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(54) **CUTTING ELEMENT FOR USE IN A DRILL BIT FOR DRILLING SUBTERRANEAN FORMATIONS**

(75) Inventors: **Jorge A. Dovalina, JR.**, Magnolia, TX (US); **Nicholas J. Lyons**, Houston, TX (US)

Correspondence Address:
LARSON NEWMAN & ABEL, LLP
5914 WEST COURTYARD DRIVE, SUITE 200
AUSTIN, TX 78730 (US)

(73) Assignee: **BAKER HUGHES INCORPORATED**, Houston, TX (US)

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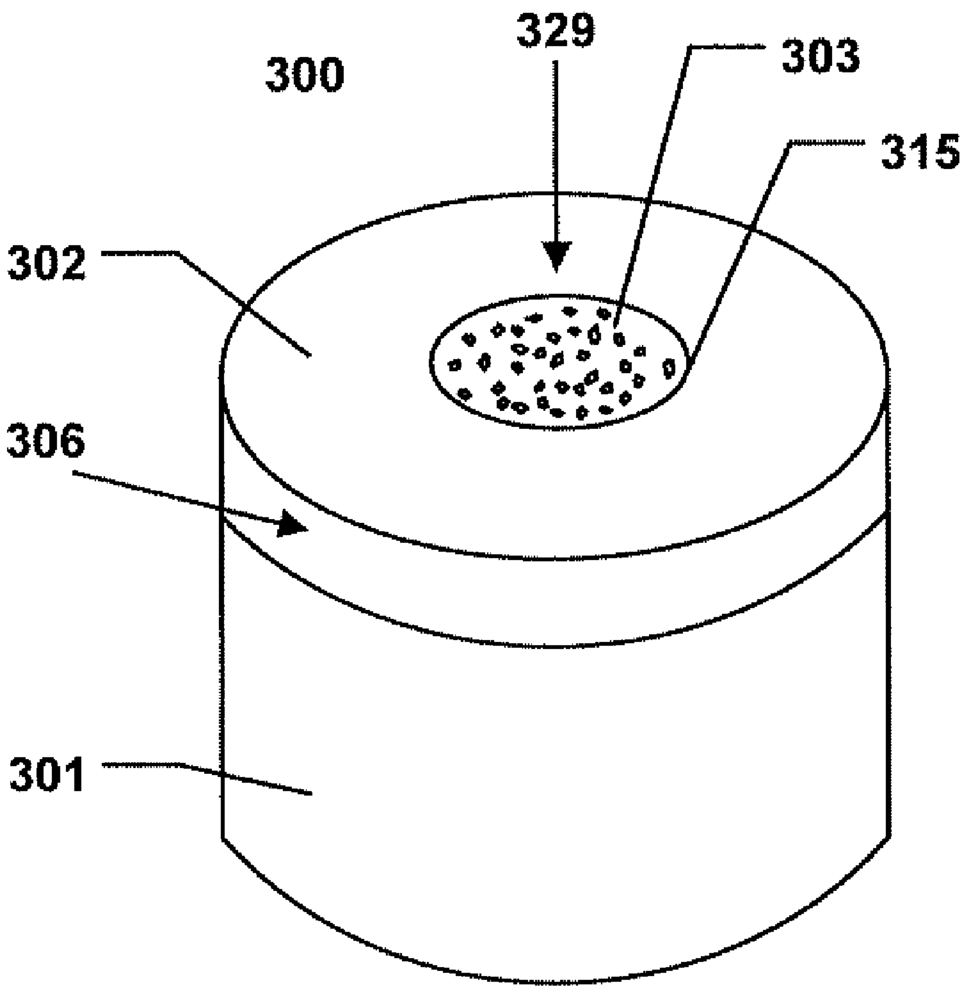
(52) **U.S. Cl.** **175/428**

(57) **ABSTRACT**

A cutting element for use in a drill bit for drilling subterranean formations including a substrate having a body including an upper surface extending transversely to a longitudinal axis of the body, a superabrasive layer overlying the upper surface of the substrate, wherein the superabrasive layer includes an annular shape having a central opening defined by an inner surface. The cutting element further includes an abrasive insert overlying the upper surface of the substrate and disposed within the central opening of the superabrasive layer, wherein the abrasive insert has an upper surface having a surface roughness (R_a) of greater than about 1 micron.



