

**IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE**

CHIEN-MIN SUNG,

Plaintiff,

v.

KINIK COMPANY,

Defendant.

Civil Action No. 1:20-cv-00247-RGA

JURY TRIAL DEMANDED

**DECLARATION OF ALEX CHAN
IN SUPPORT OF PLAINTIFF'S ANSWERING BRIEF IN OPPOSITION TO
DEFENDANT'S MOTION TO STAY**

I, Alex Chan, declare as follows:

1. I am a senior associate at the Devlin Law Firm LLC. I am currently in good standing and licensed to practice in the State of California and Texas.
2. I am counsel of record for Plaintiff Vantage Micro LLC in this action, and make this Declaration in support of Plaintiff's Answering Brief In Opposition to Defendant's Motion to Stay (D.I. 13). The facts set forth herein are true to my personal knowledge, and if called upon to testify thereto, I could and would competently do so under oath.
3. Attached as Exhibit 1 to this Declaration is a true and correct copy of a detailed redline showing all new subject matter in the specification of U.S. Patent No. 9,724,802 ("802 Patent") that is not disclosed in the specification of U.S. Patent No. 9,138,862 ("862 Patent").
4. Attached as Exhibit 2 to this Declaration is a true and correct copy of a detailed redline showing all new subject matter in Claim 1 of the '802 Patent that is not disclosed in Claim 1 of the '862 Patent.
5. Attached as Exhibit 3 to this Declaration is a true and correct copy of a detailed redline showing all new subject matter in the specification of the '802 Patent that is not disclosed

in the specification of U.S. Patent No. 8,974,270 (“’270 Patent”).

6. Attached as Exhibit 4 to this Declaration is a true and correct copy of a detailed redline showing all new subject matter in Claim 1 of the ’802 Patent that is not disclosed in Claim 1 of the ’270 Patent.

7. Attached as Exhibit 5 to this Declaration is a true and correct copy of U.S. Application No. 13/797,704, which the United States Patent and Trademark Office (“USPTO”) published as U.S. Pub. No. 2014/0120724 (the “’724 Publication”), and cited and considered by the USPTO during the prosecution of the ’802 Patent.

8. Attached as Exhibit 6 to this Declaration is a true and correct copy of a certified English translation of Taiwan Patent No. 101112625 (“Taiwan ’625 Patent”).

9. Attached as Exhibit 7 to this Declaration is a true and correct copy of a detailed redline showing all new subject matter in the specification of the ’802 Patent that is not disclosed in the certified English translation of the specification of Taiwan ’625 Patent.

10. Attached as Exhibit 8 to this Declaration is a true and correct copy of a detailed redline showing all new subject matter in the specification of the ’802 Patent that is not disclosed in the certified English translation of the specification of the ’724 Publication.

11. Attached as Exhibit 9 to this Declaration is a true and correct copy of a corporation statement of information filed by Kinik Corporation with the California Secretary of State on November 14, 2019.

12. Attached as Exhibit 10 to this Declaration is a true and correct copy of Kinik’s Notice of Withdrawal of its Motion to Dismiss and Stipulation to Extend Deadline to Answer Complaint filed by Dr. Sung, which was filed in this Court in *Sung v. Kinik Co.*, Case 1:14-cv-

01027-RGA (D. Del. Aug. 27, 2015). Kinik also agreed to waive service of process in this action. (D.I. 7.)

13. I declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under section 1001 or Title 18 of the United States Code.

By: /s/ Alex Chan
Alex Chan

EXHIBIT 1

Comparison between U.S. Patent No. 9,138,862 and U.S. Patent No. 9,724,802
(New subject matter added to the '802 Patent is shown in blue)

Description:

BACKGROUND OF THE INVENTION

The semiconductor industry currently spends in excess of one billion U.S. dollars each year manufacturing silicon wafers that must exhibit very flat and smooth surfaces. Known techniques to manufacture smooth and even-surfaced silicon wafers are plentiful. The most common of these involves the process known as Chemical Mechanical Polishing (CMP) which includes the use of a polishing pad in combination with an abrasive slurry. Of central importance in a CMP process is the attainment of high performance levels in aspects such as uniformity of polished wafer, smoothness of the IC circuitry, removal rate for productivity, longevity of consumables for CMP economics, etc.

SUMMARY OF THE INVENTION

The present disclosure provides ~~off-on~~CMP pad dressers and associated methods, including without limitation, methods directed to the manufacture and use of conditioning a CMP pad. One such method can include pressing dressers. In one aspect, for example, a CMP pad dresser against can include a support substrate and a plurality of superabrasive particles secured to the support substrate with each superabrasive particle extending away from the support substrate to a protrusion distance. The plurality of superabrasive particles can be positioned such that the highest protruding tip of each of the plurality of superabrasive particles is along a designated profile with a tip variation of from about 5 microns to about 100 microns. In another aspect, the highest protruding tip of each of the plurality of superabrasive particles is along the designated profile with a tip variation of from about 10 microns to about 50 microns. In yet another aspect, the highest protruding tip of each of the plurality of superabrasive particles is along the designated profile with a tip variation of from about 20 microns to about 40 microns. In a further aspect, the highest protruding tip of each of the plurality of superabrasive particles is along the designated profile with a tip variation of less than about 20 microns. The designated profile can include any geometric configuration that can be useful in dressing a CMP pad, where the and any such configuration is considered to be within the present scope. Non-limiting examples can include a plane, a slope, a curved shape, a dome shape, and the like, including appropriate combinations thereof.

The positioning of superabrasive particles relative to the support substrate can also be described in terms of the depths that the superabrasive particles cut into a CMP pad when used to abrade the CMP pad. In one aspect, for example, the protrusions of the plurality of superabrasive particles produce cutting depths of less than about 20 microns when used to abrade a CMP pad. In another aspect, the protrusions of the plurality of superabrasive particles produce cutting depths of from about 1 micron to about 20 microns when used to abrade a CMP pad. In yet another aspect, the protrusions of the plurality of superabrasive particles produce cutting depths of from about 10 microns to about 20 microns when used to abrade a CMP pad.

As another exemplary aspect of the present disclosure, a CMP pad dresser includes a can include a rigid support substrate and a monolayer of a plurality of superabrasive particles protruding from a matrix layer. The coupled to the support substrate, where each superabrasive particle in the monolayer extends from the support substrate to a protrusion distance. In one aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 4050 microns, and the difference in protrusion distance between the highest 401% of the protruding tips of the monolayer of superabrasive particles are within about 20 microns or less. The method can further include with about 80 microns or less. In another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In a further aspect, the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns.

As yet another exemplary aspect of the present disclosure, a CMP pad dresser can include a rigid support substrate and a monolayer of a plurality of superabrasive particles coupled to the support substrate, where the plurality of superabrasive particles includes a plurality of working superabrasive particles, such that rotating the dresser against the a CMP pad such that cuts asperities are cut into the CMP pad having a maximum cutting depth of less than or equal to about 6050 microns. In another aspect, the cutting depth is from about 10 microns to about 50 microns. In yet another aspect, the plurality of working superabrasive particles includes at least 100 tips of the plurality of working superabrasive particles cut asperities into the CMP pad as the dresser is rotated. In another further aspect, the plurality of working superabrasive particles includes at least 50 tips of the plurality of superabrasive particles 1000 working superabrasive particles. In yet another aspect, the plurality of working superabrasive particles includes from about 1000 to about 6000 working superabrasive particles. In another aspect, the plurality of working superabrasive particles includes from about 2000 to about 5000 working superabrasive particles. In a further aspect, the plurality of working superabrasive particles include at least about 1000 working superabrasive particles that protrude from the rigid support substrate to distances within about 30 microns of one another.

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As another exemplary aspect of the present disclosure, a method of dressing a CMP pad can include applying a CMP pad dresser to a CMP pad, and moving at least one of the CMP pad or the CMP pad dresser with respect to one another to cut asperities into the CMP pad as the dresser is rotated. In a further aspect, at least 25 tips of the plurality of superabrasive particles cut asperities into the CMP pad as the dresser is rotated having a cutting depth of from about 10 microns to about 50 microns.

Furthermore, in one aspect substantially all of the asperities are cut in the CMP pad by superabrasive particles located at a peripheral location of the dresser. In one specific aspect, the peripheral location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 90% of the dresser radius. In another specific aspect, the peripheral location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 50% of the dresser radius. In yet another specific aspect, the peripheral location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 33% of the dresser radius. Additionally, in some aspects substantially all of the superabrasive particles are located at a peripheral location of the dresser. In another aspect, substantially all of the superabrasive particles are arranged in a uniform predetermined pattern at a peripheral location of the dresser.

The method can further include interactions between the CMP pad and a workpiece being polished. For example, in one aspect the method can include rotating the CMP pad, applying a slurry to a polishing surface of the rotating CMP pad, and applying a workpiece to the polishing surface such that the workpiece is polished by the asperities in combination with the slurry. In one aspect, the workpiece is a semiconductor device. In another aspect, the semiconductor device includes one or more layers of Cu, W, an oxide layer, or a combination thereof. In yet another aspect, the semiconductor device can have a node size of less than or equal to 28 nm. In a further aspect, the semiconductor device can have a new width of less than or equal to about 30 nm. In yet a further aspect, the semiconductor device can have a wafer having a size greater than 400 mm. Furthermore, in some aspects the slurry can include an abrasive such as silica, alumina, ceria, and combinations thereof. In other aspects, the slurry can include an oxidant compound.

As a further exemplary aspect of the present disclosure, a CMP pad dresser is provided including a support substrate and a plurality of superabrasive particles secured to the support substrate and positioned to engage and dress a CMP pad, where the plurality of superabrasive particles cut to depths of less than 50 microns into a CMP pad during a dressing procedure.

There has thus been outlined, rather broadly, various features of the invention so that the detailed description thereof that follows may be better understood, and so that the present contribution to the art may be better appreciated. Other features of the present invention will become clearer from the following detailed description of the invention, taken with the accompanying claims, or may be learned by the practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention; ~~FIG. 1 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention;~~

FIG. 2 is a ~~flow chart diagram showing steps~~ schematic side view of a ~~method of dressing a~~ CMP pad dresser in accordance with an embodiment of the present invention; ~~FIG. 2 is a flow chart diagram showing steps of a method of dressing a CMP pad in accordance with an embodiment of the present invention;~~

FIG. 3 is a ~~flow chart diagram showing steps of a method of polishing a workpiece~~ schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention; ~~FIG. 3 is a flow chart diagram showing steps of a method of polishing a workpiece in accordance with an embodiment of the present invention;~~

FIG. 4 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention; ~~FIG. 4 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention;~~

~~FIG. 5 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention;~~

~~FIG. 6 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention; and~~

~~FIG. 7 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention.~~

It will be understood that the above figures are merely for illustrative purposes in furthering an understanding of the invention. Further, the figures are not drawn to scale, thus dimensions, proportions, and other aspects may, and generally are, exaggerated to make illustrations thereof clearer. Therefore, departure can be made from the specific dimensions and aspects shown in the figures in order to produce the heat spreaders of the present invention.

DETAILED DESCRIPTION

Before the present invention is described and described, it is to be understood that this invention is not limited to the particular structures, method steps, or materials described here, but is extended to equivalents thereof as would be

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recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular embodiments only and is not intended to be limiting.

It must be noted that, as used in this specification and the appended claims, the singular forms "a," "an" and, "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a diamond part" includes one or more of such parts and reference to "the layer" includes reference to one or more of such layers.

DEFINITIONS

In describing and claiming the present invention, the following terminology will be used in accordance with the definitions set forth below.

As used herein, the terms "conditioner" and "dresser" can be used interchangeably, and refer to a tool used to condition or dress a pad, such as a CMP pad.

~~As used herein, "dressing segment" refers to a dressing or conditioning element of a CMP pad dresser. Dressing segments are utilized in the present invention to carry superabrasive particles having exposed tips. Thus superabrasive particles are introduced into a CMP pad dresser by the incorporation of multiple dressing segments. It should be noted that a variety of techniques of attaching the dressing segments to the substrates, and a variety of techniques of attaching the superabrasive particles to the dressing segments, are discussed herein. It is to be understood that a of these various attachment mechanisms can be used interchangeably herein: that is, a method of attaching a dressing segment to a substrate is discussed herein, the method of attachment discussed can also be used to attach a superabrasive particles to a dressing segment. For any part of a CMP pad dresser being discussed, however, it is understood that attachment methods of the superabrasive particles to the dressing segments can differ from, or can be the same as, the method used to attach the dressing segments to the pad conditioner substrate.~~

As used herein, "superabrasive" may be used to refer to any crystalline, or polycrystalline material, or mixture of such materials ~~which has~~ that has a Mohr's hardness of about 8 or greater. In some aspects, the Mohr's hardness may be about 9.5 or greater. ~~Such materials include but are not limited to~~ In other aspects, superabrasive materials can be materials having a Vickers hardness of about 4000 Kg/mm² or greater. Suitable superabrasive materials examples can include, without limitation, diamond, polycrystalline diamond (PCD), cubic boron nitride (cBN), polycrystalline cubic boron nitride (PcBN), corundum and sapphire, as well as other superabrasive materials known to those skilled in the art. Superabrasive materials may be incorporated into ~~the present invention~~ on various tools in a variety of forms including particles, grits, films, layers, pieces, segments, etc. ~~In some cases, the~~ Where superabrasive materials ~~of the present invention are~~ in the very next and thus difficult to form of polycrystalline chemical bonds with, it is known that certain reactive elements, such as chromium and titanium are capable of chemically reacting with superabrasive materials, ~~such as PCD and PcBN materials at certain temperatures.~~

~~As used herein, "organic material" refers to a semiconductor or solid complex or mix of organic compounds. "Organic material layer" and "organic matrix" may be used interchangeably, and refer to a layer or mass of a compound or solid complex or mix of organic compounds, including resins, polymers, gums, etc. The organic material can be a polymer or copolymer formed from the polymerization of one or more monomers. In some cases, such organic material can be adhesive.~~

~~As used herein, the process of " brazing" is intended to refer to the creation of chemical bonds between the carbon atoms of the superabrasive particles/materials and the braze material. Further, "chemical bond" means a covalent bond, such as a carbide or boride bond, rather than mechanical or weaker interatomic attractive forces. Thus, when " brazing" is used in connection with superabrasive particles a true chemical bond is being formed. However, when " brazing" is used in connection with metal to metal bonding the term is used in the more traditional sense of a metallurgical bond. Therefore, brazing of a superabrasive segment to a tool body does not necessarily require the presence of a carbide former.~~

As used herein, "part" ~~as~~ refers, when used ~~herein~~ in connection with ~~diamonds~~ superabrasive particles, ~~and refers~~ to a particulate form of ~~diamonds~~ superabrasive particles. Such particles may take a variety of shapes, including round, oblong, square, euhedra, etc., can be either single crystal or polycrystalline, and can have a number of mesh sizes. As is known in the art, "mesh" refers to the number of holes per unit area, as in the case of U.S. meshes. A mesh size referred to herein are U.S. mesh unless otherwise indicated. Further, mesh sizes are generally understood to indicate an average mesh size of a given collection of particles since each particle with a particular "mesh size" may actually vary over a small distribution of sizes, unless noted otherwise.

~~As used herein, "sharp portion" means any narrow portion to which a crystal or particle may come, including but not limited to corners, apexes, ridges, edges, obelisks, and other protrusions. In some cases, corners and/or apexes are formed at the convergence of more than two faces of the particle or crystal, or other body, disposed in intersecting planes. In other aspects, edges and/or ridges may be formed at the convergence of two or at least two faces of the particle or crystal, or other body, disposed in intersecting planes. In some aspects, "sharp portion" can include a~~

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~~port on that is broken, chipped, cracked, jagged, and the like. In some aspects, degrees of sharpness can be correlated with the geometric angle formed by the part, crystal, or other body, at the location in question. In some aspects, an angle of 90 degrees or less can be considered sharp. In other aspects, an angle of 60 degrees or less can be considered sharp. In yet other aspects, an angle of 45 degrees or less, or 30 degrees or less can be considered to be sharp.~~

~~As used herein, "periphery located," "periphery location" and the like, mean any part of a dresser that is located in an area that originates at the leading edge or outer rim of a dresser and extends inwardly towards the center for up to about 90% of the radius of the dresser. In some aspects, the area may extend inwardly from about 20% to 90% of the radius. In other aspects, the area may extend in to about 50% of the radius. In yet another aspect, the area may extend in to about 33% of the radius of a dresser (i.e. 66% away from the center).~~

As used herein, "working superabrasive particles" are superabrasive particles that touchcut or otherwise deform a CMP pad during a dressing or conditioning procedure. These touchngact on can remove debris from the surface, it can deform the surface either aesthetically or practically, or it can cut the surface to create a groove or asperity in the surface of the CMP pad. In one specific aspect, a working superabrasive particle can cut deeper than about 10 microns into a CMP pad during a dressing procedure.

As used herein, "non-working superabrasive particles" are superabrasive particles in a CMP pad dresser that do not significantly touchcut or deform the pad sufficient to remove debris from the surface, deform the surface, cut or create grooves in the surface to create a groove.

As used herein, "overly-aggressive superabrasive particles" are superabrasive particles in a CMP pad dresser that aggressively dress or condition a CMP pad. In one aspect, aggressive superabrasive particles are superabrasive particles that cut deeper than about 50 microns into a CMP pad during a dressing procedure. In another aspect, aggressive superabrasive particles are superabrasive particles that remove at least 1/5 of the material from the CMP pad. In yet another aspect, aggressive superabrasive particles are superabrasive particles that remove at least 1/2 of the material from the CMP pad.

~~As used herein, "indicator substrate" refers to a substrate material upon which a portion of the superabrasive particles of a CMP pad dresser can be positioned and moved to make markings indicative of working superabrasive particles.~~

~~As used herein, "marking pattern" refers to a pattern on an indicator substrate created by moving superabrasive particles thereacross. The markings can be any detectable marking known, including cuts, scratches, depressions, material deposition (e.g. pigment markers, chemical markers, fluorescent markers, radioactive markers, etc.).~~

~~As used herein, "transverse" refers to a directional orientation that is cross-wise to a reference axis. In one aspect, "transverse" can include a directional orientation that is at least at a substantial right angle to the reference axis.~~

~~As used herein, "alignment orientation direction" refers to the direction of an alignment axis of the purity of superabrasive particles. For example, a purity of superabrasive particles aligned in a grid formation would have at least two alignment axes; an alignment axis in the column direction and an alignment axis in the row direction or oriented 90° to the column direction.~~

~~As used herein, "ablate" or "abating" refer to a process of removing a superabrasive particle from a CMP pad dresser or reducing the projection of a superabrasive particle thus reducing the degree of contact between the superabrasive particle and the indicator substrate.~~

~~As used herein, "superabrasive segment" refers to a too-body having multiple superabrasive particles associated therewith. In some aspect, a superabrasive segment can include superabrasive polycrystalline materials as cutting elements.~~

~~As used herein, a "too-substrate" refers a portion of a pad conditioner that supports abrasive materials, and to which abrasive materials and/or superabrasive segments that carry abrasive materials may be affixed. Substrates useful in the present invention may of a variety of shapes, thicknesses, or materials that are capable of supporting abrasive materials in a manner that is sufficient to provide a pad conditioner useful for its intended purpose. Substrates may be of a solid material, a powdered material that becomes solid when processed, or a flexible material. Examples of typical substrate materials include without limitation, metal, metal alloys, ceramic, relatively hard polymers or other organic materials, glasses, and mixtures thereof. Further, the substrate may include a material that adheres attaching abrasive materials to the substrate, including without limitation, brazing alloy material, cementing a deposit and the like.~~

As used herein, "working end" refers to an end of a particle which that is oriented towards the CMP pad and that during a dressing operation makes contact with the pad. Most often in many cases the working end of a particle will be distal from a substrate to which the particle is attached.

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As used here n, cutt ng "t p" refers to a port on of a cutt ng e ement or part c e that protrudes the greatest d stance from the support substrate, e.g., that s the frst port on of the cutt ng e ement that contacts a CMP pad when n use. It s to be understood that a cutt ng "t p" can ncude a p anar surface, a po nted surface, or an edge; so ong as the p anar surface, po nted surface or edge of the cutt ng e ement s the frst port on of the cutt ng e ement that contacts a CMP pad from wh ch mater a s to be removed.

As used here n, "sharp port on" refers to any narrow port on to wh ch a crista or part c e may converge, ncud ng but not m ted to corners, apexes, r dges, edges, obe sks, and other protrus ons. In some cases corners and/or apexes are formed at the convergence of more than two faces of the part c e or crista or other body d posed n ntersect ng p anes. In other aspects, edges and/or r dges may be formed at the convergence of two or at east two faces of the part c e or crista or other body d posed n ntersect ng p anes. In some aspects "sharp port on" can ncude a port on that s broken, chpped, cracked, agged, and the ke. In some aspects, degrees of sharpness can be corre ated w th the geometr c ang e formed by the part c e, crista, or other body, at the ocat on n quest on. In some aspects, an ang e of 90 degrees or ess can be cons dered sharp. In other aspects, an ang e of 60 degrees or ess can be cons dered sharp. In yet other aspects, and ang e of 45 degrees or ess, or 30 degrees or ess can be cons dered to be sharp.

As used here n, cutt ng "edge" refers to a port on of a cutt ng e ement or part c e that ncudes some measurab e w dth across a port on that contacts and removes mater a from a workp ece. As an exemp ary ustrat on, a typ ca kn fe b ade has a cutt ng edge that extends ong tud na y a ong the kn fe b ade, and the kn fe b ade wou d have to be or ented transverse y to a workp ece to scrape or p ane mater a from the workp ece n order for the cutt ng "edge" of the kn fe b ade to remove mater a from the workp ece.

As used here n, "per phera y ocat ed," "per phera ocat on," and the ke, refer to any part c e or other cutt ng e ement of a dresser that s ocat ed n an area that or g nates at the ead ng edge or o ter r m of a dresser and extends nward y towards the center for up to about 90% of the rad us of the dresser. In some aspects, the area may extend nward y from abo t 20% to 90% of the rad s. In other aspects, the area may extend n to abo t 50% of the rad s. In yet another aspect, the area may extend n to abo t 33% of the rad s of a dresser (e 66% away from the center).

As used here n, "centra y ocat ed part c e," "part c e n a centra ocat on," and the ke refer to any part c e or other cutt ng e ement of a too that s ocat ed n an area of the too that or g nates at a center po nt of the too and extends outward y towards the too 's edge for up to about 90% of the rad us of the too. In some aspects, the area may extend outward y from about 20% to about 90% of the rad us. In other aspects, the area may extend out to about 50% of the rad us. In yet another aspect, the area may extend out to about 33% of the rad us of a too.

As used here n, "att tude" means refers to the pos t on or arrangement of a superabras ve part c e n re at on to a def ned surface, such as a substrate to wh ch t s attached, or a CMP pad to wh ch t s to be app ed dur ng a work operat on. For examp e, a superabras ve part c e can have an att tude that prov des a spec f c port on of the part c e n or entat on toward a CMP pad.

As used here n, "ead ng edge" refers to the edge of a CMP pad dresser that s a fronta edge based on the d rect on that the CMP pad s mov ng, or the d rect on that the pad s mov ng, or both. Notab y, n some aspects, the ead ng edge may be cons dered to encompass not on y the area spec f ca y at the edge of a dresser, but may a so ncude port ons of the dresser wh ch extend s ght y nward from the actua edge. In one aspect, the ead ng edge may be ocat ed a ong an outer edge of the CMP pad dresser. In another aspect, the CMP pad dresser may be conf gured w th a pattern of abras ve part c es that prov des at east one effect ve ead ng edge on a centra or nner port on of the CMP pad dresser work ng surface. In other words, a centra or nner port on of the dresser may be conf gured to prov de a funct ona effect s m ar to that of a ead ng edge on the outer edge of the dresser.

As used here n, the term "prof e" and "geometr c prof e" can be used nterchangeab y, and refer to a predeterm ned contour above a support substrate to wh ch a p ura ty of superabras ve part c es or other cutt ng e ements are ntended to a gn. Examp es of such prof es may ncude, w thout m tat on, f at or p anar prof es, curved prof es, wavy prof es, convex prof es, concave prof es, mu t-tered prof es, and the ke, ncud ng comb nat ons thereof.

As used here n, "geometr c conf gurat on" refers to a shape that s capab e of be ng descr bed n read y understood and recogn zed mathemat ca terms. Examp es of shapes qua fy ng as "geometr c conf gurat ons" ncude, w thout m tat on, cub c shapes, po yhedra (ncud ng regu ar po yhedra) shapes, tr angu ar shapes (ncud ng equ atera tr ang es, sosce es tr ang es and three-d mens ona tr angu ar shapes), pyram da shapes, spheres, rectang es, "p e" shapes, wedge shapes, octagona shapes, c rc es, etc.

As used here n, "dress ng segment" refers to a dress ng or cond t on ng e ement of a CMP pad dresser. In one aspect, dress ng segments are ut zed to carry superabras ve part c es hav ng eve ed t ps. Thus, n some cases superabras ve part c es can be ntroduced nto a CMP pad dresser by the ncorporat on of mu t p e dress ng segments. It shou d be noted that a var ety of techn ques of attach ng the dress ng segments to the substrates, and a var ety of techn ques of attach ng the superabras ve part c es to the dress ng segments, are poss b e, a of wh ch are

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considered to be within the present scope. It is to be understood that a of these various attachment mechanisms can be used interchangeably herein: that is, for a method of attaching a dressing segment to a substrate disclosed herein, the method of attachment disclosed can also be used to attach superabrasive particles to a dressing segment. For any particular CMP pad dresser being disclosed, however, it is understood that attachment methods of the superabrasive particles to the dressing segments can differ from, or can be the same as, the method used to attach the dressing segments to the pad conditioner substrate.

As used herein, "cutting element" describes a variety of structures capable of removing (e.g., cutting) material from a CMP pad. A cutting element can be a mass having several cutting points, ridges or mesas formed thereon or thereon. It is notable that such cutting points, ridges or mesas may be from a multiplicity of protrusions or asperities included in the mass. Furthermore, a cutting element can also refer to a individual part that may have only one cutting point, ridge or mesa formed thereon or thereon.

As used herein, "organic material" refers to a semiconductor or solid complex or mix of organic compounds. "Organic material layer" and "organic matrix" may be used interchangeably, and refer to a layer or mass of a semiconductor or solid complex or mix of organic compounds including resins, polymers, gums, etc. The organic material can be a polymer or copolymer formed from the polymerization of one or more monomers. In some cases, such organic material can be adhesive.

As used herein, the process of "brazing" is intended to refer to the creation of chemical bonds between the carbon atoms of the superabrasive particles/materials and the braze material. Further, "chemical bond" means a covalent bond, such as a carbide or boride bond, rather than mechanical or weaker inter-atom attractive forces. Thus, when "brazing" is used to connect with superabrasive particles, a true chemical bond is being formed. However, when "brazing" is used to connect with metal to metal bonding, the term is used in the more traditional sense of a metalurgical bond. Therefore, brazing of a superabrasive segment to a tool body does not necessarily require the presence of a carbide former.

As used herein, "mechanical bond" and "mechanical bonding" may be used interchangeably, and refer to a bond interface between two objects or layers formed primarily by frictional forces. In some cases the frictional forces between the bonded objects may be increased by expanding the contacting surface areas between the objects, and by imposing other specific geometrical and physical configurations, such as substantially surrounding one object with another.

As used herein, "sintering" refers to the joining of two or more individual parts to form a continuous solid mass. The process of sintering involves the consolidation of particles to at least partially eliminate voids between particles. Sintering may occur in either metal or carbonaceous particles, such as diamond. Sintering of metal particles occurs at various temperatures depending on the composition of the material. Sintering of diamond particles generally requires ultrahigh pressures and the presence of a carbon solvent as a diamond sintering aid. Sintering aids are often present to aid in the sintering process and a portion of such may remain in the final product.

The term "metal" refers to both metals and metalloids. Metals include those compounds typically considered metals found within the transition metals, alkali and alkali earth metals. Examples of metals are Ag, Au, Cu, Al, and Fe. Metalloids include specifically Si, B, Ge, Sb, As, and Te. Metal materials also include alloys or mixtures that include metal materials. Such alloys or mixtures may further include additional additives. In the present invention, carbide formers and carbon wetting agents may be included as alloys or mixtures, but are not anticipated to be the only metal component. Examples of such carbide formers are Sc, Y, Ti, Zr, Hf, V, Nb, Cr, Mo, Mn, Ta, W, and Ta. Examples of carbon wetting agents are Co, Ni, Mn, and Cr.

As used herein, "infiltration" refers to a situation where a material is heated to its melting point and then flows as a liquid through the interstitial voids between particles.

As used herein, the terms "substrate" and "support substrate" can be used interchangeably, and refer to a portion of a pad conditioner that supports superabrasive material, and to which abrasive material and/or superabrasive segments that carry abrasive material may be affixed. Substrates can have a variety of shapes, thicknesses, and/or materials that are capable of supporting abrasive material in a manner that is sufficient to provide a CMP pad dresser useful for its intended purpose. Substrates may be of a solid material, a powdered material that becomes solid when processed, or a flexible material. Examples of typical substrate materials include without limitation metal alloys, ceramics, resins, hard polymers or other organic materials, glasses, and mixtures thereof. Further, the substrate may include a material that aids in attaching abrasive material to the substrate, including without limitation brazing alloy material, sintering aids and the like.

As used herein, the term "substantially" refers to the complete or nearly complete extent or degree of an action, characteristic, property, state, structure, item, or result. For example, an object that is "substantially" enclosed would mean that the object is either completely enclosed or nearly completely enclosed. The exact allowable degree of deviation from absolute completeness may in some cases depend on the specific context. However, generally

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speaking the nearness of composition will be so as to have the same overall result as if absolute and total composition were obtained.

The use of "substantially" is equally applicable when used in a negative connotation to refer to the complete or near complete lack of an action, characteristic, property, state, structure, item, or result. For example, a composition that is "substantially free of" parts would either completely lack parts, or so nearly completely lack parts that the effect would be the same as if it completely lacked parts. In other words, a composition that is "substantially free of" an ingredient or element may still actually contain such item as long as there is no measurable effect thereof.

As used herein, the term "about" is used to provide flexibility to a numerical range endpoint by providing that a given value may be "at least above" or "at least below" the endpoint. However, it is to be understood that even when the term "about" is used in the present specification in connection with a specific numerical value, that support for the exact numerical value recited apart from the "about" term is so provided.

In this disclosure, "comprises," "comprising," "containing" and "having" and the like can have the meaning ascribed to them in U.S. Patent law and can mean "includes," "including," and the like, and are generally interpreted to be open ended terms. The terms "consisting of" or "consists of" are closed terms, and include only the components, structures, steps, or the like specified in connection with such terms, as well as that which is in accordance with U.S. Patent law. "Consisting essentially of" or "consists essentially of" have the meaning generally ascribed to them by U.S. Patent law. In particular, such terms are generally closed terms, with the exception of a allowing inclusion of additional items, materials, components, steps, or elements, that do not materially affect the basic and novel characteristics or function of the item(s) used in connection therewith. For example, trace elements present in a composition, but not affecting the composition's nature or characteristics would be permissible present under the "consisting essentially of" language, even though not expressly recited in a list of items for which such term is used. When using an open ended term, like "comprising" or "including," it is understood that direct support should be afforded as to "consisting essentially of" language as well as "consisting of" language as if stated explicitly and vice versa.

As used herein, a plurality of items, structural elements, compositions, and/or materials may be presented in a common list for convenience. However, these items should be construed as though each member of the list is individually defined as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on the representation in a common group without indications to the contrary.

Concentrations, amounts, and other numerical data may be expressed or presented herein in a range format. It is to be understood that such a range format is used merely for convenience and brevity and thus should be interpreted flexibly to include not only the numerical values explicitly recited as the limits of the range, but also to include all the individual numerical values or sub-ranges encompassed within that range as if each numerical value and sub-range is explicitly recited. As an illustration, a numerical range of "about 1 to about 5" should be interpreted to include not only the explicitly recited values of about 1 to about 5, but also to include individual values and sub-ranges within the indicated range. Thus, included in this numerical range are individual values such as 2, 3, and 4 and sub-ranges such as from 1-3, from 2-4, and from 3-5, etc., as well as 1, 2, 3, 4, and 5, individually. The same principle applies to ranges reciting only one numerical value as a minimum or a maximum. Furthermore, such an interpretation should apply regardless of the breadth of the range or the characteristics being described.

The Invention

The present disclosure generally provides CMP pad dressers, methods associated with pad conditioning (e.g., smoothing, polishing, dressing), and the CMP polishing of a workpiece. Pad conditioners according to aspects of the present ~~invention and disclosure~~ can be advantageously utilized, for example, in dressing CMP pads that are used in polishing, finishing or otherwise affecting semiconductor materials. Specifically, in some aspects the present disclosure concerns CMP pad dressers having superabrasive particles with substantialy evened tips. In other aspects, the present CMP pad dressers can have superabrasive particles that are agitated across a designated profile, and as such, are "evened" with respect to that profile. Traditional CMP pad dresser manufacturing methods, even many of those describing techniques for evening superabrasive particle tips prior to fixation, generally contain significant variation in tip height across the surface of the dresser that is not accounted for by an intended tip agnment profile. Often, the superabrasive particles are affixed to the CMP pad dresser support in a manner that disrupts any evening that has occurred. For example, fixation techniques that utilize high heat and/or pressure can cause warping of the dresser support as the dresser cools. Thus, unnecessary steps are taken to avoid such warpage, superabrasive particles are not maintained in the evened state following cooling of the dresser. This can be particularly problematic with brazing techniques.

A CMP pad dresser can be used to dress or condition a CMP pad by removing dirt and debris (i.e. degazing the pad), as well as opening up asperities on the pad surface to capture and hold chemicals during a polishing

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procedure. As has been described, due to different features associated with superabrasive particles engaging in many traditional manufacturing processes, only a small percentage of superabrasive particles in a typical CMP pad dresser are positioned so as to penetrate or cut into a CMP pad. As this small percentage of superabrasive particles become worn, past deformation of the CMP pad becomes large relative to the amount of CMP of pad that is cut. Consequently, the pad becomes highly deformed and accumulated with dirt. As a result the polishing rate of the CMP pad decreases, and the scratch rate of the wafer or work piece increases.

CMP pads are typically made of a relatively soft polymer, such as, [for example](#), polyurethane. As the CMP pad is engaged by the CMP pad dresser, the polymer material is deformed first by elastic strain and then by plastic strain. Eventually, the strain energy in the deformed material exceeds the bond energy density (i.e. the hardness of the pad) and the polymer material ruptures. Thus, the function of superabrasive particles in the CMP pad dresser is to dress the CMP pad material by breaking polymer bonds through this deformation process. It should be noted that sharp superabrasive particles can penetrate the CMP pad material without causing excessive deformation. As such, the sharpness of a superabrasive particle can be defined as being inverse to the deformed volume prior to rupture. In other words, the smaller the volume of deformation prior to cutting, the sharper the cutting tip. This deformation information can be used to determine the sharpness of superabrasive particles in the CMP pad dresser.

Additionally, a superabrasive particle having a tip with smaller tip radius, such as would be the case with a broken corner, can cut more cleanly through the CMP pad with less deformation as compared to a superabrasive particle having a larger tip radius. Consequently, an irregularly shaped superabrasive particle can be sharper than a euhedra superabrasive corner having an obtuse angle relative to the CMP pad. This also applies to the difference between a superabrasive particle corner as compared with a superabrasive particle face.

It is thus noted that sharp superabrasive particles can cut CMP pad material with less deformation and material strain. Conversely, a dull superabrasive particle may deform but not cut the CMP pad material because the strain energy does not exceed the bond energy density of the polymer material. As the tips of such particles are worn, the contact area between the polymer material and the particles increase. This increase in contact area results in an increase in the deformation volume of the pad. Due to the increased strain energy required for the polymer material to rupture with such an increased deformation volume, the number of superabrasive particles cutting the polymer material will decrease in relation to the degree of dulling during a CMP process.

CMP pad dressing can also be affected by the proportion of superabrasive particles in the CMP pad dresser that are working and the proportion that are overly-aggressive cutting. As an example, a typical CMP pad dresser can have greater than 10,000 superabrasive particles. Of these 10,000 particles, in some cases there may only be a few working superabrasive particles that are actually able to cut the CMP pad. Additionally, out of these few working superabrasive particles, there may be a smaller proportion of overly-aggressive superabrasive particles that cut over 50% of the entire pad that is consumed during conditioning, and in some cases can remove more than 25% of the total pad material. This uneven workload distribution can cause erratic CMP performance, and can result in over consumption of the CMP pad, chipping of the overly-aggressive superabrasive particles that can scratch the wafer, unpredictable wafer removal rates, uneven wafer surface planarization, shortened CMP pad dresser life, compaction of the CMP pad with debris, and the like. Such effects can greatly lower the yield of wafers or work pieces processed under these conditions. [A more effective normalization of workload distribution across the surface of the CMP pad dresser can lead to a more uniformly degazed pad and more uniform pad asperities.](#)

~~The present disclosure seeks to more effectively normalize the workload distribution across the surface of the CMP pad dresser in order to more uniformly degaze the pad and create more uniform pad asperities.~~ The present CMP pad dressers include a layer of superabrasive particles having substantial evenly distributed particles across the working surface of the finished CMP pad dresser. A variety of techniques can be utilized to maintain tip evenness, and any such technique is considered to be within the present scope. A few non-limiting examples of such techniques are described below. [It is intended that the term "evening" with respect to superabrasive particles can refer to superabrasive particles that are evenly distributed with respect to a planar profile, as well as to superabrasive particles that are a given angularly designated profile that is non-planar. In the latter case, "evening" would thus describe the alignment of the superabrasive particles along the designated profile. So in the case of a profile having a dome-shape, evenly distributed superabrasive particles would be particles that were in alignment with the profile.](#)

[In one aspect, as is shown in FIG. 1, a CMP pad dresser 100 includes a monolayer of a plurality of superabrasive particles 102 embedded in a matrix layer 104 such that each superabrasive particle in the monolayer protrudes from the matrix layer 104. Furthermore, superabrasive tip alignment can additionally be described in terms of height distribution, or in some cases protrusion distance from the support substrate that is represented by a height distribution across the plurality of superabrasive particles. An even height distribution of superabrasive particles may function to more effectively preserve the integrity of the CMP pad dresser as compared to CMP pad dressers lacking such an even height distribution. Similarly, a plurality of superabrasive particles can be described as extending away from a support substrate to a predetermined height, represented by a protrusion distance from the substrate, where the predetermined heights of the particles align along a designated profile. Thus, the actual distribution of protrusion](#)

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d stances across the p u r a t y of superabras ve part c es n a f n shed dresser can be compared aga nst the des gnated prof e to determ ne the var ance, or degree of " eve ng" ach eved.

