing element disposed on the support element, wherein the shearing element comprises;
- thermally stable polycrystalline diamond;
- a sharpened cutting edge proximal to a leading edge of the downhole cutting tool; and
- at least one blended edge, wherein the at least one blended edge forms part of an interface with the support element.

13. The cutting element of claim 12, wherein the shearing element comprises a composite of silicon carbide and thermally stable polycrystalline diamond.

14. The cutting element of claim 12, wherein the cutting element further comprises a retaining element overlaying at least a portion of the shearing element.

15. The cutting element of claim 12, wherein the shearing element further comprises at least one tapered surface.

16. The cutting element of claim 12, wherein the shearing element further comprises at least one perturbation on at least one surface of the shearing element.

17. The cutting element of claim 12, wherein the shearing element comprises a non-planar cutting face geometry selected from the group consisting of concave, convex, saddle shaped, chiseled, and beveled.

18. A drill bit for drilling earth formations comprising:

- a bit body having at least one support element disposed thereon;
- and
- a shearing element disposed on the at least one support element, wherein the shearing element comprises;
- thermal stable polycrystalline diamond;
- a sharpened cutting edge proximal to a leading edge of the downhole cutting tool; and
- at least one blended edge, wherein the at least one blended edge forms part of an interface with the at least one support element.

19. The drill bit of claim 18, wherein the shearing element further comprises at least one tapered surface.

20. The drill bit of claim 18, wherein the shearing element further comprises at least one perturbation on at least one surface of the shearing element.

21. A drill bit for drilling earth formations comprising:

- a bit body;
- a plurality of inserts disposed on the bit body, wherein at least one of the plurality of inserts comprises an insert body and a shaped shearing element disposed on the insert body; and
- a retaining element overlaying at least a portion of the shaped shearing element.

22. The bit of claim 21, wherein the shaped shearing element comprises at least one beveled cutting edge.

23. The drill bit of claim 21, wherein the shaped shearing element comprises at least one rounded cutting edge.

24. The drill bit of claim 21, wherein the shaped shearing element comprises at least one selected from the group consisting of cubic boron nitride, polycrystalline diamond, and thermally stable polycrystalline diamond.

25. The drill bit of claim 21, wherein the bit body comprises a diamond-impregnated material.

26. A drill bit comprising:

- a bit body;
- a plurality of inserts disposed on the bit body, wherein at least one of the plurality of inserts comprises an insert body and a shearing element disposed on the insert body, wherein the shearing element comprises;
- thermally stable polycrystalline diamond;
- a sharpened cutting edge located proximal a leading edge of the drill bit; and
- at least one blended edge, wherein the at least one blended edge forms part of an interface with the insert body.

27. The drill bit of claim 26, wherein the shearing element further comprises at least one tapered surface.

28. The drill bit of claim 26, wherein the shearing element is tapered toward the insert body.

29. The drill bit of claim 26, wherein the shearing element further comprises at least one perturbation on at least one surface of the shearing element.

30. The drill bit of claim 26, wherein the bit body comprises a diamond-impregnated material.

31. The drill bit of claim 26, wherein the insert body comprises a tungsten carbide composite.

32. The drill bit of claim 26, wherein the insert body comprises a diamond-impregnated material.

33. The drill bit of claim 32, wherein the diamond-impregnated insert body comprises thermally stable polycrystalline diamond.

34. The drill bit of claim 32, wherein the shearing element is disposed on the diamond-impregnated insert body post-infiltration.

35. A method of forming a diamond-impregnated insert having a shearing portion, the method comprising:

- forming a diamond-impregnated insert body;
- forming a beveled shearing portion; and
- bonding the beveled shearing portion to the diamond-impregnated insert body.
36. The method of claim 35, wherein the diamond-impregnated insert body is formed by a hot press process.

37. The method of claim 36, wherein the hot press process is performed with a powder material in a mold, the powder material being selected to form the diamond-impregnated insert body.

38. A method of forming an insert having a shearing portion, the method comprising:
   forming an insert body;
   forming a shearing portion, wherein the shearing portion comprises,
   a sharpened cutting face located proximal a leading edge of the diamond-impregnated insert; and
   at least one blended edge, wherein the at least one blended edge forms part of an interface with the insert body; and
   bonding the shearing portion to the diamond-impregnated insert body to form the diamond-impregnated insert.

39. A composite cutting element for a drill bit comprising:
   an abrasive body having a mixture of ultra-hard material and a less abrasive resistant matrix material cemented together; and
   a shearing element disposed on the abrasive body.

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