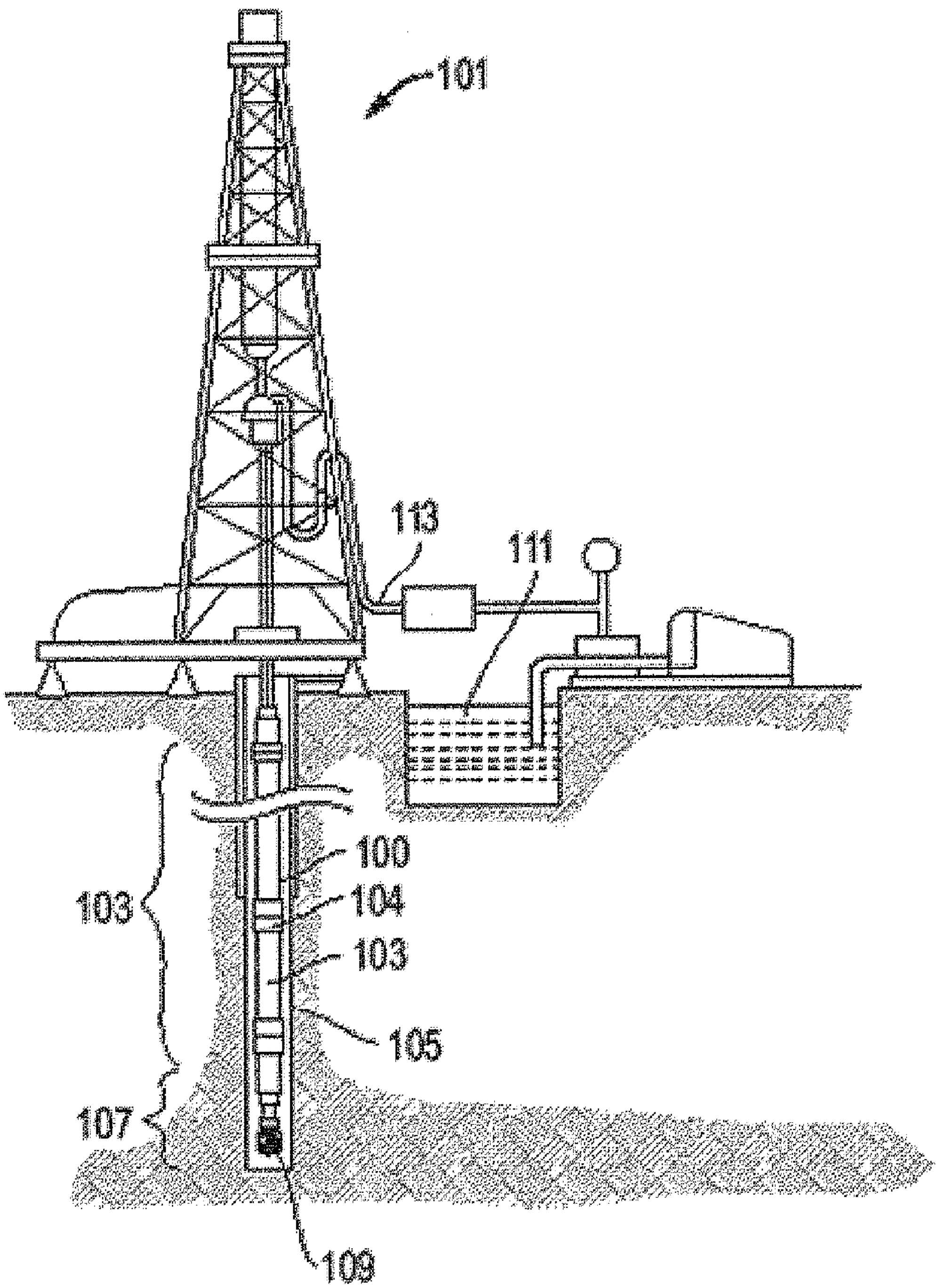


FIG. 1

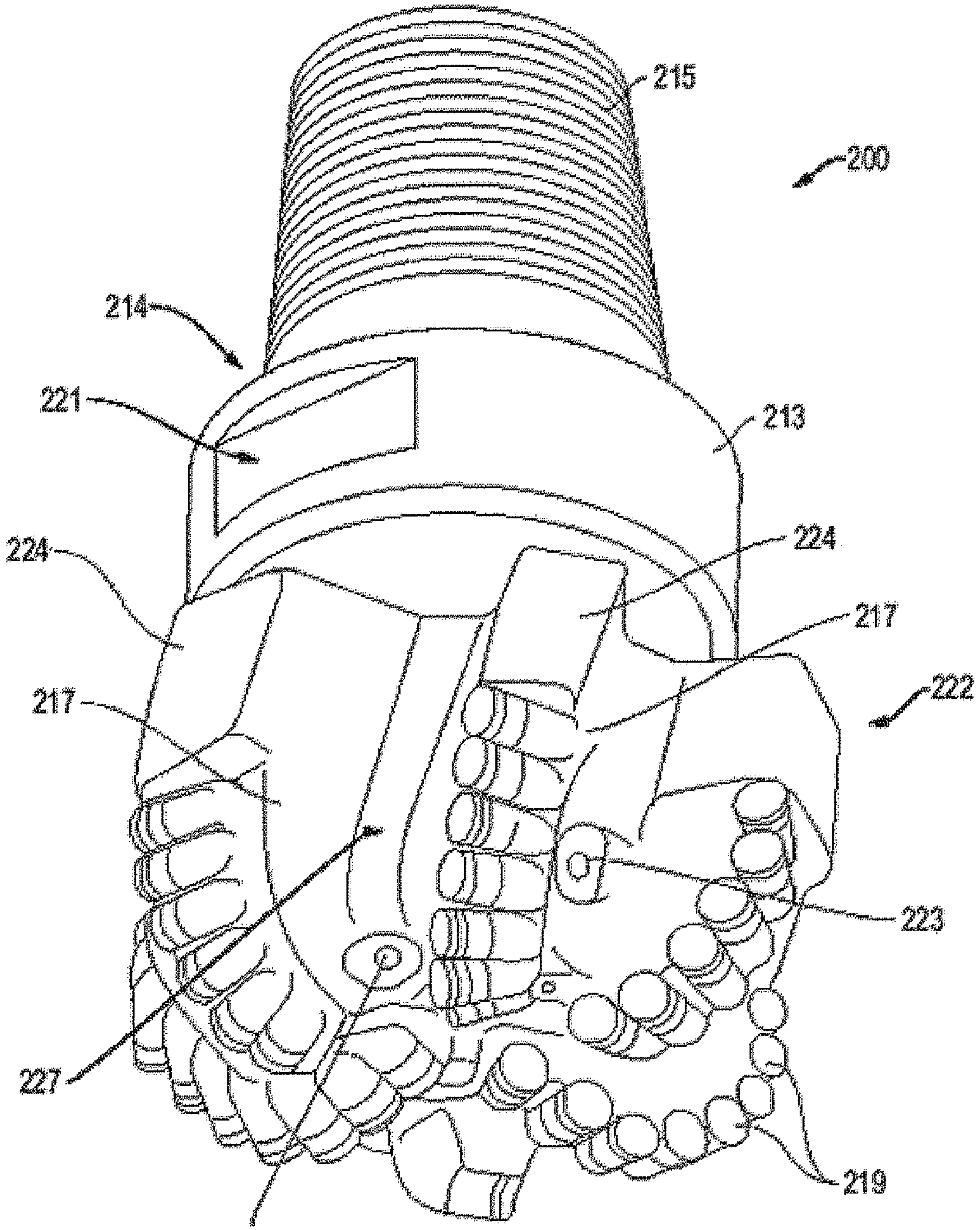


FIG. 2

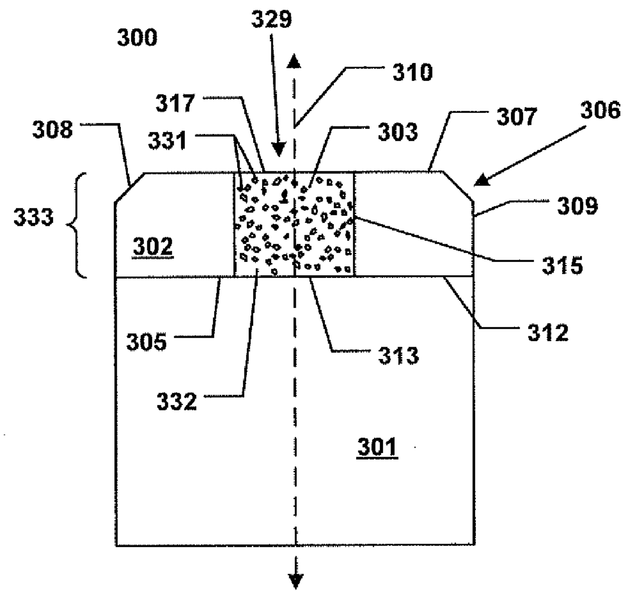


FIG. 3A

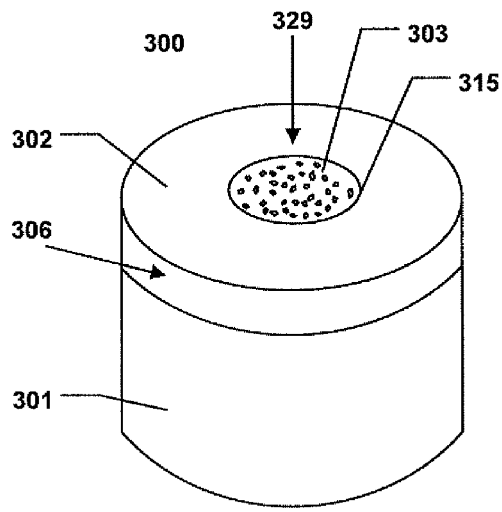


FIG. 3B

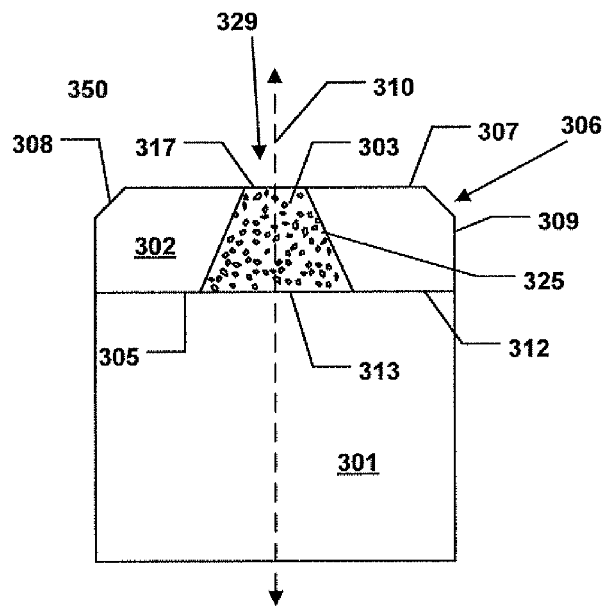


FIG. 3C

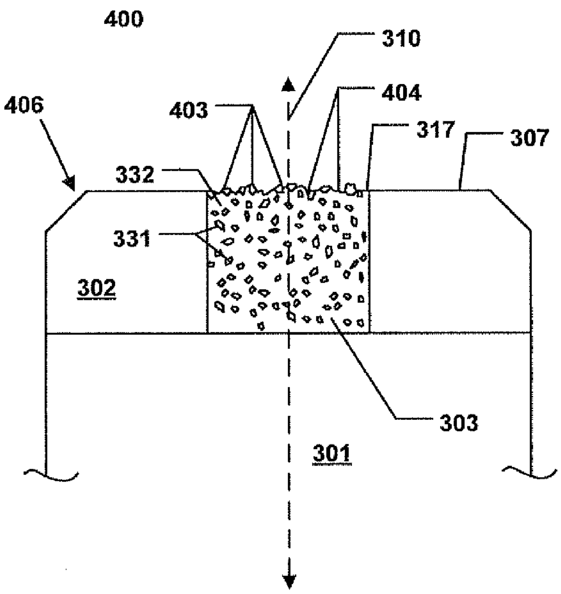


FIG. 4

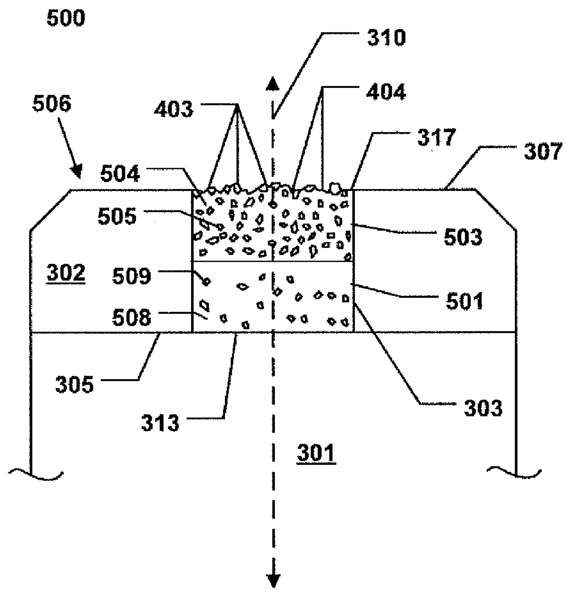


FIG. 5

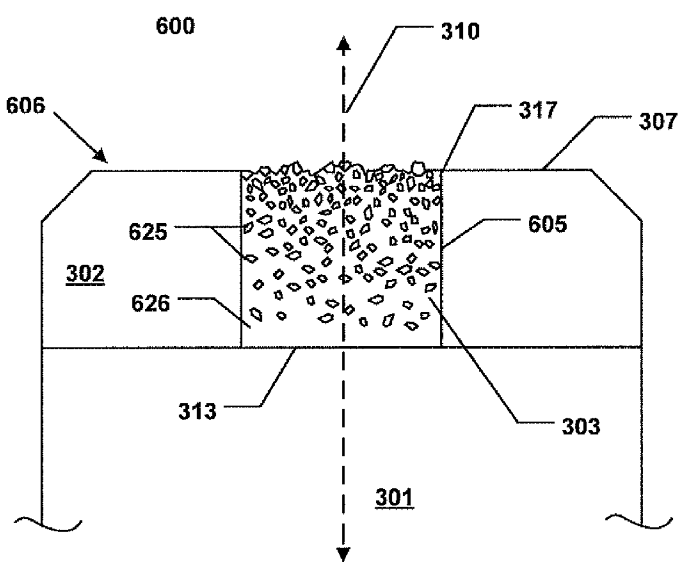


FIG. 6

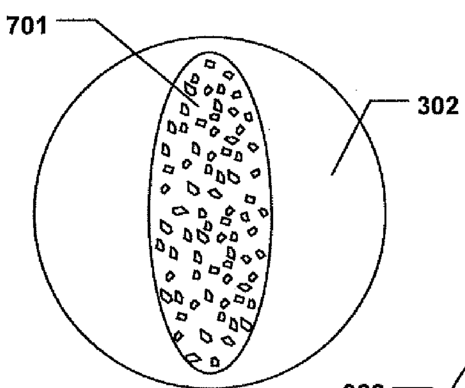


FIG. 7A