In one aspect, for examp e, a CMP pad dresser s prov ded nc ud ng a support substrate and a p u r a t y of superabras ve part c es secured to the support substrate, w th each superabras ve part c e extend ng away from the support substrate to a protrus on d stance, where the h ghest protrud ng t p of each of the p u r a t y of superabras ve part c es a gn a ong a des gnated prof e. Wh e t s ntended that the t ps of the superabras ve part c es a gn a ong the des gnated prof e, some eve of dev at on may occur. These dev at ons may be a resu t of the des gn or manufactur ng process of the too . G ven the w de var ety of s zes of superabras ve part c es that may potent a y be ut zed n a g ven too , such dev at ons may be h gh y dependent on a part cu ar app cat on. A so, when referr ng to the des gnated prof e, t shou d be noted that the term "t p" s ntended to nc ude the h ghest protrud ng po nt of a superabras ve part c e, whether that po nt be an apex, an edge, or a face.

As such, n one aspect the p u r a t y of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 1 m cron to about 150 m crons. In another aspect, the p u r a t y of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 5 m crons to about 100 m crons. In yet another aspect, the p u r a t y of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 10 m crons to about 75 m crons. In a further aspect, the p u r a t y of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 10 m crons to about 50 m crons. In another aspect, the p u r a t y of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 50 m crons to about 150 m crons. In yet another aspect, the p u r a t y of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 20 m crons to about 100 m crons. In a further aspect, the p u r a t y of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 20 m crons to about 50 m crons. In another aspect, the p u r a t y of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 20 m crons to about 40 m crons. Add t ona y, n one aspect, the p u r a t y of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by ess than about 20 m crons. In another aspect the p u r a t y of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by ess than about 10 m crons. In yet another aspect, the p u r a t y of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by ess than about 5 m crons. In yet another aspect, the p u r a t y of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by ess than about 1 m cron. In a further aspect, a ma or ty of the p u r a t y of superabras ve part c es are arranges such that the r t ps vary from the des gnated prof e to ess than about 10% of the average s ze of the superabras ve part c es.

In another aspect, each of the p u r a t y of superabras ve part c es can be def ned by a protrus on d stance from an exposed surface of a b nd ng mater a from wh ch they protrude to a predeterm ned he ght. Though the predeterm ned he ght may vary between too app cat ons, n one aspect the predeterm ned he ght may be greater than about 20 m crons. In another aspect the var at on from the predeterm ned he ght may be from about 1 m cron to about 20 m crons. In yet another aspect the var at on from the predeterm ned he ght may be from about 5 m crons to about 20 m crons. In a further aspect the var at on from the predeterm ned he ght may be from about 10 m crons to about 20 m crons. Superabras ve part c es may a so be arranged w th respect to arrangement or d str but on, att tude, s ze, etc. Furthermore, the d str but on of protrus on of the p u r a t y of superabras ve part c es s refected n the depth that the part c es cut nto a CMP pad.

As such, n one spec f c aspect the predeterm ned he ght or protrus on d stance may produce a cutt ng depth of ess than about 20 m crons when used to dress a CMP pad. In another spec f c aspect, the predeterm ned he ght or protrus on d stance may produce a cutt ng depth of from about 1 m cron to about 20 m crons when used to dress a CMP pad. In yet another spec f c aspect, the predeterm ned he ght or protrus on d stance may produce a cutt ng depth of from about 10 m cron to about 20 m crons when used to dress a CMP pad. It shou d a so be noted that the eve ng of superabras ve part c es to a predeterm ned he ght may be dependent on superabras ve part c e spac ng. In other words, the farther superabras ve part c es are separated, the more the mp ng ng forces w affect each superabras ve part c e. As such, patterns w th ncreased spac ng between the superabras ve part c es may benef t from a sma er var at on from predeterm ned he ght.

In one spec f c examp e, a p u r a t y of cutt ng e ments such as superabras ve part c es can protrude to a predeterm ned he ght above a b nd ng mater a such as, for examp e, a so d f ed organ c mater a ayer. Though any predeterm ned he ght that wou d be usefu n an abrad ng or cutt ng too wou d be cons dered to be w th n the present y c a med scope, n one spec f c aspect the predeterm ned he ght may produce a cutt ng depth of ess than about 20 m crons when used to abrade a workp ece. In another spec f c aspect, the predeterm ned he ght may produce a cutt ng depth of from about 1 m cron to about 20 m crons when used to abrade a workp ece. In yet another spec f c aspect, the predeterm ned he ght may produce a cutt ng depth of from about 10 m cron to about 20 m crons when used to abrade a workp ece. In yet another aspect, the predeterm ned he ght may produce a depth of up to or more than 50 or 100 m crons.

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As a further example, it may also be beneficial for the cutting elements to protrude from the bonding material, for example, so that the organ carrier layer to a predetermined height or series of heights that are along a designated profile. Numerous configurations for designated profiles are possible, depending on the particular use of the abrading tool. In one aspect, the designated profile may be a plane. In planar profiles, the highest protruding points of the cutting elements are intended to be substantially even. It is important to point out that, though it is preferred that these points align with the designated profile, there may be some height deviation between cutting elements that occur due to variations inherent in the manufacturing process.

In addition to planar profiles, in another aspect the designated profile has a slope. Tools having sloping surfaces may function to more evenly spread the fracturing forces imparting thereon across the cutting elements, particularly for rotating tools such as disk sanders and CMP pad dressers. The greater downward force applied by higher central portions of the tool may offset the higher rotational velocity at the periphery, thus reducing the mechanical stress experienced by cutting elements in that location. As such, the slope may be continuous from a central point of the tool to a peripheral point, or the slope may be discontinuous, and thus be present on only a portion of the tool. Similarly, a given tool may have a single slope or multiple slopes. In certain aspects, the tool may slope in a direction from a central point to a peripheral point, or it may slope from a peripheral point to a central point.

Various slopes are contemplated that may provide a benefit to soiled organ carrier material layers. It is not intended that the claims of the present invention be limited as to specific slopes, as a variety of slopes in numerous different tools are possible. In one aspect, however, a CMP pad dresser may benefit from an average slope of 1/1000 from the center to the periphery.

As a variation on tools having a slope, in certain aspects the designated profile may have a curved shape. One specific example of a curved shape is a dome shape tool. Such curved profiles function in a similar manner to the sloped surfaces. Tools may include such curved profiles in order to more effectively distribute the fracturing forces between a set of the cutting elements, thus reducing failures of individual parts and prolonging the life of the tool.

Furthermore, in some aspects the determination of the distance that the tips of the cutting elements extend from a binder material, such as an organ carrier, can also be affected by considering how much of the cutting elements extend above the binder compared to how much of the cutting elements remain submerged beneath the binder surface. In one aspect, a ratio of an amount the cutting elements protrude above the binder to an amount submerged beneath the binder is about 4 to 1. In another aspect, about 2/3 of the cutting elements are submerged, with about 1/3 being exposed above the binder. Other ratios are also possible, from a 20 to 1 ratio to about 0.2 to 1, inclusive of ranges therebetween.

As a non-limiting example, in one aspect a CMP pad dresser can include a support substrate, such as a rigid support substrate, and a monolayer of a plurality of superabrasive particles coupled to the support substrate, where the plurality of superabrasive particles includes a plurality of working superabrasive particles. In use the dresser can be engaged against a CMP pad and cut asperities into the CMP pad having a cutting depth of less than or equal to about 50 microns. In another aspect, the cutting depth is from about 10 microns to about 50 microns. Additionally, in one aspect the plurality of working superabrasive particles includes at least 100 working superabrasive particles, at least 300 working superabrasive particles, or at least 500 working superabrasive particles. In another aspect, the plurality of working superabrasive particles includes at least 1000 working superabrasive particles. In yet another aspect, the plurality of working superabrasive particles includes from about 1000 to about 6000 working superabrasive particles. In a further aspect, the plurality of working superabrasive particles includes from about 2000 to about 5000 working superabrasive particles. In yet another aspect, the plurality of working superabrasive particles include at least about 1000 working superabrasive particles that protrude from the rigid support substrate to distances within about 30 microns of one another.

It is noted that, in some cases, the number of working superabrasive particles can be determined by observing edge or tip wear after use in a dressing operation. As such, in one aspect a CMP pad dresser can have greater than about 300 superabrasive particles with worn tips or edges following a CMP pad dressing procedure. In another aspect, a CMP pad dresser can have greater than about 500 superabrasive particles with worn tips or edges following a CMP pad dressing procedure. In a further aspect, a CMP pad dresser can have greater than about 1000 superabrasive particles with worn tips or edges following a CMP pad dressing procedure.

In one example, superabrasive particle tips can be described in terms of the distance that each superabrasive particle protrudes from the bonding material, or matrix layer. The difference in protrusion distance between the highest protruding tip and the next highest protruding tip of the monolayer of superabrasive particles is described as the protrusion difference. In one aspect, the protrusion difference can be less than or equal to about 50 microns. In another aspect, the protrusion difference can be less than or equal to about 20 microns. In a further aspect, the protrusion difference can be less than or equal to about 10 microns. It is noted that the term "protrusion difference" can also be used to describe the difference in protrusion distance between any two or more superabrasive particles.

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~~The difference in protrusion distance 106 between the highest protruding tip 108 and the next highest protruding tip 110 of the mono layer of superabrasive particles is described as the protrusion difference. In one aspect, the protrusion difference can be less than or equal to about 50 microns. In another aspect, the protrusion difference can be less than or equal to about 20 microns. In a further aspect, the protrusion difference can be less than or equal to about 10 microns. It is noted that the term "protrusion difference" can also be used to describe the difference in protrusion distance between any two or more superabrasive particles.~~

In another aspect, and in addition to the protrusion difference between the highest two protruding tips, the difference in protrusion distance between the highest 10 protruding tips of the mono layer of superabrasive particles are within about 30 microns or less. In yet another aspect, the difference in protrusion distance between the highest 10 protruding tips of the mono layer of superabrasive particles are within about 20 microns or less.

Additionally, in some aspects the difference in protrusion distance between the highest 1% of the protruding tips of the first mono layer of superabrasive particles can be within about 80 microns or less. In other words, for the 1% of the purity of superabrasive particles that have the highest protruding tips, the variance in protrusion distance for that 1% is less than or equal to about 80 microns. For example, the two highest protruding superabrasive particles protrude to within about 10 microns or less of each other, and in addition, the highest protruding 1% of superabrasive particles protrude to within about 80 microns or less of each other. In yet another aspect, the difference in protrusion distance between the highest 1% of the protruding tips of the mono layer of superabrasive particles are within about 60 microns or less. In yet another aspect, the difference in protrusion distance between the highest 1% of the protruding tips of the mono layer of superabrasive particles are within about 40 microns or less.

It is noted that the recited protrusion distances can include a distribution across the entire mono layer surface or a discrete area or segment of the mono layer. For example, the highest 1% of protruding tips can be located around the periphery of the mono layer. In one aspect, for example, substantiality of the asperities are cut in the CMP pad by superabrasive particles located at a peripheral location of the dresser. In another aspect, the peripheral location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 90% of the dresser radius. In yet another aspect, the peripheral location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 50% of the dresser radius. In a further aspect, the peripheral location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 33% of the dresser radius. Additionally, in some aspects, substantiality of the superabrasive particles are located at a peripheral location of the dresser. In other aspects, substantiality of the superabrasive particles are arranged in uniform predetermined pattern at a peripheral location of the dresser.

In another example, discrete regions of leveled superabrasive particles can be located within a larger area of superabrasive particles having a lower protrusion distance than the leveled portion. It is also contemplated that the mono layer can include multiple regions or segments of superabrasive particles that are leveled as described, within a larger area of superabrasive particles having a lower protrusion distance.

Thus, the relative leveling of the mono layer of superabrasive particles can greatly affect the morphology and distribution of asperities cut into the CMP pad by the dresser. For example, in one aspect, the mono layer is leveled such that rotating the dresser against the CMP cuts asperities having a maximum cutting depth of about 80 microns. In another aspect, the mono layer is leveled such that rotating the dresser against the CMP cuts asperities having a maximum cutting depth of about 60 microns. In yet another aspect, the mono layer is leveled such that rotating the dresser against the CMP cuts asperities having a maximum cutting depth of about 40 microns. By forming pointed asperities, the contact pressure between the work piece and the CMP pad is increased, thus improving the polishing characteristics of the pad. As these pointed regions begin to flatten, the contact pressure begins to decrease, and is thereby offset by the effect of the pressed against the work piece. In some aspects it can be beneficial for the contact area between the pad and the wafer to be less than or equal to about 1% of the total wafer surface area facing the pad. In other aspects, it can be beneficial for the contact area between the pad and the wafer to be less than or equal to about 0.1% of the total wafer surface area facing the pad. This small contact area is due to the wafer being perched on the contact points of the asperities. During the polishing process, the sharp tips of the asperities become worn, thus increasing the contact area and decreasing the contact pressure to a point whereby the slurry abrasives do not effectively abrade the wafer. At this point the removal rate of material from the wafer drops, and the pad needs to be redressed to sharpen the asperities.

Additionally, the load placed on the CMP pad by the dresser can affect the morphology of the spacers, such as, in some cases, the asperity depth. The load can be adjusted for a given dresser to adjust penetration depth. In one aspect, for example, the load can be from about 0.1 Kg to about 60 Kg. In other aspects, the load can be from about 2 Kg to about 20 Kg. In further aspects, the load may be from about 6 Kg to about 12 Kg. In some aspects the load may be Kg/m². For example, in one aspect an 11.5 Kg load can allow a material removal rate from the wafer of about 200 microns per hour for Cu layers. In a related example, an 11.5 Kg load can allow a material removal rate from the wafer of about 100 microns per hour for oxides. In many cases, a lower load can be used in order to minimize the superabrasive particle damage (e.g., less than or equal to about 2 Kg).

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Furthermore, even if the tips of the superabrasive particles in the mono layer are shown as having different amounts of superabrasive particles to actually cut asperities into the pad. In one aspect, for example, the tips are evened such that at least 100 tips of the plurality of superabrasive particles cut asperities into the CMP pad as the dresser is rotated. In another aspect, the tips are evened such that at least 50 tips of the plurality of superabrasive particles cut asperities into the CMP pad as the dresser is rotated. In a further aspect, the tips are evened such that at least 25 tips of the plurality of superabrasive particles cut asperities into the CMP pad as the dresser is rotated.

Various additional various methods can be utilized to measure superabrasive particle height to determine the difference in protrusion distance between tips. As such, any method for making such a determination is considered to be within the present scope. It should be noted that for the purposes of the present disclosure, the term "protrusion" refers to the height of a particle relative to some reference point. Techniques for such measurements can include direct measurements of the particle heights relative to a reference point such as, for example, the highest particle tip, a surface of a rigid support, the bottom surface of the matrix, etc. Measurements of particle height from the surface of the matrix material can be problematic, however, due to the irregular nature of such materials due to working around the superabrasive particles. In those cases whereby the matrix material is uniform, such a surface may be used to determine particle height. Additionally, a relative protrusion or height difference between two particles would be the difference in the heights between these particles measured from a common reference point. Furthermore, in some cases the superabrasive particles may be on a slope, curvature, or some other arrangement that is not parallel to the underlying support, such as, for example, a meta support layer. In these cases, the protrusion height would be normalized against the slope, curvature, or other arrangement so that the relative protrusion height difference between particles can be measured in the absence of the slope, curvature, etc. It should be noted that superabrasive particle height even if can, in some cases, be independent from the positioning or patterning of the superabrasive particles across the surface of the dresser.

One example of a direct measurement technique can include an optical scanning process to evaluate superabrasive particle positions. In one such process, an optical scanner can scan the surface of the CMP pad dresser to determine the height of the superabrasive particles relative to a fixed point. For example, the scanner can scan downward in space toward the dresser until the highest tip is located. The highest tip can then be set to the reference point, and the scanner can continue scanning in a direct line toward the dresser measuring the distance from the reference point to each superabrasive particle across the surface of the dresser. Accordingly, the difference in protrusion distance between any of the superabrasive particles across the dresser can be directly measured.

Furthermore, measurement techniques can also include indirect measurements, such as, for example, applying the diamond mono layer to a deformable substrate that deforms relative to the protrusion distance of the particles. The diamond mono layer can be pressed into the deformable substrate and/or moved across the deformable substrate to form a scratch pattern therein. Tip height can thus be extrapolated from such indirect measurements.

Numerous configurations for designed profiles are possible depending on the particular use of the abrading tool, and such designed profiles are considered to be within the present scope. In one aspect, for example, the designed profile can be a plane. In planar profiles, the highest protruding points of the superabrasive particles are intended to be substantially even in the traditional sense. It is important to point out that, though it is preferred that these points align with the designed profile, there may be some height deviation between superabrasive particles that occur due to limitations inherent in the manufacturing process.

In addition to planar profiles, in another aspect of the present invention on the designed profile has a slope. Tools having sloping surfaces may function to more evenly spread the frictional forces imparting thereon across the superabrasive particles, particularly for rotating tools such as disk sanders and CMP pad dressers. The greater downward force applied by higher central portions of the tool may offset the higher rotational velocity at the periphery, thus reducing the mechanical stress experienced by superabrasive particles in that location. As such, the slope may be continuous from a central point of the tool to a peripheral point, or the slope may be discontinuous, and thus be present on only a portion of the tool. Similarly, a given tool may have a single slope or multiple slopes. In certain aspects, the tool may slope in a direction from a central point to a peripheral point, or it may slope from a peripheral point to a central point. Various slopes are contemplated that may provide a benefit to so called organic materials. It is not intended that the claims of the present invention be limited as to specific slopes, as a variety of slopes in numerous different tools are possible. In one aspect, however, a CMP pad dresser may benefit from an average slope of 1/1000 from the center to the periphery.

Furthermore, in certain aspects the designed profile may have a curved shape. One specific example of a curved shape is a dome shape CMP pad dresser. Such curved profiles function in a similar manner to the sloped surfaces. CMP pad dressers may include such curved profiles in order to more effectively distribute the frictional forces between any of the superabrasive particles, thus reducing failures of individual particles and prolonging the life of the dresser. As so, CMP pad dressers can have designed profiles that combine any of a plane, a slope, a curved shape, a dome shape, and the like, into a variety of complex profiles.

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In another aspect of the present disclosure, a CMP pad dresser can include a support substrate, such as a rigid support substrate, and a monolayer of a plurality of superabrasive particles coupled to the support substrate, where each superabrasive particle in the monolayer extends away from the support substrate to a protrusion distance, and where the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 50 microns. Additionally, the difference in protrusion distance between the highest 1% of the protruding tips of the monolayer of superabrasive particles are within about 80 microns or less. In another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In a further aspect, the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns.

In another aspect of the present disclosure, a CMP pad dresser is provided including a support substrate and a plurality of superabrasive particles secured to the support substrate and positioned to engage and dress a CMP pad, where the plurality of superabrasive particles cut to depths of less than 50 microns into a CMP pad during a dressing procedure.

In a further aspect, a method of dressing a CMP pad is provided. Such a method can include applying a CMP pad dresser to a CMP pad, and moving at least one of the CMP pad or the CMP pad dresser with respect to one another to cut asperities into the CMP pad having a cutting depth of from about 10 microns to about 50 microns. As one non-limiting example, an exemplary CMP pad can include a support substrate and a monolayer of a plurality of superabrasive particles coupled to the support substrate, where the plurality of superabrasive particles includes a plurality of working superabrasive particles.

In one exemplary aspect, as shown in FIG. 1, a CMP pad dresser 100 includes a monolayer of a plurality of superabrasive particles 102 coupled to a support substrate 104 with, for example, a bonding material 105. Each superabrasive particle in the monolayer protrudes to a protrusion distance from the support substrate. The difference in protrusion distance 106 between the highest protruding tip 108 and the next highest protruding tip 110 of the monolayer of superabrasive particles is described as the protrusion difference. In one aspect, the protrusion difference can be less than or equal to about 50 microns. In another aspect, the protrusion difference can be less than or equal to about 20 microns. In a further aspect, the protrusion difference can be less than or equal to about 10 microns. It is noted that the term "protrusion difference" can also be used to describe the difference in protrusion distance between any two or more superabrasive particles.

A variety of materials are contemplated for use as superabrasive particles. Any superabrasive known that can be utilized in a CMP pad dresser should be considered to be within the present scope. Non-limiting examples of such materials include diamond materials, synthetic materials, ceramics, and the like. In one aspect, the superabrasive particles include diamond materials. Such diamond materials can include natural or synthetic diamond, single crystals, polycrystalline, and the like. In another aspect, the superabrasive particles include cubic boron nitride materials.

It is intended that the scope of the present disclosure include superabrasive particles of a conceivable sizes that would be useful in dressing a CMP pad. Aspects of the present disclosure, however, specifically allow the retention of superabrasive particles in a CMP pad dresser of sizes that have not previously been feasible for use in metal too small made using traditional techniques with particles exposed and arranged in a pattern. In one aspect, superabrasive particles may range in size from about 30 microns to about 250 microns. In another aspect, superabrasive particles may range in size from about 100 microns to about 200 microns. In yet another aspect, superabrasive particles can range from 100 microns to 150 microns. Additionally, various diamond particle sizes can be used, including mesh sizes such as 10/20, 30/40, 80/90, 90/100, 100/120, 120/140, 140/170, 170/200, 200/230, 230/270, 270/325, and 325/400.

Additionally, the plurality of the superabrasive particles can be oriented so as to affect dressing performance of a CMP pad. Orienting the superabrasive particles in a specific attitude in relation to the CMP pad to be dressed creates different asperities in the pad surface, thus altering the performance of the CMP pad. Different asperities retain surface in different manners and thus show a workpiece differently according to asperity depth, width, density, etc. The superabrasive particles of a CMP pad dresser can be oriented according to the desired polishing characteristics of the CMP pad. For example, if the superabrasive particles predominantly have an apex oriented towards the CMP pad, the asperities of the pad will be narrow and deep. The advantages of narrow and deep asperities are that the pad can better retain the polishing surface, and thus the polishing rate of the wafer increases. However, the increased polishing rate may also increase the wear rate of the superabrasive particles. As such, wear rate may vary depending on the attitude of the superabrasive particles, and therefore, the orientation of each superabrasive particle may be considered when designing a device with desired performance characteristics. Generally speaking, superabrasive

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part c e att tudes that prov de h gher dress ng rates (.e. deeper penetrat on nto a pad) a so wear part c es out at a h gher rate.

In contrast, f the superabras ve part c es are or ented w th a face towards the pad, the resu t ng asper t es may po sh at a ower rate. The face of the part c e s genera y thought to be more durab e, but does not typ ca y cut deep and narrow asper t es n the pad, but rather asper t es that are sha ow and broad. Therefore the face port on of a part c e w dress a CMP pad at a reduced rate compared to the apex port on of a part c e, but the superabras ve part c e w wear at a much ower rate.

The edge port ons of a superabras ve part c e have dress ng and wear character st cs that are between those of the face and apex port ons. It has been thought that f the edge port on s ut zed to dress a CMP pad, the asper t es are not as deep or narrow as those dressed w th an apex port on, but may prov de asper t es hav ng des rab e ntermed ate character st cs. Further, the edge port on of the part c e does not wear at such a h gh rate as that of an apex.

In one aspect, the p ura ty of superabras ve part c es are substant a y a conf gured n an att tude hav ng e ther an apex port on or an edge port on or ented toward a pad to be dressed. In another aspect, the p ura ty of superabras ve part c es are substant a y a conf gured n an att tude hav ng e ther an edge port on or a face port on or ented toward a pad to be dressed. In yet another aspect, the p ura ty of superabras ve part c es can be conf gured n an att tude hav ng a sharp port on or ented towards a pad to be dressed. In a further aspect, the p ura ty of superabras ve part c es can be conf gured n an att tude hav ng an apex port on or ented towards a pad to be dressed.

A CMP pad dresser hav ng such a substant a y eve ed t p arrangements can have a ow scratch rate because superabras ve part c es are ess ke y to pu out of the matr x ayer due to the r more un form protrus on d str but on compared to trad tona dressers. Add tona y, the more un form protrus on d str but ons of such a dressers a ows the cond t on ng of CMP pads n such a manner as to fac tate good po sh ng rates wh e at the same t me extend ng the effect ve work ng fe of the dresser. These benef ts can be affected by, for examp e, un form asper ty spac ng and sze d str but on n the CMP pad.

In one aspect, as s shown n FIG. 2, a method of cond t on ng a CMP pad can ncude 202 press ng a CMP pad dresser aga nst a CMP pad, 204 the dresser ncud ng a mono ayer of a p ura ty of superabras ve part c es protrud ng from a matr x ayer, where n the d fference n protrus on d stance between the h ghst protrud ng t p and the second h ghst protrud ng t p of the mono ayer of superabras ve part c es s less than or equa to about 10 m crons and the d fference n protrus on d stance between the h ghst 10 protrud ng t ps of the mono ayer of superabras ve part c es are w th n about 20 m crons or ess. The method can further ncude 206 rotat ng the dresser aga nst the CMP pad such that asper t es are cut nto the CMP pad hav ng a max mum cutt ng depth of about 60 m crons. In another aspect, as s shown n FIG. 3, the method can further ncude 302 rotat ng the CMP pad, 304 app y ng a s urry to a po sh ng surface of the rotat ng CMP pad, and 306 app y ng a workp ece to the po sh ng surface such that the workp ece s po shed by the asper t es n comb nat on w th the s urry.

In another aspect of the present d sc osure, superabras ve t p eve ng can be accomp shed by manufactur ng the CMP pad dresser n such a way that the effects of warpage are m n m zed. For examp e, n one aspect CMP pad dressers hav ng substant a y eve ed or eve ed superabras ve part c e t ps can be made us ng var ous manufactur ng techn ques, and any such techn que s cons dered to be w th n the present scope. The fo ow ng descr pt on prov des a few non- m t ng descr pt ons of such exemp ary processes.

In one aspect, for examp e, a CMP pad dresser can be made us ng a braz ng process, and as such wou d genera y ncude a support substrate and a p ura ty of superabras ve part c es coup ed to the support substrate by a meta or meta a oy braze mater a . As has been descr bed, trad tona braz ng techn ques create warpage n the dresser as the braze mater a coo s. As such, superabras ve part c e t ps that were eve ed pr or to braz ng are substant a y m sa gned n the manufactured dresser. Therefore, steps to m n m ze or e m nate the warpage must be taken when us ng a braze process n order to ma nta n t p eve ng. Var ous techn ques to m n m ze or e m nate warpage are contemp ated, and any such techn que s cons dered to be w th n the present scope.

As one genera examp e, a CMP pad dresser can be made n at east a two stage process, where the fr st stage s performed n a manner that m n m zes perturbat ons of the eve ed t ps n a process that wou d norma y s gn f cant y move the superabras ve t ps out of a eve ed arrangement, such as, for examp e, by braz ng. The second stage of the process can further enhance the eve ng of superabras ve part c e t ps across the CMP pad dresser. Other examp es may ncude ut z ng ower temperature a oys, us ng s ow temperature ramp ng n heat ng and/or coo ng of the support substrate, us ng add tona mechan ca support to frm y ho d the support substrate from mov ng when warpage occurs, and the ke.

Var ous exemp ary conf gurat ons of CMP pad dressers hav ng substant a y eve ed t ps are contemp ated. In one aspect, for examp e, Warpage can a so be m n m zed or e m nated through the structura des gn of the dresser. For examp e, n one aspect a CMP pad dresser can ncude a fr st mono ayer of superabras ve part c es d sposed on one

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s de of a meta support ayer and a second mono ayer of superabras ve part ces d sposed on the meta support ayer on an oppos te s de from the fr st mono ayer. The superabras ve part ces of the second mono ayer are pos t oned to have substant a y the same d str but on as the superabras ve part ces of the fr st mono ayer. A r g d support s coup ed to the second mono ayer of superabras ve part ces oppos te the fr st mono ayer to prov de support to the dresser.

As s shown n FIG. 42, for exam e, a fr st mono ayer of superabras ve part ces 402202 s arranged on a surface of a meta support ayer 404substrate 204. A second mono ayer of superabras ve part ces 406206 s arranged on the meta support ayer 404substrate 204 on a s de that s oppos te to the fr st mono ayer. As s d scussed further be ow, n some cases the fr st and second mono ayers of superabras ve part ces can be arranged such that correspond ng superabras ve part ces across the meta support ayer are n substant a a gment, as s shown n FIG. 42. In other cases, the superabras ve part ces of the fr st and second mono ayers can be arranged n a substant a y s m ar d str but on, but may or may not be substant a y a gned w th one another across the meta support ayersubstrate.

~~The meta support ayer can be any mater a capab e of support ng the d amond mono ayer dur ng too format on. Such mater a s can ncude, w thout m tat on, meta mater a s, meta a oy mater a s, braze a oy mater a s, ceram e mater a s, compos tes, and the ke.~~

~~In one aspect, the superabras ve part ces can be arranged nto a predeterm ned pattern. Such a pattern can be a un form y d str buted pattern or a non un form y d str buted pattern. Add t onal y, a var ety of techn ques are contem pated to fac tate the arrangement of s perabras ve part ces nto a predeterm ned pattern. Predeterm ned s understood to mean a non random pattern that has been determ ned pr or to arrang ng the superabras ve part ces. In one aspect, a predeterm ned pattern can a so app y to a predeterm ned spac ng between part ces. Non m t ng exam es of such techn ques ncude arrangement by a temp ate, arrangement us ng cpots of adhoc vec, arrangement on a fr st substrate fo owed by a pattern spec f c transfer from the fr st substrate to the meta support ayer, and the ke, ncud ng comb nat ons thereof. The superabras ve part ces from o ther of the mono ayers can be temporar y he d n pos t on n the predeterm ned pattern us ng a var ety of techn ques, ncud ng, w thout m tat on, adhoc vec, d mp ed ocat ons on the meta support matr x, a support ng compound such as, for exam e, a wax, and the ke, ncud ng comb nat ons thereof. In one spec f c aspect, the superabras ve part ces can be temporar y coup ed to the meta support ayer us ng an adhes ve that then vo at zes away and s e m nated dur ng construct on of the dresser.~~

~~In one aspect, the predeterm ned pattern can be a un form y d str buted gr d. In another aspect, the predeterm ned pattern can be an annu ar conf gurat on hav ng a contra rog on doved of superabras ve part ces. In one spec f c aspect, the annu ar conf gurat on can ncude an annu ar r ng. In another spec f c aspect, the annu ar conf gurat on can ncude a port on of an annu ar r ng. In yet another aspect, an annu ar conf gurat on can ncude one or more concent e annu ar r ngs nested ns de one another. In other aspects, the mono ayer d str but on can be d screte rad a reg ons, sp ra reg ons, and the ke.~~

The d sposit on of a mono ayer of superabras ve part ces on each s de of the meta ayersupport substrate thus moderates the therma shr nkage from the braz ng temperature that wou d otherw se buck e a d str but on of superabras ve part ces arranged on just one s de. By app y ng a mono ayer to each s de of the meta support ayersubstrate, warp ng forces such as therma movement and pressure can be equa zed or substant a y equa zed onfrom both s des. As such, the warpage of the meta support ayersubstrate can be m n m zed. In other words, the forces respons b e for warp ng are app ed substant a y equa y to each s de of the meta ayersupport substrate and can thus at east part a y cance one another out, thus m n m z ng warpage that can otherw se occur. In some aspects, the superabras ve part ces mak ng up the mono ayers on each s de of the meta ayersupport substrate can have match ng conf gurat ons, patterns, or or entat ons to one another. In th s way there can be a substant a y match ng spat a arrangement of superabras ve part ces on each s de of the meta ayer support substrate. In another aspect, the conf gurat ons, patterns, or or entat ons can be d fferent or var ed from one another, or may be part a y match ng. In yet another aspect, the patterned p acement of the superabras ve part ces on one s de of the meta support ayersubstrate can be substant a y a gned w th the pattern of superabras ve part ces on the other s de of the meta ayersupport substrate so that part ce ocat ons match one another. In some aspects, there can be a d rect correspondence between the spat a pos t on ng of superabras ve part ces on one s de of the meta support ayersubstrate and the spat a pos t on ng of superabras ve part ces on the other s de of the meta support ayersubstrate. In another aspect, the patterns of superabras ve part ces may match or substant a y match one another, but may be offset on oppos te s des of the meta support ayersubstrate so that part ce ocat ons do not match one another.

Accord ng y, m n m z ng the warpage of the meta support ayersubstrate can ma nta n a greater degree of eve ng of superabras ve part ce t ps n the f n shed too . When heat and/or pressure are used to make a superabras ve too , warpage of the meta support ayersubstrate can cause great var at ons n t p he ght eve , even for those part ces that were eve ed pr or to heat ng and/or app y ng pressure. In one aspect, d str but ng the warpage forces equa y or substant a y equa y on both s des of a meta support ayersubstrate through the arrangement of the superabras ve

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part c es can effect ve y cance forces on oppos ng s des and thus great y reduce the degree of warp ng occur ng n the ~~meta~~-support ~~ayer~~substrate, thus a so m n m z ng the re at ve he ght movement of the superabras ve part c es re at ve to one another. In other aspects, CMP pad dressers can be made us ng processes that do not ut zed h gh pressure and/or h gh temperature.

The support substrate can be any materia capab e of s pport ng the d amond mono ayer d r ng too format on. S ch materia s can ncude, without m tat on, meta materia s, meta a oy materia s, braze a oy materia s, ceram c materia s compos tes, and the ke.

In one aspect, the superabras ve part c es can be arranged nto a predeterm ned pattern. Such a pattern can be a n form y d str b ted pattern or a non- n form y d str b ted pattern. Add t ona y a var ety of techn q es are contemp ated to fac tate the arrangement of superabras ve part c es nto a predeterm ned pattern. Predeterm ned s nd understood to mean a non-random pattern that has been determ ned pr or to arrang ng the s perabras ve part c es. In one aspect a predeterm ned pattern can a so app y to a predeterm ned spac ng between part c es. Non- m t ng exam es of such techn ques ncude arrangement by a temp ate, arrangement us ng spots of adhes ves, arrangement on a frst s bstrate fo owed by a pattern spec f c transfer from the frst s bstrate to the support substrate, and the ke, nc ud ng comb nat ons thereof. The s perabras ve part c es from e ther of the mono ayers can be temporar y he d n pos t on n the predeterm ned pattern us ng a var ety of techn ques, nc ud ng, without m tat on, adhes ves, d mp ed ocat ons on the meta support matr x, a support ng compound such as, for exam e, a wax, and the ke, nc ud ng comb nat ons thereof. In one spec f c aspect, the superabras ve part c es can be temporar y coup ed to the support substrate us ng an adhes ve that then vo at zes away and s e m nated dur ng construct on of the dresser.

In one aspect, the predeterm ned pattern can be a un form y d str buted gr d. In another aspect, the predeterm ned pattern can be an ann ar conf g rat on hav ng a centra reg on devo d of s perabras ve part c es. In one spec f c aspect, the annu ar conf gurat on can ncude an annu ar r ng. In another spec f c aspect, the annu ar conf gurat on can nc de a port on of an ann ar r ng. In yet another aspect an ann ar conf g rat on can nc de one or more concentr c ann ar r ngs nested ns de one another. In other aspects the mono ayer d str b t on can be d screte rad a reg ons, sp ra reg ons, and the ke.

In another aspect, as s shown n FIG. 53, a frst mono ayer of superabras ve part c es ~~502302~~ s arranged on a surface of a ~~meta~~-support ~~ayer~~~~504~~substrate ~~304~~. A second mono ayer of superabras ve part c es ~~506306~~ s arranged on the ~~meta~~-support ~~ayer~~~~504~~substrate ~~304~~ on a s de that s oppos te to the frst mono ayer. A bond ng materia ~~508308~~ secures the frst mono ayer and the second mono ayer to the ~~meta~~-support ~~ayer~~~~504~~substrate ~~34~~. The bond ng materia can be any materia capab e of secur ng the frst and second mono ayer to the ~~meta~~-support ~~ayers~~substrate. In some aspect, the bond ng materia can be the same for secur ng the frst mono ayer and the second mono ayer, wh e n other aspects, the bond ng materia can be d fferent for secur ng the frst mono ayer and the second mono ayer.

Thelt s noted that the var ous descr pt ons of materia s, attachment techn ques, and the ke, can be genera y app cab e to any CMP pad dresser des gn to wh ch such materia s, techn ques, and the ke are app cab e. For exam e, a materia that can be used to secure a superabras ve part c e to a substrate can be used n both dua mono ayer and s ng e mono ayer dresser des gns.

Accord ng y, the bond ng materia can be any materia capab e of secur ng superabras ve part c es there n. Non- m t ng exam es of bond ng materia s ncude meta brazes, meta braze a oys, organ c matr x materia s, s ntered materia s, e ctrop ated materia s, and the ke, nc ud ng comb nat ons thereof.

In one aspect, for exam e, the superabras ve part c es can be brazed to the ~~meta~~-support ~~ayers~~substrate, and thus the bond ng materia can be a meta braze or meta braze a oy. Meta braz ng techn ques are known n the art. A green braze materia can be app ed to the ~~meta~~-support ~~ayers~~substrate on or around the superabras ve part c es. The meta braze can be app ed n any ~~known~~ known conf gurat on, nc ud ng braze sheets, powders, pastes, sprays, and the ke, nc ud ng comb nat ons thereof. Once app ed to the ~~meta~~-support ~~ayers~~substrate, the braze can be heated and me ted to coat at east a port on of the ~~meta~~-support ~~ayers~~substrate and to bond the superabras ve part c es. The heat ng temperature can vary depend ng on the braze materia used, but n one aspect can be from about 700° C. to about 1200° C. ~~The superabras ve part c es n the frst and second mono ayer are thus arranged such that therma forces exerted on the meta support ayer dur ng heat ng and coo ng are substant a y equa ze n order to m n m ze warp ng.~~

In one non- m t ng exam e, the superabras ve part c es can be bonded to the ~~meta~~-support ~~ayers~~substrate by braz ng w th a n ke-based a oy conta ng chrom um. In another exam e, the braz ng can ncude press ng the superabras ve part c es w th a f at ceram c materia that cannot be bonded to the braze n order to eve the superabras ve part c e t ps. Var ous braze a oys are contemp ated, nc ud ng non- m t ng exam es such as BN₂, BN₇, and the ke.

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Additona y, in one aspect ~~at least one of the first and second mono-ayers of~~ superabrasive part c es can be coup ed to the ~~meta~~-support ~~-ayersubstrate~~ by an e ectrodepos t on process, and thus the bond ng mater a can be an ~~e-ectrodepos tede ectrodepos ted~~ meta mater a . As an examp e of a su tab e method for pos t on ng and reta n ng abras ve mater a s pr or to and dur ng the e ectrodepos t on process, a mo d can be used that nc udes an nsu at ng mater a that can effect ve y prevent the accumu at on of e ectrodepos ted mater a on the mo d ng surface. Superabras ve part c es can be he d on the mo d ng surface of the mo d dur ng e ectro depos t on. As such, the accumu at on of ~~e-ectrodepos tede ectrodepos ted~~ mater a can be prevented from occur ng on the part c e t ps and the work ng surface of the pad cond t oner substrate. Such techn ques are descr bed n U.S. patent app cat on Ser. No. 11/292,938, f ed Dec. 2, 2005, wh ch s hereby nc orporated here n by reference.