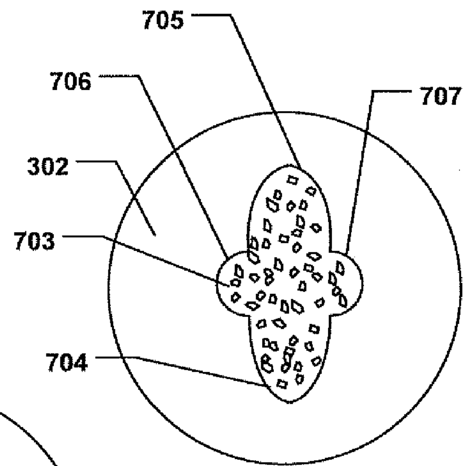


FIG. 7B

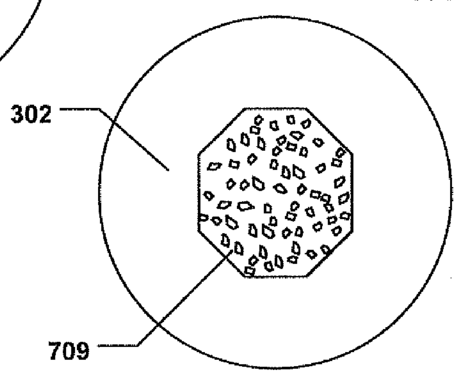


FIG. 7C

CUTTING ELEMENT FOR USE IN A DRILL BIT FOR DRILLING SUBTERRANEAN FORMATIONS

BACKGROUND

[0001] 1. Field of the Disclosure

[0002] The following is directed to cutting elements for use in drill bits for drilling subterranean formations and more particularly, cutting elements utilizing a cutting table comprising a superabrasive layer and an abrasive insert.