In another aspect, the superabras ve part c es can be bonded to the ~~meta~~-support ~~-ayersubstrate~~ by s nter ng, and thus the bond ng mater a can nc ude a s nter ng mater a . For examp e, the bond ng of the superabras ve part c es to the ~~meta~~-support ~~-ayersubstrate~~ can nc ude d spos ng a s nter ng compound on the ~~meta~~-support ~~-ayersubstrate~~ n contact w th ~~at least one of the p ura ty of the first mono-ayer and the second mono-ayers~~ superabras ve part c es, and s nter ng the s nter ng compound to bond the ~~at least one of the first mono-ayer and the second mono-ayers~~ superabras ve part c es to the ~~meta~~-support ~~-ayersubstrate~~. Su tab e s nter ng methods w be read y apprec ated by one of ord nary sk n the art hav ng possess on of th s d sc osure. Bas ca y, a s nter ng compound s app ed around the superabras ve part c es and n contact w th the ~~meta~~-support ~~-ayersubstrate~~. The s nter ng compound can be any known s nter ng mater a that can be used to secure superabras ve part c es to a substrate. Non- m t ng examp es of such mater a s can nc ude meta and meta a oy powders, ceram c powders, and the ke. One spec f c non- m t ng examp e of a s nter ng compound s cobra t powder.

Once the s nter ng compound has been app ed around the superabras ve part c es and to the ~~meta~~-support substrate, heat and n some cases pressure can be app ed to cause s nter ng to occur. In some aspects, a braze or braze a oy can be nf trated nto the s nter ng compound dur ng bond ng to further strengthen the bond ng mater a matr x.

~~In another aspect, as s shown n FIG. 6, In yet another aspect, s nter ng can be used to s nter the p ura ty of superabras ve part c es nto a CMP pad dresser, where the support substrate s the s nter ng mater a . In th s case, the above rec ted procedure can be repeated w thout the use of a support substrate.~~

~~In another aspect,~~ heat and pressure can be app ed to bond the ~~first mono-ayer~~ p ura ty of superabras ve part c es ~~602 and/or the second mono-ayer of superabras ve part c es 606~~ d rect y nto the ~~meta~~-support ~~-ayer 604~~ substrate. Thus, upon the app cat on of heat and pressure, the ~~meta~~-support ~~-ayer 604~~ substrate can be softened or part a y med ted. The superabras ve part c es ~~n one or more of the mono-ayers~~ are then pressed nto the ~~meta~~-support ~~-ayersubstrate~~. A p anar eve ng surface can be used to app y pressure to the mono ayer ~~and of superabras ve part c es to~~ thus ma nta n the eve nature of the superabras ve part c e t ps as the superabras ve part c es are pressed nto the ~~meta~~-support ~~-ayer~~. ~~Upon coo ng, the d str but on of superabras ve part c es on e ther s de of the meta support -ayer at east part a y equa zes the therma forces act ng on support substrate. Pressure can be ma nta ned upon~~ the ~~meta~~-support ~~-ayersubstrate~~ and superabras ve part c es unt coo ed, thus m n m z ng warp ng.

In yet another aspect, as s shown n FIG. 74, a ~~dua mono ayer~~ CMP pad dresser can nc ude a first mono ayer of superabras ve part c es ~~702402~~ and a second mono ayer of superabras ve part c es ~~706406~~ coup ed to a ~~meta~~-support ~~-ayer 704~~ substrate ~~404~~. The superabras ve part c es can be coup ed to the ~~meta~~-support ~~-ayersubstrate~~ d rect y or v a bond ng mater a . The second mono ayer of superabras ve part c es ~~706406~~ s coup ed to a ~~rg-dsecond~~ support ~~708~~ substrate ~~408~~. A port on of the ~~rg-dsecond~~ support ~~708~~ substrate s shown removed n FIG. 74 to expose the second mono ayer. The ~~rg-dsecond~~ support ~~708~~ substrate ~~408~~ can fac tate hand ng and use of the CMP pad dresser. By bond ng the superabras ve part c es of the second mono ayer to the ~~rg-dsecond~~ support substrate, the first mono ayer of superabras ve part c es rema ns exposed for CMP pad cond t on ng operat ons.

The ~~rg-dsecond~~ support substrate can be made from any mater a compat b e w th the abrad ng or dress ng process. Such mater a s can nc ude po ymer c mater a s, meta mater a s, ceram c mater a s, g asses, compos tes, and the ke. In one aspect, the ~~rg-dsecond~~ support substrate can be a po ymer c mater a and the second mono ayer of superabras ve part c es can be embedded there n us ng heat, pressure, adhes ves, etc. In some aspects, the ~~rg-dsecond~~ support substrate can be a non-po ymer c mater a such as a meta ayer. In such cases, the superabras ve part c es can be bonded to the ~~rg-dsecond~~ support substrate by adhes ve attachment, so der ng, braz ng, e ectrop at ng, and the ke. For braz ng techn ques, care can be taken to m n m ze or e m nate warpage n the ~~meta~~-ayersubstrate dur ng the heat ng and coo ng process. In another aspect, one or more magnet c e ements can be p aced nto the ~~rg-dsecond~~ support substrate to attract and ho d the CMP pad dresser n p ace, thus form ng a temporary attachment. An opt ona ock ng mechan sm can be ut zed to further mmob ze the CMP pad dresser to the ~~rg-dsecond~~ support substrate dur ng use. In some aspects the ~~rg-dsecond~~ support substrate can nc ude surface features to ho d the dresser n p ace dur ng rotat ona movement aga nst a CMP pad. The ~~rg-dsecond~~ support

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substrate can have approximately the same diameter as the meta support layer, a larger diameter than the meta support layer, or, in some cases, a smaller diameter than the meta support layer.

In another aspect, a CMP pad dresser can be comprised of a plurality of dressing segments having a plurality of evenly spaced superabrasive particles, where the plurality of dressing segments are held in place by a rigid support-or support substrate. Such a design allows a plurality of smaller dressing segments to be manufactured having precise evenly spaced particles. Smaller diameter ~~meta~~ support layers in these dressing segments can be made by processes involving heat and/or pressure with less warpage due to the smaller size. For example, a 4 inch diameter meta disc can exhibit greater warpage due to brazing as compared to a 0.5 inch diameter meta disc. Thus thermal distortion and particle floating problems are decreased. A plurality of such dressing segments can then be coupled to a larger diameter ~~rigid~~-support substrate by processes that do not introduce significant warpage, such as bonding in an organic material. Such dressing segments can have one or more layer(s) of superabrasive particles coupled to a support layer. In one aspect, a segment can have a single layer of superabrasive particles coupled to a ~~meta~~-support layer. In another aspect, a segment can have a layer of superabrasive particles coupled to each side of a ~~meta~~-support layer, as has been described herein. Thus, this process allows the manufacture of CMP pad dressers that can have precise protrusion to tolerances. Additionally, in one aspect, each dressing segment can have at least three superabrasive particles that protrude to the greatest extent. If the three highest protruding superabrasive particles on every dressing segment are evenly spaced across the entire ~~rigid~~-support substrate, a CMP pad dresser is made having very precise topography across the entire surface. If, for example, ten dressing segments are used to make the CMP pad dresser, then the highest protruding thirty superabrasive particles in the too will have effectively the same protrusion distance and be substantially evenly spaced. Various additional details regarding dressing segments are detailed in U.S. patent application Ser. No. 13/034,213, filed Feb. 24, 2011, which is hereby incorporated herein by reference.

Various organic materials are contemplated for use as a ~~rigid~~-support substrate, and/or to ~~be used to secure the~~ second monolayer of superabrasive particles and/or the dressing segments to the ~~rigid~~-support substrate. Examples of suitable organic matrix materials include, without limitation, amorphous resins, acrylic resins, polyether resins, polyamide resins, polyimide resins, polyurethane resins, phenolic resins, phenol/acrylic resins, epoxy resins, isocyanate resins, isocyanurate resins, polysiloxane resins, reactive vinyl resins, polyethylene resins, polypropylene resins, polystyrene resins, phenoxy resins, perylene resins, polysulfone resins, acrylic on tri-n-butylstyrene resins, acrylic resins, polycarbonate resins, polyimide resins, and mixtures thereof. In one specific aspect, the organic material can be an epoxy resin. In another aspect, the organic material can be a polyimide resin. In yet another aspect, the organic material can be a polyurethane resin.

Additionally, so-called "reverse cast" methods can be used to accurately orient and attach the dressing segments to the ~~rigid~~-support substrate. Such methods can include attaching the plurality of dressing segments to a substrate using a "mask" material. The portions of the dressing segments protruding from the mask material can then be attached to the rigid support using the methods discussed herein, after which (or during which), the mask material can be removed.

When an organic material is sintered, methods of curing the organic material can be a variety of processes known to one skilled in the art that cause a phase transition in the organic material from at least a pliable state to at least a rigid state. Curing can occur, without limitation, by exposing the organic material to energy in the form of heat, electromagnetic radiation, such as ultraviolet, infrared, and microwave radiation, particle bombardment, such as an electron beam, organocatalysts, inorganic catalysts, or any other curing method known to one skilled in the art.

In one aspect of the present invention, the organic material can be a thermoplastic material. Thermoplastic materials can be reversibly hardened and softened by cooling and heating respectively. In another aspect, the organic material layer may be a thermosetting material. Thermosetting materials cannot be reversibly hardened and softened with the thermoplastic materials. In other words, once curing has occurred, the process can be essentially irreversible, if desired.

As a more detailed list of what is described above, organic materials that may be useful in embodiments of the present invention include, but are not limited to: amorphous resins including acrylated urea-formaldehyde resins, melamine-formaldehyde resins, and acrylated benzoguanamine-formaldehyde resins; acrylic resins including vinyl acrylates, acrylated epoxies, acrylated urethanes, acrylated polyethers, acrylated acrylics, acrylated polyethers, vinyl ethers, acrylated oils, acrylated siloxanes, and associated methacrylates; acrylic resins such as urethane acrylic resins; polyether resins; polyamide resins; polyimide resins; reactive urethane resins; polyurethane resins; phenolic resins such as resole and novolac resins; phenol/acrylic resins; epoxy resins such as bisphenol epoxy resins; isocyanate resins; isocyanurate resins; polysiloxane resins including polyarylsiloxane resins; reactive vinyl resins; resins marketed under the Bake-It™ trade name, including polyethylene resins, polypropylene resins, epoxy resins, phenolic resins, polystyrene resins, phenoxy resins, perylene resins, polysulfone resins, ethylene copolymer resins, acrylic on tri-n-butylstyrene (ABS) resins, acrylic resins, and vinyl resins; acrylic resins; polycarbonate resins; and mixtures and combinations thereof. In one aspect of the present invention, the organic material may be an epoxy

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res n. In another aspect, the organ c mater a may be a po y m de res n. In yet another aspect, the organ c mater a may be a po yurethane res n.

Numerous add t ves may be nc uded n the organ c mater a to fac tate ts use. For examp e, add t ona cross nk ng agents and f ers may be used to mprove the cured character st cs of the organ c mater a ayer. Add t ona y, so vents may be ut zed to a ter the character st cs of the organ c mater a n the uncured state. A so, a re nforc ng mater a may be d sposed w th n at east a port on of the so d f ed organ c mater a ayer. Such re nforc ng mater a may funct on to ncrease the strength of the organ c mater a ayer, and thus further mprove the retent on of the nd v dua abras ve segments. In one aspect, the re nforc ng mater a may nc ude ceram cs, meta s, or comb nat ons thereof. Examp es of ceram cs nc ude a um na, a um num carb de, s ca, s con carb de, z rcon a, z rcon um carb de, and m xtures thereof.

Add t ona y, n one aspect a coup ng agent or an organometa c compound may be coated onto the surface of a superabras ve mater a to fac tate the retent on of the superabras ve part c es n the organ c mater a v a chem ca bond ng. A w de var ety of organ c and organometa c compounds s known to those of ord nary sk n the art and may be used. Organometa c coup ng agents can form chem ca s bonds between the superabras ve mater a s and the organ c mater a , thus ncreas ng the retent on of the superabras ve mater a s there n. In th s way, the organometa c coup ng agent can serve as a br dge to form bonds between the organ c mater a and the surface of the superabras ve mater a . In one aspect of the present nvent on, the organometa c coup ng agent can be a t tanate, z rconate, s ane, or m xture thereof. The amount of organometa c coup ng agent used can depend upon the coup ng agent and on the surface area of the superabras ve mater a . Oftent mes, 0.05% to 10% by we ght of the organ c mater a ayer can be suff c ent.

Spec f c non- m t ng examp es of s anes su tab e for use n the present nvent on nc ude: 3-g yc doxypropy tr methoxy s ane (ava ab e from Dow Corn ng as Z-6040); y-methacry oxy propy tr methoxy s ane (ava ab e from Un on Carb de Chem ca s Company as A-174); β -(3,4-epoxycyclohexy)ethy tr methoxy s ane, y-am nopropy tr ethoxy s ane, N-(β -am noethy)-y-am nopropy methy d methoxy s ane (ava ab e from Un on Carb de, Sh n-etsu Kagaku Kogyo K.K., etc.). Spec f c non- m t ng examp es of t tanate coup ng agents nc ude: sopropy tr sostearoy t tanate, d (cumy pheny ate)oxyacetate t tanate, 4-am nobenzenesu fony dodecy benzenesu fony t tanate, tetraocty b s (d tr decy phosph te) t tanate, sopropy tr (N-ethy am no-ethy am no) t tanate (ava ab e from Kenr ch Petrochem ca s, Inc.), neoa kyoxo t tanates such as LICA-01, LICA-09, LICA-28, LICA-44 and LICA-97 (a so ava ab e from Kenr ch), and the ke. Spec f c non- m t ng examp es of a um num coup ng agents nc ude acetoa koxy a um num d sopropy ate (ava ab e from Aj nomoto K.K.), and the ke. Spec f c non- m t ng examp es of z rconate coup ng agents nc ude: neoa koxy z rconates, LZ-01, LZ-09, LZ-12, LZ-38, LZ-44, LZ-97 (a ava ab e from Kenr ch Petrochem ca s, Inc.), and the ke. Other known organometa c coup ng agents, e.g., th o ate based compounds, can be used n the present nvent on and are cons dered w th n the scope of the present nvent on.

In other aspects of the present d sc osure, superabras ve part c e t ps can be eve ed by reduc ng the protrus ons of part c es that are outs de of the des red to erance range. Once such part c es are dent f ed, var ous techn ques can be ut zed to reduce such protrus ons. In one aspect, for examp e, mechan ca abras on of the dresser can reduce the protrud ng part c es. In another aspect, a v brat on too can be used to nd v dua y break such part c es. In yet another aspect, a aser such as a Nd:YAG aser can be used to d rrupt such part c es.

In another aspect of the present d sc osure, a method of mak ng a CMP pad dresser can nc ude d spos ng a frst mono ayer of superabras ve part c es on a meta support ayer, and d spos ng a second mono ayer of superabras ve part c es on the meta support ayer on a s de oppos te the frst mono ayer. The superabras ve part c es of the second mono ayer are pos t oned to have substant a y the same d str but on as the superabras ve part c es of the frst mono ayer. The method can further nc ude bond ng the frst mono ayer of superabras ve part c es and the second mono ayer of superabras ve part c es to the meta support ayer such that symmetr ca forces due to the substant a y s m ar d str but on between the frst mono ayer and the second mono ayer prec udes substant a warp ng of the meta support ayer.

In yet another aspect, d spos ng at east one of the frst mono ayer of superabras ve part c es or the second mono ayer of superabras ve part c es can nc ude adher ng a p ura ty of superabras ve part c es to an adhes ve transfer sheet n a predeterm ned pattern estab shed by apertures n a temp ate, and remov ng the temp ate from the adhes ve transfer sheet such that the p ura ty of superabras ve part c es rema n adhered to the adhes ve transfer sheet n the predeterm ned pattern. The p ura ty of superabras ve part c es s then transferred w th the adhes ve transfer sheet to the meta support ayer, and the adhes ve transfer sheet s removed from the p ura ty of superabras ve part c es to form at east one of the frst mono ayer of superabras ve part c es or the second mono ayer of superabras ve part c es.

In a further aspect of the present d sc osure, a method of m n m z ng warpage of a CMP pad dresser dur ng manufacture can nc ude substant a y equa z ng warp ng forces on oppos ng s des of a meta support ayer dur ng bond ng of a p ura ty of superabras ve part c es thereto, where n warpage of the support ayer s m n m zed dur ng

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~~bonding due to the equalized forces on opposing sides. In one aspect, substantially equalizing forces includes arranging the purity of superabrasive particles on opposing sides of the support layer such that the purity of superabrasive particles has substantially the same distribution on either side of the support layer to substantially equalize warping forces during bonding.~~

In yet a further aspect of the present disclosure, a CMP pad dresser can include a purity of superabrasive particles arranged as a working surface, where the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the first mono layer of superabrasive particles is less than or equal to about 20 microns, and where the difference in protrusion distance between the highest 1% of the protruding tips of the first mono layer of superabrasive particles, excluding the highest protruding tip, are within about 80 microns.

In another aspect, a CMP pad dresser can include a purity of superabrasive particles arranged as a working surface, where the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns, the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns, the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns, and the highest protruding tip has a protrusion distance of greater than or equal to about 50 microns.

It is noted that, while the above disclosure refers primarily to CMP pad dressers, other processing grinding and/or abrading tools are considered to be within the present scope. As such, the techniques and teaching disclosed here can additionally be applied to such tools.

Additionally, it is noted that traditional CMP processing techniques, including pad dressing, has limited the critical dimensions of integrated circuits. The presently disclosed CMP dressing devices and techniques can, however, allows processing of wafers having integrated circuit critical dimensions of less than or equal to 45 nm, 32 nm, 28 nm, 22 nm, or less.

Of course, it is to be understood that the above-described arrangements are only illustrative of the application of the principles of the present invention. Numerous modifications and alternative arrangements may be devised by those skilled in the art without departing from the spirit and scope of the present invention and the appended claims are intended to cover such modifications and arrangements. Thus, while the present invention has been described above with particularity and detail in connection with what is presently deemed to be the most practical and preferred embodiments of the invention, it will be apparent to those of ordinary skill in the art that numerous modifications, including, but not limited to, variations in size, shape, form, function and manner of operation, assembly and use may be made without departing from the principles and concepts set forth herein.

Claims:

What is claimed is:

1. A ~~method of conditioning a CMP pad, comprising: pressing a CMP pad dresser against a CMP pad, the dresser including, comprising: a rigid support substrate; and~~ a mono layer of a purity of superabrasive particles ~~protruding coupled to the support substrate, where each superabrasive particle in the mono layer extends away from the support substrate to a protrusion distance, where a tip of each of the purity of superabrasive particles engages a matrix layer, designated profile with a tip variation of from about 5 microns to about 100 microns, and~~ where the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the mono layer of superabrasive particles is less than or equal to about ~~40 microns and the difference in protrusion distance between the highest 10 protruding tips of the mono layer of superabrasive particles are within about 20 microns or less; and rotating the dresser against the CMP pad such that asperities are cut into the CMP pad having a maximum cutting depth of about 60 microns.~~

~~2. The method of claim 1, where at least 100 tips of the purity of superabrasive particles cut asperities into the CMP pad as the dresser is rotated.~~

~~3. The method of claim 1, where at least 50 tips of the purity of superabrasive particles cut asperities into the CMP pad as the dresser is rotated.~~

~~4. The method of claim 1, where at least 25 tips of the purity of superabrasive particles cut asperities into the CMP pad as the dresser is rotated.~~

~~5. The method of claim 1, where substantially a of the asperities are cut in the CMP pad by superabrasive particles located at a peripheral location of the dresser.~~

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~~6. The method of claim 5, wherein the peripheral coating extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 90% of the dresser radius.~~

~~7. The method of claim 5, wherein the peripheral coating extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 50% of the dresser radius.~~

~~8. The method of claim 5, wherein the peripheral coating extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 33% of the dresser radius.~~

~~9. The method of claim 1, wherein substantially all of the superabrasive particles are located at a peripheral coating of the dresser.~~

~~10. The method of claim 1, wherein substantially all of the superabrasive particles are arranged in uniform predetermined pattern at a peripheral coating of the dresser.~~

~~11. The method of claim 1, further comprising: rotating the CMP pad; applying a slurry to a polishing surface of the rotating CMP pad; applying a workpiece to the polishing surface such that the workpiece is polished by the asperities in combination with the slurry.~~

~~12. The method of claim 11, wherein the workpiece is a semiconductor device.~~

~~13. The method of claim 12, wherein the semiconductor device includes one or more layers of Cu, W, an oxide layer, or a combination thereof.~~

~~14. The method of claim 12, wherein the semiconductor device has a node size of less than or equal to 28 nm.~~

~~15. The method of claim 12, wherein the semiconductor device has a node width of less than or equal to about 30 nm.~~

~~16. The method of claim 12, wherein the semiconductor device is a wafer having a size greater than 400 mm.~~

~~17. The method of claim 11, wherein the slurry includes an abrasive selected from the group consisting of silica, alumina, ceria, and combinations thereof.~~

~~18. The method of claim 11, wherein the slurry includes an oxidative compound.~~

~~19. The method of claim 17, wherein the oxidative compound is hydrogen peroxide.~~

20. The method of claim 11, wherein the CMP pad is polyurethane, 50 microns, and the difference in protrusion distance between the highest 1% of the protruding tips of the mono layer of superabrasive particles are within about 80 microns or less.

2. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns.

3. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than about 10 microns.

4. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns.

5. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns.

6. The dresser of claim 1, wherein the property of superabrasive particles includes a property of working superabrasive particles, such that rotating the dresser against a CMP pad cuts asperities into the CMP pad having a cutting depth of less than or equal to about 50 microns.

7. The dresser of claim 6, wherein the cutting depth is from about 10 microns to about 50 microns.

8. The dresser of claim 6, wherein the property of working superabrasive particles includes at least 100 working superabrasive particles.

Comparison between U.S. Patent No. 9,138,862 and U.S. Patent No. 9,724,802
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9. The dresser of claim 6, wherein the purity of working superabrasive particles includes at least 1000 working superabrasive particles.

10. The dresser of claim 6, wherein the purity of working superabrasive particles includes from about 1000 to about 6000 working superabrasive particles.

11. The dresser of claim 6, wherein the purity of working superabrasive particles includes from about 2000 to about 5000 working superabrasive particles.

12. The dresser of claim 6, wherein the purity of working superabrasive particles include at least about 1000 working superabrasive particles that protrude from the rigid support substrate to distances within about 30 microns of one another.

13. The dresser of claim 1, wherein the highest protruding tip of each of the purity of superabrasive particles is along the designated profile with a tip variation of from about 10 microns to about 50 microns.

14. The dresser of claim 1, wherein the highest protruding tip of each of the purity of superabrasive particles is along the designated profile with a tip variation of from about 20 microns to about 40 microns.

15. The dresser of claim 1, wherein the highest protruding tip of each of the purity of superabrasive particles is along the designated profile with a tip variation of less than about 20 microns.

16. The dresser of claim 1, wherein the protrusions of the purity of superabrasive particles produce cutting depths of less than about 20 microns when used to abrade a CMP pad.

17. The dresser of claim 1, wherein the protrusions of the purity of superabrasive particles produce cutting depths of from about 1 micron to about 20 microns when used to abrade a CMP pad.

18. The dresser of claim 1, wherein the protrusions of the purity of superabrasive particles produce cutting depths of from about 10 microns to about 20 microns when used to abrade a CMP pad.

19. The dresser of claim 1, wherein the designated profile includes a configuration selected from the group consisting of a plane, a slope, a curved shape, a dome shape, and combinations thereof.

20. The dresser of claim 1, wherein the purity of superabrasive particles is arranged across the support substrate in a predetermined pattern.

21. The dresser of claim 20, wherein the predetermined pattern includes an even distribution of the purity of superabrasive particles spaced at a distance of from about 100 microns to about 800 microns.

EXHIBIT 2

Comparison of Claim 1 of U.S. Patent No. 9,138,862 and Claim 1 of U.S. Patent No. 9,724,802
(New subject matter added to the '802 Patent is shown in blue)

1. ~~A method of conditioning a CMP pad, comprising: pressing a CMP pad dresser against a CMP pad, the dresser including~~ comprising: a rigid support substrate; and a monolayer of a plurality of superabrasive particles ~~protruding from a matrix layer, coupled to the support substrate, wherein each superabrasive particle in the monolayer extends away from the support substrate to a protrusion distance, wherein a tip of each of the plurality of superabrasive particles aligns along a designated profile with a tip variation of from about 5 microns to about 100 microns, and~~ wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about ~~10~~ 50 microns, and the difference in protrusion distance between the highest ~~10~~ 1% of ~~the~~ protruding tips of the monolayer of superabrasive particles are within about ~~20~~ 80 microns or less; ~~and rotating the dresser against the CMP pad such that asperities are cut into the CMP pad having a maximum cutting depth of about 60 microns.~~

EXHIBIT 3

Comparison between U.S. Patent No. 8,974,270 and U.S. Patent No. 9,724,802
(New subject matter added to the '802 Patent is shown in red)

Description:

BACKGROUND OF THE INVENTION

The semiconductor industry currently spends in excess of one billion U.S. dollars each year manufacturing silicon wafers that must exhibit very flat and smooth surfaces. Known techniques to manufacture smooth and even-surfaced silicon wafers are plentiful. The most common of these involves the process known as Chemical Mechanical Polishing (CMP) which includes the use of a polishing pad in combination with an abrasive slurry. Of central importance in a CMP process is the attainment of high performance even in aspects such as uniformity of polished wafer, smoothness of the IC circuitry, removal rate for productivity, longevity of consumables for CMP economics, etc.

SUMMARY OF THE INVENTION

The present disclosure provides CMP pad dressers and associated methods ~~thereof, including without limitation, methods directed to the manufacture and use of such dressers.~~ In one aspect, for example, a CMP pad dresser can include a ~~matrix-ayer~~ support substrate and a plurality of superabrasive particles secured to the support substrate with each superabrasive particle extending away from the support substrate to a protrusion distance. The plurality of superabrasive particles can be positioned such that the highest protruding tip of each of the plurality of superabrasive particles is along a designated profile with a tip variation of from about 5 microns to about 100 microns. In another aspect, the highest protruding tip of each of the plurality of superabrasive particles is along the designated profile with a tip variation of from about 10 microns to about 50 microns. In yet another aspect, the highest protruding tip of each of the plurality of superabrasive particles is along the designated profile with a tip variation of from about 20 microns to about 40 microns. In a further aspect, the highest protruding tip of each of the plurality of superabrasive particles is along the designated profile with a tip variation of less than about 20 microns. The designated profile can include any geometric configuration that can be useful in dressing a CMP pad, and any such configuration is considered to be within the present scope. Non-limiting examples can include a plane, a slope, a curved shape, a dome shape, and the like, including appropriate combinations thereof.

The positioning of superabrasive particles relative to the support substrate can also be described in terms of the depths that the superabrasive particles cut into a CMP pad when used to abrade the CMP pad. In one aspect, for example, the protrusions of the plurality of superabrasive particles produce cutting depths of less than about 20 microns when used to abrade a CMP pad. In another aspect, the protrusions of the plurality of superabrasive particles produce cutting depths of from about 1 micron to about 20 microns when used to abrade a CMP pad. In yet another aspect, the protrusions of the plurality of superabrasive particles produce cutting depths of from about 10 microns to about 20 microns when used to abrade a CMP pad.

As another exemplary aspect of the present disclosure, a CMP pad dresser can include a rigid support substrate and a monolayer of a plurality of superabrasive particles embedded ~~acoup~~ed to the ~~matrix-ayer~~ support substrate, where each superabrasive particle in the monolayer ~~protrudes~~ extends from the ~~matrix-ayer~~. The support substrate to a protrusion distance. In one aspect, the difference in the protrusion distance between the highest protruding tip and the ~~next~~ second highest protruding tip of the monolayer of superabrasive particles ~~can be~~ is less than or equal to about 2050 microns, and the difference in protrusion distance between the highest 1% of the protruding tips of the monolayer of superabrasive particles ~~are~~ is within about 80 microns or less. ~~In one specific aspect, a rigid support is coup~~ed to the ~~matrix-ayer~~.

In another aspect, the difference in protrusion distance between the highest protruding tip and the next highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 15 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the next highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 10 microns. In a further aspect, the difference in protrusion distance between the highest 10 protruding tips of the monolayer of superabrasive particles are within about 30 microns or less. In another aspect, the difference in protrusion distance between the highest 100 protruding tips of the monolayer of superabrasive particles are within about 50 microns or less. In yet another aspect, the difference in protrusion distance between the highest 1% of the protruding tips of the first monolayer of superabrasive particles are within about 50 microns or less. In another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the ~~40~~ second highest protruding tip is less than or equal to about 2010 microns. In a further aspect, the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns. In another aspect, the highest protruding tip protrudes from the ~~matrix-ayer~~ to a height greater than or equal to about 50 microns.

In another aspect, a CMP pad dresser is provided. Such a dresser can include a first monolayer of superabrasive particles disposed on one side of a meta-support layer and a second monolayer of superabrasive particles disposed on the meta-support layer on an opposite side from the first monolayer. The superabrasive particles of the second

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~~mono-ayer are positioned to have substantially the same distal but on as the superabrasive particles of the first mono-ayer, and a rigid support is coupled to the second mono-ayer of superabrasive particles opposite the first mono-ayer.~~

~~In yet another aspect, a method of making a CMP pad dresser includes disposing a first mono-ayer of superabrasive particles on a meta-support-ayer and disposing a second mono-ayer of superabrasive particles on the meta-support-ayer on a side opposite the first mono-ayer. As yet another exemplary aspect of the present disclosure, a CMP pad dresser can include a rigid support substrate and a mono-ayer of a plurality of superabrasive particles coupled to the support substrate, where the plurality of superabrasive particles includes a plurality of work ng superabrasive particles, such that rotating the dresser against a CMP pad cuts asperities into the CMP pad having a cutting depth of less than or equal to about 50 microns. In another aspect, the cutting depth is from about 10 microns to about 50 microns. In yet another aspect, the plurality of work ng superabrasive particles includes at least 100 work ng superabrasive particles. In a further aspect, the plurality of work ng superabrasive particles includes at least 1000 work ng superabrasive particles. In yet another aspect, the plurality of work ng superabrasive particles includes from about 1000 to about 6000 work ng superabrasive particles. In another aspect, the plurality of work ng superabrasive particles includes from about 2000 to about 5000 work ng superabrasive particles. In a further aspect, the plurality of work ng superabrasive particles includes at least about 1000 work ng superabrasive particles that protrude from the rigid support substrate to distances within about 30 microns of one another.~~

~~As another exemplary aspect of the present disclosure, a method of dressing a CMP pad can include applying a CMP pad dresser to a CMP pad, and moving at least one of the CMP pad or the CMP pad dresser with respect to one another to cut asperities into the CMP pad having a cutting depth of from about 10 microns to about 50 microns.~~

~~As a further exemplary aspect of the present disclosure, a CMP pad dresser is provided including a support substrate and a plurality of superabrasive particles secured to the support substrate and positioned to engage and dress a CMP pad, where the plurality of superabrasive particles cut to depths of less than 50 microns into a CMP pad during a dressing procedure.~~

~~The superabrasive particles of the second mono-ayer are positioned to have substantially the same distal but on as the superabrasive particles of the first mono-ayer. The method further includes bonding the first mono-ayer of superabrasive particles and the second mono-ayer of superabrasive particles to the meta-support-ayer such that symmetrical forces due to the substantially symmetrical distal but on between the first mono-ayer and the second mono-ayer precludes substantial warpage of the meta-support-ayer. In one aspect, the method can further include coupling the second mono-ayer of superabrasive particles to a rigid support.~~

~~In one aspect, the bonding of at least one of the first mono-ayer and the second mono-ayer is by brazing with a brazematerial. In another aspect, the bonding of at least one of the first mono-ayer and the second mono-ayer is under heat and pressure. In one specific aspect, the heat and pressure bonds at least one of the first mono-ayer and the second mono-ayer directly to the meta-support-ayer. In another specific aspect, the bonding of at least one of the first mono-ayer and the second mono-ayer further includes disposing a sintering compound on the meta-support-ayer in contact with at least one of the first mono-ayer and the second mono-ayer and sintering the sintering compound to bond the at least one of the first mono-ayer and the second mono-ayer to the meta-support-ayer. In one specific aspect, the method further includes infiltrating the sintering compound with a brazematerial during bonding.~~

~~In yet another aspect, a method of minimizing warpage of a CMP pad dresser during manufacture is provided. Such a method can include substantially equalizing warpage forces on opposing sides of a meta-support-ayer during bonding of a plurality of superabrasive particles thereto, where warpage of the support-ayer is minimized during bonding due to the equalized forces on opposing sides. In one aspect, substantially equalizing forces includes arranging the plurality of superabrasive particles on opposing sides of the support-ayer such that the plurality of superabrasive particles has substantially the same distal but on on either side of the support-ayer to substantially equalize warpage forces during bonding.~~

~~In a further aspect, a CMP pad dresser is provided. Such a dresser can include a plurality of superabrasive particles arranged as a work ng surface, where the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns, the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns, the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns, and the highest protruding tip has a protrusion distance of greater than or equal to about 50 microns.~~

There has thus been outlined, rather broadly, various features of the invention so that the detailed description thereof that follows may be better understood, and so that the present contribution to the art may be better appreciated. Other features of the present invention will become clearer from the following detailed description of the invention, taken with the accompanying claims, or may be learned by the practice of the invention on.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present ~~invention~~ disclosure;

FIG. 2 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present ~~invention~~ disclosure;

FIG. 3 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present ~~invention~~ disclosure; and

FIG. 4 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present ~~invention~~ disclosure.

~~FIG. 5 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention;~~

It will be understood that the above figures are merely for illustrative purposes in furthering an understanding of the invention. Further, the figures are not drawn to scale, thus dimensions, proportions, and other aspects may, and generally are, exaggerated to make illustrations thereof clearer. Therefore, departure can be made from the specific dimensions and aspects shown in the figures in order to produce the heat spreaders of the present invention.

DETAILED DESCRIPTION

Before the present invention is disclosed and described, it is to be understood that this invention is not limited to the particular structures, method steps, or materials disclosed herein, but is extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular embodiments only and is not intended to be limiting.

It must be noted that, as used in this specification and the appended claims, the singular forms "a," "an" and, "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a diamond part" includes one or more of such parts and reference to "the layer" includes reference to one or more of such layers.

DEFINITIONS

In describing and claiming the present invention, the following terminology will be used in accordance with the definitions set forth below.

As used herein, the terms "conditioner" and "dresser" can be used interchangeably, and refer to a tool used to condition or dress a pad, such as a CMP pad.

~~As used herein, "dressing segment" refers to a dressing or conditioning element of a CMP pad dresser. Dressing segments are utilized in the present invention to carry superabrasive particles having edge tips. Thus superabrasive particles are introduced into a CMP pad dresser by the incorporation of multiple dressing segments. It should be noted that a variety of techniques of attaching the dressing segments to the substrates, and a variety of techniques of attaching the superabrasive particles to the dressing segments, are discussed herein. It is to be understood that a of these various attachment mechanisms can be used interchangeably herein: that is, a method of attaching a dressing segment to a substrate is discussed herein, the method of attachment discussed can also be used to attach a superabrasive particle to a dressing segment. For any particular CMP pad dresser being discussed, however, it is understood that attachment methods of the superabrasive particles to the dressing segments can differ from, or can be the same as, the method used to attach the dressing segments to the pad conditioner substrate.~~

As used herein, "superabrasive" may be used to refer to any crystalline, or polycrystalline material, or mixture of such materials ~~which that~~ has a Mohr's hardness of about 8 or greater. In some aspects, the Mohr's hardness may be about 9.5 or greater. Such materials include but are not limited to diamond, polycrystalline diamond (PCD), cubic boron nitride (cBN), polycrystalline cubic boron nitride (PcBN), corundum and sapphire, as well as other superabrasive materials known to those skilled in the art. Superabrasive materials may be incorporated into the present invention in a variety of forms including particles, grits, films, layers, pieces, segments, etc. In some cases, the superabrasive materials of the present invention are the very inert and thus difficult to form of polycrystalline chemical bonds with, it is known that certain reactive elements, such as chromium and titanium are capable of chemically reacting with superabrasive materials, such as PCD and PcBN materials at certain temperatures.

~~As used herein, "organic material" refers to a semiconductor or semiconductor of organic compounds. "Organic material" and "organic matrix" may be used interchangeably, and refer to a layer or mass of a semiconductor or semiconductor of organic compounds, including resins, polymers, gums, etc. The organic material can be a polymer~~

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~~or copolymer formed from the polymerization of one or more monomers. In some cases, such organic material can be adhesive.~~

~~As used herein, the process of "brazeing" is intended to refer to the creation of chemical bonds between the carbon atoms of the superabrasive particles/materials and the braze material. Further, "chemical bond" means a covalent bond, such as a carbide or boride bond, rather than mechanical or weaker interatomic attractive forces. Thus, when "brazeing" is used in connection with superabrasive particles, a true chemical bond is being formed. However, when "brazeing" is used in connection with metal-to-metal bonding, the term is used in the more traditional sense of a metalurgical bond. Therefore, brazeing of a superabrasive segment to a tool body does not necessarily require the presence of a carbide former.~~

As used herein, "particle" ~~as~~ refers, when used herein in connection with ~~diamonds~~ superabrasive particles, and refers to a particulate form of ~~diamonds~~ superabrasive particle. Such particles may take a variety of shapes, including round, oblong, square, euhedra, etc., can be either single crystals or polycrystalline, and can have a number of mesh sizes. As is known in the art, "mesh" refers to the number of holes per unit area, as in the case of U.S. meshes. A mesh size referred to herein are U.S. mesh unless otherwise indicated. Further, mesh sizes are generally understood to indicate an average mesh size of a given collection of particles since each particle within a particular "mesh size" may actually vary over a small distribution of sizes. unless noted otherwise.

As used herein, "working superabrasive particles" are superabrasive particles that cut or otherwise deform a CMP pad during a dressing or conditioning procedure. This action can remove debris from the surface, it can deform the surface either aesthetically or pastcally, or it can create a groove or asperity in the surface of the CMP pad. In one specific aspect, a working superabrasive particle can cut deeper than about 10 microns into a CMP pad during a dressing procedure.

As used herein, "non-working superabrasive particles" are superabrasive particles in a CMP pad dresser that do not significantly cut or deform the pad sufficient to remove debris from the surface, deform the surface, or create grooves in the surface.

As used herein, "overly-aggressive superabrasive particles" are superabrasive particles in a CMP pad dresser that aggressively dress or condition a CMP pad. In one aspect, aggressive superabrasive particles are superabrasive particles that cut deeper than about 50 microns into a CMP pad during a dressing procedure. In another aspect, aggressive superabrasive particles are superabrasive particles that remove at least 1/5 of the material from the CMP pad. In yet another aspect, aggressive superabrasive particles are superabrasive particles that remove at least 1/2 of the material from the CMP pad.

As used herein, "working end" refers to an end of a particle that is oriented towards the CMP pad and that during a dressing operation makes contact with the pad. In many cases the working end of a particle will be distant from a substrate to which the particles are attached.

As used herein, cutting "tip" refers to a portion of a cutting element or particle that protrudes the greatest distance from the support substrate, e.g., that is the first portion of the cutting element that contacts a CMP pad when in use. It is to be understood that a cutting "tip" can include a planar surface, a pointed surface, or an edge; so long as the planar surface, pointed surface or edge of the cutting element is the first portion of the cutting element that contacts a CMP pad from which material is to be removed.

As used herein, "sharp portion" ~~means~~ refers to any narrow portion to which a crystal or particle may ~~come~~ converge, including but not limited to corners, apexes, ridges, edges, obelisks, and other protrusions. In some cases, corners and/or apexes are formed at the convergence of more than two faces of the particle or crystal, or other body, disposed in intersecting planes. In other aspects, edges and/or ridges may be formed at the convergence of two or at least two faces of the particle or crystal, or other body, disposed in intersecting planes. In some aspects, "sharp portion" can include a portion that is broken, chipped, cracked, jagged, and the like. In some aspects, degrees of sharpness can be correlated with the geometric angle formed by the particle, crystal, or other body, at the location in question. In some aspects, an angle of 90 degrees or less can be considered sharp. In other aspects, an angle of 60 degrees or less can be considered sharp. In yet other aspects, an angle of 45 degrees or less, or 30 degrees or less can be considered to be sharp.

As used herein, cutting "edge" refers to a portion of a cutting element or particle that includes some measurable width across a portion that contacts and removes material from a workpiece. As an exemplary illustration, a typical knife blade has a cutting edge that extends longitudinally along the knife blade, and the knife blade would have to be oriented transverse to a workpiece to scrape or plane material from the workpiece in order for the cutting "edge" of the knife blade to remove material from the workpiece.

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As used herein, "peripherally located," "peripheral location," and the like, ~~mean~~refer to any part ~~of~~ or other cutting element of a dresser that is located in an area that originates at the leading edge or outer rim of a dresser and extends inwardly towards the center for up to about 90% of the radius of the dresser. In some aspects, the area may extend inwardly from about 20% to 90% of the radius. In other aspects, the area may extend in to about 50% of the radius. In yet another aspect, the area may extend in to about 33% of the radius of a dresser (i.e. 66% away from the center).

~~As used herein, "working end" refers to an end of a part which is oriented towards the CMP pad and during a dressing operation makes contact with the pad. Most often the working end of a part will be distal from a substrate to which the part is attached.~~

~~As used herein, "centrally located part," "part in a central location," and the like refer to any part or other cutting element of a tool that is located in an area of the tool that originates at a center point of the tool and extends outwardly towards the tool's edge for up to about 90% of the radius of the tool. In some aspects, the area may extend outwardly from about 20% to about 90% of the radius. In other aspects, the area may extend out to about 50% of the radius. In yet another aspect, the area may extend out to about 33% of the radius of a tool.~~

As used herein, "attitude" ~~means~~refers to the position or arrangement of a superabrasive part in relation to a defined surface, such as a substrate to which it is attached, or a CMP pad to which it is to be applied during a work operation. For example, a superabrasive part can have an attitude that provides a specific portion of the part in orientation toward a CMP pad.

~~As used herein, "leading edge" refers to the edge of a CMP pad dresser that is a front edge based on the direction that the CMP pad is moving, or the direction that the pad is moving, or both. Notably, in some aspects, the leading edge may be considered to encompass not only the area specifically at the edge of a dresser, but may also include portions of the dresser which extend slightly inward from the actual edge. In one aspect, the leading edge may be located along an outer edge of the CMP pad dresser. In another aspect, the CMP pad dresser may be configured with a pattern of abrasive particles that provides at least one effective leading edge on a central or inner portion of the CMP pad dresser working surface. In other words, a central or inner portion of the dresser may be configured to provide a functional effect similar to that of a leading edge on the outer edge of the dresser.~~

~~As used herein, the term "profile" and "geometric profile" can be used interchangeably, and refer to a predetermined contour above a support substrate to which a plurality of superabrasive particles or other cutting elements are intended to a gain. Examples of such profiles may include, without limitation, flat or planar profiles, curved profiles, wavy profiles, convex profiles, concave profiles, multi-terred profiles, and the like, including combinations thereof.~~

~~As used herein, "geometric configuration" refers to a shape that is capable of being described in readily understood and recognized mathematical terms. Examples of shapes qualifying as "geometric configurations" include, without limitation, cubic shapes, polyhedra (including regular polyhedra) shapes, triangular shapes (including equilateral triangles, isosceles triangles and three-dimensional triangular shapes), pyramidal shapes, spheres, rectangles, "pent" shapes, wedge shapes, octagonal shapes, circles, etc.~~

As used herein "dressing segment" refers to a dressing or conditioning element of a CMP pad dresser. In one aspect, dressing segments are utilized to carry superabrasive particles having edge tips. Thus, in some cases superabrasive particles can be introduced into a CMP pad dresser by the incorporation of multiple dressing segments. It should be noted that a variety of techniques of attaching the dressing segments to the substrates, and a variety of techniques of attaching the superabrasive particles to the dressing segments, are possible, any of which are considered to be within the present scope. It is to be understood that any of these various attachment mechanisms can be used interchangeably herein: that is, for a method of attaching a dressing segment to a substrate is discussed herein, the method of attachment discussed can also be used to attach superabrasive particles to a dressing segment. For any particular CMP pad dresser being discussed, however, it is understood that attachment methods of the superabrasive particles to the dressing segments can differ from or can be the same as the method used to attach the dressing segments to the pad conditioner substrate.

~~As used herein, "cutting element" describes a variety of structures capable of removing (e.g., cutting) material from a CMP pad. A cutting element can be a mass having several cutting points, ridges or mesas formed thereon or thereon. It is notable that such cutting points, ridges or mesas may be from a multiplicity of protrusions or asperities included in the mass. Furthermore, a cutting element can also refer to an individual part that may have only one cutting point, ridge or mesa formed thereon or thereon.~~

As used herein, "organic material" refers to a semisolid or solid complex or mix of organic compounds. "Organic material layer" and "organic matrix" may be used interchangeably and refer to a layer or mass of a semisolid or solid complex or mix of organic compounds including resins, polymers, gums, etc. The organic material can be a polymer

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or copolymer formed from the polymerization of one or more monomers. In some cases, such organic material can be adhesive.

As used herein, the process of "brazing" is intended to refer to the creation of chemical bonds between the carbon atoms of the superabrasive particles/materials and the braze material. Either "chemical bond" means a covalent bond, such as a carbide or boride bond, rather than mechanical or weaker inter-atom attractive forces. Thus, when "brazing" is used to connect with superabrasive particles, a true chemical bond is being formed. However, when "brazing" is used to connect with metal to metal bonding, the term is used in the more traditional sense of a metalurgical bond. Therefore, brazing of a superabrasive segment to a tool body does not necessarily require the presence of a carbide former.

As used herein, "mechanical bond" and "mechanical bonding" may be used interchangeably, and refer to a bond interface between two objects or layers formed primarily by frictional forces. In some cases the frictional forces between the bonded objects may be increased by expanding the contacting surface areas between the objects, and by imposing other specific geometrical and physical configurations, such as substantially surrounding one object with another.

As used herein, "sintering" refers to the joining of two or more individual parts to form a continuous solid mass. The process of sintering involves the consolidation of particles to at least partially eliminate voids between particles. Sintering may occur in either metal or carbonaceous particles, such as diamond. Sintering of metal particles occurs at various temperatures depending on the composition of the material. Sintering of diamond particles generally requires ultrahigh pressures and the presence of a carbon solvent as a diamond sintering aid. Sintering aids are often present to aid in the sintering process and a portion of such may remain in the final product.

The term "metal" refers to both metals and metalloids. Metals include those compounds typically considered metals found within the transition metals, alkali and alkali earth metals. Examples of metals are Ag, Au, Cu, Al, and Fe. Metalloids include semiconductors, S, B, Ge, Sb, As, and Te. Metal materials also include alloys or mixtures that include metal materials. Such alloys or mixtures may further include additional additives. In the present invention, carbide formers and carbon wetting agents may be included as alloys or mixtures, but are not anticipated to be the only metal component. Examples of such carbide formers are Sc, Y, Ti, Zr, Hf, V, Nb, Cr, Mo, Mn, Ta, W, and Ta. Examples of carbon wetting agents are Co, Ni, Mn, and Cr.

As used herein, "infiltrating" refers to a situation where a material is heated to its melting point and then flows as a liquid through the interstitial voids between particles.

As used herein, the terms "substrate" and "support substrate" can be used interchangeably, and refer to a portion of a pad conditioner that supports superabrasive material, and to which abrasive material and/or superabrasive segments that carry abrasive material may be affixed. Substrates can have a variety of shapes, thicknesses, and/or materials that are capable of supporting abrasive material in a manner that is sufficient to provide a CMP pad dresser useful for its intended purpose. Substrates may be of a solid material, a powdered material that becomes solid when processed, or a flexible material. Examples of typical substrate materials include without limitation, metals, metal alloys, ceramics, relatively hard polymers or other organic materials, glasses, and mixtures thereof. Further, the substrate may include a material that aids in attaching abrasive material to the substrate, including, without limitation, brazing alloy material, sintering aids and the like.

As used herein, the term "substantially" refers to the complete or nearly complete extent or degree of an action, characteristic, property, state, structure, item, or result. For example, an object that is "substantially" enclosed would mean that the object is either completely enclosed or nearly completely enclosed. The exact allowable degree of deviation from absolute completeness may in some cases depend on the specific context. However, generally speaking the nearness of completion will be so as to have the same overall result as if absolute and total completion were obtained.

The use of "substantially" is equally applicable when used in a negative connotation to refer to the complete or nearly complete lack of an action, characteristic, property, state, structure, item, or result. For example, a composition that is "substantially free of" particles would either completely lack particles, or so nearly completely lack particles that the effect would be the same as if completely lacked particles. In other words, a composition on that is "substantially free of" an ingredient or element may still actually contain such item as long as there is no measurable effect thereof.

As used herein, the term "about" is used to provide flexibility to a numerical range endpoint by providing that a given value may be "at least above" or "at least below" the endpoint. However, it is to be understood that even when the term "about" is used in the present specification in connection with a specific numerical value, that support for the exact numerical value recited apart from the "about" term is also provided.

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In this disclosure, “comprises,” “comprising,” “containing” and “having” and the like can have the meaning ascribed to them in U.S. Patent law and can mean “includes,” “including,” and the like, and are generally interpreted to be open ended terms. The terms “consisting of” or “consists of” are closed terms, and include only the components, structures, steps, or the like specified by the claim in connection with such terms, as well as that which is in accordance with U.S. Patent law. “Consisting essentially of” or “consists essentially of” have the meaning generally ascribed to them by U.S. Patent law. In particular, such terms are generally closed terms, with the exception of a following inclusion of additional terms, materials, components, steps, or elements, that do not materially affect the basic and novel character of the invention of the claim(s) used in connection therewith. For example, trace elements present in a composition, but not affecting the composition's nature or characteristics would be permissible present under the “consisting essentially of” language, even though not expressly recited in a list of terms following such term. When using an open ended term, the “comprising” or “including” is understood that direct support should be afforded so to “consisting essentially of” language as well as “consisting of” language as further stated explicitly and vice versa.

As used herein, a plurality of terms, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually defined as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on the representation in a common group without indications to the contrary.

Concentrations, amounts, and other numerical data may be expressed or presented herein in a range format. It is to be understood that such a range format is used merely for convenience and brevity and thus should be interpreted flexibly to include not only the numerical values explicitly recited as the limits of the range, but also to include all the individual numerical values or sub-ranges encompassed within that range as well as each numerical value and sub-range explicitly recited. As an illustration, a numerical range of “about 1 to about 5” should be interpreted to include not only the explicitly recited values of about 1 to about 5, but also to include individual values and sub-ranges within the indicated range. Thus, included numerical ranges are individual values such as 2, 3, and 4 and sub-ranges such as from 1-3, from 2-4, and from 3-5, etc., as well as 1, 2, 3, 4, and 5, individually. The same principle applies to ranges reciting only one numerical value as a minimum or a maximum. Furthermore, such an interpretation should apply regardless of the breadth of the range or the characteristics being described.

The Invention

The present disclosure generally provides CMP pad dressers ~~and methods~~ associated methods that can be utilized with the pad condition (e.g., smoothing, polishing, dressing) ~~), and the CMP pad-polishing of a work piece.~~ Pad conditioners according to aspects of the present ~~invention and disclosure~~ can be advantageously utilized, for example, in dressing CMP pads that are used in polishing, finishing or otherwise affecting semiconductor materials. Specifically, in some aspects the present disclosure concerns CMP pad dressers having superabrasive particles with substantial evened tips. In other aspects, the present CMP pad dressers can have superabrasive particles that are a gned across a designated profile, and as such, are “evened” with respect to that profile. Traditional CMP pad dresser manufacturing methods, even many of those describing techniques for evening superabrasive particles prior to fixation, generally contain significant variation in tip height across the surface of the dresser ~~that is not accounted for by an intended tip alignment profile.~~ Often, the superabrasive particles are affixed to the CMP pad dresser support in a manner that disrupts any evening that has occurred. For example, fixation techniques that utilize high heat and/or pressure can cause warping of the dresser support as the dresser cools. Thus, unnecessary steps are taken to avoid such warpage, superabrasive particles are not maintained in the required state following cooling of the dresser. This can be particularly problematic with brazing techniques.

Accordingly, minimizing the warpage of the meta-support layer can maintain a greater degree of evening of superabrasive particles in the finished tool. When heat and/or pressure are used to make a superabrasive tool, warpage of the meta-support layer can cause great variations in tip height even, even for those particles that were evened prior to heating and/or applying pressure. By distributing the warpage forces equally or substantially equally on both sides of the meta-support layer through the arrangement of the superabrasive particles, these forces effectively cancel each other with respect to the degree of warpage occurring in the meta-support layer, thus also minimizing the relative height movement of the superabrasive particles relative to one another.

A CMP pad dresser can be used to dress or condition a CMP pad by removing dirt and debris (i.e. degazing the pad), as well as opening up asperities in the pad surface to capture and hold chemicals during a polishing procedure. As has been described, due to difficulties associated with superabrasive particles evening in many traditional manufacturing processes, only a small percentage of superabrasive particles in a typical CMP pad dresser are positioned so as to penetrate or cut into a CMP pad. As this small percentage of superabrasive particles become worn, plastic deformation of the CMP pad becomes directly related to the amount of CMP of pad that is cut.

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Consequently, the pad becomes highly deformed and accumulated with dirt. As a result the polishing rate of the CMP pad decreases, and the scratch rate of the wafer or work piece increases.

CMP pads are typically made of a relatively soft polymer, such as, for example, polyurethane. As the CMP pad is engaged by the CMP pad dresser, the polymer material is deformed first by elastic strain and then by plastic strain. Eventually, the strain energy in the deformed material exceeds the bond energy density (i.e. the hardness of the pad) and the polymer material ruptures. Thus, the function of superabrasive particles in the CMP pad dresser is to dress the CMP pad material by breaking polymer bonds through this deformation process. It should be noted that sharp superabrasive particles can penetrate the CMP pad material without causing excessive deformation. As such, the sharpness of a superabrasive particle can be defined as being inverse to the deformed volume prior to rupture. In other words, the smaller the volume of deformation prior to cutting, the sharper the cutting tip. This deformation information can be used to determine the sharpness of superabrasive particles in the CMP pad dresser.

Additionally, a superabrasive particle having a tip with smaller tip radius, such as would be the case with a broken corner, can cut more cleanly through the CMP pad with less deformation as compared to a superabrasive particle having a larger tip radius. Consequently, an irregularly shaped superabrasive particle tip can be sharper than a euhedra superabrasive corner having an obtuse angle relative to the CMP pad. This also applies to the difference between a superabrasive particle corner as compared with a superabrasive particle face.

It is thus noted that sharp superabrasive particles can cut CMP pad material with less deformation and material strain. Conversely, a dull superabrasive particle may deform but not cut the CMP pad material because the strain energy does not exceed the bond energy density of the polymer material. As the tips of such particles are worn, the contact area between the polymer material and the particles increase. This increase in contact area results in an increase in the deformation volume of the pad. Due to the increased strain energy required for the polymer material to rupture with such an increased deformation volume, the number of superabrasive particles cutting the polymer material will decrease in relation to the degree of dulling during a CMP process.

CMP pad dressing can also be affected by the proportion of superabrasive particles in the CMP pad dresser that are working and the proportion that are over-y-aggressive cutting. As an example, a typical CMP pad dresser can have greater than 10,000 superabrasive particles. Of these 10,000 particles, in some cases there may only be a few working superabrasive particles that are actually able to cut the CMP pad. Additionally, out of these few working superabrasive particles, there may be a smaller proportion of over-y-aggressive superabrasive particles that cut over 50% of the entire pad that is consumed during cond t on ng, and in some cases can remove more than 25% of the total pad material. This uneven workload distribution can cause erratic CMP performance, and can result in over consumption of the CMP pad, chipping of the over-y-aggressive superabrasive particles that can scratch the wafer, unpredictable wafer removal rates, uneven wafer surface planarization, shortened CMP pad dresser life, compaction of the CMP pad with debris, and the like. Such effects can greatly lower the yield of wafers or work pieces processed under these conditions. A more effective normalization of workload distribution across the surface of the CMP pad dresser can lead to a more uniformly deglazed pad and more uniform pad asperities.

The present CMP pad dressers include a layer of superabrasive particles having substantially evened tips across the working surface of the finished CMP pad dresser. A variety of techniques can be utilized to maintain tip evenness, and any such techniques considered to be within the present scope. A few non-limiting examples of such techniques are described below. It is intended that the term "evening" with respect to superabrasive particles can refer to superabrasive particles that are evened with respect to a planar profile, as well as to superabrasive particles that are assigned a designated profile that is non-planar. In the latter case, "evening" would thus describe the assignment of the superabrasive particles a along the designated profile. So in the case of a profile having a dome-shape, evened superabrasive particles would be particles that were in alignment with the profile.

Furthermore, superabrasive tip assignment can additionally be described in terms of height distribution, or in some cases protrusion distance from the support substrate that is represented by a height distribution across the periphery of superabrasive particles. An even height distribution of superabrasive particles may function to more effectively preserve the integrity of the CMP pad dresser as compared to CMP pad dressers lacking such an even height distribution. Similarly, a periphery of superabrasive particles can be described as extending away from a support substrate to a predetermined height, represented by a protrusion distance from the substrate, where the predetermined heights of the particles assign a designated profile. Thus, the actual distribution of protrusion distances across the periphery of superabrasive particles in a finished dresser can be compared against the designated profile to determine the variance, or degree of "evening" achieved.

In one aspect, as is shown in FIG. for example, a CMP pad dresser is provided including a support substrate and a periphery of superabrasive particles secured to the support substrate, with each superabrasive particle extending away from the support substrate to a protrusion distance, where the highest protruding tip of each of the periphery of superabrasive particles assign a designated profile. Where it is intended that the tips of the superabrasive

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part c es a gn a ong the des gnated prof e, some eve of dev at on may occur. These dev at ons may be a resu t of the des gn or manufactur ng process of the too . G ven the w de var ety of s zes of superabras ve part c es that may potent a y be ut zed n a g ven too , such dev at ons may be h gh y dependent on a part cu ar app cat on. A so, when referr ng to the des gnated prof e, t shou d be noted that the term "tp" s ntended to ncude the h ghest protrud ng po nt of a superabras ve part c e, whether that po nt be an apex, an edge, or a face.

As such, n one aspect the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 1, a CMP pad dresser, m cron to about 150 m crons. In another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 5 m crons to about 100 m crons. In yet another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 10 neudes a m crons to about 75 m crons. In a further aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 10 m crons to about 50 m crons. In another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 50 m crons to about 150 m crons. In yet another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 20 m crons to about 100 m crons. In a further aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 20 m crons to about 50 m crons. In another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 20 m crons to about 40 m crons. Add t ona y, n one aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by ess than about 20 m crons. In another aspect the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by ess than about 10 m crons. In yet another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by ess than about 5 m crons. In yet another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by ess than about 1 m cron. In a further aspect, a ma or ty of the p ura ty of superabras ve part c es are arranges such that the r t ps vary from the des gnated prof e to ess than about 10% of the average s ze of the superabras ve part c es.

In another aspect, each of the p ura ty of superabras ve part c es can be def ned by a protrus on d stance from an exposed surface of a b nd ng mater a from wh ch they protrude to a predeterm ned he ght. Though the predeterm ned he ght may vary between too app cat ons, n one aspect the predeterm ned he ght may be greater than about 20 m crons. In another aspect the var at on from the predeterm ned he ght may be from about 1 m cron to about 20 m crons. In yet another aspect the var at on from the predeterm ned he ght may be from about 5 m crons to about 20 m crons. In a further aspect the var at on from the predeterm ned he ght may be from about 10 m crons to about 20 m crons. Superabras ve part c es may a so be arranged w th respect to arrangement or d str but on, att tude, s ze, etc. Furthermore, the d str but on of protrus on of the p ura ty of superabras ve part c es s refected n the depth that the part c es cut nto a CMP pad.

As such, n one spec f c aspect the predeterm ned he ght or protrus on d stance may produce a cutt ng depth of ess than about 20 m crons when used to dress a CMP pad. In another spec f c aspect, the predeterm ned he ght or protrus on d stance may produce a cutt ng depth of from about 1 m cron to about 20 m crons when used to dress a CMP pad. In yet another spec f c aspect, the predeterm ned he ght or protrus on d stance may produce a cutt ng depth of from about 10 m cron to about 20 m crons when used to dress a CMP pad. It shou d a so be noted that the eve ng of superabras ve part c es to a predeterm ned he ght may be dependent on superabras ve part c e spac ng. In other words, the farther superabras ve part c es are separated, the more the mp ng ng forces w affect each superabras ve part c e. As such, patterns w th ncreased spac ng between the superabras ve part c es may benef t from a sma er var at on from predeterm ned he ght.

In one spec f c examp e, a p ura ty of cutt ng e ements such as superabras ve part c es can protrude to a predeterm ned he ght above a b nd ng mater a such as, for examp e, a so d fed organ c mater a ayer. Though any predeterm ned he ght that wou d be usefu n an abrad ng or cutt ng too wou d be cons dered to be w th n the present y c a med scope, n one spec f c aspect the predeterm ned he ght may produce a cutt ng depth of ess than about 20 m crons when used to abrade a workp ece. In another spec f c aspect, the predeterm ned he ght may produce a cutt ng depth of from about 1 m cron to about 20 m crons when used to abrade a workp ece. In yet another spec f c aspect, the predeterm ned he ght may produce a cutt ng depth of from about 10 m cron to about 20 m crons when used to abrade a workp ece. In yet another aspect, the predeterm ned he ght may produce a depth of up to or more than 50 or 100 m crons.

As a further examp e, t may a so be benef c a for the cutt ng e ements to protrude from the b nd ng mater a , for examp e, so d fed organ c mater a ayer to a predeterm ned he ght or ser es of he ghts that s/are a ong a des gnated prof e. Numerous configurat ons for des gnated prof es are poss b e, depend ng on the part cu ar use of the abrad ng too . In one aspect, the des gnated prof e may be a p ane. In p anar prof es, the h ghest protrud ng po nts of the cutt ng e ements are ntended to be substant a y eve . It s mportant to po nt out that, though t s preferred that these

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points again with the designated profile, there may be some height deviation between cutting elements that occur due to variations inherent in the manufacturing process.

In addition to planar profiles, in another aspect the designated profile has a slope. Tools having sloping surfaces may function to more evenly spread the frictional forces imparting thereon across the cutting elements, particularly for rotating tools such as disk sanders and CMP pad dressers. The greater downward force applied by higher central portions of the tool may offset the higher rotational velocity at the periphery, thus reducing the mechanical stress experienced by cutting elements in that location. As such, the slope may be continuous from a central point of the tool to a peripheral point, or the slope may be discontinuous, and thus be present on only a portion of the tool. Similarly, a given tool may have a single slope or multiple slopes. In certain aspects, the tool may slope in a direction from a central point to a peripheral point, or it may slope from a peripheral point to a central point.

Various slopes are contemplated that may provide a benefit to so defined organic materialayer tools. It is not intended that the claims of the present invention be limited as to specific slopes, as a variety of slopes in numerous different tools are possible. In one aspect, however, a CMP pad dresser may benefit from an average slope of 1/1000 from the center to the periphery.

As a variation on tools having a slope, in certain aspects the designated profile may have a curved shape. One specific example of a curved shape is a dome shape tool. Such curved profiles function in a similar manner to the sloped surfaces. Tools may include such curved profiles in order to more effectively distribute the frictional forces between a set of the cutting elements, thus reducing failures of individual parts and prolonging the life of the tool.

Furthermore, in some aspects the determination of the distance that the tips of the cutting elements extend from a binder material, such as an organic binder, can also be affected by considering how much of the cutting elements extend above the binder compared to how much of the cutting elements remain submerged beneath the binder surface. In one aspect, a ratio of an amount the cutting elements protrude above the binder to an amount submerged beneath the binder is about 4 to 1. In another aspect, about 2/3 of the cutting elements are submerged, with about 1/3 being exposed above the binder. Other ratios are also possible, from a 20 to 1 ratio to about 0.2 to 1, inclusive of ranges therebetween.

As a non-limiting example, in one aspect a CMP pad dresser can include a support substrate, such as a rigid support substrate, and a monolayer of a plurality of superabrasive particles ~~12 embedded in a matrix layer 14~~, such that each superabrasive particle is in the monolayer coupled to the support substrate, where the plurality of superabrasive particles includes a plurality of working superabrasive particles. In use the dresser can be engaged against a CMP pad and cut asperities into the CMP pad having a cutting depth of less than or equal to about 50 microns. In another aspect, the cutting depth is from about 10 microns to about 50 microns. Additionally, in one aspect the plurality of working superabrasive particles includes at least 100 working superabrasive particles, at least 300 working superabrasive particles, or at least 500 working superabrasive particles. In another aspect, the plurality of working superabrasive particles includes at least 1000 working superabrasive particles. In yet another aspect, the plurality of working superabrasive particles includes from about 1000 to about 6000 working superabrasive particles. In a further aspect, the plurality of working superabrasive particles includes from about 2000 to about 5000 working superabrasive particles. In yet another aspect, the plurality of working superabrasive particles include at least about 1000 working superabrasive particles that protrude from the rigid support substrate to distances within about 30 microns of one another.

It is noted that, in some cases, the number of working superabrasive particles can be determined by observing edge or tip wear after use in a dressing operation. As such, in one aspect a CMP pad dresser can have greater than about 300 superabrasive particles with worn tips or edges following a CMP pad dressing procedure. In another aspect, a CMP pad dresser can have greater than about 500 superabrasive particles with worn tips or edges following a CMP pad dressing procedure. In a further aspect, a CMP pad dresser can have greater than about 1000 superabrasive particles with worn tips or edges following a CMP pad dressing procedure.

In one example, superabrasive particle tips can be described in terms of the distance that each superabrasive particle protrudes from the binding material, or matrix layer. The difference in protrusion distance ~~16~~ between the highest protruding tip ~~17~~ and the next highest protruding tip ~~18~~ of the monolayer of superabrasive particles is ~~less than or equal to about 20 microns. In some aspects, described as the protrusion difference may.~~ In one aspect, the protrusion difference can be less than or equal to about 50 microns. In another aspect, the protrusion difference can be less than or equal to about 20 microns. In a further aspect, the protrusion difference can be less than or equal to about 10 microns. It is noted that the term "protrusion difference" can also be used to describe the difference in protrusion distance between any two or more superabrasive particles.

In another aspect, and in addition to the protrusion difference between the highest two protruding tips, the difference in protrusion distance between the highest 10 protruding tips of the monolayer of superabrasive particles are within

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about 30 microns or less. In yet another aspect, the difference in protrusion distance between the highest 10 protruding tips of the mono layer of superabrasive particles are within about 20 microns or less.

Additionally, in some aspects the difference in protrusion distance between the highest 1% of the protruding tips of the first mono layer of superabrasive particles are can be within about 80 microns or less. In other words, for the 1% of the plurality of superabrasive particles that have the highest protruding tip, the variance in protrusion distance for that 1% is less than or equal to about 80 microns. In other words, for the 1% of the plurality of superabrasive particles that have the highest protruding tip, the variance in protrusion distance for that 1% is less than or equal to about 80 microns. Thus, for example, the two highest protruding superabrasive particles protrude to within about 2010 microns or less of each other, and in addition, the highest protruding 1% of superabrasive particles protrude to within about 80 microns or less of each other. In another aspect, the difference in protrusion distance between the highest protruding tip and the next highest protruding tip of the mono layer of superabrasive particles is less than or equal to about 15 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the next highest protruding tip of the mono layer of superabrasive particles is less than or equal to about 10 microns. In a further aspect, the difference in protrusion distance between the highest 1% of the protruding tips of the first mono layer of superabrasive particles are within about 7060 microns or less. In yet another aspect, the difference in protrusion distance between the highest 1% of the protruding tips of the first mono layer of superabrasive particles are within about 50 microns or less. In another aspect, and in addition to the protrusion variance of the highest two protruding tips, the difference in protrusion distance between the highest 10 protruding tips of the mono layer of superabrasive particles are within about 30 microns or less. In yet another aspect, the difference in protrusion distance between the highest 100 protruding tips of the mono layer of superabrasive particles are within about 50 microns or less. Additionally, in one aspect, the rigid support can be coupled to the matrix layer (not shown) 40 microns or less.

In another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns. In a further aspect, the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns. In yet a further aspect, the highest protruding tip protrudes from the matrix layer to a height greater than or equal to about 50 microns. In another aspect, the highest protruding tip has a protrusion distance of greater than or equal to about 50 microns.

It is noted that the recited protrusion distances can include a distribution across the entire mono layer surface or a discrete area or segment of the mono layer. For example, the highest 1% of protruding tips can be located around the periphery of the mono layer. In one aspect, for example, substantial a y a of the asperities are cut in the CMP pad by superabrasive particles located at a periphery location of the dresser. In another aspect, the periphery location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 90% of the dresser radius. In yet another aspect, the periphery location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 50% of the dresser radius. In a further aspect, the periphery location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 33% of the dresser radius. Additionally, in some aspects, substantial a y a of the superabrasive particles are located at a periphery location of the dresser. In other aspects, substantial a y a of the superabrasive particles are arranged in uniform predetermined pattern at a periphery location of the dresser.

In another example, discrete regions of leveled superabrasive particles can be located within a larger area of superabrasive particles having a lower protrusion distance than the leveled portion. It is also contemplated that the mono layer can include multiple regions or segments of superabrasive particles that are leveled as described, within a larger area of superabrasive particles having a lower protrusion distance.

VariousThus, the relative leveling of the mono layer of superabrasive particles can greatly affect the morphology and distribution of asperities cut into the CMP pad by the dresser. For example, in one aspect, the mono layer is leveled such that rotating the dresser against the CMP cuts asperities having a maximum cutting depth of about 80 microns. In another aspect, the mono layer is leveled such that rotating the dresser against the CMP cuts asperities having a maximum cutting depth of about 60 microns. In yet another aspect, the mono layer is leveled such that rotating the dresser against the CMP cuts asperities having a maximum cutting depth of about 40 microns. By forming pointed asperities, the contact pressure between the work piece and the CMP pad is increased, thus improving the polishing characteristics of the pad. As these pointed regions begin to flatten, the contact pressure begins to decrease, and is thereby located therebetween is less effectively pressed against the work piece. In some aspects it can be beneficial for the contact area between the pad and the wafer to be less than or equal to about 1% of the total wafer surface area facing the pad. In other aspects, it can be beneficial for the contact area between the pad and the wafer to be less than or equal to about 0.1% of the total wafer surface area facing the pad. This small contact area is due to the wafer being perched on the contact points of the asperities. During the polishing process, the sharp tips of the asperities become worn, thus increasing the contact area and decreasing the contact pressure to a point whereby the slurry

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abrasives do not effectively abrade the wafer. At this point the removal rate of material from the wafer drops, and the pad needs to be redressed to sharpen the asperities.

Additionally, the load placed on the CMP pad by the dresser can affect the morphology of the spacers, such as, in some cases, the asperity depth. The load can be adjusted for a given dresser to adjust penetration depth. In one aspect, for example, the load can be from about 0.1 Kg to about 60 Kg. In other aspects, the load can be from about 2 Kg to about 20 Kg. In further aspects, the load may be from about 6 Kg to about 12 Kg. In some aspects the load may be Kg/m². For example, in one aspect an 11.5 Kg load can allow a material removal rate from the wafer of about 200 m crons per hour for Cu layers. In a related example, an 11.5 Kg load can allow a material removal rate from the wafer of about 100 m crons per hour for oxides. In many cases, a lower load can be used in order to minimize the superabrasive particle damage (e.g., less than or equal to about 2 Kg).

Furthermore, evening of the tops of the superabrasive particles in the monolayer allows differing amounts of superabrasive particles to actually cut asperities into the pad. In one aspect, for example, the tops are evened such that at least 100 tops of the purity of superabrasive particles cut asperities into the CMP pad as the dresser is rotated. In another aspect, the tops are evened such that at least 50 tops of the purity of superabrasive particles cut asperities into the CMP pad as the dresser is rotated. In a further aspect, the tops are evened such that at least 25 tops of the purity of superabrasive particles cut asperities into the CMP pad as the dresser is rotated.

Additionally, various methods can be utilized to measure superabrasive particle top height to determine the difference in protrusion distance between tops. As such, any method for making such a determination is considered to be within the present scope. It should be noted that for the purposes of the present disclosure, the term "protrusion" refers to the height of a particle relative to some reference point. Techniques for such measurements can include direct measurements of the top heights relative to a reference point such as, for example, the highest particle top, a surface of a rigid support, the bottom surface of the matrix, etc. Measurements of particle height from the surface of the matrix material can be problematic, however, due to the irregular nature of such materials due to working around the superabrasive particles. In those cases whereby the matrix material is uniform, such a surface may be used to determine particle height. Additionally, a relative protrusion or height difference between two particles would be the difference in the heights between these particles measured from a common reference point. Furthermore, in some cases the superabrasive particles may have a shape, curvature, or some other arrangement that is not parallel to the underlying support, such as, for example, a meta support layer. In these cases, the protrusion height would be normalized against the shape, curvature, or other arrangement so that the relative protrusion height difference between particles can be measured in the absence of the shape, curvature, etc. It should be noted that superabrasive particle top height evening can, in some cases, be independent from the positioning or patterning of the superabrasive particles across the surface of the dresser.

One example of a direct measurement technique can include an optical scanning process to evaluate superabrasive particle top positions. In one such process, an optical scanner can scan the surface of the CMP pad dresser to determine the height of the superabrasive particle tops relative to a fixed point. For example, the scanner can scan downward in space toward the dresser until the highest tops are located. The highest top can then be set to the reference point, and the scanner can continue scanning in a direct on toward the dresser measuring the distance from the reference point to each superabrasive particle top across the surface of the dresser. Accordingly, the difference in protrusion distance between any of the superabrasive particles across the dresser can be directly measured.

Furthermore, measurement techniques can also include indirect measurements, such as, for example, applying the diamond monolayer to a deformable substrate that deforms relative to the protrusion distance of the particles. The diamond monolayer can be pressed into the deformable substrate and/or moved across the deformable substrate to form a scratch pattern therein. Top height can thus be extrapolated from such indirect measurements.

Numerous configurations for designed profiles are possible depending on the particular use of the abrading tool, and a such designed profiles are considered to be within the present scope. In one aspect, for example, the designed profile can be a plane. In planar profiles, the highest protruding points of the superabrasive particles are intended to be substantially even in the traditional sense. It is important to point out that, though it is preferred that these points align with the designed profile, there may be some height deviation between superabrasive particles that occur due to variations inherent in the manufacturing process.

In addition to planar profiles, in another aspect of the present invention on the designed profile has a slope. Tools having sloping surfaces may function to more evenly spread the fractonal forces imparting thereon across the superabrasive particles, particularly for rotating tools such as disk sanders and CMP pad dressers. The greater downward force applied by higher central portions of the tool may offset the higher rotational velocity at the periphery, thus reducing the mechanical stress experienced by superabrasive particles in that location. As such, the slope may be continuous from a central portion of the tool to a peripheral portion, or the slope may be discontinuous, and thus be present on only a portion of the tool. Similarly, a given tool may have a single slope or multiple slopes. In certain

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aspects, the tool may slope in a direction from a central point to a peripheral point, or it may slope from a peripheral point to a central point. Various slopes are contemplated that may provide a benefit to a soft organ or material layer. It is not intended that the claims of the present invention be limited as to specific slopes, as a variety of slopes in numerous different tools are possible. In one aspect, however, a CMP pad dresser may benefit from an average slope of 1/1000 from the center to the periphery.

Furthermore, in certain aspects the designed profile may have a curved shape. One specific example of a curved shape is a dome shape CMP pad dresser. Such curved profiles function in a similar manner to the sloped surfaces. CMP pad dressers may include such curved profiles in order to more effectively distribute the frictional forces between a pair of the superabrasive particles, thus reducing failures of individual particles and prolonging the life of the dresser. Also, CMP pad dressers can have designed profiles that combine any of a plane, a slope, a curved shape, a dome shape, and the like, into a variety of complex profiles.

In another aspect of the present disclosure, a CMP pad dresser can include a support substrate, such as a rigid support substrate, and a monolayer of a plurality of superabrasive particles coupled to the support substrate, where each superabrasive particle in the monolayer extends away from the support substrate to a protrusion or distance, and where the difference in protrusion or distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 50 microns. Additionally, the difference in protrusion or distance between the highest 1% of the protruding tips of the monolayer of superabrasive particles are within about 80 microns or less. In another aspect, the difference in protrusion or distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In yet another aspect, the difference in protrusion or distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In a further aspect, the difference in protrusion or distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns. In yet another aspect, the difference in protrusion or distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns.

In another aspect of the present disclosure, a CMP pad dresser is provided including a support substrate and a plurality of superabrasive particles secured to the support substrate and positioned to engage and dress a CMP pad, where the plurality of superabrasive particles cut to depths of less than 50 microns into a CMP pad during a dressing procedure.

In a further aspect, a method of dressing a CMP pad is provided. Such a method can include applying a CMP pad dresser to a CMP pad, and moving at least one of the CMP pad or the CMP pad dresser with respect to one another to cut asperities into the CMP pad having a cutting depth of from about 10 microns to about 50 microns. As one non-limiting example, an exemplary CMP pad can include a support substrate and a monolayer of a plurality of superabrasive particles coupled to the support substrate, where the plurality of superabrasive particles includes a plurality of working superabrasive particles.