[0003] 2. Description of the Related Art

[0004] In the past, rotary drill bits have incorporated cutting elements employing superabrasive materials, including synthetic diamond cutters using polycrystalline diamond compacts, otherwise termed "PDC" cutters. Such PDC cutters have had various shapes and designs, including self-supported cutters, otherwise a monolithic object solely of the made of the desired cutting material, or alternatively, cutters employing a polycrystalline diamond layer or "table" on a substrate made of a hard metal material suitable for supporting the diamond layer.

[0005] Despite improvements in PDC cutter designs, certain obstacles remain, including for example, performance degradation and failure of cutters due to mechanical strain, thermal-induced strain, and a combination of such forces. Delamination and fracture of a cutter can occur given the extreme loading and temperatures generated during drilling operations. Furthermore, repetitive heating and cooling of the cutter can amplify damage to the cutter due to differences in thermal expansion coefficient and thermal conductivity of the cutter components. Wear characteristics of cutters have also been studied to mitigate catastrophic damage to the cutter surfaces.

[0006] Various different configurations of cutters have been used to overcome some of the above noted obstacles, however, significant shortcomings are still exhibited by conventional cutters, and there remains a need in the art for improvements.

SUMMARY

[0007] According to one aspect, a cutting element for use in a drill bit for drilling subterranean formations includes a substrate having a body having an upper surface extending transversely to a longitudinal axis of the body, a superabrasive layer overlying the upper surface of the substrate, wherein the superabrasive layer comprises an annular shape having a central opening defined by an inner surface, and an abrasive insert overlying the upper surface of the substrate. The abrasive insert can be disposed within the central opening of the superabrasive layer, wherein the abrasive insert comprises an upper surface having a surface roughness (R_a) of greater than about 1 micron.

[0008] In another aspect, a cutting element for use in a drill bit for drilling subterranean formations includes a cutting table made of a superabrasive layer comprising an annular shape having a central opening defined by an inner surface, and an abrasive insert overlying the upper surface of the substrate and disposed within the central opening of the superabrasive layer. The abrasive insert includes abrasive grit contained within a matrix material, wherein an upper region of the abrasive insert comprising an upper surface has a different amount of abrasive grit than a lower region of the abrasive insert.

[0009] In accordance with still another aspect, a cutting element for use in a drill bit for drilling subterranean formations includes a cutting table made of a superabrasive layer having an annular shape having a central opening defined by an inner surface, and an abrasive insert disposed within the central opening of the superabrasive layer, wherein the abrasive insert comprises an upper surface having a texture comprising protrusions and recesses.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The present disclosure may be better understood, and its numerous features and advantages made apparent to those skilled in the art by referencing the accompanying drawings.

[0011] FIG. **1** includes an illustration of a subterranean drilling operation.

[0012] FIG. **2** includes an illustration of a drill bit in accordance with an embodiment.

[0013] FIGS. **3**A-**3**C include cross-sectional illustrations and a perspective view of cutter elements in accordance with embodiments.

[0014] FIG. **4** includes a cross-sectional illustration of a portion of a cutter element in accordance with an embodiment.

[0015] FIG. **5** includes a cross-sectional illustration of a portion of a cutter element in accordance with an embodiment.

[0016] FIG. **6** includes a cross-sectional illustration of a portion of a cutter element in accordance with an embodiment.

[0017] FIGS. **7**A-**7**C include top view illustrations of cutter elements in accordance with embodiments.

[0018] The use of the same reference symbols in different drawings indicates similar or identical items.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0019] The following is directed to earth boring drill bits, and more particularly, towards cutting elements used in such drill bits. The terms "bit", "drill bit", and "matrix drill bit" may be used in this application to refer to "rotary drag bits", "drag bits", "fixed cutter drill bits" or any other earth boring drill bit incorporating the teachings of the present disclosure. Such drill bits may be used to form well bores or boreholes in subterranean formations.

[0020] An example of a drilling system for drilling such well bores in earth formations is illustrated in FIG. **1**. In particular, FIG. **1** illustrates a drilling system including a drilling rig **101** at the surface, serving as a station for a crew of workers to operate a drill string **103**. The drill string **103** defines a well bore **105** extending into the earth and can include a series of drill pipes **100** and **103** that are coupled together via joints **104** facilitating extension of the drill string **103** for great depths into the well bore **105**. The drill string **103** may include additional components, such as tool joints, a kelly, kelly cocks, a kelly saver sub, blowout preventers, safety valves, and other components known in the art.

[0021] Moreover, the drill string can be coupled to a bottom hole assembly **107** (BHA) including a drill bit **109** used to penetrate earth formations and extend the depth of the well bore **105**. The BHA **107** may further include one or more drill collars, stabilizers, a downhole motor, MWD tools, LWD tools, jars, accelerators, push and pull directional drilling tools, point stab tools, shock absorbers, bent subs, pup joints, reamers, valves, and other components. A fluid reservoir **111** is also present at the surface that holds an amount of liquid that can be delivered to the drill string **103**, and particularly the drill bit **109**, via pipes **113**, to facilitate the drilling procedure.

[0022] FIG. **2** includes a perspective view of a fixed cutter drill bit according to an embodiment. As shown in FIG. **2**, the fixed cutter drill bit **200** can include a bit body **213** which may be connected to a shank portion **214** via a weld. The shank portion **214** can include a threaded portion **215** for connection of the drill bit **200** to other components of the BHA. The drill bit body **213** can further include a breaker slot **221** extending laterally along the circumference of the drill bit body **213** to aid coupling and decoupling of the drill bit **200** to other components.

[0023] The drill bit **200** can include a crown portion **222** coupled to the drill bit body **213**. As will be appreciated, the crown portion **222** can be integrally formed with the drill bit body **213** such that they are a single, monolithic piece. The crown portion **222** can include gage pads **224** situated along the sides of protrusions or blades **217** that extend radially from the crown portion **222**. Each of the blades **217** extend from the crown portion **222** and include a plurality of cutting members **219** bonded to the blades **217** for cutting, scraping, and shearing through earth formations when the drill bit **200** is rotated during drilling. The cutting members **219** may be tungsten carbide inserts, polycrystalline diamond compacts (PDC), milled steel teeth, and particularly those cutting elements described herein. Coatings or hard facings may be applied to the cutting members **219** and other portions of the bit body **213** or crown portion **222** to reduce wear and increase the life of the drill bit **200**.

[0024] The crown portion **222** can further include junk slots **227** or channels formed between the blades **217** that facilitate fluid flow and removal of cuttings and debris from the well bore. Notably, the junk slots **227** can further include openings **223** for passages extending through the interior of the crown portion **222** and bit body **213** for communication of drilling fluid through the drill bit **200**. The openings **223** can be positioned at exterior surfaces of the crown portion **222** at various angles for dynamic fluid flow conditions and effective removal of debris from the cutting region during drilling.