In one exemplary aspect, as is shown in FIG. 1, a CMP pad dresser 100 includes a monolayer of a plurality of superabrasive particles 102 coupled to a support substrate 104 with, for example, a bonding material 105. Each superabrasive particle in the monolayer protrudes to a protrusion or distance from the support substrate. The difference in protrusion or distance 106 between the highest protruding tip 108 and the next highest protruding tip 110 of the monolayer of superabrasive particles is described as the protrusion or distance. In one aspect, the protrusion or distance can be less than or equal to about 50 microns. In another aspect, the protrusion or distance can be less than or equal to about 20 microns. In a further aspect, the protrusion or distance can be less than or equal to about 10 microns. It is noted that the term "protrusion or distance" can also be used to describe the difference in protrusion or distance between any two or more superabrasive particles.

A variety of materials are contemplated for use as superabrasive particles. Any superabrasive known that can be utilized in a CMP pad dresser should be considered to be within the present scope. Non-limiting examples of such materials include diamond materials, nitride materials, ceramics, and the like. In one aspect, the superabrasive particles include diamond materials. Such diamond materials can include natural or synthetic diamond, single crystals, polycrystalline, and the like. In another aspect, the superabrasive particles include cubic boron nitride materials.

It is intended that the scope of the present disclosure include superabrasive particles of a conceivable size that would be useful in dressing a CMP pad. Aspects of the present disclosure, however, specifically allow the retention of superabrasive particles in a CMP pad dresser of sizes that have not previously been feasible for use in metal tooling made using traditional techniques with particles exposed and arranged in a pattern. In one aspect, superabrasive particles may range in size from about 30 microns to about 250 microns. In another aspect, superabrasive particles may range in size from about 100 microns to about 200 microns. In yet another aspect, superabrasive particles can range from 100 microns to 150 microns. Additionally, various diamond particle sizes can be used, including mesh

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sizes such as 10/20, 30/40, 80/90, 90/100, 100/120, 120/140, 140/170, 170/200, 200/230, 230/270, 270/325, and 325/400.

Additionally, the purity of the superabrasive particles can be oriented so as to affect dressing performance of a CMP pad. Orienting the superabrasive particles in a specific attitude in relation to the CMP pad to be dressed creates different asperities on the pad surface, thus altering the performance of the CMP pad. Different asperities retain slurry in different manners and thus provide a workpiece differently according to asperity depth, width, density, etc. The superabrasive particles of a CMP pad dresser can be oriented according to the desired polishing characteristics of the CMP pad. For example, if the superabrasive particles predominantly have an apex oriented towards the CMP pad, the asperities of the pad will be narrow and deep. The advantages of narrow and deep asperities are that the pad can better retain the polishing slurry, and thus the polishing rate of the wafer increases. However, the increased polishing rate may also increase the wear rate of the superabrasive particles. As such, wear rate may vary depending on the attitude of the superabrasive particles, and therefore, the orientation of each superabrasive particle may be considered when designing a device with desired performance characteristics. Generally speaking, superabrasive particle attitudes that provide higher dressing rates (i.e. deeper penetration into a pad) also wear particles out at a higher rate.

In contrast, if the superabrasive particles are oriented with a face towards the pad, the resulting asperities may polish at a lower rate. The face of the particles is generally thought to be more durable, but does not typically cut deep and narrow asperities on the pad, but rather asperities that are shallow and broad. Therefore the face portion of a particle will dress a CMP pad at a reduced rate compared to the apex portion of a particle, but the superabrasive particle will wear at a much lower rate.

The edge portions of a superabrasive particle have dressing and wear characteristics that are between those of the face and apex portions. It has been thought that if the edge portion is used to dress a CMP pad, the asperities are not as deep or narrow as those dressed with an apex portion, but may provide asperities having desirable intermediate characteristics. Further, the edge portion of the particle does not wear at such a high rate as that of an apex.

In one aspect, the purity of superabrasive particles are substantially configured in an attitude having either an apex portion or an edge portion oriented toward a pad to be dressed. In another aspect, the purity of superabrasive particles are substantially configured in an attitude having either an edge portion or a face portion oriented toward a pad to be dressed. In yet another aspect, the purity of superabrasive particles can be configured in an attitude having a sharp portion oriented towards a pad to be dressed. In a further aspect, the purity of superabrasive particles can be configured in an attitude having an apex portion oriented towards a pad to be dressed.

A CMP pad dresser having ~~such a~~ substantially evened top arrangements can have a low scratch rate because superabrasive particles are essentially out of the matrix layer due to the more uniform protrusion distribution compared to traditional dressers. Additionally, the more uniform protrusion distributions of such a dresser allows the conditioning of CMP pads in such a manner as to facilitate good polishing rates while at the same time extending the effective working life of the dresser. These benefits can be affected by, for example, uniform asperity spacing and sized distribution on the CMP pad.

In one aspect of the present disclosure, CMP pad dressers having substantially evened or evened superabrasive top surfaces can be accomplished by making various manufacturing the CMP pad dresser techniques, and any such techniques considered to be within the present scope. The following description provides a way that the effects of warpage are minimized. Few non-limiting descriptions of such exemplary processes.

In one aspect, for example, a CMP pad dresser can be made using a brazing process, and as such would generally include a support substrate and a purity of superabrasive particles coupled to the support substrate by a metal or metal alloy braze material. As has been described, traditional brazing techniques create warpage in the dresser as the braze material cools. As such, superabrasive particles that were evened prior to brazing are substantially misaligned in the manufactured dresser. Therefore, steps to minimize or eliminate the warpage must be taken when using a braze process in order to maintain the evening. Various techniques to minimize or eliminate warpage are contemplated, and any such techniques considered to be within the present scope.

As one aspect, for example, a CMP pad dresser can be made in at least a two stage process, where the first stage is performed in a manner that minimizes perturbations of the evened tops in a process that would normally significantly move the superabrasive tops out of an evened arrangement, such as, for example, by brazing. The second stage of the process can further enhance the evening of superabrasive particles across the CMP pad dresser. Other examples may include using lower temperature alloys, using slow temperature ramping, heating and/or cooling of the support substrate, using additional mechanical support to firmly hold the support substrate from moving when warpage occurs, and the like.

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~~Various exemplary configurations~~ Warpage can also be minimized or eliminated through the structural design of CMP pad dressers having substantially evened tops are contemplated. In the dresser, for example, one aspect, for example, a CMP pad dresser can include a first mono ayer of superabrasive particles disposed on one side of a meta support ayer and a second mono ayer of superabrasive particles disposed on the meta support ayer on an opposite side from the first mono ayer. The superabrasive particles of the second mono ayer are positioned to have substantially the same distribution as the superabrasive particles of the first mono ayer. ~~The superabrasive particles of the second mono ayer are positioned to have substantially the same distribution as the superabrasive particles of the first mono ayer.~~ A rigid support is coupled to the second mono ayer of superabrasive particles opposite the first mono ayer to provide support to the dresser.

As shown in FIG. 2, for example, a first mono ayer of superabrasive particles ~~22202~~ is arranged on a surface of a meta support ~~ayer 24~~ substrate 204. A second mono ayer of superabrasive particles ~~26206~~ is arranged on the meta support ~~ayer 24~~ substrate 204 on a side that is opposite to the first mono ayer. As discussed further below, in some cases the first and second mono ayers of superabrasive particles can be arranged such that corresponding superabrasive particles across the meta support ayer are in substantial alignment, as shown in FIG. 2. In other cases, the superabrasive particles of the first and second mono ayers can be arranged in a substantially symmetrical distribution, but may or may not be substantially aligned with one another across the meta support ~~ayer~~ substrate.

~~The meta support ayer can be any material capable of supporting the diamond mono ayer during the formation. Such materials can include, without limitation, metal materials, metal alloy materials, brazing alloy materials, ceramic materials, composites, and the like.~~

~~In one aspect, the superabrasive particles can be arranged into a predetermined pattern. Such a pattern can be a uniformly distributed pattern or a non-uniformly distributed pattern. Additionally, a variety of techniques are contemplated to facilitate the arrangement of superabrasive particles into a predetermined pattern. Predetermined is understood to mean a non-random pattern that has been determined prior to arranging the superabrasive particles. In one aspect, a predetermined pattern can also apply to a predetermined spacing between particles. Non-limiting examples of such techniques include arrangement by a template, arrangement using spots of adhesive, arrangement on a first substrate followed by a pattern specific transfer from the first substrate to the meta support ayer, and the like, including combinations thereof. The superabrasive particles from either of the mono ayers can be temporarily held in position in the predetermined pattern using a variety of techniques, including, without limitation, adhesive, dmped coating on the meta support matrix, a supporting compound such as, for example, a wax, and the like, including combinations thereof. In one specific aspect, the superabrasive particles can be temporarily coupled to the meta support ayer using an adhesive that then volatilizes away and is eliminated during construction of the dresser.~~

~~In one aspect, the predetermined pattern can be a uniformly distributed grid. In another aspect, the predetermined pattern can be an annular configuration having a central region devoid of superabrasive particles. In one specific aspect, the annular configuration can include an annular ring. In another specific aspect, the annular configuration can include a portion of an annular ring. In yet another aspect, an annular configuration can include one or more concentric annular rings nested inside one another. In other aspects, the mono ayer distribution can be discrete radial regions, spiral regions, and the like.~~

The disposition of a mono ayer of superabrasive particles on each side of the ~~meta~~ ayersupport substrate thus moderates the thermal shrinkage from the brazing temperature that would otherwise buckle a distribution of superabrasive particles arranged on just one side. By applying a mono ayer to each side of the ~~meta~~ support ~~ayersubstrate~~, warping forces such as thermal movement and pressure can be equalized or substantially equalized ~~on from~~ both sides. As such, the warpage of the ~~meta~~ support ~~ayersubstrate~~ can be minimized. In other words, the forces responsible for warping are applied substantially equally to each side of the ~~meta~~ ayersupport substrate and can thus at least partially cancel one another out, thus minimizing warpage that can otherwise occur. In some aspects, the superabrasive particles making up the mono ayers on each side of the ~~meta~~ ayersupport substrate can have matching configurations, patterns, or entanglements to one another. In this way there can be a substantially matching spatial arrangement of superabrasive particles on each side of the ~~meta~~ ayer-support substrate. In another aspect, the configurations, patterns, or entanglements can be different or varied from one another, or may be partially matching. In yet another aspect, the patterned placement of the superabrasive particles on one side of the ~~meta~~ support ~~ayersubstrate~~ can be substantially aligned with the pattern of superabrasive particles on the other side of the ~~meta~~ ayersupport substrate so that particle locations match one another. In some aspects, there can be a direct correspondence between the spatial positioning of superabrasive particles on one side of the ~~meta~~ support ~~ayersubstrate~~ and the spatial positioning of superabrasive particles on the other side of the meta support ~~ayersubstrate~~. In another aspect, the patterns of superabrasive particles may match or substantially match one another, but may be offset on opposite sides of the ~~meta~~ support ~~ayersubstrate~~ so that particle locations do not match one another.

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Accordingly, minimizing the warpage of the support substrate can maintain a greater degree of evenness of superabrasive particles in the finished too. When heat and/or pressure are used to make a superabrasive too, warpage of the support substrate can cause great variations in the height evenness, even for those particles that were evened prior to heating and/or applying pressure. In one aspect, distributing the warpage forces evenly or substantially equally on both sides of a support substrate through the arrangement of the superabrasive particles can effectively cancel forces on opposing sides and thus greatly reduce the degree of warpage occurring in the support substrate, thus also minimizing the relative height movement of the superabrasive particles relative to one another. In other aspects, CMP pad dressers can be made using processes that do not utilized high pressure and/or high temperature.

The support substrate can be any material capable of supporting the diamond monolayer during too formation. Such materials can include, without limitation, metal materials, metal alloy materials, braze alloy materials, ceramic materials, composites, and the like.

In one aspect, the superabrasive particles can be arranged into a predetermined pattern. Such a pattern can be a uniform distributed pattern or a non-uniform distributed pattern. Additionally, a variety of techniques are contemplated to facilitate the arrangement of superabrasive particles into a predetermined pattern. Predetermined is understood to mean a non-random pattern that has been determined prior to arranging the superabrasive particles. In one aspect, a predetermined pattern can also apply to a predetermined spacing between particles. Non-limiting examples of such techniques include arrangement by a template arrangement, using spots of adhesives, arrangement on a first substrate followed by a pattern specific transfer from the first substrate to the support substrate, and the like, including combinations thereof. The superabrasive particles from either of the monolayers can be temporarily held in position in the predetermined pattern using a variety of techniques including, without limitation, adhesives, deposited coatings on the meta support matrix, a supporting compound such as, for example, a wax, and the like, including combinations thereof. In one specific aspect, the superabrasive particles can be temporarily coupled to the support substrate using an adhesive that then volatilizes away and is eliminated during construction of the dresser.

In one aspect, the predetermined pattern can be a uniform distributed grid. In another aspect, the predetermined pattern can be an annular configuration having a central region devoid of superabrasive particles. In one specific aspect, the annular configuration can include an annular ring. In another specific aspect, the annular configuration can include a portion of an annular ring. In yet another aspect, an annular configuration can include one or more concentric annular rings nested inside one another. In other aspects, the monolayer distribution can be discretely distributed regions, spirals, regions, and the like.

In another aspect, as shown in FIG. 3, a first monolayer of superabrasive particles **32302** is arranged on a surface of a ~~meta~~-support ~~layer~~ **34** ~~substrate~~ **304**. A second monolayer of superabrasive particles **36306** is arranged on the ~~meta~~-support ~~layer~~ **34** ~~substrate~~ **304** on a side that is opposite to the first monolayer. A bonding material **38308** secures the first monolayer and the second monolayer to the ~~meta~~-support ~~layer~~ **34** ~~substrate~~ **34**. The bonding material can be any material capable of securing the first and second monolayer to the ~~meta~~-support ~~layer~~ **34** ~~substrate~~ **34**. In some aspect, the bonding material can be the same for securing the first monolayer and the second monolayer, while in other aspects, the bonding material can be different for securing the first monolayer and the second monolayer.

It is noted that the various descriptions of materials, attachment techniques, and the like, can be generally applicable to any CMP pad dresser designed to which such materials, techniques, and the like are applicable. For example, a material that can be used to secure a superabrasive particle to a substrate can be used in both dual monolayer and single monolayer dresser designs.

Accordingly, the bonding material can be any material capable of securing superabrasive particles thereon. Non-limiting examples of bonding materials include metal brazes, metal braze alloys, organic matrix materials, sintered materials, electroplated materials, and the like, including combinations thereof.

In one aspect, for example, the superabrasive particles can be brazed to the ~~meta~~-support ~~layer~~ **34** ~~substrate~~ **34**, and thus the bonding material can be a metal braze or metal braze alloy. Metal brazing techniques are known in the art. A green braze material can be applied to the ~~meta~~-support ~~layer~~ **34** ~~substrate~~ **34** on or around the superabrasive particles. The metal braze can be applied in any ~~known~~ configuration, including braze sheets, powders, pastes, sprays, and the like, including combinations thereof. Once applied to the ~~meta~~-support ~~layer~~ **34** ~~substrate~~ **34**, the braze can be heated and melted to coat at least a portion of the ~~meta~~-support ~~layer~~ **34** ~~substrate~~ **34** and to bond the superabrasive particles. The heating temperature can vary depending on the braze material used, but in one aspect can be from about 700° C. to about 1200° C. ~~The superabrasive particles in the first and second monolayer are thus arranged such that thermal forces exerted on the meta-support layer during heating and cooling are substantially equal in order to minimize warpage.~~

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In one non-limiting example, the superabrasive particles can be bonded to the ~~meta~~-support ~~ayer~~substrate by brazing with a nickel-based alloy containing chromium. In another example, the brazing can include pressing the superabrasive particles with a flat ceramic material that cannot be bonded to the braze in order to leave the superabrasive particles. Various braze alloys are contemplated, including non-limiting examples such as BN₂, BN₇, and the like.

Additionally, in one aspect ~~at least one of the first and second mono-ayers of~~ superabrasive particles can be coupled to the ~~meta~~-support ~~ayer~~substrate by an electrodeposition process, and thus the bonding material can be an electrodeposited material. As an example of a suitable method for positioning and retaining material a surface prior to and during the electrodeposition process, a mold can be used that includes an insulating material that can effectively prevent the accumulation of electrodeposited material on the molding surface. Superabrasive particles can be held on the molding surface of the mold during electrodeposition. As such, the accumulation of electrodeposited material can be prevented from occurring on the particles and the working surface of the pad conditioner substrate. Such techniques are described in U.S. patent application Ser. No. 11/292,938, filed Dec. 2, 2005, which is hereby incorporated herein by reference.

In another aspect, the superabrasive particles can be bonded to the ~~meta~~-support ~~ayer~~substrate by sintering, and thus the bonding material can include a sintering material. For example, the bonding of the superabrasive particles to the ~~meta~~-support ~~ayer~~substrate can include depositing a sintering compound on the ~~meta~~-support ~~ayer~~substrate in contact with ~~at least one of the purity of the first mono-ayer and the second mono-ayer~~superabrasive particles, and sintering the sintering compound to bond the ~~at least one of the first mono-ayer and the second mono-ayer~~superabrasive particles to the ~~meta~~-support ~~ayer~~substrate. Suitable sintering methods will be readily appreciated by one of ordinary skill in the art having possession of this disclosure. Basically, a sintering compound is applied around the superabrasive particles and in contact with the ~~meta~~-support ~~ayer~~substrate. The sintering compound can be any known sintering material that can be used to secure superabrasive particles to a substrate. Non-limiting examples of such materials can include metal and metal alloy powders, ceramic powders, and the like. One specific non-limiting example of a sintering compound is cobalt powder.

Once the sintering compound has been applied around the superabrasive particles and to the ~~meta~~-support substrate, heat and in some cases pressure can be applied to cause sintering to occur. In some aspects, a braze or braze alloy can be infiltrated into the sintering compound during bonding to further strengthen the bonding material matrix.

In another aspect, as shown in FIG. 4, in yet another aspect, sintering can be used to sinter the purity of superabrasive particles into a CMP pad dresser, where the support substrate is the sintering material. In this case, the above recited procedure can be repeated without the use of a support substrate.

In another aspect, heat and pressure can be applied to bond the first mono-ayer purity of superabrasive particles 42 and/or the second mono-ayer of superabrasive particles 46 directly into the meta-support ayer 44 substrate. Thus, upon the application of heat and pressure, the meta-support ayer 44 substrate can be softened or partially melted. The superabrasive particles ~~in one or more of the mono-ayers~~ are then pressed into the meta-support ayer substrate. A planar evening surface can be used to apply pressure to the mono-ayer and of superabrasive particles to thus maintain the even nature of the superabrasive particles as the superabrasive particles are pressed into the meta-support ayer. Upon cooling, the distribution of superabrasive particles on either side of the meta-support ayer at least partially equalizes the thermal forces acting on support substrate. Pressure can be maintained upon the meta-support ayer substrate and superabrasive particles until cooled, thus minimizing warpage.

In yet another aspect, as shown in FIG. 54, a dua mono-ayer CMP pad dresser can include a first mono-ayer of superabrasive particles 52402 and a second mono-ayer of superabrasive particles 56406 coupled to a ~~meta~~-support ~~ayer~~substrate 404. The superabrasive particles can be coupled to the ~~meta~~-support ~~ayer~~substrate directly or via a bonding material. The second mono-ayer of superabrasive particles 56406 is coupled to a ~~first~~second support ~~58~~substrate 408. A portion of the ~~first~~second support ~~58~~substrate is shown removed in FIG. 54 to expose the second mono-ayer. The ~~first~~second support ~~58~~substrate 408 can facilitate handling and use of the CMP pad dresser. By bonding the superabrasive particles of the second mono-ayer to the ~~first~~second support ~~58~~substrate, the first mono-ayer of superabrasive particles remains exposed for CMP pad conditioning operations.

The ~~first~~second support ~~58~~substrate can be made from any material compatible with the abrading or dressing process. Such materials can include polymeric materials, metal materials, ceramic materials, glasses, composites, and the like. In one aspect, the ~~first~~second support ~~58~~substrate can be a polymeric material and the second mono-ayer of superabrasive particles can be embedded therein using heat, pressure, adhesives, etc. In some aspects, the ~~first~~second support ~~58~~substrate can be a non-polymeric material such as a metal-ayer. In such cases, the superabrasive particles can be bonded to the ~~first~~second support ~~58~~substrate by adhesive attachment, so dering,

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(New subject matter added to the '802 Patent is shown in red)

brazing, electroplating, and the like. For brazing techniques, care can be taken to minimize or eliminate warpage in the ~~meta-ayer~~substrate during the heating and cooling process. In another aspect, one or more magnetic elements can be placed into the ~~rg-d~~second support substrate to attract and hold the CMP pad dresser in place, thus forming a temporary attachment. An optional locking mechanism can be utilized to further minimize the CMP pad dresser to the ~~rg-d~~second support substrate during use. In some aspects the ~~rg-d~~second support substrate can include surface features to hold the dresser in place during rotational movement against a CMP pad. The ~~rg-d~~second support substrate can have approximately the same diameter as the meta support layer, a larger diameter than the meta support layer, or, in some cases, a smaller diameter than the meta support layer.

In another aspect, a CMP pad dresser can be comprised of a plurality of dressing segments having a plurality of elevated superabrasive particles, where the plurality of dressing segments are held in place by a rigid support-~~or~~ support substrate. Such a design allows a plurality of smaller dressing segments to be manufactured having precise elevated tips. Smaller diameter ~~meta~~-support layers in these dressing segments can be made by processes involving heat and/or pressure with less warpage due to the smaller size. For example, a 4 inch diameter meta disc can exhibit greater warpage due to brazing as compared to a 0.5 inch diameter meta disc. Thus thermal distortion and particle float problems are decreased. A plurality of such dressing segments can then be coupled to a larger diameter ~~rg-d~~support substrate by processes that do not introduce significant warpage, such as bonding in an organic material. Such dressing segments can have one or more layer(s) of superabrasive particles coupled to a support layer. In one aspect, a segment can have a single layer of superabrasive particles coupled to a ~~meta~~-support layer. In another aspect, a segment can have a layer of superabrasive particles coupled to each side of a ~~meta~~-support layer, as has been described herein. Thus, this process allows the manufacture of CMP pad dressers that can have precise tip protrusion tolerances. Additionally, in one aspect, each dressing segment can have at least three superabrasive particles that protrude to the greatest extent. If the three highest protruding superabrasive particles on every dressing segment are elevated across the entire ~~rg-d~~support substrate, a CMP pad dresser is made having very precise tip elevating across the entire surface. If, for example, ten dressing segments are used to make the CMP pad dresser, then the highest protruding thirty superabrasive particles in the tool will have effectively the same protrusion distance and be substantially elevated. Various additional details regarding dressing segments are detailed in U.S. patent application Ser. No. 13/034,213, filed Feb. 24, 2011, which is hereby incorporated herein by reference.

Various organic materials are contemplated for use as a ~~rg-d~~support substrate, and/or to ~~be used to secure the~~ second mono layer of superabrasive particles and/or the dressing segments to the ~~rg-d~~support substrate. Examples of suitable organic matrix materials include, without limitation, amorphous resins, acrylic resins, polyether resins, polyamide resins, polyimide resins, polyurethane resins, phenolic resins, phenocyanate resins, epoxy resins, cyanate resins, cyanurate resins, polysiloxane resins, reactive vinyl resins, polyethylene resins, polypropylene resins, polystyrene resins, phenoxy resins, perylene resins, polysulfone resins, acrylic on tri-n-butylstyrene resins, acrylic resins, polycarbonate resins, polyimide resins, and mixtures thereof. In one specific aspect, the organic material can be an epoxy resin. In another aspect, the organic material can be a polyimide resin. In yet another aspect, the organic material can be a polyurethane resin.

Additionally, so-called "reverse cast" methods can be used to accurately orient and attach the dressing segments to the ~~rg-d~~support substrate. Such methods can include initially securing the plurality of dressing segments to a substrate using a "mask" material. The portions of the dressing segments protruding from the mask material can then be attached to the rigid support using the methods discussed herein, after which (or during which), the mask material can be removed.

When an organic material is utilized, methods of curing the organic material can be a variety of processes known to one skilled in the art that cause a phase transition in the organic material from at least a pliable state to at least a rigid state. Curing can occur, without limitation, by exposing the organic material to energy in the form of heat, electromagnetic radiation, such as ultraviolet, infrared, and microwave radiation, particle bombardment, such as an electron beam, organocatalysts, inorganocatalysts, or any other curing method known to one skilled in the art.

In one aspect of the present invention, the organic material can be a thermoplastic material. Thermoplastic material can be reversibly hardened and softened by cooling and heating respectively. In another aspect, the organic material layer may be a thermosetting material. Thermosetting materials cannot be reversibly hardened and softened as with the thermoplastic materials. In other words, once curing has occurred, the process can be essentially irreversible, ~~if desired~~.

As a more detailed list of what is described above, organic materials that may be useful embodiments of the present invention include, but are not limited to: amorphous resins including acrylated urea-formaldehyde resins, melamine-formaldehyde resins, and acrylated benzoguanamine-formaldehyde resins; acrylic resins including vinyl acrylates, acrylated epoxies, acrylated urethanes, acrylated polyethers, acrylated acrylics, acrylated polyethers, vinyl ethers, acrylated oxides, acrylated siloxanes, and associated methacrylates; acrylic resins such as urethane acrylic resins; polyether resins; polyamide resins; polyimide resins; reactive urethane resins; polyurethane resins; phenolic resins

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such as resins and novolac resins; phenolic/ate resins; epoxy resins such as bisphenol epoxy resins; isocyanate resins; isocyanurate resins; polyoxane resins including a ketaloxane resins; reactive vinyl resins; resins marketed under the Bakelite™ trade name, including polyethylene resins, polypropylene resins, epoxy resins, phenolic resins, polystyrene resins, phenoxyl resins, perylene resins, polysulfone resins, ethylene copolymer resins, acrylic/ter-butylstyrene (ABS) resins, acrylic resins, and vinyl resins; acrylic resins; polycarbonate resins; and mixtures and combinations thereof. In one aspect of the present invention, the organic material may be an epoxy resin. In another aspect, the organic material may be a polyimide resin. In yet another aspect, the organic material may be a polyurethane resin.

Numerous additives may be included in the organic material to facilitate its use. For example, additive crosslinking agents and fillers may be used to improve the cured characteristics of the organic material layer. Additively, solvents may be utilized to alter the characteristics of the organic material in the uncured state. Also, a reinforcing material may be disposed within at least a portion of the solidified organic material layer. Such reinforcing material may function to increase the strength of the organic material layer, and thus further improve the retention of the individual abrasive segments. In one aspect, the reinforcing material may include ceramics, metals, or combinations thereof. Examples of ceramics include alumina, aluminum carbide, silica, silicon carbide, zirconia, zirconium carbide, and mixtures thereof.

Additively, in one aspect a coupling agent or an organometallic compound may be coated onto the surface of a superabrasive material to facilitate the retention of the superabrasive particles in the organic material via chemical bonding. A wide variety of organic and organometallic compounds is known to those of ordinary skill in the art and may be used. Organometallic coupling agents can form chemical bonds between the superabrasive material and the organic material, thus increasing the retention of the superabrasive material therein. In this way, the organometallic coupling agent can serve as a bridge to form bonds between the organic material and the surface of the superabrasive material. In one aspect of the present invention, the organometallic coupling agent can be a titanate, zirconate, silane, or mixture thereof. The amount of organometallic coupling agent used can depend upon the coupling agent and on the surface area of the superabrasive material. Often times, 0.05% to 10% by weight of the organic material layer can be sufficient.

Specific non-limiting examples of silanes suitable for use in the present invention include: 3-glycidypropyltrimethoxysilane (available from Dow Corning as Z-6040); γ-methacryloxypropyltrimethoxysilane (available from Union Carbide Chemicals Company as A-174); β-(3,4-epoxycyclohexyl)ethyltrimethoxysilane, γ-aminopropyltriethoxysilane, N-(β-aminooethyl)-γ-aminopropylmethyldimethoxysilane (available from Union Carbide, Shin-etsu Kagaku Kogyo K.K., etc.). Specific non-limiting examples of titanate coupling agents include: isopropyltriisostearoyl titanate, dicumylphenylateoxyacetate titanate, 4-aminobenzenesulfonate dodecyl benzenesulfonate titanate, tetraoctylbis(dodecyl phosphite) titanate, isopropyltri(N-ethylamino-ethylamino) titanate (available from Kenrich Petrochemicals, Inc.), neokyoxy titanates such as LICA-01, LICA-09, LICA-28, LICA-44 and LICA-97 (also available from Kenrich), and the like. Specific non-limiting examples of aluminum coupling agents include acetoxy aluminum isopropylate (available from Ajinomoto K.K.), and the like. Specific non-limiting examples of zirconate coupling agents include: neokyoxy zirconates, LZ-01, LZ-09, LZ-12, LZ-38, LZ-44, LZ-97 (also available from Kenrich Petrochemicals, Inc.), and the like. Other known organometallic coupling agents, e.g., thiolate based compounds, can be used in the present invention and are considered within the scope of the present invention.

In other aspects of the present disclosure, superabrasive particles can be leveled by reducing the protrusions of particles that are outside of the desired tolerance range. Once such particles are identified, various techniques can be utilized to reduce such protrusions. In one aspect, for example, mechanical abrasion of the dresser can reduce the protruding particles. In another aspect, a vibratory motion can be used to individually break such particles. In yet another aspect, a laser such as a Nd:YAG laser can be used to disrupt such particles.

In another aspect of the present disclosure, a method of making a CMP pad dresser can include depositing a first mono-layer of superabrasive particles on a metal support layer, and depositing a second mono-layer of superabrasive particles on the metal support layer on a side opposite to the first mono-layer. The superabrasive particles of the second mono-layer are positioned to have substantially the same distribution as the superabrasive particles of the first mono-layer. The method can further include bonding the first mono-layer of superabrasive particles and the second mono-layer of superabrasive particles to the metal support layer such that symmetrical forces due to the substantially symmetrical distribution between the first mono-layer and the second mono-layer precludes substantial warping of the metal support layer.

In yet another aspect, depositing at least one of the first mono-layer of superabrasive particles or the second mono-layer of superabrasive particles can include adhering a plurality of superabrasive particles to an adhesive transfer sheet in a predetermined pattern established by apertures in a template, and removing the template from the adhesive transfer sheet such that the plurality of superabrasive particles remain adhered to the adhesive transfer sheet in the predetermined pattern. The plurality of superabrasive particles is then transferred with the adhesive

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~~transfer sheet to the meta-support layer, and the adhesive transfer sheet is removed from the purity of superabrasive particles to form at least one of the first mono-layer of superabrasive particles or the second mono-layer of superabrasive particles.~~

~~In a further aspect of the present disclosure, a method of minimizing warpage of a CMP pad dresser during manufacture can include substantially equalizing warpage forces on opposing sides of a meta-support layer during bonding of a purity of superabrasive particles thereto, wherein warpage of the support layer is minimized during bonding due to the equalized forces on opposing sides. In one aspect, substantially equalizing forces includes arranging the purity of superabrasive particles on opposing sides of the support layer such that the purity of superabrasive particles has substantially the same distribution on either side of the support layer to substantially equalize warpage forces during bonding.~~

In yet a further aspect of the present disclosure, a CMP pad dresser can include a purity of superabrasive particles arranged as a working surface, where the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the first mono-layer of superabrasive particles is less than or equal to about 20 microns, and where the difference in protrusion distance between the highest 1% of the protruding tips of the first mono-layer of superabrasive particles, excluding the highest protruding tip, are within about 80 microns.

In another aspect, a CMP pad dresser can include a purity of superabrasive particles arranged as a working surface, where the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns, the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns, the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns, and the highest protruding tip has a protrusion distance of greater than or equal to about 50 microns.

It is noted that, while the above disclosure refers primarily to CMP pad dressers, other processes on grinding and/or abrading tools are considered to be within the present scope. As such, the techniques and teaching disclosed here can additionally be applied to such tools.

Additionally, it is noted that traditional CMP processing techniques, including pad dressing, has limited the critical dimensions of integrated circuits. The presently disclosed CMP dressing devices and techniques can, however, allow processing of wafers having integrated circuit critical dimensions of less than or equal to 45 nm, 32 nm, 28 nm, ~~or~~ 22 nm, or less.

Of course, it is to be understood that the above-described arrangements are only illustrative of the application of the principles of the present invention. Numerous modifications and alternative arrangements may be devised by those skilled in the art without departing from the spirit and scope of the present invention and the appended claims are intended to cover such modifications and arrangements. Thus, while the present invention has been described above with particularity and detail in connection with what is presently deemed to be the most practical and preferred embodiments of the invention, it will be apparent to those of ordinary skill in the art that numerous modifications, including, but not limited to, variations in size, materials, shape, form, function and manner of operation, assembly and use may be made without departing from the principles and concepts set forth herein.

Claims:

What is claimed is:

1. ~~A CMP pad dresser, comprising: a first mono-layer of superabrasive particles disposed on and protruding from one side of a meta-support layer, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the mono-layer of superabrasive particles is less than or equal to about 50 microns; a second mono-layer of superabrasive particles disposed on the meta-support layer on an opposite side from the first mono-layer, wherein the superabrasive particles of the second mono-layer are positioned to have substantially the same distribution as the superabrasive particles of the first mono-layer; and a rigid support coupled to the second mono-layer of superabrasive particles opposite the first mono-layer.~~

~~2. The dresser of claim 1, wherein the purity of superabrasive particles are arranged in at least one annular configuration having a central region devoid of superabrasive particles.~~

~~3. The dresser of claim 1, wherein the purity of superabrasive particles are configured in an attitude having a sharp portion oriented towards a pad to be dressed.~~

~~4. The dresser of claim 1, wherein the purity of superabrasive particles are substantially a configured in an attitude having either an apex or an edge portion oriented toward a pad to be dressed.~~

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~~5. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the first mono layer of superabrasive particles is less than or equal to about 10 microns.~~

~~6. The dresser of claim 5, wherein the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip of the first mono layer of superabrasive particles is less than or equal to about 20 microns.~~

~~7. The dresser of claim 6, wherein the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip of the first mono layer of superabrasive particles is less than or equal to about 40 microns.~~

~~8. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the first mono layer of superabrasive particles is less than or equal to about 20A CMP pad dresser, comprising: a rigid support substrate; and a mono layer of a plurality of superabrasive particles coupled to the support substrate, wherein each superabrasive particle in the mono layer extends away from the support substrate to a protrusion distance, wherein a tip of each of the plurality of superabrasive particles defines a designated profile with a tip variation of from about 5 microns to about 100 microns, and wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the mono layer of superabrasive particles is less than or equal to about 50 microns, and the difference in protrusion distance between the highest 1% of the protruding tips of the mono layer of superabrasive particles are within about 80 microns or less.~~

2. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns.

3. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than about 10 microns.

4. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns.

5. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns.

6. The dresser of claim 1, wherein the plurality of superabrasive particles includes a plurality of working superabrasive particles, such that rotating the dresser against a CMP pad cuts asperities into the CMP pad having a cutting depth of less than or equal to about 50 microns.

7. The dresser of claim 6, wherein the cutting depth is from about 10 microns to about 50 microns.

8. The dresser of claim 6, wherein the plurality of working superabrasive particles includes at least 100 working superabrasive particles.

9. The dresser of claim 6, wherein the plurality of working superabrasive particles includes at least 1000 working superabrasive particles.

10. The dresser of claim 6, wherein the plurality of working superabrasive particles includes from about 1000 to about 6000 working superabrasive particles.

11. The dresser of claim 6, wherein the plurality of working superabrasive particles includes from about 2000 to about 5000 working superabrasive particles.

12. The dresser of claim 6, wherein the plurality of working superabrasive particles include at least about 1000 working superabrasive particles that protrude from the rigid support substrate to distances within about 30 microns of one another.

13. The dresser of claim 1, wherein the highest protruding tip of each of the plurality of superabrasive particles defines a designated profile with a tip variation of from about 10 microns to about 50 microns.

14. The dresser of claim 1, wherein the highest protruding tip of each of the plurality of superabrasive particles defines a designated profile with a tip variation of from about 20 microns to about 40 microns.

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15. The dresser of claim 1, wherein the highest protruding tip of each of the plurality of superabrasive particles along the designated profile with a tip variation of less than about 20 microns.

16. The dresser of claim 1, wherein the protrusions of the plurality of superabrasive particles produce cutting depths of less than about 20 microns when used to abrade a CMP pad.

17. The dresser of claim 1, wherein the protrusions of the plurality of superabrasive particles produce cutting depths of from about 1 micron to about 20 microns when used to abrade a CMP pad.

18. The dresser of claim 1, wherein the protrusions of the plurality of superabrasive particles produce cutting depths of from about 10 microns to about 20 microns when used to abrade a CMP pad.

19. The dresser of claim 1, wherein the designated profile includes a configuration selected from the group consisting of a plane, a slope, a curved shape, a dome shape, and combinations thereof.

20. The dresser of claim 1, wherein the plurality of superabrasive particles are arranged across the support substrate in a predetermined pattern.

21. The dresser of claim 20, wherein the predetermined pattern includes an even distribution of the plurality of superabrasive particles spaced at a distance of from about 100 microns to about 800 microns.

EXHIBIT 4

Comparison of Claim 1 of U.S. Patent No. 8,974,270 and Claim 1 of U.S. Patent No. 9,724,802
(New subject matter added to the '802 Patent is shown in blue):

1. A CMP pad dresser, comprising: a ~~first~~ rigid support substrate; and a monolayer of a plurality of superabrasive particles ~~disposed on and protruding from one side of a metal support layer;~~ coupled to the support substrate, wherein each superabrasive particle in the monolayer extends away from the support substrate to a protrusion distance, wherein a tip of each of the plurality of superabrasive particles aligns along a designated profile with a tip variation of from about 5 microns to about 100 microns, and wherein the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 50 microns; ~~a second monolayer of superabrasive particles disposed on the metal support layer on an opposite side from the first monolayer, wherein the superabrasive particles of the second monolayer are positioned to have substantially the same distribution as the superabrasive particles of the first monolayer; and a rigid support coupled to the second monolayer of superabrasive particles opposite the first monolayer,~~ and the difference in protrusion distance between the highest 1% of the protruding tips of the monolayer of superabrasive particles are within about 80 microns or less.