[0025] FIGS. **3**A-**3**C include cross-sectional illustrations and a perspective view illustration of cutting elements in accordance with an embodiment. Referring to FIG. **3**A, a cross-sectional illustration of a cutting element is provided. The cutting element **300** includes a substrate **301** which can have a shape suitable for maintaining a cutting table **306** thereon. The substrate **301** can have various shapes, for example, a cylindrical shape having a height as defined by a longitudinal axis **310** extending through the body of the substrate **301**. Substrates herein can have an upper surface **305** that extends transversely to the longitudinal axis **310**, and a rear surface opposite and parallel to the upper surface **305**. It will be appreciated that other geometries may be suitable for the substrate **301**.

[0026] The substrate **301** can have a hardness suitable for withstanding drilling operations. That is, certain substrates **301** can be made of a material having a Mohs hardness of at least about 8, or at least about 8.5, at least about 9.0, or even at least about 9.5. Particular metals or metal alloy materials may be used to form the substrate **301**. For example, the substrate **301** can be formed of carbides, nitrides, oxides, borides, carbon-based materials, and a combination thereof. Reference herein to carbon-based materials is reference to synthetically-produced molecules made entirely of carbon and the various carbon allotropes, such as carbon nanotubes and the like. In some instances, the substrate **301** may be made of a cemented material such as a cemented carbide. Some suitable cemented carbides may include metal carbides, and more particularly cemented tungsten carbide such that the substrate **301** consists essentially of cemented tungsten carbide.

[0027] As illustrated, the cutting element **300** can be formed such that a cutting table **306** overlies the upper surface **305** of the substrate **301**. The cutting table **306** can be formed of two components, notably including a superabrasive layer **302** having an annular shape and comprising a central opening **329** as defined by an inner surface **315** of the superabrasive layer **302**. Furthermore, the cutting table **306** includes an abrasive insert **303** overlying the upper surface **305** of the substrate **301** and disposed within the central opening **329** of the superabrasive layer **302** as defined by the inner surface **315**.

[0028] Referring briefly to FIG. 3B, a perspective view illustration provides an alternative view demonstrating the orientation between the superabrasive layer **302** and the abrasive insert **303**. The superabrasive layer **302** is formed such that it has an annular shape, including a central opening **329** extending radially and axially around a central point at the center of the cutting table **306**. As further illustrated in FIG. 3B, the cutting table **306** is formed such that the abrasive insert **303** is configured to fit within the central opening **329** of the superabrasive layer **302**.

[0029] Referring again to FIG. **3**A, the superabrasive layer **302** can be formed such that the central opening **329**, and therein the abrasive insert **303**, extend through the entire height **333** of the cutting table **306**. However, in other embodiments, the central opening may extend for a fraction of the height **333**, and therein the abrasive insert **303** extends for only a fraction of the height **333** of the abrasive table **306**. In such designs, the superabrasive layer **302** would be formed with a central recess (as opposed to a central opening **329**) that would contain the abrasive insert **303**.

[0030] Moreover, the cutting table **306** can be formed such that the superabrasive layer **302** comprises a bottom surface **312** that can directly contact the upper surface **305** of the substrate **301**, and more particularly can be bonded to the upper surface **305** of the substrate **301**. The abrasive insert **303** of the cutting table **306** can be formed such that it comprises a rear surface **313** that is directly contacting the upper surface **305** of the substrate **301**, and more particularly is bonded to the upper surface **305** of the substrate **301**. Additionally, the cutting table **306** can be formed such that the superabrasive layer **302** is bonded to the abrasive insert **303** at the inner surface **315** defining the interface between the components.

[0031] The superabrasive layer **302** can include superabrasive materials such as diamond, boron nitride (e.g., cubic boron nitride), carbon-based materials, and a combination thereof. Some superabrasive layers may be in the form of polycrystalline materials. For instance, the superabrasive layer **302** can consist essentially of polycrystalline diamond. With reference to those embodiments using polycrystalline diamond, the superabrasive layer **302** can be made of various types of diamond including thermally-stable polycrystalline diamond, which can contain a lesser amount of catalyst materials (e.g., cobalt) than other diamond materials, making the material stable at higher temperatures.

[0032] The cutting table **306** can be formed such that the superabrasive layer **302** comprises a side surface **309** that extends parallel to the longitudinal axis **310**, an upper surface **307** that extends transversely to the longitudinal axis **310**, and a chamfered surface **308** extending between the side surface **309** and upper surface **307** at an angle to the longitudinal axis **310**. The length and angle of the chamfered surface **308** may be controlled depending on the intended application of the cutting element **300**. It will further be appreciated that embodiments herein may utilize cutting elements having a radiused edge, wherein the edge between the upper surface and the side surface of the cutting element comprises a curved or arcuate surface defined by a radius.

[0033] The abrasive insert **303** can be formed such that it includes abrasive grit **331** contained within a matrix material **332**, which may facilitate improved wear characteristics, mechanical integrity, and cutting ability of the cutting table **306**. As used herein, reference to a matrix material is reference to a solid material for containing abrasive grit therein, such as a polycrystalline material, formed from a metal or cermet material as will be described in more detail. For some cutter designs, the abrasive insert **303** can be formed such that the abrasive grit **331** is dispersed uniformly throughout the entire volume of matrix material **332**. In accordance with one embodiment, the abrasive insert **303** is formed such that it includes at least 10 vol % abrasive grit **331** contained within the matrix material **332** for the entire volume of the abrasive insert **303**. In other designs, the amount of abrasive grit can be greater, such as on the order of at least 15 vol %, at least 25 vol %, at least 40 vol %, or even at least about 50 vol % of abrasive grit **331** contained within the matrix material **332** for the entire volume of the abrasive insert **303**. In particular instances, the cutting table **306** is designed such that the abrasive insert **303** contains an amount of abrasive grit within a range between about 10 vol % and **70** vol %, such as between about 15 vol % and **60** vol %, and more particularly between about 20 vol % and **50** vol %.

[0034] The abrasive grit **331** can be contained within a matrix material **332** that comprises a metal or metal alloy material. For example, the matrix material **332** can be made of a carbide material, such as a metal carbide. One suitable metal carbide material is tungsten carbide, and in fact, some cutter designs utilize a matrix material **332** that consists essentially of tungsten carbide. Some other suitable metals or metal alloys may include transition metal elements.

[0035] Additionally, the abrasive grit **331** can be formed of abrasive material having suitable abrading and cutting capabilities. For example, suitable abrasive materials can include oxides, borides, nitrides, carbides, carbon-containing materials, and a combination thereof. Reference herein to carbon-based materials is reference to synthetically produced molecules made entirely of carbon and various carbon allotropes, such as carbon nanotubes and the like. Certain abrasive materials for use as the abrasive grit can include alumina, silica, silicon carbide, combinations thereof and the like. In certain instances, the abrasive grit **331** is formed of a superabrasive material, such as diamond, cubic boron nitride, and a combination thereof. Particular cutting elements are formed such that the abrasive insert **303** uses only abrasive grit **331** consisting of diamond.

[0036] With particular reference to embodiments employing diamond abrasive grit, the grit material can have particular multi-faceted shapes providing a plurality of sharp edges suitable for cutting and abrading hard formations. For example, the diamond abrasive grit can be cubo-octahedral, cubic faced, and the like.

[0037] Additionally, the abrasive grit **331** can employ encapsulated grit, such that each of the particles of abrasive grit **331** are substantially surrounded by an encapsulating material. The encapsulating material may improve the mechanical properties of the abrasive grit (e.g., wear resistance), provide added protection for the abrasive grit during processing, particularly with regard to thermal cycling used in various manufacturing processes, and further improve the bonding characteristics between the abrasive grit and the matrix material **332**. Additionally, provision of encapsulated grit can facilitate proper spacing and distribution of the abrasive grit **331** within the matrix material **332**. Suitable compositions for use as the encapsulant material can include ceramics, such as oxides, carbides, borides, nitrides, and carbon-based materials. Other encapsulant materials can include refractory metal or refractory metal alloy compositions.

[0038] Certain sizes of abrasive grit **331** can be used to aid proper functioning of the abrasive insert **303**. For example, the abrasive grit **331** can have an average grit size of at least about 25 microns, such as at least about 50 microns, at least about 100 microns, or even at least about 200 microns. In certain instances, the abrasive grit has an average grit size within a range between about 25 microns and about 2 millimeters and more particularly between about 100 microns and about 1 millimeters, and even more particularly between about 100 microns and about 0.5 millimeter.

[0039] FIG. **3**C includes a cross-sectional illustration of a cutting element in accordance with an embodiment. The cutting element **350** includes a cutting table **306** overlying the upper surface **305** of the substrate **301** as previously described in accordance with FIG. **3**A. Notably, the cutting table **306** of FIG. **3**C demonstrates an abrasive insert **303** having a different shape than the abrasive insert of embodiment in FIG. **3**A. The abrasive insert **303** and particularly, the superabrasive layer **302** is formed such that the interface between the abrasive insert **303** and superabrasive layer **303** comprises a tapered surface **325**. The tapered surface **325** extends at an angle to the longitudinal axis **310** such that the diameter of the central opening **329** at the upper surface **307** of the superabrasive layer **302** is smaller than the diameter of the central opening **329** at the bottom surface **312**.

[0040] FIG. **4** includes a cross-sectional illustration of a portion of a cutting element in accordance with an embodiment. The cutting element **400** includes a cutting table **406** comprising the superabrasive layer **302** and abrasive insert **303** disposed within a central opening of the superabrasive layer **302**. As illustrated, the abrasive insert **303** is formed such that it has an upper surface **317** having particular features. That is, in accordance with one embodiment, the abrasive insert **303** can be formed such that the upper surface **317** has a particular surface roughness, which may be suitable for conducting certain types of cutting operations and improving the wear characteristics of the cutting table **406**. In accordance with one embodiment, the abrasive insert **303** can have a surface roughness (R_a) of greater than about 1 micron. It will be noted that the reference to surface roughness is an arithmetic average of the roughness profile as measured through physical (e.g., a stylus) or optical measuring techniques. In other embodiments, the abrasive insert **303** is formed such that the upper surface **317** has a greater surface roughness, such as on the order of greater than about 3 microns, greater than about 5 microns, greater than about 10 microns, or even greater than about 15 microns. In particular instances, the abrasive insert **303** can be formed such that the upper surface **317** has a surface roughness (R_a) within a range between about 1 micron and about 50 microns, such as between about 1 micron and about 30 microns, and more particularly between 1 micron and 20 microns or even more particularly between 1 micron and about 10 microns.

[0041] In addition to the characteristics of surface roughness described herein, the abrasive insert **303** can be formed with an upper surface **317** that has a texture defined by projections **403** and recesses **404** extending across the upper surface **317**. Notably, the projections **403** can be formed by abrasive grit **332** protruding through the matrix material **332**, while the recesses **404** can be regions along the upper surface **317** that may be absent the abrasive grit **332**. In particular, the recesses **404** can be regions comprising primarily the matrix material **332** between the projections **403** formed by the abrasive grit **332**.

[0042] In certain embodiments, the arrangement of projections **403** along the upper surface **317** of the abrasive insert **303** can be a random orientation. That is, there is no long range or short range order between the orientation of the projections **403** with respect to each other. Moreover, the recesses **404** can have a random arrangement with no short range order or long range order with respect to the projections **403** or each other. However, in other embodiments, the abrasive insert **303** can be formed such that the upper surface **317** has a pattern of projections **403** and recesses **404** such that they are ordered relative to each other in an array. In such embodiments, the abrasive insert **303** may be cast or molded initially to form the pattern of projections **403** and recesses **404**.

[0043] Embodiments herein may utilize a particular arrangement between the amount of superabrasive layer and the amount of abrasive insert forming the cutting table. For example, in certain designs the abrasive insert is formed such that it comprises at least 10 vol % of the total volume of the cutting table. In fact, certain embodiments may utilize a larger abrasive insert, such that it comprises at least 20 vol %, at least about 30 vol %, or even at least about 40 vol % of the total volume of the cutting table. Still, the size of the abrasive insert **303** may be limited such that the abrasive insert comprises between about 10 vol % and **60** vol %, and more particularly between about 10 vol % and **50** vol % of the total volume of the cutting table.

[0044] Additionally, cutting tables of the cutting elements herein may utilize a particular arrangement between the superabrasive layer **302** and abrasive insert **303** such that a certain amount of the upper surfaces of these components **307** and **317** is exposed. For example, certain designs utilize a cutting table wherein the upper surface of the abrasive insert **303** comprises at least about 10% of the total surface area of the upper surface of the cutting table, which includes the upper surface **307** of the superabrasive layer **302** and the upper surface **317** of the abrasive insert **303**. In other embodiments, the percentage of the surface area occupied by the upper surface **317** of the abrasive insert **303** is greater, such as on the order of at least 20%, at least about 25%, or even at least 30% of the total surface area of the upper surface of the cutting table. However, the total surface area occupied by the upper surface **317** of the abrasive insert **303** may be limited such that it may be between about 10% and 75%, such as between about 20% and 60%, and more particularly between about 20% and 50% of the total surface area of the upper surface of the cutting table.

[0045] FIG. **5** includes a cross-sectional illustration of a portion of a cutting element in accordance with an embodiment. The cutting element **500** illustrates a cutting table **506** comprising a superabrasive layer **302** and an abrasive insert **303** disposed within the central opening of the superabrasive layer **302**. In particular, the abrasive insert **303** comprises a lower region **501** that includes the rear surface **313**, which is bonded to the upper surface **305** of the substrate **301**. Additionally, the abrasive insert **303** comprises an upper region **503** comprising the upper surface **317** that is axially spaced apart from the rear surface **313** along the longitudinal axis **310**. Notably, the abrasive insert **303** comprises at least two distinct regions; the lower region **501** and upper region **503**, which can represent at least two distinct layers within the abrasive insert **303**.