EXHIBIT 5

(19) **United States**(12) **Patent Application Publication**
Sung(10) **Pub. No.: US 2014/0120724 A1**(43) **Pub. Date: May 1, 2014**(54) **COMPOSITE CONDITIONER AND
ASSOCIATED METHODS**61/246,816, filed on Sep. 29, 2009, provisional appli-
cation No. 61/333,162, filed on May 10, 2010.(71) Applicant: **Chien-Min Sung**, Tansui (TW)(30) **Foreign Application Priority Data**(72) Inventor: **Chien-Min Sung**, Tansui (TW)

Apr. 10, 2012 (TW) 101112625

(21) Appl. No.: **13/797,704****Publication Classification**(22) Filed: **Mar. 12, 2013****Related U.S. Application Data**

(63) Continuation-in-part of application No. 12/726,786, filed on Mar. 18, 2010, now Pat. No. 8,622,787, which is a continuation-in-part of application No. 12/255,823, filed on Oct. 22, 2008, now Pat. No. 8,393,934, which is a continuation-in-part of application No. 12/168,110, filed on Jul. 5, 2008, now Pat. No. 8,398,466, which is a continuation-in-part of application No. 11/560,817, filed on Nov. 16, 2006, now Pat. No. 7,762,872, which is a continuation-in-part of application No. 11/357,713, filed on Feb. 17, 2006, now abandoned, Continuation-in-part of application No. 12/628,859, filed on Dec. 1, 2009, now Pat. No. 7,901,272, which is a continuation-in-part of application No. 11/804,221, filed on May 16, 2007, now Pat. No. 7,651,386, which is a continuation-in-part of application No. 11/223,786, filed on Sep. 9, 2005, now abandoned, Continuation-in-part of application No. 12/850,747, filed on Aug. 5, 2010, Continuation-in-part of application No. 13/034,213, filed on Feb. 24, 2011, now abandoned.

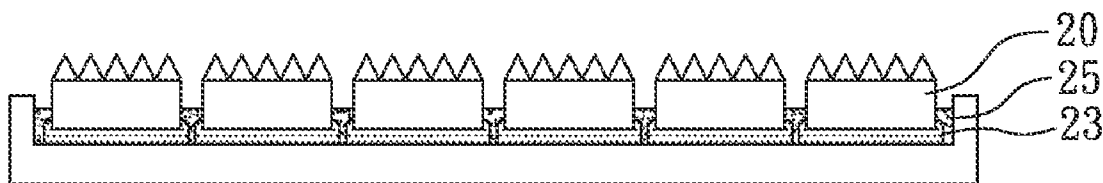
(60) Provisional application No. 60/976,198, filed on Sep. 28, 2007, provisional application No. 60/681,798, filed on May 16, 2005, provisional application No.

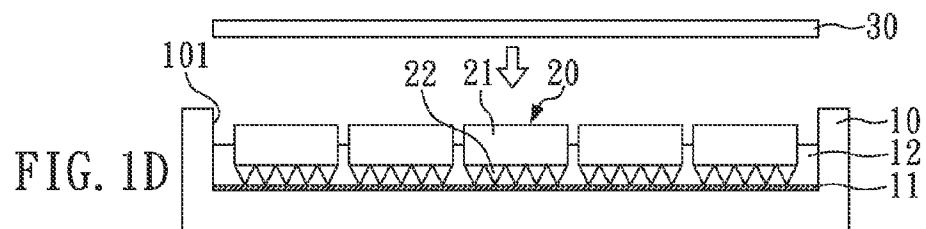
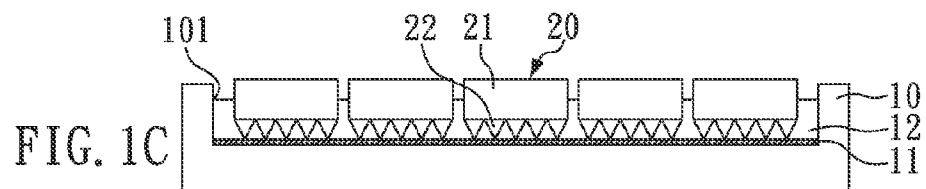
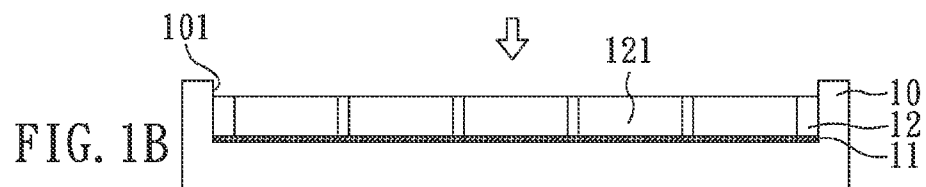
(51) **Int. Cl.****B24B 53/017** (2006.01)**H01L 21/306** (2006.01)**B24D 18/00** (2006.01)(52) **U.S. Cl.**CPC **B24B 53/017** (2013.01); **B24D 18/0072**
(2013.01); **H01L 21/30625** (2013.01)USPC **438/692**; 451/443; 51/297

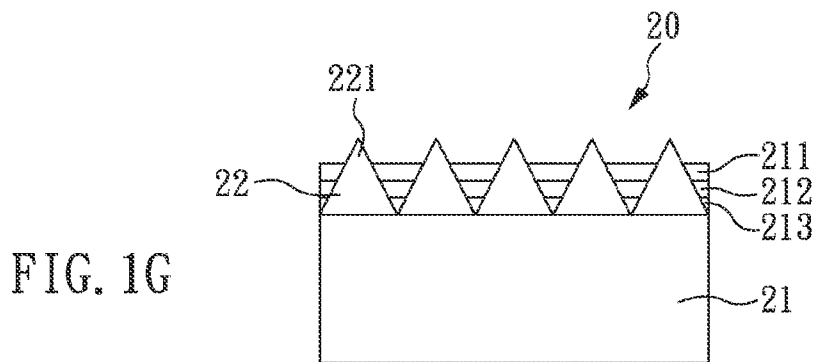
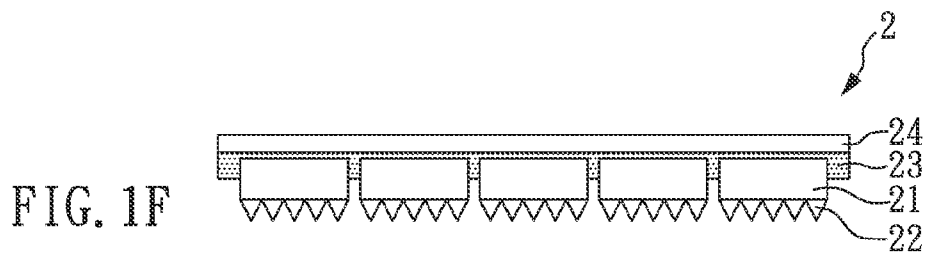
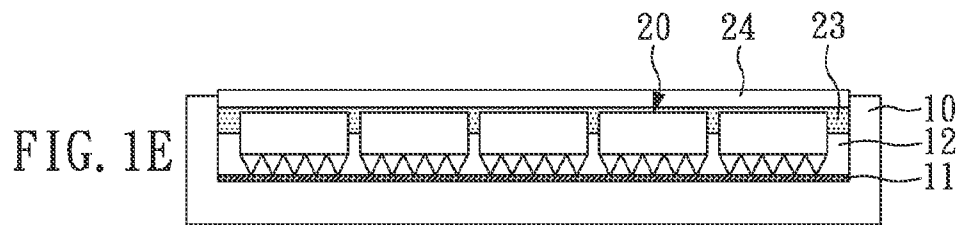
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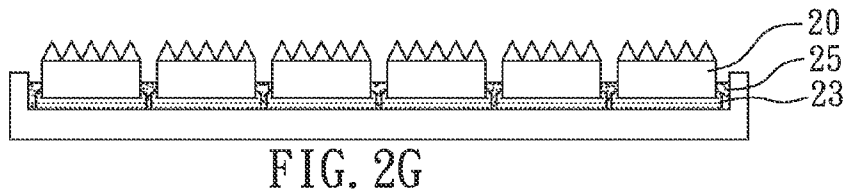
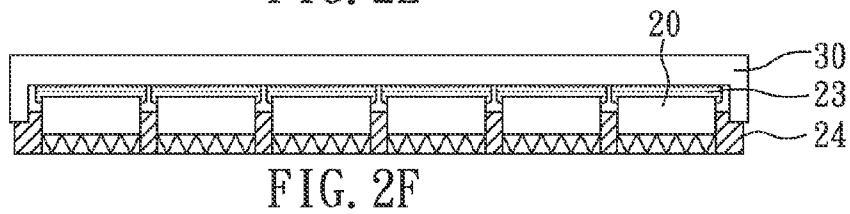
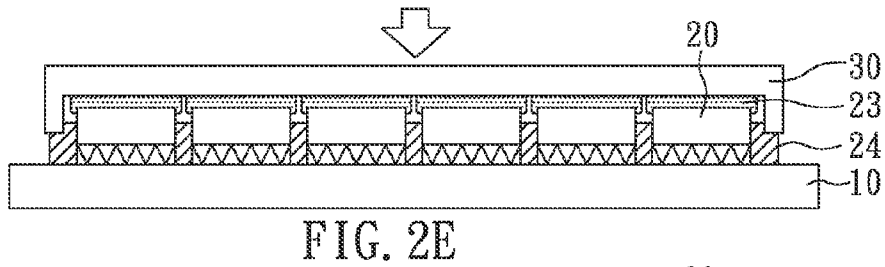
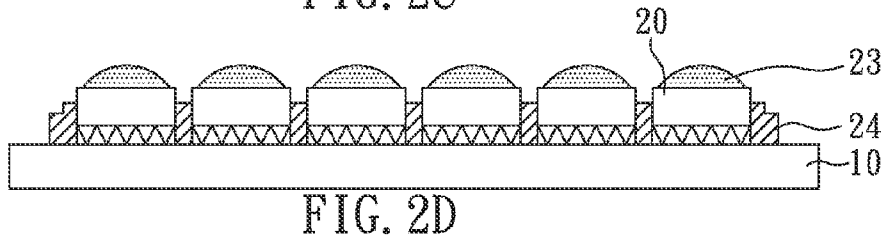
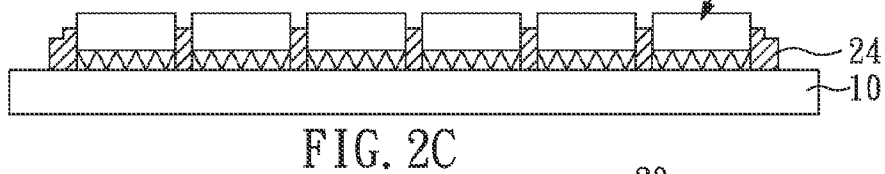
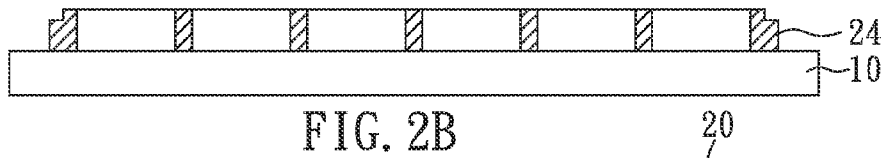
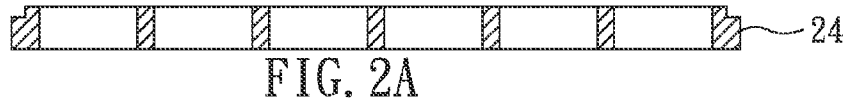
ABSTRACT

CMP pad dressers having leveled tips and associated methods are provided. In one aspect, for example, a composite conditioner can include a base plate and a plurality of polishing units secured to a surface of the base plate by an adhesive layer, where each polishing unit includes a plurality of polishing tips secured in a binding layer. Additionally, a height difference between a first highest polishing tip and a second highest polishing tip is less than or equal to about 10 μm , a height difference between the first highest polishing tip and a tenth highest polishing tip is less than or equal to about 20 μm , and a height difference between the first highest polishing tip and a 100th highest polishing tip is less than or equal to about 40 μm . Furthermore, the first highest polishing tip protrudes from the binding layer to a height of greater than or equal to about 50 μm .









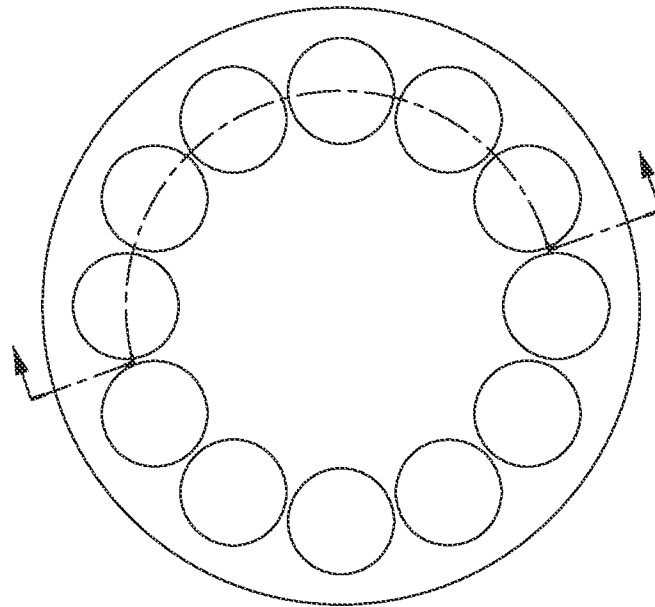


FIG. 2H

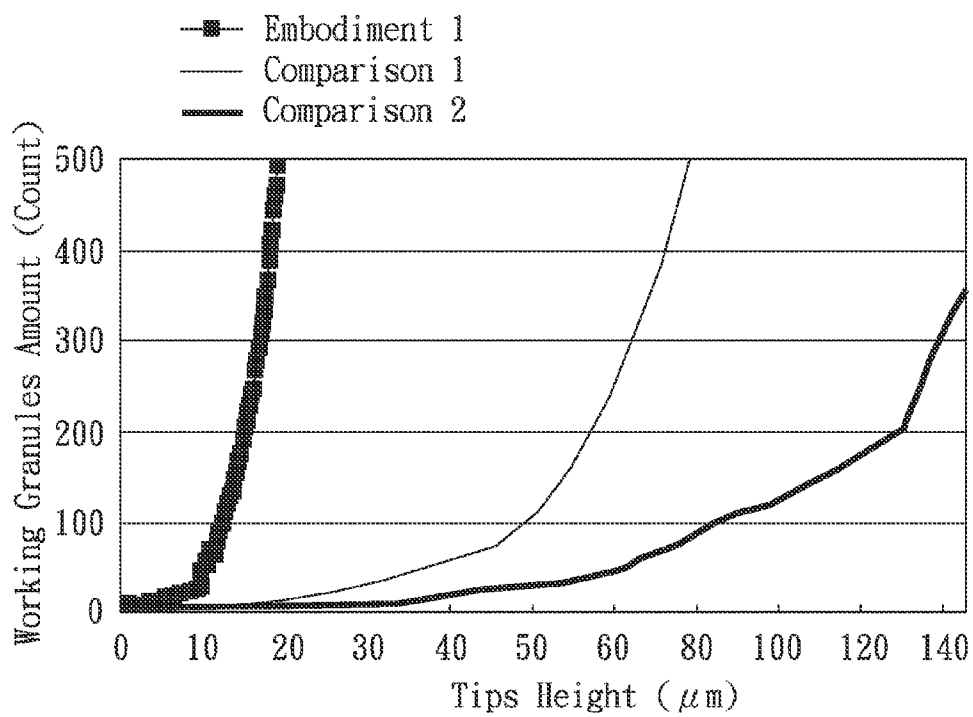


FIG. 3

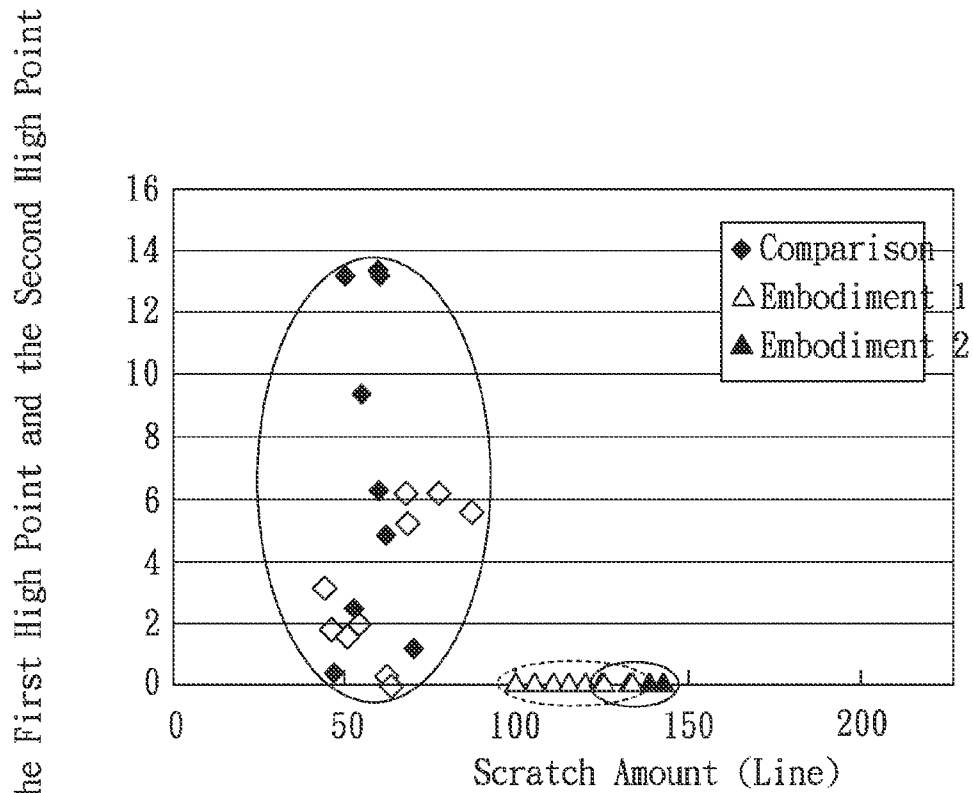


FIG. 4

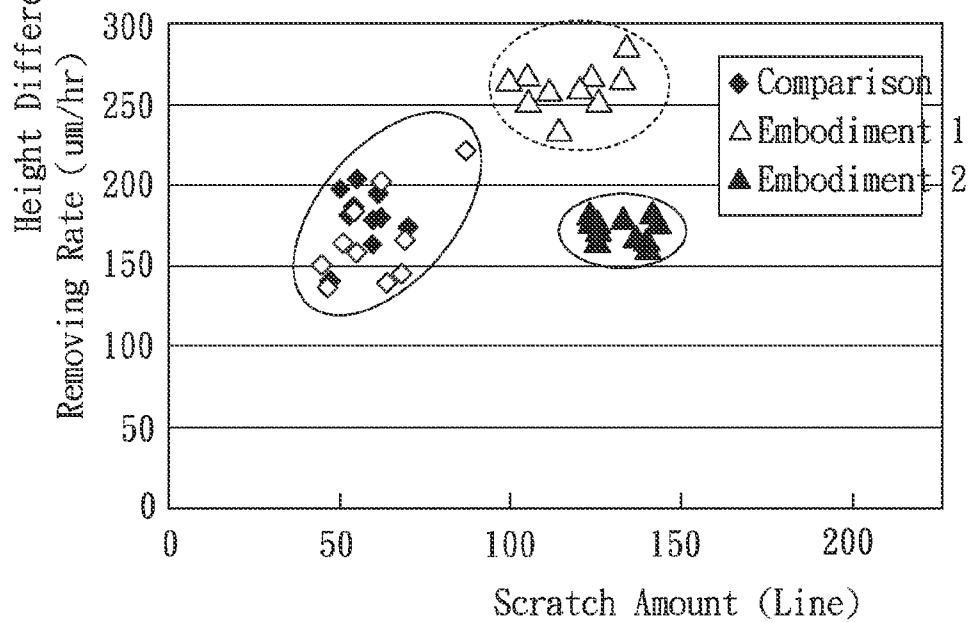


FIG. 5

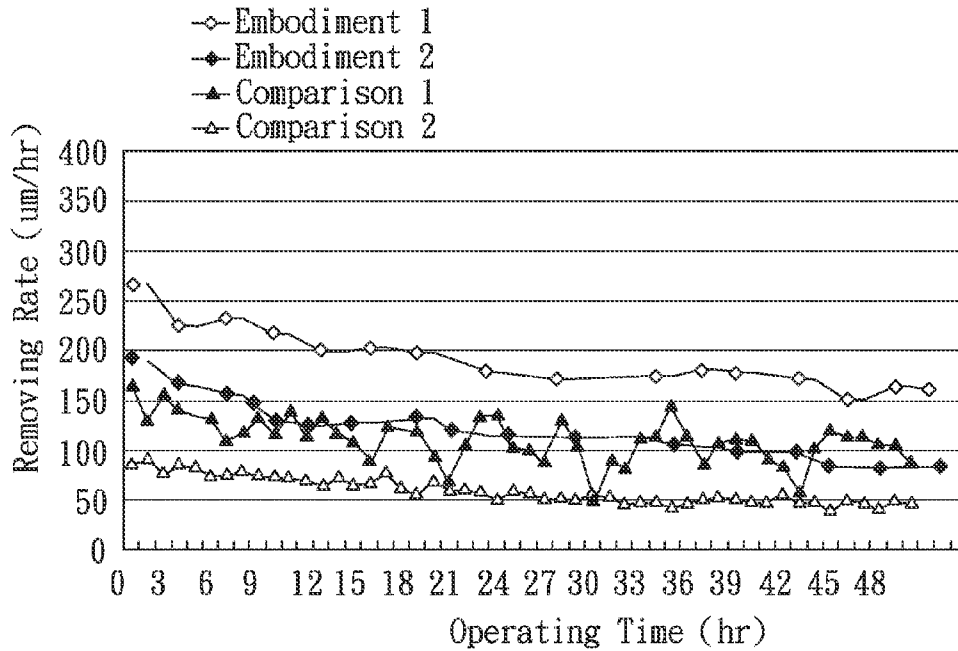


FIG. 6

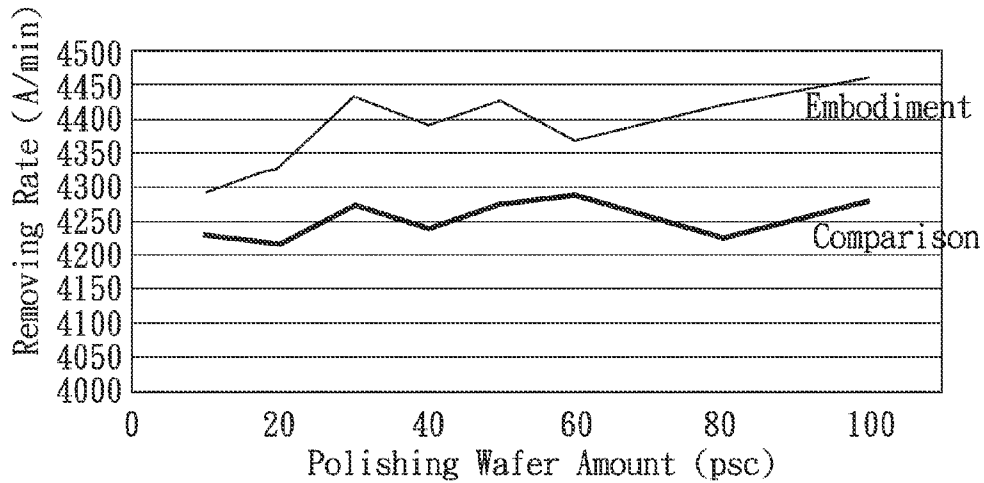


FIG. 7

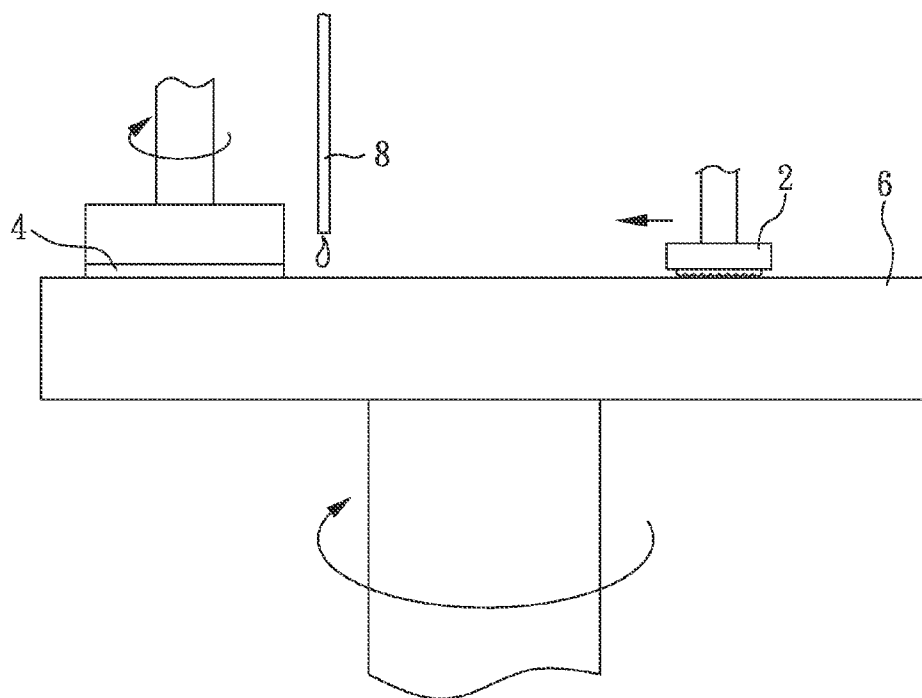


FIG. 8

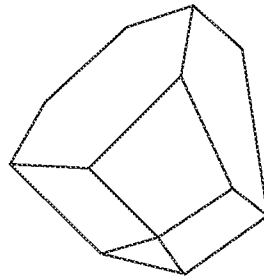
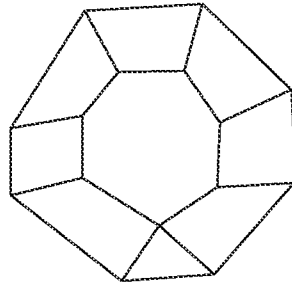


FIG. 9

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COMPOSITE CONDITIONER AND ASSOCIATED METHODS

PRIORITY DATA

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 12/726,786, filed on Mar. 18, 2010, which is a continuation-in-part of U.S. patent application Ser. No. 12/255,823, filed Oct. 22, 2008, which is a continuation-in-part of U.S. patent application Ser. No. 12/168,110, filed on Jul. 5, 2008, which claims the benefit of U.S. Provisional Patent Application Ser. No. 60/976,198, filed Sep. 28, 2007, and which is also a continuation-in-part of U.S. patent application Ser. No. 11/560,817, filed Nov. 16, 2006, which is a continuation-in-part of U.S. patent application Ser. No. 11/357,713, filed Feb. 17, 2006, which claims the benefit of U.S. Provisional Patent Application Ser. No. 60/681,798, filed May 16, 2005. This application is additionally a continuation-in-part of U.S. patent application Ser. No. 12/628,859, filed Dec. 1, 2009, which is a continuation of U.S. patent application Ser. No. 11/804,221, filed May 16, 2007, which is a continuation of U.S. patent application Ser. No. 11/223,786, filed Sep. 9, 2005. This application is also a continuation-in-part of U.S. patent application Ser. No. 12/850,747, filed Aug. 5, 2010, which claims the benefit of U.S. Provisional Patent Application Ser. No. 61/246,816, filed on Sep. 29, 2009. This application is further a continuation-in-part of U.S. patent application Ser. No. 13/034,213, filed Feb. 24, 2011, which claims the benefit of U.S. Provisional Patent Application Ser. No. 61/333,162, filed on May 10, 2010. Each of these applications is incorporated herein by reference. This application also claims the benefit of Taiwan Patent Application Serial No. 101112625, filed on Apr. 10, 2012, which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] For the tiny copper circuit or the interlayer tungsten circuit on the silicon wafer surface, even for the oxide film dielectric layer of the insulated circuit, making the surface flat through the planarization process to facilitate the subsequent process steps is necessary. Currently, with the process of manufacture integrated circuits (IC) on the semiconductor wafer, the most outstanding planarization technology is the chemical-mechanical planarization (CMP), which flattens a surface by pressing the wafer grinding on a rotating polishing pad.

[0003] The chemical-mechanical planarization is processed by transferring the slurry in between the wafer and the polishing pad stably and evenly to soak the polishing pad surface with slurry which containing chemicals (for instance, acid and oxidant) to erode the film on the wafer surface. The myriad of nano ceramics abrasive (ex. SiO₂, Al₂O₃ and CeO₂) in the slurry further pierce and scrape trace film, and simultaneously conduct chemical etching and mechanical grinding to remove the protruding deposit layer on the wafer. The purpose of planarization can be achieved by polishing the wafer surface.

[0004] A conditioner, whose function is to polish pad, is a necessary supply for chemical-mechanical planarization. The so-called condition is directed to shaving polishing pad surface and removing the waste accumulated on the polishing pad surface to maintain the roughness of the polishing pad surface. In addition, a conditioner could also produce tiny uplift and compression on the surface, and it is known as the

height different of the asperities. Accordingly, the contact area on the polishing pad would be reduced significantly. Once the contact area becomes smaller, the contact pressure becomes greater to make the slurry at the contact point extrusion the protruding part of the wafer and the chemicals (ex. H₂O₂) in the slurry would be oxidation to soften or erode the wafer.

[0005] However, the waste produced in the process of the chemical-mechanical planarization, including the debris of the wafer, ex. copper wires, tungsten filled holes, oxidation film, slurry, abrasive and polishing pad scrap etc, the debris usually accumulates on the polishing pad surface and is pressed to become glaze. Once the glaze is formed, polishing pad would become slippery and difficult to maintain grinding power. Therefore, after polishing each wafer, it is necessary to utilize a conditioner to achieve the grinding efficiency of the process (ex. polishing speed) and flatness (ex. the thickness distributed of the wafer coating) as to stabilize the wafer quality.

[0006] However, previous diamond conditioner is usually secured the diamond on the metal table surface by binder. Although it is adapted for conditioning the polishing pad, with regard to the more accurate chemical-mechanical planarization process, scratch, partial dishing, erosion and thickness non-uniformity of the wafer would cause easily by the rough asperities of the polishing pad. The smaller the required IC critical dimension, the greater the demand to the flatness of the wafer surface, also the greater the demand to the conditioner, and which can lead to previous diamond conditioner not being able to satisfy the pre-requirement of the chemical-mechanical planarization process smaller than 45 nm.

[0007] In an effort to obtain a dresser with abrasive tips that are as level as possible, it is often prudent to use diamond abrasives of high shape regularity, and the crystal surface coverage of this kind of crystal is quite high, otherwise, using the crystal with low crystal surface coverage would cause an overshooting height difference. Additionally, a diamond having the highest polishing pad penetration ability, the so-called killer diamond, presents no difference when compared to other diamonds with respect to pad height. In order to meet the demand for a smaller critical dimension, continuing improvement of the conditioner is necessary. Using the sharper polishing tips and maintaining the flatness of the tips height (i.e. the difference of the polishing tips top height), making conditioner forming the subtler and more uniform nick on the polishing pad, and improving the removal ratio to the polishing pad simultaneously, by this, it is efficient to remove the hard layer and recover the asperities on the polishing pad to polish the coating on the wafer rapidly.

SUMMARY OF THE INVENTION

[0008] The present disclosure provides efficient methods, devices, and systems of conditioning a CMP pad. In one aspect, for example, a composite conditioner can include a base plate and a plurality of polishing units secured to a surface of the base plate by an adhesive layer, where each polishing unit includes a plurality of polishing tips secured in a binding layer. Additionally, a height difference between a first highest polishing tip and a second highest polishing tip is less than or equal to about 10 μ m, a height difference between the first highest polishing tip and a tenth highest polishing tip is less than or equal to about 20 μ m, and a height difference between the first highest polishing tip and a 100th highest polishing tip is less than or equal to about 40 μ m. Further-

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more, the first highest polishing tip protrudes from the binding layer to a height of greater than or equal to about 50 μm . In some aspects, at least 1% of the plurality of polishing tips actively condition a CMP pad during a conditioning process. In other aspects, less than 40% of the surface of the base plate is covered with polishing units. The polishing units can be arranged on the plate in a variety of configurations. Non-limiting examples can include a single ring, double rings, multi-rings, radial arrangements, spiral arrangements, and the like.

[0009] In another aspect of the present disclosure, a method of making a composite conditioner can include disposing a second mold on a first mold, wherein the second mold includes a plurality of holes, placing a polishing unit in each of the plurality of holes of the second mold, where each polishing unit includes a plurality of polishing tips secured in a binding layer, applying an adhesive layer over the second mold to secure the polishing units, and removing the first mold and the second mold to form a composite conditioner. Regarding the conditioner, a height difference between a first highest polishing tip and a second highest polishing tip is less than or equal to about 10 μm , a height difference between the first highest polishing tip and a tenth highest polishing tip is less than or equal to about 20 μm , and a height difference between the first highest polishing tip and a 100th highest polishing tip is less than or equal to about 40 μm and the first highest polishing tip protrudes from the binding layer to a height of greater than or equal to about 50 μm .

[0010] In yet another aspect, a process of chemical-mechanical planarization (CMP) can include polishing a wafer against a rotating polishing pad and applying the conditioner as has been described against the polishing pad to remove debris and condition the pad.

[0011] There has thus been outlined, rather broadly, various features of the invention so that the detailed description thereof that follows may be better understood, and so that the present contribution to the art may be better appreciated. Other features of the present invention will become clearer from the following detailed description of the invention, taken with the accompanying claims, or may be learned by the practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1A to 1G show a flow chart of manufacturing a composite conditioner in accordance with one embodiment of the present invention;

[0013] FIG. 2A to 2G show a flow chart of manufacturing the composite conditioner in accordance with one embodiment of the present invention;

[0014] FIG. 2H shows a top view of a composite CMP pad dresser in accordance with an embodiment of the present invention;

[0015] FIG. 3 shows a comparison chart of the tip height difference and the working granule amount of a conditioner in accordance with one embodiment of the present invention as compared to a prior art conditioner;

[0016] FIG. 4 shows a comparison chart of the height difference (μm) and the scratch amount of the first highest point and the second highest point of a conditioner in accordance with one embodiment of the present invention as compared to a prior art conditioner;

[0017] FIG. 5 shows a comparison chart of the scratch amount and the removal rate of a conditioner in accordance with one embodiment of the present invention as compared to a prior art conditioner;

[0018] FIG. 6 shows a comparison chart of the in use time and the removing rate of a conditioner in accordance with one embodiment of the present invention as compared to a prior art conditioner;

[0019] FIG. 7 shows a comparison chart of the polishing wafer amount and the removal rate of a conditioner in accordance with one embodiment of the present invention as compared to a prior art conditioner;

[0020] FIG. 8 shows a schematic diagram of the chemical-mechanical planarization process in accordance with one embodiment of the present invention; and

[0021] FIG. 9 shows a schematic diagram of polishing granules in accordance with one embodiment of the present invention.

[0022] It will be understood that the above figures are merely for illustrative purposes in furthering an understanding of the invention. Further, the figures are not drawn to scale, thus dimensions, particle sizes, and other aspects may, and generally are, exaggerated to make illustrations thereof clearer. Therefore, departure can be made from the specific dimensions and aspects shown in the figures in order to produce the heat spreaders of the present invention.

DETAILED DESCRIPTION

[0023] Before the present invention is disclosed and described, it is to be understood that this invention is not limited to the particular structures, method steps, or materials disclosed herein, but is extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular embodiments only and is not intended to be limiting.

[0024] It must be noted that, as used in this specification and the appended claims, the singular forms “a,” “an” and, “the” include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to “a diamond particle” includes one or more of such particles and reference to “the layer” includes reference to one or more of such layers.

DEFINITIONS

[0025] In describing and claiming the present invention, the following terminology will be used in accordance with the definitions set forth below.

[0026] As used herein, the terms “conditioner” and “dresser” can be used interchangeably, and refer to a tool used to condition or dress a pad, such as a CMP pad.

[0027] As used herein, “dressing segment” and “polishing unit” can be used interchangeably, and refer to a dressing or conditioning element of a CMP pad dresser. Dressing segments are utilized in the present invention to carry superabrasive particles having leveled tips. Thus superabrasive particles are introduced into a CMP pad dresser by the incorporation of multiple dressing segments. It should be noted that a variety of techniques of attaching the dressing segments to the substrates, and a variety of techniques of attaching the superabrasive particles to the dressing segments, are discussed herein. It is to be understood that all of these various attachment mechanisms can be used interchangeably herein: that is, if a method of attaching a dressing

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segment to a substrate is discussed herein, the method of attachment discussed can also be used to attach a superabrasive particles to a dressing segment. For any particular CMP pad dresser being discussed, however, it is understood that attachment methods of the superabrasive particles to the dressing segments can differ from, or can be the same as, the method used to attach the dressing segments to the pad conditioner substrate.

[0028] As used herein, “superabrasive” may be used to refer to any crystalline, or polycrystalline material, or mixture of such materials which has a Mohr’s hardness of about 8 or greater. In some aspects, the Mohr’s hardness may be about 9.5 or greater. Such materials include but are not limited to diamond, polycrystalline diamond (PCD), cubic boron nitride (cBN), polycrystalline cubic boron nitride (PcBN), corundum and sapphire, as well as other superabrasive materials known to those skilled in the art. Superabrasive materials may be incorporated into the present invention in a variety of forms including particles, grits, films, layers, pieces, segments, etc. In some cases, the superabrasive materials of the present invention are in the form of polycrystalline superabrasive materials, such as PCD and PcBN materials.

[0029] As used herein, “organic material” refers to a semi-solid or solid complex or mix of organic compounds. “Organic material layer” and “organic matrix” may be used interchangeably, and refer to a layer or mass of a semisolid or solid complex or mix of organic compounds, including resins, polymers, gums, etc. The organic material can be a polymer or copolymer formed from the polymerization of one or more monomers. In some cases, such organic material can be adhesive.

[0030] As used herein, the process of “brazing” is intended to refer to the creation of chemical bonds between the carbon atoms of the superabrasive particles/materials and the braze material. Further, “chemical bond” means a covalent bond, such as a carbide or boride bond, rather than mechanical or weaker inter-atom attractive forces. Thus, when “brazing” is used in connection with superabrasive particles a true chemical bond is being formed. However, when “brazing” is used in connection with metal to metal bonding the term is used in the more traditional sense of a metallurgical bond. Therefore, brazing of a superabrasive segment to a tool body does not necessarily require the presence of a carbide former.

[0031] As used herein, “particle” is as used herein in connection with diamond particles, and refers to a particulate form of diamond. Such particles may take a variety of shapes, including round, oblong, square, euhedral, etc., can be either single crystal or polycrystalline, and can have a number of mesh sizes. As is known in the art, “mesh” refers to the number of holes per unit area as in the case of U.S. meshes. All mesh sizes referred to herein are U.S. mesh unless otherwise indicated. Further, mesh sizes are generally understood to indicate an average mesh size of a given collection of particles since each particle within a particular “mesh size” may actually vary over a small distribution of sizes.