[0046] In particular cutting elements, the abrasive insert **303** can be formed such that the upper region **503** includes a different amount of abrasive grit **505** within the matrix material **504** than the amount of abrasive grit **509** contained within the matrix material **508** of the lower region **501**. For example, in particular embodiments, the bonding interface at the rear surface **313** of the lower region **501** and the upper surface **305** of the substrate **301** can be substantially free of abrasive grit **509** to facilitate bonding between the lower region **501** of the abrasive insert **303** and the upper surface **305** of the substrate **301**. Such a design may facilitate bonding of the lower region **501** to the upper surface **305** of the substrate **301**

[0047] In certain designs, the upper region **503** comprises at least about 10% greater amount (per unit volume) of abrasive grit than the lower region **501** of the abrasive insert **303**. In other embodiments, the amount of abrasive grit in the upper region **503** as compared to the lower region **501** may be greater, such as on the order of at least about 15% greater, at least about 20% greater, or even at least about 50% greater amount of abrasive grit within the upper region **503** than the lower region **501**. Such a design may facilitate a greater amount of abrasive grit in the upper region for improved cutting and wear resistance and a lower amount of abrasive grit in the lower region **501** for improved bonding of the abrasive insert **303** to the substrate **301**. In particular embodiments, the upper region **503** comprises between about 10% and about 100%, and more particularly between about 15% and about 80% greater amount of abrasive grit than the lower region **501** of the abrasive insert **503**.

[0048] In alternative embodiments, the upper region **503** can be formed such that it contains a lesser amount of abrasive grit than the lower region **501**. For instance, particular cutting designs utilize an upper region **503** having at least about 10% lesser amount (per unit volume) of abrasive grit than the lower region **501** of the abrasive insert **303**. In other embodiments, the amount of abrasive grit in the upper region **503** as compared to the lower region **501** may be lesser, such as on the order of at least about 15% less, at least about 20% less, or even at least about 30% less than the lower region **501**. Such a design can facilitate a greater stiffness of material within the lower region **501** for supporting the upper region **503**.

[0049] While the cutting table **506** is illustrated as having distinct or discrete layers defining the lower region **501** and upper region **503**, it will be appreciated that such a change in the amount of abrasive grit may not necessarily include a layered structure, but a gradual change in the amount of abrasive grit present within the matrix material over the height of the abrasive insert **303**.

[0050] FIG. **6** includes a cross-sectional illustration of a portion of a cutting element in accordance with an embodiment. The cutting element **600** includes a cutting table **606** having a superabrasive layer **302** of an annular shape and defining a central opening, and further includes an abrasive insert **303** disposed within the central opening of the superabrasive layer **302**. In accordance with one particular embodiment, the abrasive insert **303** can comprise a graded concentration of abrasive grit **625** through the height of the abrasive insert **303** such that the amount of abrasive grit **625** within the matrix material **626** is different at different positions along the longitudinal axis **310** from the rear surface **313** of the abrasive insert **303** to the upper surface **317** of the abrasive insert.

[0051] In particular designs the amount of abrasive grit at the upper surface **317** is greater than the amount of abrasive grit at the rear surface **313** such that the amount of abrasive grains increases along the height of the abrasive insert **303** as defined by the longitudinal axis **310**. In particular instances, the upper surface. It will be appreciated, that in certain embodiments, the abrasive insert **303** can be formed such that the upper surface **317** is formed to have a greater amount of abrasive grit **625** than matrix material **626**.

[0052] Still, in some alternative embodiments, the direction of abrasive grit concentration grading through the volume of the abrasive insert **303** can be alternated in an axial direction, radial direction, or a combination thereof. For example, the graded direction of abrasive grit may be reversed, such that the amount of abrasive grit **625** contained within the matrix material **626** decreases at distances along the longitudinal axis **310** away from the rear surface **313**. In still other alternative embodiments, a cutting element can be formed that includes an abrasive insert having a graded amount of abrasive grit **625** contained within the matrix material **626**, wherein the concentration of abrasive grit increases with proximity to the inner surface **605** of the superabrasive layer **302**. That is, the abrasive insert can be formed such that regions in the center of the abrasive insert along the longitudinal axis **310** comprise a lesser amount of abrasive grit **625** than regions within the abrasive insert spaced apart from the longitudinal axis **310** at a radial distance which are closer in proximity to the inner surface **605** of the superabrasive layer **302**. Such designs may facilitate the formation of a cutting element capable of maintaining suitable cutting rates when the cutting table **606** wears into the abrasive insert.

[0053] FIG. 7A-7C provides top view illustrations of cutting elements in accordance with an embodiment. In particular, FIGS. **7**A-**7**C demonstrate various shapes of the abrasive insert that can be formed. In particular, FIG. **7**A illustrates an abrasive insert **701** contained within a central opening of a superabrasive layer **302**, wherein the abrasive insert **701** comprises an elliptical shape. FIG. **7**B includes an abrasive insert **703** having an irregular shaped abrasive insert **703** containing long arm sections **704** and **705** that are joined by short arm sections **706** and **707**. FIG. **7**B illustrates that various irregular shapes are suitable for use in the abrasive insert. FIG. **7**C includes a polygonal shaped abrasive insert **709**, in particular, an octahedral-shaped abrasive insert **703** contained within a central opening of a superabrasive layer **302** for use in a cutting element.

[0054] The cutting elements described herein can be formed using one or more particular methods. For example, the superabrasive layer of the cutting table and the substrate can be formed using a high pressure/high temperature (HP/HT) process, wherein the substrate material is loaded into a HP/HT cell with the appropriate orientation and amount of diamond crystal material, typically of a size of 100 microns or less. Furthermore, a metal catalyst powder can be added to the HP/HT cell, which can be provided in the substrate or intermixed with the diamond crystal material. The loaded HP/HT cell is then placed in a process chamber, and subject to high temperatures (approximately between 1450-1600° C.) and high pressures (approximately between 50-70 kilobar), wherein the diamond crystals, stimulated by the catalytic effect of the metal catalyst powder, bond to each other and to the substrate material to form a PDC product.

[0055] For certain cutting elements, the PDC product can be further processed to form a thermally stable polycrystalline diamond material (commonly referred to as "TSP") by leaching out the remaining metal catalyst material in the diamond layer. Alternatively, silicon, which possesses a coefficient of thermal expansion similar to that of diamond, may be used to bond diamond particles to produce a Si-bonded TSP. Such TSP materials are capable of enduring higher temperatures (on the order of 1200° C.).

[0056] With regard the to the abrasive insert, in certain processes, the abrasive insert can be formed separately from the superabrasive layer and the substrate. Certain suitable forming methods can include molding, casting, heating, pressing, and a combination thereof to give the abrasive insert the proper shape such that it fits into the cutting table with the superabrasive layer as described in embodiments herein. Notably, for more complex designs of the abrasive insert, such as those having layers or graded compositions of abrasive grit within the matrix material, individual layers or films of the appropriate material may be formed in a molding or casting cell before the final forming process. For example, a series of layers may be formed in a molding cell that includes a first layer having a predetermined amount of abrasive grit, a second layer may be formed on the first layer having a greater content of abrasive grit than the first layer, and a third layer may be formed on the second layer having a greater content of abrasive grit than the second layer, and so on. The layered structure may then be formed in a single process utilizing heat and/or pressure, such as a hot isostatic pressing process to form the abrasive insert.