[0032] As used herein, “sharp portion” means any narrow portion to which a crystal or particle may come, including but not limited to corners, apexes, ridges, edges, obelisks, and other protrusions. In some cases, corners and/or apexes are formed at the convergence of more than two faces of the particle or crystal, or other body, disposed in intersecting planes. In other aspects, edges and/or ridges may be formed at the convergence of two or at least two faces of the particle or crystal, or other body, disposed in intersecting planes. In

some aspects, “sharp portion” can include a portion that is broken, chipped, cracked, jagged, and the like. In some aspects, degrees of sharpness can be correlated with the geometric angle formed by the particle, crystal, or other body, at the location in question. In some aspects, an angle of 90 degrees or less can be considered sharp. In other aspects, an angle of 60 degrees or less can be considered sharp. In yet other aspects, an angle of 45 degrees or less, or 30 degrees or less can be considered to be sharp.

[0033] As used herein, “peripherally located,” “peripheral location” and the like, mean any particle of a dresser that is located in an area that originates at the leading edge or outer rim of a dresser and extends inwardly towards the center for up to about 90% of the radius of the dresser. In some aspects, the area may extend inwardly from about 20% to 90% of the radius. In other aspects, the area may extend in to about 50% of the radius. In yet another aspect, the area may extend in to about 33% of the radius of a dresser (i.e. 66% away from the center).

[0034] As used herein, “working superabrasive particles” are superabrasive particles that touch a CMP pad during a dressing or conditioning procedure. This touching can remove debris from the surface, it can deform the surface either elastically or plastically, or it can cut the surface to create a groove. In one specific aspect, a working superabrasive particle can cut deeper than about 10 microns into a CMP pad during a dressing procedure.

[0035] As used herein, “non-working superabrasive particles” are superabrasive particles in a CMP pad dresser that do not significantly touch the pad sufficient to remove debris from the surface, deform the surface, cut the surface to create a groove.

[0036] As used herein, “overly-aggressive superabrasive particles” are superabrasive particles in a CMP pad dresser that aggressively dress or condition a CMP pad. In one aspect, aggressive superabrasive particles are superabrasive particles that cut deeper than about 50 microns into a CMP pad during a dressing procedure. In another aspect, aggressive superabrasive particles are superabrasive particles that remove at least $\frac{1}{2}$ of the material from the CMP pad. In yet another aspect, aggressive superabrasive particles are superabrasive particles that remove at least $\frac{1}{2}$ of the material from the CMP pad.

[0037] As used herein, “indicator substrate” refers to a substrate material upon which a portion of the superabrasive particles of a CMP pad dresser can be positioned and moved to make markings indicative of working superabrasive particles.

[0038] As used herein, “marking pattern” refers to a pattern on an indicator substrate created by moving superabrasive particles thereacross. The markings can be any detectable marking known, including cuts, scratches, depressions, material deposition (e.g. pigment markers, chemical markers, fluorescent markers, radioactive markers, etc.).

[0039] As used herein, “transverse” refers to a directional orientation that is cross-wise to a reference axis. In one aspect, “transverse” can include a directional orientation that is at least at a substantial right angle to the reference axis.

[0040] As used herein, “alignment orientation direction” refers to the direction of an alignment axis of the plurality of superabrasive particles. For example, a plurality of superabrasive particles aligned in a grid formation would have at

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least two alignment axes; an alignment axis in the column direction and an alignment axis in the row direction oriented 90° to the column direction.

[0041] As used herein, “ablate” or “ablating” refer to a process of removing a superabrasive particle from a CMP pad dresser or reducing the projection of a superabrasive particle thus reducing the degree of contact between the superabrasive particle and the indicator substrate.

[0042] As used herein, “superabrasive segment” refers to a tool body having multiple superabrasive particles associated therewith. In some aspect, a superabrasive segment can include superabrasive polycrystalline materials as cutting elements.

[0043] As used herein, a “tool substrate” refers a portion of a pad conditioner that supports abrasive materials, and to which abrasive materials and/or superabrasive segments that carry abrasive materials may be affixed. Substrates useful in the present invention may of a variety of shapes, thicknesses, or materials that are capable of supporting abrasive materials in a manner that is sufficient to provide a pad conditioner useful for its intended purpose. Substrates may be of a solid material, a powdered material that becomes solid when processed, or a flexible material. Examples of typical substrate materials include without limitation, metals, metal alloys, ceramics, relatively hard polymers or other organic materials, glasses, and mixtures thereof. Further, the substrate may include a material that aids in attaching abrasive materials to the substrate, including, without limitation, brazing alloy material, sintering aids and the like.

[0044] As used herein, “working end” refers to an end of a particle which is oriented towards the CMP pad and during a dressing operation makes contact with the pad. Most often the working end of a particle will be distal from a substrate to which the particle is attached.

[0045] As used herein, “attitude” means the position or arrangement of a superabrasive particle in relation to a defined surface, such as a substrate to which it is attached, or a CMP pad to which it is to be applied during a work operation. For example, a superabrasive particle can have an attitude that provides a specific portion of the particle in orientation toward a CMP pad.

[0046] As used herein, “sintering” refers to the joining of two or more individual particles to form a continuous solid mass. The process of sintering involves the consolidation of particles to at least partially eliminate voids between particles.

[0047] The term “metallic” refers to both metals and metalloids. Metals include those compounds typically considered metals found within the transition metals, alkali and alkali earth metals. Examples of metals are Ag, Au, Cu, Al, and Fe. Metalloids include specifically Si, B, Ge, Sb, As, and Te. Metallic materials also include alloys or mixtures that include metallic materials. Such alloys or mixtures may further include additional additives. In the present invention, carbide formers and carbon wetting agents may be included as alloys or mixtures, but are not anticipated to be the only metallic component. Examples of such carbide formers are Sc, Y, Ti, Zr, Hf, V, Nb, Cr, Mo, Mn, Ta, W, and Tc. Examples of carbon wetting agents are Co, Ni, Mn, and Cr.

[0048] As used herein, “infiltrating” refers to a situation where a material is heated to its melting point and then flows as a liquid through the interstitial voids between particles.

[0049] As used herein, the term “substantially” refers to the complete or nearly complete extent or degree of an action,

characteristic, property, state, structure, item, or result. For example, an object that is “substantially” enclosed would mean that the object is either completely enclosed or nearly completely enclosed. The exact allowable degree of deviation from absolute completeness may in some cases depend on the specific context. However, generally speaking the nearness of completion will be so as to have the same overall result as if absolute and total completion were obtained.

[0050] The use of “substantially” is equally applicable when used in a negative connotation to refer to the complete or near complete lack of an action, characteristic, property, state, structure, item, or result. For example, a composition that is “substantially free of” particles would either completely lack particles, or so nearly completely lack particles that the effect would be the same as if it completely lacked particles. In other words, a composition that is “substantially free of” an ingredient or element may still actually contain such item as long as there is no measurable effect thereof.

[0051] As used herein, the term “about” is used to provide flexibility to a numerical range endpoint by providing that a given value may be “a little above” or “a little below” the endpoint.

[0052] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary.

[0053] Concentrations, amounts, and other numerical data may be expressed or presented herein in a range format. It is to be understood that such a range format is used merely for convenience and brevity and thus should be interpreted flexibly to include not only the numerical values explicitly recited as the limits of the range, but also to include all the individual numerical values or sub-ranges encompassed within that range as if each numerical value and sub-range is explicitly recited. As an illustration, a numerical range of “about 1 to about 5” should be interpreted to include not only the explicitly recited values of about 1 to about 5, but also include individual values and sub-ranges within the indicated range. Thus, included in this numerical range are individual values such as 2, 3, and 4 and sub-ranges such as from 1-3, from 2-4, and from 3-5, etc., as well as 1, 2, 3, 4, and 5, individually. This same principle applies to ranges reciting only one numerical value as a minimum or a maximum. Furthermore, such an interpretation should apply regardless of the breadth of the range or the characteristics being described.

The Invention

[0054] One objective according to some aspects of the present invention is to provide a composite conditioner, which is utilizing the shape of polishing tips while maintaining the distribution of tip height to avoid the over aggressive cutting of highly exposed abrasives (e.g. killer diamond) so as to improve the ratio of working polishing tips on the polishing pad during conditioning, and to increase the removal ratio from the wafer and the durability of the conditioner.

[0055] In one embodiment, for example, a composite conditioner can include a base plate and a plurality of polishing units secured to a surface of the base plate by an adhesive layer, where each polishing unit includes a plurality of pol-

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ishing tips secured in a binding layer. The height difference between the first highest polishing tip and the second highest polishing tip is less than or equal to about 10 μm , the height difference between the first highest polishing tip and the tenth highest polishing tip is less than or equal to about 20 μm , and the height difference between the first highest polishing tip and the 100th highest polishing tip is less than or equal to about 40 μm . Furthermore, the first highest polishing tip protrudes from the binding layer to a height of greater than or equal to about 50 μm .

[0056] Due to the fact the chemical-mechanical planarization (CMP) is directed to planar polishing, the contact distribution between the high point of the wafer and the polishing pad leads to confirm the quality (i.e. yield rate) and the efficiency (i.e. production capacity) of the CMP. If the distribution of the high point of the asperities in the CMP pad is uneven, the abrasion rate of the wafer in different parts of the polishing pad would be different and the wafer surface may become uneven. Furthermore, it is possible that some areas would be over-polished to result in dishing or layer erosion; or in some cases can result in under-polished regions producing residuals. If within wafer non-uniformity (WIWNU) is high, the effect of the chemical-mechanical planarization would be not desired. Accordingly, the present disclosure provides an enhanced conditioner based on extensive data from testing and experiment, and especially adjusts the height of the working polishing tips by a thickness adjustable adhesive layer to compensate for the difference of polishing units thickness and achieve aforesaid height distribution of the highest tip to avoid producing killer diamond and improve the ratio of the effective working polishing tips on the polishing units.

[0057] With regard to the present invention aforesaid composite conditioner the material of the thickness adjustable adhesive layer could be any suitable organic adhesive. Each polishing unit further comprises a unit substrate, and a binding layer is positioned between the surface of the unit substrate and the polishing tips. This binding layer can be a solder, a braze, an organic polymer, a plating layer, a sintered layer, a resin layer, or the like. The polishing tips refer to tips, a plurality of which are located on each polishing unit, can achieve the polishing effect, and the tips are exposed at the binding layer, that is, the height of the polishing tips means the height of the polishing tips protrude over the binding layer surface.

[0058] With regard to high-precision measurement for the height of the polishing tips, various techniques are contemplated. In one aspect, for example, measurement can be accomplished by an optical detection system such as the surface detector manufactured by Germany FRT (Fries Research & Technology GmbH). The surface detector detects the height of total polishing tips (ex. more than 10000) of the conditioner, that is, detects the height of the polishing tips protrusion over the binding layer surface. Using the least square method with the height data, a theorized plane may be calculated across the tops of the polishing tips. The first highest tip is the height of the polishing tip that protrudes over the theorized plane to the greatest extent, the second highest tip is the height of the polishing tip that protrudes over the theorized plane to the second most extent, and so on.

[0059] The position of the wafer to be polished mostly depends on the distribution of the polishing pad top, and the distribution depends on the height of the polishing tips of the conditioner. The conditioner can be disk-shaped (as adapted for Applied Materials) or ring-shaped (as adapted for Ebara).

The diameter of the disk can be about 100 mm in general, and the diameter of the ring can be greater than 250 mm. Generally, there are tens of thousands polishing tips (e.g. diamond particles) distributed on the conditioner, for example: the polishing tips of 80/90 mesh, 100/120 mesh and 120/140 mesh, but the difference in size might be greater than 30% even in the same mesh. Additionally, there can also be a difference in size in similar polishing tips when oriented different directions; for example, the distance between the tips is 30% greater than that between particle planes, and if the shape of the polishing tips is not regular, the difference would be greater.

[0060] Therefore, the present invention regulates the polishing particles such that the height difference between the first highest polishing tip and the second highest polishing tip is less than or equal to about 10 μm , the height difference between the first highest polishing tip and the tenth highest polishing tip is less than or equal to about 20 μm , and the height difference between the first highest polishing tip and the 100th highest polishing tip is less than or equal to about 40 μm , and the first highest polishing tip protrudes from the binding layer to a height of greater than or equal to about 50 μm to ensure that there are sufficient working tips in the conditioner to achieve effective polishing of the IC wafer surface rapidly and uniformly. Additionally, it should be noted that the first highest tip and the second highest tip might be located in different polishing units or at the same polishing unit, similar with the other polishing tips; in another words, the tip distribution is not centralized at single polishing unit.

[0061] With respect to the aforesaid composite conditioner, the particles of the polishing tips can be any superabrasive material, including, without limitation, artificial or natural diamond, polycrystalline diamond (PCD), cubic boron nitride (CBN), poly crystal cubic boron nitride (PCBN), or a combination thereof. In some aspects, particle size can be in the range from about 100 μm to about 500 μm . The aforesaid diamond can be deposition diamond, polycrystalline diamond or the combination thereof. Additionally, there is no restriction to the material of the base plate, for example, resin, metal, alloy, plastic, rubber, ceramics, glass or the combination thereof (examples include the admixture between resin and alloy).

[0062] Additionally, in some cases diamond is formed by transforming graphite with iron-nickel alloy at high pressure (ex. 5 GPa), thus leaving iron-nickel inclusion inside. The alloy can transform the diamond back to the graphite or carbon at high temperature, and the volume will increase substantially to often split the diamond. Thus, diamond secured to the diamond disk by brazing can be problematic in these cases where high temperature of the braze can cause the diamond to split. In the CMP process, such fractured diamond tips may crumble along the micro-fracture surface, releasing diamond chips that can scratch the wafer. In some aspects, an electromagnetic separator can be used to separate diamond particles having excessive metal inclusions. In some aspects, it can be beneficial to choose a low melting point solder for attaching the diamond particles to the polishing units.

[0063] In the present invention, when choosing the solder as the material of the binding layer, the solder layer could comprise greater than about 1 weight percentage of at least one of Cr, B, P, Ti and alloys thereof, and greater than about 50 weight percentage of at least one of Ni, Cu and alloys thereof. The Cr, B, P, Ti etc. can be used for activating the solder layer.

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Specifically, the solder can be Ni—Cr—B, Ni—Cr—P, or Cu—Sn—Ti alloy, where the melting point is between about 800° C. and about 1000° C.

[0064] Additionally, each polishing unit can further selectively include a metal cover layer which covers on the surface of the binding layer, and the material of the metal cover layer can be at least one of Ni, Cr, Pd, Co, Pt, Au, Ti, Cu, W and alloys thereof to further adhere the polishing tips on the unit substrate of the polishing unit. Furthermore, each polishing unit further selectively comprises a protective layer which is thin inert material and covers on the surface of the metal cover layer, and the material of the protective layer is metal such as Pd, Pt, or non-metal as silicon carbide, silicon nitride, aluminum nitride, alumina, zirconia, diamond-like carbon (DLC), organic film (as Teflon) or a combination thereof to avoid the solder be eroded by the polishing slurry (ex. pH=3 tungsten process slurry).

[0065] Generally, the height of the diamond tips will determine the power pressed into the polishing pad but the sharpness will affect the depth of the diamond penetration into the polishing pad. In general, when the diamond gets sharper, the polishing pad deformation of elasticity and plasticity will be smaller, and the depth of cut is greater. Because the diamond abrasive formed on the conditioner surface is different in shape and direction, the top hundred-height diamond could contact the polishing pad. If the diamond is regular in shape and in symmetry, the angle will be obtuse and may be difficult to pierce into the polishing pad, and the diamond will push onto the polishing pad surface and form protruding plastic deformation from two sides; on the other hand, if the diamond has a sharp surface, which if not regular in shape, it may pierce into the polishing pad, cut the polishing pad surface and remove the waste simultaneously.

[0066] Therefore, with regard to the aforesaid composite conditioner of the present invention, the crystal surface coverage of more than 50% of the top 100 height polishing tips are less than 80%, and the preferred is less than 50%.

[0067] In some aspects, the highest 100 diamond tips may dress or condition less than 50% of a CMP pad. In other words, the 100 highest diamond tips perform less than 50% of the overall dressing workload. In some aspects, the workload is less than 80% of the overall dressing workload. In additional aspects, the 10 highest tips may dress or condition less than 50% of the CMP pad. Again, in this respect, the 10 highest diamond tips perform less than 50% of the overall dressing workload. In some aspects, the workload is less than 80%. Conversely described, the diamond particles in the dresser outside of the highest 100 or 10 may perform more than 50% of the overall dressing workload. In some aspects, the overall workload may be more than 80%.

[0068] As the crystal surface coverage of the polishing tips becomes lower that those polishing tips have more crack surface (sharp surface) and the polishing tips of the polishing unit working surface comprises corners and ridges, have more ridges with the angle less than 45° (means the angle of the two crystal surface which form the ridge), or have more angle less than 90°, therefore have higher removal ratio for the polishing pad.

[0069] Referring now to FIG. 9, the schematic diagram to polish abrasive, wherein A, E and S respectively points to corner, ridge and surface, wherein S_1 is the crystal surface, A_1 is the angle of the crystal surface, S_2 is the crack surface and A_2 is the angle of at least one crack surface. From this, A_1 and A_2 are two different angle, A_1 is greater than 90° (obtuse

angle) and A_2 is less than 90° (acute angle), means that when using A_2 as polishing tips, the removal efficiency is greater than A_1 .

[0070] The polishing tips can be arranged in a pattern on the unit substrate or the polishing tips form a plurality of clusters and the clusters are arranged in a pattern on the unit substrate, where each the cluster is composed of two to six polishing tips.

[0071] Additionally, the polishing units can be arranged on the base plate as single ring, double rings, multi-rings, radial or spiral in shape and it could be disk in shape, blade in shape or polygon. If the polishing units are disk in shape, the diameter is in the range of 5 mm to 30 mm. The diameter in the range of 14 mm to 18 mm is preferred. The base plate also could be disk in shape and the diameter is in the range of 80 mm to 120 mm. It also could secure the polishing unit on the ring substrate, which is 250 mm to 270 mm in diameter, for actual use. Additionally, if the polishing unit with a disk shape is positioned at an inner surface, the polishing unit on the inner surface can be obstructed by the outer polishing units when conditioning the polishing pad, so that the inner polishing unit may not function well. Therefore, the polishing units can be arranged at the outer edge of the disk-shape base plate surface, it could create a fringe effect on a outer edge during the CMP process, such that it will increase the working amount of the polishing units, and the CMP process is adapted to apply for the nanometer process of 18 inch wafer or 22 nm wire.

[0072] In the aforesaid composite conditioner of the present invention, the spacing between the polishing units is not less than 0.1 mm, a spacing of greater than 0.5 mm is preferred, so it could be sure that in the CMP process, the slurry could flow favorably along the spacing between the polishing units and would not remain inside due to defect as the scratch to the wafer. Besides, the thickness of the binding layer of the polishing unit's bottom is in the range less than 0.6 mm so that it could fully adjust the polishing tips of each polishing unit to the same plane to increase the amount of the diamonds efficiently.

[0073] Formerly, the height difference of the tips is too big so that the amount of the tips utilized by traditional conditioner (comprising the tips piercing into polishing pad) is less than 1% of the tips total amount and the diamond coverage area of traditional conditioner is over 40%; on the other hand, in the aforesaid composite conditioner of the present invention, the amount of the polishing tips used for conditioning a polishing pad is more than 1% of the total polishing tips; besides, the area of the polishing units covering the base plate is less than 40% of the total area of the base plate surface to achieve the best remove ratio.

[0074] It is another objective of the present invention to provide a manufacture method of a composite conditioner, wherein using the polishing unit with sharp polishing tips, through the inversion method, setting the top several tips of each polishing unit as standard plane, adjusting the thickness of the binding material under each polishing unit to secure on the substrate so that the top several tips of the polishing units would not protrude to form the destructive "killer diamond". Using coplanar to make the highest point of each polishing unit achieve common height could also improve the ratio of working polishing tips, further to improve the removal ratio and durability of the conditioner.

[0075] As such, another embodiment of the present invention provides a manufacture method of a composite condi-

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tioner, including the following steps: installing a second mold on a first mold, wherein the second mold comprises a plurality of holes; installing a polishing unit in each the hole of the second mold, wherein each the polishing unit comprises a plurality of polishing tips and a binding layer securing the polishing tips; forming a thickness adjustable adhesive layer to secure the polishing units on a base plate; and removing the first mold and the second mold to form a composite conditioner, wherein the height difference between a first and a second highest tip, between the first and a tenth highest tip, and between the first and a 100th highest tip protruding from a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the height of the first highest tip protruding from the binding layer is greater than 50 μm .

[0076] Generally, diamond conditioner is made by additive manufacturing method, that is, arranging in flat the diamond abrasive (like matrix distribution) on the plane substrate (as stainless steel No. 316). Obtaining a diamond conditioner or tool with diamond particles having a height difference of the diamond top of single conditioner surface of about 50 μm or less is difficult using known methods of securing the diamond abrasive such as electroplating with nickel or by brazing with an alloy, which suffers from curdling and gripping due to surface tensions when the braze is liquified. The former diamond surface is usually upward and the latter tips or the ridge usually protrude, and the diamonds with surface upward pierce into the polishing pad with difficulty and the diamond with tips or the ridge cut the polishing pad more easily. In contrast, the present invention can utilize electroplating first to form polishing units, combines organic flexible material and compensates a plurality of polishing units to arrange the polishing units at the base plate, it not only has the advantage of brazing but also could avoid the disadvantage thereof. Therefore, when the diamond conditioner is conditioning the polishing pad, the protrusion diamond top could contact and pierce into the polishing pad without having the polishing tips protruding too much, so piercing into the polishing pad too deep may increase the height difference between the asperities and therefore preventing the outstanding asperities from dipping too much slurry, and ultimately leading to the nano particle of the slurry to penetrate excessively into the wafer surface to produce over-polishing, and even scratching the wafer.

[0077] With the aforesaid manufacture method of a composite conditioner of the present invention, the thickness adjustable adhesive layer could be formed after using another plate to leveling the top tips of the polishing units, or after forming the thickness adjustable adhesive layer before the thickness adjustable adhesive layer solidified using the base plate to leveling the top tips of the polishing units.

[0078] The thickness adjustable adhesive layer could be composed by the organic adhesive, for example: a plastic material, a rubber material, a hot melt adhesive or the combination thereof; besides, the holes of the second mold are arranged at the second mold outer. Specifically, the holes of the second mold are arranged at the outer ring of the second mold as 12 holes. Additionally, with the composite conditioner, the polishing units also could be arranged at inner or outer ring, and the smaller the polishing units are, the more the amount of the working granules when polishing, but the cost of manufacturing will be higher, so manufacturing the conditioner with appropriate amount of polishing units could balance the effect and cost.

[0079] With the aforesaid manufacture method of a composite conditioner of the present invention, before the second mold set on the first mold, further comprising: forming a temporary adhesive layer on the first mold surface and setting the second mold on the temporary adhesive layer to fold the temporary adhesive layer between the second mold and the first mold, and after removing the second mold, further comprising: removing the temporary adhesive layer. With a preferred embodiment of the present invention, the temporary adhesive layer is a double-sided tape.

[0080] In another preferred embodiment of the present invention, a side of the polishing units has the polishing tips, and the thickness adjustable adhesive layer is set on the opposite side, and the polishing units set at the holes contact the first mold through the polishing tips. Besides, after removing the first mold and the second mold, further comprising: forming a mold sealing glue layer to secure the polishing units. From the above, it is possible to make the polishing units arranged orderly on the same plane by adding pressure at the side having the polishing tips of the polishing units.

[0081] With the aforesaid manufacture method of a composite conditioner of the present invention, further selectively comprising: after removing the first mold, moving the second mold. That is, the conditioner might comprise the second mold.

[0082] It is another object of the present invention to provide a chemical-mechanical planarization (CMP) process, wherein sharp polishing tips may be used while the planarity of the working surface is maintained and the ratio of the effective working polishing tips on the polishing units is improved, and the removing rate and durability are increased.

[0083] To achieve aforesaid object, another embodiment of the present invention provides a process of chemical-mechanical planarization, including the following steps: providing a polishing pad; installing a wafer on the surface of the polishing pad to polish the polishing pad with each other; and using a conditioner, which is installed on the surface of the polishing pad and removing the scrap of the polished wafer, wherein the conditioner is the aforesaid composite conditioner of the present invention.

[0084] The Moore's law states that the amount of the transistor in the same size in the same wafer will double every 18 months because of the improvement of the process technology and improved speed of the wafer executing computing. In accordance with the continuing improvement suggested by the Moore's law, the critical dimension of integrated circuit (IC) gradually exceeds the limit of 32 nm, however, the bottleneck that is occurring now is that the it is current state of art of the chemical-mechanical process is difficult to surpass, so the process could not enter a stage for finer critical dimension. In other hand, because we utilize the improved conditioner in the chemical-mechanical planarization process of the present invention, we could use the diameter of the wafer in 200 mm, 300 mm or 450 mm in the chemical-mechanical planarization process of the present invention, and the wafer surface having the IC critical dimension is smaller than or equal to 45 nm, 28 nm, or 22 nm. Therefore, if the related technology utilizes the technology of the present invention, for example applying the chemical-mechanical planarization process of the present invention for manufacturing logic device, DRAM, flash memory or hard drive, the speed of the each aforesaid device executing computing will improve as postulated by the Moore's law.

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[0085] Generally speaking, because diamond sizes differ in great variety, shape and direction, and the random distance of the high point, the plough of the polishing pad and the cut manner are multifarious and which leads to uneven height of the conditioned polishing pad and then leads to difficult controlling the high point position of the wafer contacting, the area and the pressure of each contact point, and result the high variability to the polishing rate and the uniformity. When the wafer varies greatly (8 inch to 12 inch even to 18 inch in the future), the variability to the polishing rate and the uniformity will become higher, and the quality and the efficiency of the chemical-mechanical planarization process will become lower. Not only that, when the critical dimension becomes more and more narrow (45 nm to 32 nm even to 22 nm in the future), the high point of the polishing pad gets broken more easily. When the electric circuit becomes narrow, the dielectric materials therebetween have to be hollower to avoid leakage, but the hollow dielectric layer is weak, so the contact pressure of the chemical-mechanical planarization process has to weaken, but lowered contact pressure will cause the speed of polishing wafer become lower and the poor productivity.

[0086] Currently, the diamond conditioner usually adopts the method of adding diamond on the plane to manufacture, for the reason that the top height is difficult to control. Besides, under the high temperature manufacturing (as brazing), the substrates will distort to make the top height more irregular, and significantly decrease the working granule amount, and even lead to tens of thousands of diamond on the conditioner, but there are only several hundred of working granule. Because the diamond conditioner adopts addition (flattening by the top which has diamond abrasive presses thereon) to manufacture, the size, shape and direction of the diamond are difficult to control, and the diamond amount, position and piercing depth are also difficult to control, cause the predictability of the chemical-mechanical planarization process effect to greatly reduce. Although it strictly controls the flatness, diamond shape, etc. of the conditioner substrate in industry, but the improving effect is not enough.

[0087] In view that the top of the diamond is not easy to be regular, the present invention adopts a method of reversed composite, and manufactures the diamond polishing units first, and inverts the diamond polishing units on a plane to make each of the polishing tips regular. At this time, set a thickness adjustable adhesive layer at the contrary side of the polishing tips, and finally irrigate the mold sealing glue layer in (as resin) to secure all polishing units. As the aforesaid manufacturing method could avoid the "killer diamond" that is common on the diamond dish, that is, the stand up protrusion diamond. If the "killer diamond" is too sharp, it may pierce into the polishing pad too deep and pull to fracture, and then form the "killer asperities" on the polishing pad surface to cause the wafer scratch.

[0088] The following explains the implemented method of the present invention by specific concrete embodiment, and a skilled person in this art could easily understand other advantage and effect of the present invention through the content disclosed by the specification. The present invention also could be implemented and applied by other different concrete embodiment, and the detail of the present invention also could base on different view and apply for various decorations and changing without deviating the spirit of the present invention,

[0089] The drawings in the embodiment of the present invention are simplified schematic diagram. But the drawings only illustrate the components about the present invention,

and the illustrated components are not the example when actually implement. The components amount, shape and ratio are selective design when actually implement, and the components layout patterns might be more complicated.

[0090] References FIG. 1A to 1G, are the flow charts of manufacturing the composite conditioner.

[0091] First of all, as shown in FIG. 1A, it provides a first mold10, and first mold10 has an opening101. Then, as FIG. 1B illustrates, it forms a temporary adhesive layer11 on opening101 surface of first mold10, and then sets a second mold12 on temporary adhesive layer11 surface to make second mold12 position in opening101 of first mold10, so temporary adhesive layer11 is between second mold12 and first mold10, wherein second mold12 has a plurality of holes121. In this preparation, temporary adhesive layer11 is a double-sided tape.

[0092] As shown in FIGS. 1C and 1G, it sets a polishing unit20 in each holes121 of second mold12, wherein each polishing unit20 comprises a plurality of polishing granules22 (each polishing granules22 at least has a polishing tip221), a unit substrate21 and a binding layer213 set between unit substrate21 surface and polishing tips221. Polishing units20 are made by general brazing, which simply explains as follow: spot-weld the solder sheet (BNi₂) at unit substrate21 with 20 mm in diameter, 4 mm in thickness, and then arrange the polishing granules (as diamond granules) on the solder sheet which is coated with viscose through the template, and then put those into the vacuum furnace exhaust to about 5 torr to 10 torr, and heating to not more than 1020° C. with 12 min last (during this the viscose is volatilized), and the solder melts to liquid and welds the diamond granules.

[0093] Because the diamond is originally positioned on a fixed solder material, when the solder melting to form as the liquid, the carbide elements (Cr) therein will diffuse to the diamond surface. So the solder will pull sink the diamonds with capillary power and climb the diamond surface to form a gradient. The diamonds will stick the solder sheet surface with plane originally, but now the rotation in the liquid will make the sharp corners up.

[0094] Then, as shown in FIGS. 1D and 1E, flatten polishing units20 by a base plate24, and fill in a thickness adjustable adhesive layer23 to secure polishing units20. Then, as shown in FIG. 1F, remove first mold10, temporary adhesive layer11 and second mold12 to form a composite conditioner2.

[0095] Composite conditioner2 comprises: a base plate24; a plurality of polishing units20 placed on a surface of base plate24, and each polishing unit20 including a plurality of polishing tips221 and a thickness adjustable adhesive layer23 which used to secure polishing units20 on the surface of base plate24, wherein, with polishing tips221, the height difference between a first and a second highest tip, between the first and a tenth highest tip, and between the first and a one hundredth highest tip protruding from a predetermined plane is respectively less than 10 μm, 20 μm, and 40 μm, and the height of the first highest tip protruding the binding layer213 is greater than 50 μm.

[0096] Referring now to FIG. 1G, it is an enlarged schematic of the polishing units of the present invention. Each polishing unit 20 comprises a plurality of polishing granules22 (each polishing granules22 at least has a polishing tip221), a unit substrate21, a binding layer213 set between unit substrate21 surface and polishing tips221, a metal cover layer212 covering on binding layer213 surface and a protective layer211 covering on metal cover layer212 surface.

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[0097] Binding layer213 could be a solder layer, a plating layer, a sintering layer or a resin layer. If it is a solder layer, the solder layer comprises greater than 1 weight percentage selected at least one from the group consisting of: Cr, B, P, Ti and the alloy thereof, and greater than 50 weight percentage selected at least one from the group consisting of: Ni, Cu and the alloy thereof.

[0098] Metal cover layer212 could be formed by plating, the material of the metal cover layer is selected at least one from the group consisting of: Ni, Cr, Pd, Co, Pt, Au, Ti, Cu, W and the alloy thereof; the material of the protective layer211 is Pd, Pt, silicon carbide, aluminum nitride, alumina, zirconia, diamond-like carbon (DLC) or the combination thereof.

[0099] Reference to FIG. 2A to 2G, these are the flow chart of manufacturing the composite conditioner.

[0100] First of all, as shown in FIG. 2A, it provides a second mold12, and second mold12 has 12 holes121, and these holes are arranged at the outer of second mold12. Then, as shown in FIG. 2B, it set second mold12 on a first mold12 surface.

[0101] As shown in FIG. 2C, set a polishing unit20 in each holes121 of second mold12, wherein the working surface (the surface having polishing tips) of second mold12 faces to first mold12 surface. In this preparation, polishing unit20 is similar to said in preparation1. Then, as shown in FIG. 2D, it glues on the contrary side of the polishing tips of each polishing units20 to form a thickness adjustable adhesive layer23. Then, as shown in FIG. 2E, with a base plate24 presses on thickness adjustable adhesive layer23, wherein base plate24 has a notch to make base plate24 be an inverted U-shaped, and the inverted U-shaped base plate24 presses thickness adjustable adhesive layer23 by the notch.

[0102] As shown in FIG. 2F, it removes first mold10. Then, as shown in FIG. 2G, it inverts the structure of FIG. 2F, that removing second mold12, forming a mold sealing glue layer25, strengthening polishing unit20 and securing base plate24 forms a composite conditioner.

[0103] Although the polishing units made by the brazing might yield the killer diamond, but with the aforesaid method of the present invention, it could combine and use different polishing units having similar height killer diamond, and flatten the polishing tips, so the height of the killer diamond is close to that of the diamond tips on other polishing units.

[0104] Referring now to FIG. 3, it illustrates the composite conditioner manufactured by aforesaid preparation2 (embodiment1, wherein the crystal cover ratio of the chosen diamond granules is 60% to 80%, that is PDA 878 manufactured by Element Six), the composite conditioner manufactured by conventional ceramic sintering (comparison1) and the composite conditioner manufactured by the brazing (comparison2), the comparison diagram of the tips height and working granules amount of the three conditioners. As shown in FIG. 3, when polishing, the present invention conditioner in embodiment1 has 60 to 70 working granules at the height different about 10 μm ; in contrast, comparison1 and comparison2 need more tips height difference to provide more working granules amount, even the conditioner in comparison1, it needs the height difference of the polishing granules more than 40 μm to provide more than 100 working granules amount. From this, the actual working polishing granules amount for the same height difference, the present invention conditioner is far more than the prior art conditioner.

[0105] Reference to FIG. 4 and FIG. 5, it illustrates the composite conditioner manufactured by aforesaid preparation2 (embodiment1, wherein the crystal cover ratio of the

chosen diamond granules is 60% to 80%, that is PDA 878 manufactured by Element Six; embodiment2, wherein the crystal cover ratio of the chosen diamond granules is 40% to 60%, that is PDA 657 manufactured by Element Six), and the composite conditioner manufactured by the brazing (comparison2), the comparison diagram of the height difference of the first high point and the second high point to the scratch amount, and the scratch amount to the removing rate of the three conditioners.

[0106] As shown in FIG. 4, with the present invention conditioner in embodiment1 and embodiment2, when the height difference of the first high point and the second high point is about 0 mm, the polishing scratch amount is between 100 to 150 scratches, that means the quality of the conditioner in embodiment1 and embodiment2 are fine, and the quality stability is nice when polishing; in contrast, with the conditioner in comparison2, the high point difference of the polishing granules is scattered mixed, and the polishing scratch amount is less than between 50 to 150 scratches, that means the quality of the conditioner in comparison2 is scattered mixed, and the quality stability is bad when polishing. On the other hand, as shown in FIG. 5, the polishing removing rate of the present invention conditioner in embodiment2 is about 250 μm to 300 μm per hour, and the scratch amount is about 100 to 150 scratches, the polishing removing rate of the present invention conditioner in embodiment1 is about 150 μm to 200 μm per hour, and the scratch amount is about 125 to 150 scratches, that means the present invention conditioner in embodiment1 and embodiment2 are high stability and is easy for quality control; in contrast, the polishing removing rate of the conditioner in comparison2 is about 125 μm to 225 μm per hour, and the scratch amount is about 50 to 75 scratches, that means the conditioner in comparison2 has low scratch amount and is unstable in quality.

[0107] Referring next to FIG. 6, it illustrates the composite conditioner manufactured by aforesaid preparation2 (embodiment1 and embodiment2), the composite conditioner manufactured by the brazing (comparison2) and the composite conditioner manufactured by the plating (comparison3), the comparison diagram of the using time to the removing rate of the four conditioners. As shown in FIG. 6, when polishing, the removing rate of the present invention conditioner in embodiment1 and embodiment2 decrease slowly with the longer using time, that means the present invention conditioner has the fastest conditioning rate and the longest durability cause of controlling the nice planeness; in contrast, the removing rate of the conditioner in comparison2 is unstable and then lead the problem in quality controlling, and the removing rate of the conditioner in comparison3 is bad, it cannot saving the polishing process time and cost.

[0108] Reference to FIG. 7 illustrates the composite conditioner manufactured by aforesaid preparation2 (embodiment2), the composite conditioner manufactured by the brazing (comparison2), the comparison diagram of the polishing wafer amount to the removing rate of the two conditioners. As shown in FIG. 7, in contrast to the comparison2, the present invention conditioner in embodiment2 could use in the chemical-mechanical planarization process to achieve polishing more wafer amount.

[0109] Referring to FIG. 8, it is a schematic diagram of the chemical-mechanical planarization (CMP) process. As shown in FIG. 8, generally, set a wafer4 on a polishing pad6 surface, and provide the polishing slurry by pipeline8 to polish polishing pad6 with each other, and set a conditioner2 at an

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another margin portion of polishing pad surface to remove the scrap after the wafer polished, wherein, the conditioner herein could use the conditioner manufactured by aforesaid preparation of the present invention.

[0110] From of all, recently, with convention whole piece brazing diamond conditioner, the highest polishing tip is usually higher than the second highest one in more than 20 μm , and the top 10 highest polishing granules protrusion only under 10 mm; in contrast, with the aforesaid method of the present invention, manufactured the composite conditioner by inverting uniform head method to make the difference of the highest polishing tip to the second highest one in less than 10 μm , therefore, it could improve the ratio of the effective working polishing tips on the polishing units, removing rate and durability.

[0111] Of course, it is to be understood that the above-described arrangements are only illustrative of the application of the principles of the present invention. Numerous modifications and alternative arrangements may be devised by those skilled in the art without departing from the spirit and scope of the present invention and the appended claims are intended to cover such modifications and arrangements. Thus, while the present invention has been described above with particularity and detail in connection with what is presently deemed to be the most practical and preferred embodiments of the invention, it will be apparent to those of ordinary skill in the art that numerous modifications, including, but not limited to, variations in size, materials, shape, form, function and manner of operation, assembly and use may be made without departing from the principles and concepts set forth herein.

What is claimed is:

1. A composite conditioner comprising:
a base plate; and
a plurality of polishing units secured to a surface of the base plate by an adhesive layer, each polishing unit including a plurality of polishing tips secured in a binding layer, wherein a height difference between a first highest polishing tip and a second highest polishing tip is less than or equal to about 10 μm , a height difference between the first highest polishing tip and a tenth highest polishing tip is less than or equal to about 20 μm , and a height difference between the first highest polishing tip and a 100th highest polishing tip is less than or equal to about 40 μm , and the first highest polishing tip protrudes from the binding layer to a height of greater than or equal to about 50 μm .
2. The composite conditioner of claim 1, wherein at least 1% of the plurality of polishing tips actively condition a CMP pad during a conditioning process.
3. The composite conditioner of claim 1, wherein less than 40% of the surface of the base plate is covered with polishing units.
4. The composite conditioner of claim 1, wherein the polishing units are arranged on the base plate in an arrangement selected from the group consisting of a single ring, double rings, multi-rings, radial arrangements, and spiral arrangements.
5. The composite conditioner of claim 1, wherein at least one thousand polishing tips of the plurality of polishing tips condition a polishing pad during a conditioning process.
6. The composite conditioner of claim 1, wherein the plurality of polishing tips include diamond, cubic boron nitride, or a combination thereof.