[0057] After forming the abrasive insert, the insert may be fit into the cutting table, and may be particularly bonded to the superabrasive layer and the substrate. Some machining may take place such that the abrasive insert has the proper dimensions for fitting into the cutting table. Suitable processes for bonding of the abrasive insert may include hot pressing, brazing, and the like.

[0058] In other alternative processes, the abrasive insert can be formed using a high pressure/high temperature (HP/HT) process, such as the one used to form the superabrasive layer and the substrate. In fact, some forming methods may simultaneously form the superabrasive layer, abrasive insert, and the substrate in the same chamber at the same time. Such a process may require a special HP/HT cell capable of accommodating all of the components and effectively forming said components. Notably, such a process may be suitable for designs utilizing complex geometries between the superabrasive layer and the abrasive insert.

[0059] As will be appreciated, after the formation of the cutting element, finishing processes can be undertaken to prepare the surfaces for drilling applications. For example, surfaces of the superabrasive layer may be formed to have chamfers in accordance with the embodiments herein. Moreover, the surfaces of the cutting body may be polished.

[0060] The embodiments herein represent a departure from conventional cutting elements. While changes to cutting elements for use in drill bits have been disclosed, such changes generally are directed to the use of different or new materials, combinations of different materials within the cutting table, and different arrangements of the cutting table with the substrate to improve bonding between the components and reduce the likelihood of certain failure mechanisms. The embodiments herein include a combination of features not previously recognized including the provision of a cutting table including a superabrasive layer with an abrasive insert having unique surface features and employing abrasive grit in a matrix material. Such features facilitate the formation of cutting elements using less precious materials, while maintaining cutting ability and having suitable resistance to thermally-induced and mechanically induced failure mechanisms. The cutting elements herein may be particularly suitable for use in impreg drill bits and PDC drill bits. The cutting elements may be suitable for impreg drill bits designed to drill through soft formations transitioning to harder formations. For instance, in transitioning from soft formations to harder formations, the superabrasive portion of the cutting table may be worn in an initial drilling operation and as the surface wears to expose the abrasive insert, the drill bit may be capable of functioning more like an impregnated drill bit capable of moving through the harder formations. PDC drill bits may utilize such cutting elements as backup cutters, or peripheral cutters proximate to the gauge pads. Notably, such cutting elements may be utilized as rubbing or depth of cut limiting devices, strategically positioned on the drill bit at the cone, nose, or shoulder regions.

[0061] The above-disclosed subject matter is to be considered illustrative, and not restrictive, and the appended claims are intended to cover all such modifications, enhancements, and other embodiments, which fall within the true scope of the present invention. Thus, to the maximum extent allowed by law, the scope of the present invention is to be determined by the broadest permissible interpretation of the following claims and their equivalents, and shall not be restricted or limited by the foregoing detailed description.

[0062] The Abstract of the Disclosure is provided to comply with Patent Law and is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description of the Drawings, various features may be grouped together or described in a single embodiment for the purpose of streamlining the disclosure. This disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter may be directed to less than all features of any of the disclosed embodiments. Thus, the following claims are incorporated into the Detailed Description of the Drawings, with each claim standing on its own as defining separately claimed subject matter.

1. A cutting element for use in a drill bit for drilling subterranean formations comprising:

a substrate comprising a body having an upper surface extending transversely to a longitudinal axis of the body;

a superabrasive layer overlying the upper surface of the substrate, wherein the superabrasive layer comprises an annular shape having a central opening defined by an inner surface; and

an abrasive insert overlying the upper surface of the substrate and disposed within the central opening of the superabrasive layer, wherein the abrasive insert comprises an upper surface having a surface roughness (R_3) of greater than about 1 micron.

2. The cutting element of claim **1**, wherein the surface roughness (R_a) of the upper surface is greater than about 3 microns.

3. The cutting element of claim **1**, wherein the surface roughness (R_a) of the upper surface is within a range between about 1 micron and about 50 microns.

4-8. (canceled)

9. The cutting element of claim **1**, wherein the abrasive insert comprises abrasive grit contained within a matrix material.

10. The cutting element of claim **9**, wherein the abrasive grit comprise encapsulated abrasive grit comprising an encapsulating material substantially surrounding the abrasive grit.

11-15. (canceled)

16. The cutting element of claim **9**, wherein the matrix material comprises a metal.

17-19. (canceled)

20. The cutting element of claim **9**, wherein the abrasive grit comprises a material selected from the group of materials consisting of oxides, borides, nitrides, carbides, carbon, and a combination thereof.

21. The cutting element of claim **9**, wherein the abrasive grit comprises a superabrasive material.

22. (canceled)

23. The cutting element of claim **9**, wherein the abrasive grit comprises an average grit size of at least about 25 microns.

24-25. (canceled)

26. The cutting element of claim **23**, wherein the abrasive grit comprises an average grit size within a range between about 25 microns and about 2 mm.

27-34. (canceled)

35. The cutting element of claim **1**, wherein the central opening has a circular cross-sectional contour as viewed perpendicular to the longitudinal axis.

36. The cutting element of claim **1**, wherein the central opening comprises a polygonal cross-sectional contour as viewed perpendicular to the longitudinal axis.

37. The cutting element of claim **1**, wherein the central opening comprises a side surface that is tapered at an angle relative to the longitudinal axis of the body.

38-40. (canceled)

41. A cutting element for use in a drill bit for drilling subterranean formations comprising:

a cutting table comprising:

a superabrasive layer comprising an annular shape having a central opening defined by an inner surface; and

an abrasive insert overlying the upper surface of the substrate and disposed within the central opening of the superabrasive layer, wherein the abrasive insert comprises abrasive grit contained within a matrix material, wherein an upper region of the abrasive insert comprising an upper surface has a different amount of abrasive grit than a lower region of the abrasive insert.

42. The cutting element of claim **41**, wherein the upper region comprises at least about 10% less amount of abrasive grit than the lower region of the abrasive insert.

43. (canceled)

44. The cutting element of claim **41**, wherein the upper region comprises at least about a 10% greater amount of abrasive grit than the lower region of the abrasive insert.

45-46. (canceled)

47. The cutting element of claim **41**, wherein the abrasive insert comprises a graded amount of abrasive grit throughout the height of the abrasive insert.

48. The cutting element of claim **47** wherein the amount of abrasive grit within the matrix increases from a rear surface to the upper surface.

49-53. (canceled)

54. A cutting element for use in a drill bit for drilling subterranean formations comprising:

a cutting table comprising:

a superabrasive layer comprising an annular shape having a central opening defined by an inner surface; and

an abrasive insert disposed within the central opening of the superabrasive layer, wherein the abrasive insert comprises an upper surface having a texture comprising protrusions and recesses.

55. The cutting element of claim **54**, wherein the abrasive insert comprises abrasive grit contained within a matrix material and the protrusions of the upper surface comprise abrasive grit extending from the upper surface of the matrix material.

56-66. (canceled)

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