7. The composite conditioner of claim 6, wherein the plurality of polishing tips include diamond, and the diamond is deposition diamond, polycrystalline diamond, or a combination thereof.

8. The composite conditioner of claim 1, wherein the crystal surface coverage of more than 50% of the top 100 height polishing tips are less than 80%.

9. The composite conditioner of claim 8, wherein the crystal surface coverage of more than 50% of the top 100 height polishing tips are less than 50%.

10. The composite conditioner of claim 1, wherein each polishing unit further includes a polishing unit substrate upon which the plurality of polishing tips are secured with the binding layer.

11. The composite conditioner of claim 1, wherein the binding layer is selected from the group consisting of a solder layer, a plating layer, a sintering layer, and a resin layer.

12. The composite conditioner of claim 11, wherein each polishing unit further comprises a metal cover layer that covers the binding layer, wherein the metal cover layer includes at least one material selected from the group consisting of Ni, Cr, Pd, Co, Pt, Au, Ti, Cu, W, and alloys thereof.

13. The composite conditioner of claim 12, wherein each polishing unit further comprises a protective layer covering the metal cover layer, wherein the protective layer includes a material selected from the group consisting of Pd, Pt, silicon carbide, aluminum nitride, alumina, zirconia, diamond-like carbon (DLC), and combinations thereof.

14. The composite conditioner of claim 11, wherein binding layer is a solder layer comprising 1 wt % or more of a first material selected from the group consisting of Cr, B, P, Ti, or an alloy thereof, or 50 wt % or more of a second material selected from the group consisting of Ni, Cu, or an alloy thereof, or 1 wt % or more of the first material and 50 wt % or more of the second material.

15. The composite conditioner of claim 1, wherein the polishing units are disc-shaped, radial-shaped, or polygon-shaped.

16. The composite conditioner of claim 15, wherein the polishing units are disc-shaped having a diameter of from about 5 mm to about 30 mm.

17. The composite conditioner of claim 1, wherein the base plate is disc-shaped having a diameter of from about 80 mm to about 120 mm.

18. The composite conditioner of claim 1, wherein the polishing tips have a particle size of from about 100 μm to about 500 μm .

19. The composite conditioner of claim 1, wherein the adhesive layer is an organic adhesive.

20. The composite conditioner of claim 1, wherein the polishing tips are arranged in a predetermined pattern on the polishing unit substrate.

21. The composite conditioner of claim 1, wherein the polishing units are spaced no closer than about 0.1 mm.

22. The composite conditioner of claim 21, wherein the polishing units are spaced at least 0.5 mm apart.

23. The composite conditioner of claim 1, wherein the adhesive layer between the base plate and the polishing units has a thickness of less than or equal to about 0.6 mm.

24. A method of making a composite conditioner, comprising:
disposing a second mold on a first mold, wherein the second mold includes a plurality of holes;

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placing a polishing unit in each of the plurality of holes of the second mold, each polishing unit including a plurality of polishing tips secured in a binding layer;

applying an adhesive layer over the second mold to secure the polishing units; and

removing the first mold and the second mold to form a composite conditioner wherein a height difference between a first highest polishing tip and a second highest polishing tip is less than or equal to about 10 μm , a height difference between the first highest polishing tip and a tenth highest polishing tip is less than or equal to about 20 μm , and a height difference between the first highest polishing tip and a 100th highest polishing tip is less than or equal to about 40 μm and the first highest polishing tip protrudes from the binding layer to a height of greater than or equal to about 50 μm .

25. The method of claim **24**, wherein placing the polishing unit in the plurality of holes of the second mold further comprises orienting the polishing units such that the polishing tips face the first mold.

26. The method of claim **25**, wherein the polishing tips contact the first mold such that the polishing unit are leveled across the first mold.

27. The method of claim **26**, wherein the holes of the second mold are arranged around an outer periphery of the second mold.

28. A process of chemical-mechanical planarization (CMP), including the following steps:

polishing a wafer against a rotating polishing pad; and
applying the conditioner of claim **1** against the polishing pad to remove debris and condition the pad.

29. The process of claim **28**, wherein the diameter of the wafer is 200 mm, 300 mm, or 450 mm.

30. The process of claim **28**, wherein a surface of the wafer has an IC critical dimension of less than or equal to 45 nm.

31. The process of claim **30**, wherein a surface of the wafer has an IC critical dimension of less than or equal to 28 nm.

32. The process of claim **28**, wherein the surface of the wafer has an IC critical dimension of less than or equal to 22 nm.

* * * * *

EXHIBIT 6



Date: July 27, 2020

To whom it may concern:

This is to certify that the attached translation from Chinese and into English is an accurate representation of the documents received by this office.

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- TW Patent No. I537097 (101112625)

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“To the best of my knowledge, the aforementioned documents are a true, full and accurate translation of the specified documents.”

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(56) References:

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TW M406490

TW 201038362A

TW 201141663A

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(54) Title of Invention

COMPOSITE CONDITIONER AND METHOD FOR MANUFACTURING THE SAME
AND CMP APPLICATION THEREOF

(57) Abstract

A composite conditioner includes: a base plate; a plurality of polishing units placed on the base plate and each polishing unit including a bonding layer and a plurality of polishing tips that are bonded in plane by the bonding layer; and an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm . The present invention also relates to a method for manufacturing the conditioner and application thereof.

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Designated representative image:

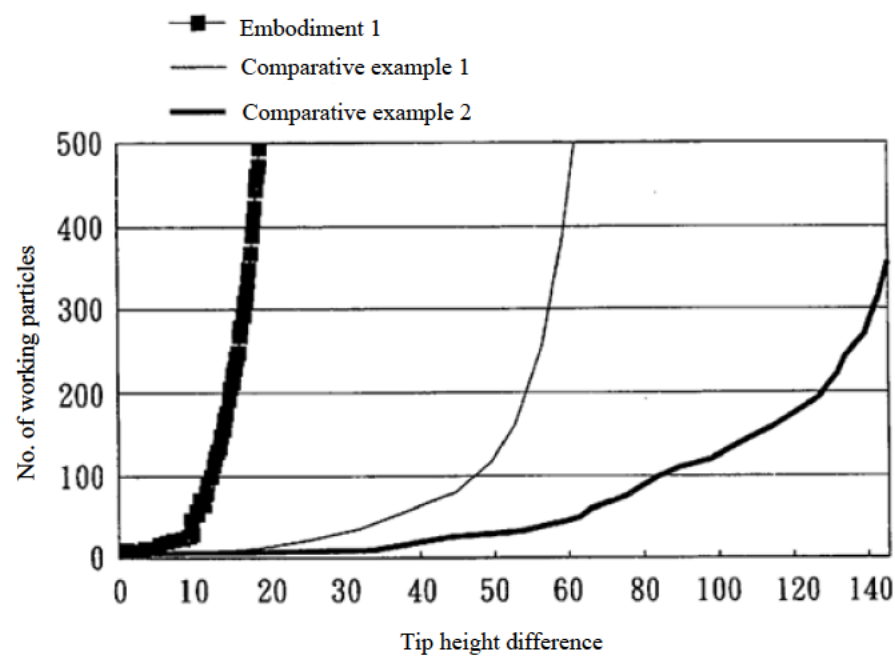


FIG. 3

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Publication

Invention Patent Specification

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I. Title of the Invention: (Chinese/English)

組合式修整器及其製法與化學機械平坦化應用

COMPOSITE CONDITIONER AND METHOD FOR MANUFACTURING THE SAME
AND CMP APPLICATION THEREOF

II. Abstract of the Invention in Chinese:

本發明係有關於一種組合式修整器，包括：一底部基板；複數個研磨單元，係設置於該底部基板之表面，每一研磨單元包括複數個研磨尖點，以及一固定該些研磨尖點之結合劑層；以及一厚度可調節之黏著劑層，係固定該些研磨單元於該底部基板之表面，其中，該些研磨尖點中突出一預定平面之第一高點與第二高點之高度差小於 10 微米，第一高點與第十高點之高度差小於 20 微米，第一高點與第一百高點之高度差小於 40 微米，且該第一高點突出該結合劑層之高度大於 50 微米。本發明亦關於該組合式修整器之製造方法與應用。

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III. Abstract of the Invention in English:

A composite conditioner includes: a base plate; a plurality of polishing units placed on the base plate and each polishing unit including a bonding layer and a plurality of polishing tips that are bonded in plane by the bonding layer; and an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm . The present invention also relates to a method for manufacturing the conditioner and application thereof.

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IV. Designated Representative Image:

- (I) Designated representative image of the present application: FIG. (3).
- (II) Description of reference signs of components in the representative image:
No

V. If there are chemical formulae in the present application, please reveal the chemical formula that best shows the characteristics of the invention:

「No」

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VI. Invention Specification:

[TECHNICAL FIELD]

The present invention relates to a composite conditioner, a method for manufacturing the same and a chemical-mechanical planarization (CMP) process using the same, particularly to a composite conditioner suitable for planarization of semiconductor wafer surface, a method for manufacturing the same and a chemical-mechanical planarization (CMP) process using the same.

[PRIOR ART]

The oxide film dielectric layers of the copper circuits or interlayer tungsten circuits, even insulation circuits on the silicon wafer surface all must be surface-flattened through a planarization process to facilitate subsequent process steps. At present, in the process of manufacturing Interconnected Circuits (ICs) on semiconductor wafers, the most eye-catching planarization technology is chemical-mechanical planarization (CMP), in which the wafer is pressed on a rotating polishing pad to polish and flatten its surface.

In the CMP process, slurry is stably and evenly delivered between the wafer and the polishing pad, so that the surface of the polishing pad is impregnated with the slurry. The slurry contains chemical agents (such as acid and oxidizer) to erode the thin film on the wafer surface, and the slurry also contains countless nano-ceramic (such as SiO_2 , Al_2O_3 and CeO_2) abrasive particles, which can cut into and scrape away micro-films and at the same time, perform chemical etching and mechanical grinding to remove the protruding deposited layer on the chip, thereby polishing the surface of the wafer and achieving the purpose of planarization.

Conditioner is a necessary consumable for CMP, and its function is to condition the polishing pad. The so-called conditioning includes shaving the surface of the polishing pad and removing the waste accumulated on the surface of the polishing pad, thereby maintaining the surface roughness of the polishing pad. Further, the conditioner can also generate a small quantity of bumps and depressions on the surface, which are the height differences of so-called asperities, so that the contacted and pressed area of the polishing pad can be reduced significantly. The smaller the contact area is, the greater the contact

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pressure will be so that the slurry at the contact points can squeeze the protruding parts of the wafer, and the chemical agent (such as H_2O_2) in the slurry will be oxidized to soften or corrode the wafer.

However, the waste generated in the CMP process, including abrasive dust of wafers, such as copper wires, tungsten pore fillings, oxide films, slurry, abrasive particles, and polishing pad debris, will typically be accumulated on the surface of the polishing pad and squeezed into a glaze. Once the glaze is formed, the polishing pad will become slippery and can hardly maintain a polishing force. Therefore, it is often necessary to use a conditioner to polish each wafer to achieve the polishing efficiency (e.g., polishing speed) and flatness (e.g., the thickness distribution of the wafer coating) of the process, thereby stabilizing the quality of the wafers.

However, the prior art diamond conditioner typically secures diamond particles on the surface of a metal tray with a bonding agent. Although it is suitable for conditioning the polishing pad, for more precise CMP processes, such as CMP processes with a line width of less than 45 nm, it is more liable to scratches, local dishing, erosion and thickness non-uniformity of the wafers due to rough asperities of the polishing pad. The requirements for line width of IC are declining, while the demand for wafer surface flatness rises, and the requirements for the conditioner increase, too, making the prior art diamond conditioner unable to meet the advanced requirements for the CMP processes of below 45 nm.

For this purpose, the prior patent publication TW 201038362 A1 and TW 201100198 disclose a composite conditioner and manufacturing method thereof respectively, wherein the sharp angles of the polishing tips of polishing units in various sizes, shapes and materials cut into a polishing pad, then pressure is applied to the other side of the polishing units and resin is filled to secure the polishing units so that the height difference between polishing tip apexes of the polishing units is within 20 μm .

However, the polishing tips used in the foregoing patent application need to use diamond abrasive particles with high shape regularity, and the crystal surface coverage rate of such crystal form is very high (for example, more than 50% of the surface is crystal growth surface). Otherwise, when sharp diamonds with a low crystal surface coverage rate are used, an excessive height difference will be caused. Further, the diamond that cuts into the polishing pad the deepest, the so-called "killer diamond", has no standard for the

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difference in height from the top pads of other diamonds. In order to meet the process requirements of a smaller line width, it is necessary to continuously improve the conditioner so that when sharper polishing tips are used, the flatness of the sharp angle heights (e.g., the height difference of the sharp angles of the polishing tips) can still be maintained, and the conditioner can form finer and more uniform scores on the polishing pad, and at the same time raises the removal rate of the polishing pad. Only in this way, can the glaze be effectively removed, the asperities on the polishing pad be restored and the coating on the wafer be polished quickly.

[SUMMARY OF THE INVENTION]

A main object of the present invention is to provide a composite conditioner, wherein sharp polishing tips are used, and can still maintain tip height distribution and avoid existence of “killer diamonds”, thereby raising the ratio of polishing tips that work effectively on the polishing units, and increasing the wafer removal rate and conditioner service life.

To achieve the foregoing object, one example of the present invention provides a composite conditioner, comprising: a base plate; a plurality of polishing units placed on the base plate and each polishing unit including a bonding layer and a plurality of polishing tips that are bonded by the bonding layer (which can be made of metal, ceramics or resin); and an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm .

As CMP is plane polishing, the contact distribution between the highest tips of the wafer and the highest tips of the polishing pad determines the quality (e.g., yield) and efficiency (e.g., capacity) of CMP. If the highest tips of the asperities of the polishing pad are not uniformly distributed, the removal rate of different parts of the wafer will be different, and the surface of the wafer will not be flat. What is more, the polishing may be excessive at some locations, causing dishing in the same layer or erosion in multiple layers; or, polishing is inadequate at some locations, causing residue. If the wafer thickness is not

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uniform after polishing (Within Wafer Non-Uniformity or WIWUU), the CMP effect will be unobvious. For this reason, the present invention modified the conditioner based on the data of many tests and experiments, particularly adjusted the heights of working polishing tips through an adhesive layer of which thickness is adjustable to compensate the difference in thickness of the polishing units, thereby achieving the foregoing height distribution of the highest tips, avoiding generation of killer diamonds and raising the ratio of effectively working polishing tips on the polishing units.

In the foregoing composite conditioner of the present invention, the material of the adhesive layer of which thickness is adjustable can be an organic adhesive. Each polishing unit may further comprise a unit substrate, and the bonding layer is arranged between the surface of the unit substrate and the polishing tips, and for example can be a solder layer, an electroplated layer, a sintered layer, or a resin layer. The foregoing polishing tips refer to terminal points that can achieve a polishing effect on abrasive particles contained in a plurality of polishing units, and are exposed to the bonding layer, in other words, the heights of polishing tips refer to the protrusion heights of the polishing tips above the bonding layer.

The heights of the polishing tips can be measured with an optical detection system, such as a surface detector produced by German FRT (Fries Research & Technology GmbH), which measures the heights of all polishing tips of the conditioner (more than 10,000 for example), i.e., the protrusion heights of the polishing tips above the bonding layer. Then from the obtained height data, the least square method is used to calculate an assumed plane constituted by sharp angles of the polishing tips. This assumed plane is the foregoing predetermined plane. The first highest tip refers to the height of the one of the polishing tips that protrudes the most from the predetermined plane, the second highest tip refers to the height of the one of the polishing tips that protrudes the second most from the predetermined plane, and the same goes for other highest tips.

The polishing positions of the wafer mostly depend on the distribution of the apexes of the polishing pad, which is determined by the heights of the polishing tips of the conditioner. The conditioner can be disc-shaped (applicable to Applied Materials machine for example) or ring-shaped (applicable to Ebara machine for example). The diameter of the disc is generally about 100 mm, while the ring can be as large as 250 mm or more. Typically, tens of thousands of polishing tips (e.g., diamond particles) are distributed on the conditioner, polishing tips of 80/90 mesh, 100/120 mesh, or 120/140 mesh for example, but

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the difference in average size even under the same mesh may still be greater than 30%. Further, the size of the same polishing tip varies remarkably in different directions. For example, the distance between tips will be up to 30% larger than that between planes, and if the shape of the polishing tips is irregular, the difference will be even larger.

Therefore, the present invention adjusts the used abrasive particles so that the height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips is less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm to ensure the conditioner has numerous working tips, thereby achieving an effect of rapid and uniform removal of the thin film on the IC wafer surface. Further, it should be noted that the first highest tip and the second highest tip can be scattered in different polishing units or in the same polishing unit, so are other highest tips; in other words, the distribution of the highest tips is not concentrated in a single polishing unit.

In the foregoing composite conditioner of the present invention, the material of the polishing tips can be man-made or natural diamond, polycrystalline diamond (PCD), cubic boron nitride (CBN), polycrystalline cubic boron nitride (PCBN) or a combination thereof, and the particle size of the polishing tips can be in the range of 100 to 500 μm . The foregoing diamond can be chemically deposited diamond, polycrystalline diamond, or a combination thereof. Further, there is no special limitation to the material of the base plate. For example, it can be pure resin, metal, alloy, plastics, rubber, ceramics, glass or a combination thereof (e.g., a mixture of resin and metal).

Further, because the diamond is typically converted from graphite under the catalysis of iron-nickel alloy at a high pressure (e.g., 5GPa), it contains molten iron-nickel inclusion. The alloy catalyzes the diamond back into graphite or carbon at high temperature, during which the volume will increase substantially to burst the diamond. If the diamonds are secured on a diamond disc by brazing, many diamonds will burst due to the high process temperature, the diamond tips that cut deep into the polishing pad in the CMP process may be disintegrated along the microcrack surface, and the diamond debris may scratch expensive wafers. In view of this, diamonds containing much inclusion are often separated by magnetic separator. Even so, more or less residual iron-nickel alloy is still contained in the diamonds. If there are undetectable cracks inside the diamonds, the diamonds may be broken and disintegrated with debris in the CMP process, causing scratches of the wafer. In

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view of this, high temperature brazing should choose a solder with a lower melting point.

In the present invention, when a solder is used as the material of the bonding layer, the solder layer may contain more than 1wt% of at least one selected from a group consisting of Cr, B, P, Ti and alloy thereof, more than 50wt% of at least one selected from a group consisting of Ni, Cu and alloy thereof, or a combination thereof, wherein materials such as Cr, B, P and Ti are used to activate the solder layer. Specifically, the solder is typically Ni-Cr-B, Ni-Cr-P, or Cu-Sn-Ti alloy, with a melting point (Solidus) of 800°C to 1,000°C.

Further, each polishing unit optionally further comprises: a metal covering layer, which covers the surface of the bonding layer and of which material is at least one selected from a group consisting of Ni, Cr, Pd, Co, Pt, Au, Ti, Cu, W and alloy thereof, so that the polishing tips are more stably attached to the unit substrate of the polishing unit. Further, each polishing unit optionally further comprises: a protective layer, which is a thin-layer inert material and covers the surface of the metal covering layer, and of which material may be a metal material such as Pd or Pt, or a nonmetal material such as a ceramic film (e.g., silicon carbide, silicon nitride, aluminum nitride, aluminum oxide and zirconia), diamond-like carbon (DLC) film, organic film (e.g. Teflon) or a combination thereof, to avoid the erosion of the solder by the polishing slurry (e.g., pH=3 tungsten process slurry).

Generally speaking, the height of the apex of the diamond determines the strength of pressing into the polishing pad, but its sharpness affects the cutting depth. Typically, the sharper the diamond is, the smaller the elastic and plastic deformation of the polishing pad will be, and the greater the depth of shaving will be. Because the diamond abrasive particles formed on the surface of the conditioner have different shapes and various directions, generally only the highest hundreds of them can come into contact with the polishing pad. If the shape of the diamond is regular and symmetric, it will be at an obtuse angle and will not cut into the polishing pad easily, but will push the surface of the polishing pad, forming bulging plastic deformation on both sides; on the contrary, if the diamond has a broken surface, e.g., an irregular shape, it may cut into the polishing pad, shave the surface of the polishing pad, and meanwhile remove waste.

Therefore, in the foregoing composite conditioner of the present invention, of the 100 highest polishing tips, more than 50% have a crystal surface coverage rate of less than 80%, preferably a crystal surface coverage rate of less than 50%. When the crystal surface

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coverage rate of the polishing tips is lower, it means that the polishing tips have more broken surfaces (i.e., sharp surfaces), and it also means that the polishing tips on the working surface of the polishing units contain sharp angles and ridges, a majority of the ridges have an included angle of less than 45 degrees (i.e., the angle between the two crystal surfaces that constitute a ridge), or a majority of the sharp angles are in a state of less than 90 degrees, so the removal rate is high to the polishing pad. Refer to FIG. 9, which is a schematic view of an abrasive particle, where A, E, and S represent a sharp angle, a ridge and a surface respectively, S_1 is a crystal surface, A_1 is an included angle between crystal surfaces, S_2 is a broken surface, and A_2 is an included angle formed by at least one broken surface. It can be seen that A_1 and A_2 are two different sharp angles. The angle of A_1 is greater than 90 degrees (i.e., an obtuse angle), and the angle of A_2 is less than 90 degrees (i.e., an acute angle), which means that when A_2 is used as a polishing tip, its removal efficiency will be greater than that of A_1 .

The polishing tips can be patterned and arranged on the unit substrate, or the polishing tips form a plurality of clusters, and the clusters are patterned and arranged on the unit substrate. For example, each cluster is composed of two to six polishing tips.

Further, the polishing units can be arranged in a single circle, double circles, multiple circles, a radial shape or a spiral shape on the base plate, and can be disc-shaped, blade-shaped or polygonal. If the polishing units are disc-shaped, their diameter is in the range of 5 to 30 mm, preferably not more than 20 mm. The base plate can also be disc-shaped and its diameter is in the range of 80 to 120 mm, and alternatively, the polishing units can be fixed on a ring-shaped substrate of 250 to 270 mm. Further, if the disc-shaped polishing units are located inside, they are often blocked by the external polishing units during conditioning of the polishing pad, making it difficult to play an effect. Therefore, preferably, the polishing units can be arranged on the outer periphery of the surface of the disc-shaped base plate to produce a cliff effect of periphery conditioning in the CMP process, which will increase the number of working particles and is suitable for the CMP process to be applied to an 18-inch wafer or 22-nanometer process.

In the foregoing composite conditioner of the present invention, the space between the polishing units is not less than 0.1 mm, preferably greater than 0.5 mm, so as to ensure that the slurry can smoothly enter and exit the gaps between the polishing units in the CMP process and will not remain in them, causing defects, such as scratches on the chip. Further,

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the thickness of the adhesive layer on the bottom surface of the polishing units is in the range of below 0.6 mm, so that the polishing tips of each polishing unit can be fully adjusted to the same plane to effectively increase the number of working diamond particles.

It is known that due to the large difference in tip height, the number of tips used by a conventional conditioner (and the number of tips cutting into the polishing pad) accounts for less than 1% of the total number of tips, and the diamond coverage area of the conventional conditioner exceeds 40% of the total; on the contrary, in the foregoing composite conditioner of the present invention, the polishing tips used to condition a polishing pad can account for above 1% of all polishing tips; further, the area of the base plate covered by the polishing units can account for less than 40% of the total area of the surface of the base plate, so that the best removal rate can be achieved while reducing costs.

Another object of the present invention is to provide a method for manufacturing a composite conditioner, wherein polishing units with sharp polishing tips are used, a couple of the highest tips of each polishing unit are used as a plane reference by the inversion method, and the thickness of the adhesive material under each polishing unit is adjusted before fixation onto the substrate, so that a couple of the highest tips on the polishing unit will not protrude very much and form destructive “killer diamonds”. The use of a co-plane forces the highest tips of each polishing unit to reach a common height and can also increase the ratio of polishing tips that work effectively, thereby increasing the removal efficiency and service life of the conditioner.

In order to achieve the foregoing object, another example of the present invention provides a method for manufacturing a composite conditioner, comprising the following steps: arranging a second mold on a first mold, wherein the second mold has a plurality of orifices; arranging a polishing unit in each orifice of the second mold, wherein each polishing unit comprises a bonding layer and a plurality of polishing tips that are bonded by the bonding layer; forming an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate; and removing the first mold and the second mold to form a composite conditioner, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm .

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A general diamond conditioner is manufactured by the additive method, that is, the diamond abrasive particles are arranged flatwise (e.g., matrix distribution) on a flat substrate (e.g., stainless steel 316). According to the prior art, the height difference of diamond apexes on a single conditioner surface is typically more than 50 μm and the diamond abrasive particles can be secured by electroplating (EDD) and nickel, or by brazing (BDD) to retain them by solidifying molten alloy. The diamond plane of the former is typically upward, while the tips or ridges of the latter are often more prominent, and the diamonds with the plane facing upwards cannot cut into the polishing pad easily, and the diamonds with tips or ridges can shave the polishing pad more easily. In comparison, the present invention first uses the brazing method to form polishing units, and then uses an organic elastic material to bond and compensate a plurality of polishing units to arrange the polishing units on a base plate, so in addition to the advantages of the brazing method, it can also avoid its shortcomings, and make the formed conditioner have the highest tips of the same height. Therefore, when the diamond conditioner is conditioning the polishing pad, the protruding diamond apexes can contact and cut into the polishing pad, but there will be no overly protruding polishing tips, so no polishing tips will cut into the polishing pad too deep, resulting in excessive height difference between asperities, thereby avoiding asperities “as if big frogs in a small pond” being smeared with too much slurry, which causes the nano abrasive particles in the slurry to excessively cut into the surface of the wafer, resulting in excessive polishing, and even scratching of the wafer.

In the method for manufacturing the foregoing composite conditioner of the present invention, the adhesive layer of which thickness is adjustable can be formed after the highest tips of the polishing units are leveled with another flat plate, or after forming the adhesive layer with adjustable thickness, or before the adhesive layer of which thickness is adjustable is cured, the base plate is used to level the highest tips of the polishing units.

The adhesive layer of which thickness is adjustable can be composed of an organic adhesive, for example, a plastic material, a rubber material, a hot melt adhesive or a combination thereof; further, the orifices of the second mold are arranged on the outer ring of the second mold, thereby setting the positions of the polishing units on the outer ring of the base plate. Specifically, the orifices of the second mold are formed with the outer ring of the second mold, for example, 12 orifices. In addition, in the composite conditioner, the polishing units can also be arranged on the inner and outer rings, and generally, the smaller

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the area of the polishing units is, the larger the number of working particles will be during polishing, but the manufacturing cost will be higher, so making a conditioner with an appropriate number of polishing units can balance effect and cost.

In the method for manufacturing the foregoing composite conditioner of the present invention, prior to arranging the second mold on the first mold, the following steps are further comprised: forming a temporary adhesive layer on the surface of the first mold, and arranging the second mold on the surface of the temporary adhesive layer, so that the temporary adhesive layer is sandwiched between the second mold and the first mold, and after removing the second mold, the following steps are further comprised: removing the temporary adhesive layer. In a preferred embodiment of the present invention, the temporary adhesive layer is a double-sided adhesive tape.

In an alternative preferred embodiment of the present invention, one side of the polishing units has the polishing tips, and the adhesive layer of which thickness is adjustable is arranged on the opposite side of the side, and the polishing units arranged in the orifices are in contact with the first mold by means of the polishing tips. Further, after removing the second mold and the first mold, the following steps are further comprised: forming a mold sealing layer to secure the polishing units. It can be seen from the above that by pressing the polishing units on the side with the polishing tips, the polishing units are flatly arranged on the same plane.

The method for manufacturing the foregoing composite conditioner of the present invention may optionally further comprise the following steps: removing the second mold after removing the first mold. In other words, it means that the conditioner may comprise a second mold.

A further object of the present invention is to provide a CMP (chemical-mechanical Planarization) process, wherein sharp polishing tips are used, and can still maintain the planarity of the working surface, thereby raising the ratio of polishing tips that work efficiently on the polishing units, and increasing the removal rate and service life.

In order to achieve the foregoing object, a further example of the present invention provides a CMP process, comprising the following steps: providing a polishing pad; placing a wafer on the surface of the polishing pad and polishing the wafer and the polishing pad with each other; and using a conditioner arranged on the surface of the polishing pad to

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remove debris after polishing of the wafer, wherein the conditioner is the foregoing composite conditioner of the present invention.

The Moore's law mentions that the number of transistors accommodated on the same chip of a single size will be doubled every eighteen months due to the improvement of the process technology, thereby increasing the speed of operation performed by the chip. Owing to the continuous progress as mentioned in the Moore's Law, the line width and line distance of integrated circuits (ICs) also gradually break through the limit of 32 nanometers. However, it also faces the difficulty for CMP process to overcome the bottleneck, so it is impossible to enter a process of even smaller line width and line distance. On the contrary, as the foregoing CMP process of the present invention uses a modified conditioner, the CMP process of the present invention can use a wafer with a diameter of 200 mm, 300 mm or 450 mm, and the line width of ICs on the surface of the wafer can be smaller than or equal to 45 nm, 28 nm or 22 nm. Therefore, if the technology of the present invention is adopted in the related technologies, for example, the CMP process of the present invention is applied to the production of logic devices, dynamic random access memories (DRAMs), caches (flash memories) or hard drives, it will improve the operation execution speed of the foregoing devices as described in the Moore's Law.

[DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS]

Generally speaking, as the diamonds differ in size, shape and direction and the distance of the highest tips is random, the ploughing and shaving forms of the polishing pad are diverse, resulting in uneven heights of the polishing pad after conditioning, which makes it difficult to control the positions of the highest tips in contact with the wafer, and the area and pressure of each contact point, so that the polishing rate and uniformity of the CMP process have extremely high variability. When the wafer changes greatly (such as 8 inches to 12 inches or even 18 inches in the future), the variability of polishing rate and uniformity will be enlarged, reducing the quality and efficiency of the CMP process. More than that, when the wire width becomes narrower (e.g., 45 nm to 32 nm or even 22 nm in the future), the highest tips of the polishing pad are more likely to cause damage. When the circuits become narrower, the dielectric material between them must be more hollow to avoid electric leakage, but the hollow dielectric layer becomes fragile, so the contact pressure of

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the CMP process needs to be even smaller, but after the contact pressure is adjusted down, it will lead to a reduced polishing speed of the wafer, resulting in poor productivity.

The current diamond conditioner is typically manufactured by a method of planar addition of diamonds, so it is difficult to control the heights of apexes. Further, under high temperature manufacturing (e.g., brazing), the substrate is distorted and deformed, which makes the heights of the diamond apexes more uneven, and also greatly reduces the number of working particles, to only a few hundred though there are tens of thousands of diamonds on the conditioner.

Because the diamond conditioner is manufactured by the additive method (pressing and leveling from the top with diamond abrasive particles), it is difficult to control the size, shape and direction of the diamonds and the number, position and cutting depth of the diamonds on the working surface are also elusive, significantly reducing the predictability of the effect of the CMP process. Although the industry continues to strictly control the flatness of the conditioner substrate and the shape of the diamonds, the improvement effect is limited.

Considering that it is difficult to make the heights of the diamond apexes even, the present invention adopts the method of reverse combination. Diamond polishing units are manufactured at first, and then are placed upside down on a plane so that the polishing tips are flush. Now, an adhesive layer of which thickness is adjustable is placed on the opposite side of the polishing tips, and finally a mold sealing layer (e.g., resin) is injected to secure all the polishing units. Such inverse and flush manufacturing method can avoid “Killer Diamonds” that often exist on the diamond disc - i.e., the protruding diamonds like big frogs in a small pond. If the Diamond Killer is too sharp, it can easily cut into the polishing pad deeply and therefore is pulled apart, thereby forming Killer Asperities on the surface of the polishing pad, causing scratches and damage of the wafer.

Below the implementation manner of the present invention is described by referring to specific embodiments. Those skilled in the art can easily understand other advantages and effects of the present invention from the content disclosed in the Description. Alternatively, the present invention can be implemented or applied through other different specific embodiments, and various modifications and changes can be made to the details of the Description based on different views and application under the precondition of not departing from the spirit of the present invention.

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The figures in the embodiments of the present invention are all simplified schematic views. However, these reference signs only display the components related to the present invention, and the components displayed are not examples of actual implementation. The number, shape and other proportions of the components during actual implementation are a selective design, and the layout type of the components may be more complex.

Preparation Example 1

FIG. 1A to FIG. 1G are schematic views of a flow for manufacturing a composite conditioner.

Firstly, as shown in FIG. 1A, a first mold 10 is provided, which has an opening 101. Then, as shown in FIG. 1B, a temporary adhesive layer 11 is formed on the surface of the opening 101 of the first mold 10, and then a second mold 12 is arranged on the surface of the temporary adhesive layer 11, so that the second mold 12 is arranged inside the opening 101 of the first mold 10. Therefore, the temporary adhesive layer 11 is sandwiched between the second mold 12 and the first mold 10, wherein the second mold 12 has a plurality of orifices 121. In this preparation example, the temporary adhesive layer 11 is a double-sided adhesive tape.

As shown in FIG. 1C and FIG. 1G, a polishing unit 20 is arranged in each orifice 121 of the second mold 12, wherein each polishing unit 20 comprises a plurality of abrasive particles 22 (each abrasive particle 22 has at least one polishing tip 221), a unit substrate 21 and a bonding layer 213 arranged between the surface of the unit substrate 21 and the polishing tips 221. These polishing units 20 are manufactured by a common brazing method, and the manufacturing method is briefly described as follows: spot weld a solder pad (BNi_2) on a unit substrate 21 with a diameter of 20 mm and a thickness of 4 mm, and then use a template to arrange approximately 150 μm abrasive particles (e.g., diamond particles) on the solder pad coated with adhesive, and then put it in a vacuum furnace for vacuumizing to a vacuum degree of about 5 to 10 torr, and heat it to maximum temperature of 1,020°C and maintain this temperature for 12 minutes (in this period, the adhesive has been evaporated) to melt the solder of the solder pad into a liquid to weld the diamond particles firmly.

As the diamonds are originally located on the fixing solder, when the solder is melted

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to form a liquid, the carbide elements (e.g., Cr) in the solder will diffuse to the diamond surface. As a result, the solder will sink the diamonds by capillary force, and will also climb up to the diamond surface under the capillary force to form a slope. The diamonds were originally stuck to the surface of the solder pad on a flat surface, but now because the diamonds rotate in the liquid, their sharp angles often face upward.

Then, as shown in FIG. 1D and FIG. 1E, the polishing units 20 are leveled with a base plate 24, and an adhesive layer 23 of which thickness is adjustable is filled in to secure the polishing units 20. Then, as shown in FIG. 1F, the first mold 10, the temporary adhesive layer 11, and the second mold 12 are removed to form a composite conditioner 2.

The composite conditioner 2 includes: a base plate 24; a plurality of polishing units 20 placed on the base plate 24 and each polishing unit 20 including a plurality of polishing tips 221; and an adhesive layer 23 of which thickness is adjustable and used to secure the polishing units 20 on the base plate 24, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips 221 based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer 213 is greater than 50 μm .

FIG. 1G is an enlarged view of the polishing units of the present invention. Each polishing unit 20 comprises a plurality of abrasive particles 22 (each abrasive particle has at least one polishing tip 221), a unit substrate 21, a bonding layer 213 arranged between the surface of the unit substrate 21 and the polishing tips 221, a metal covering layer 212 covering the surface of the bonding layer 213, and a protective layer 211 covering the surface of the metal covering layer 212.

The bonding layer 213 can be a solder layer, an electroplated layer, a sintered layer, or a resin layer. If the bonding layer 213 is the solder layer, it contains more than 1 wt% of at least one selected from a group consisting of Cr, B, P, Ti and alloy thereof, more than 50 wt% of at least one selected from a group consisting of Ni, Cu and alloy thereof, or a combination thereof.

The metal covering layer 212 can be formed by means of electroplating, and its material may be at least one selected from a group consisting of Ni, Cr, Pd, Co, Pt, Au, Ti, Cu, W and alloy thereof; the material of the protective layer 211 can be Pd, Pt, silicon

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carbide, aluminum nitride, aluminum oxide, zirconia, diamond-like carbon (DLC) or a combination thereof.

Preparation Example 2

FIG. 2A to FIG. 2G are schematic views of a flow for manufacturing a composite conditioner.

Firstly, as shown in FIG. 2A, a second mold 12 is provided, which has 12 orifices 121, arranged on the outer ring of the second mold 12. Then, as shown in FIG. 2B, the second mold 12 is arranged on the surface of a first mold 10.

As shown in FIG. 2C, a polishing unit 20 is arranged in each orifice 121 of the second mold 12, wherein the working surface of the polishing unit 20 (the surface having polishing tips) faces the surface of the first mold 10. In this preparation example, the polishing units 20 are as similarly described in preparation example 1. Then, as shown in FIG. 2D, adhesive is dispensed on a side opposite to the polishing tips of each polishing unit 20 to form an adhesive layer 23 of which thickness is adjustable. Then, as shown in FIG. 2E, a base plate 24 presses flatly on the adhesive layer 23 of which thickness is adjustable, wherein the base plate 24 has a groove, which makes the base plate 24 in a “ $\square$ ” shape, and the groove of the base plate 24 flatly presses the adhesive layer 23 of which thickness is adjustable.

As shown in FIG. 2F, remove the first mold 10. Then, as shown in FIG. 2G, inverse the structure shown in FIG. 2F, remove the second mold 12 and form a mold sealing layer 25, reinforce the polishing units 20 and secure them to the base plate 24 to form a composite conditioner.

Although the polishing units manufactured by the brazing method may have killer diamonds, different polishing units with killer diamonds of similar heights can be used in combination with the foregoing method of the present invention to make the polishing tips flush. Therefore, the heights of the killer diamonds are close to the heights of other protruding diamond tips on the polishing units.

Test Example

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FIG. 3 is a comparison diagram of tip height difference and the number of working particles among the composite conditioner manufactured in the foregoing preparation example 2 (Embodiment 1, wherein the crystal surface coverage rate of the diamond particles used is approximately 60% to 80%, i.e., PDA 878 manufactured by Element Six), a conditioner manufactured by the prior art ceramic sintering method (comparative example 1) and the conditioner manufactured by the brazing method (comparative example 2). From FIG. 3, it can be known that during polishing, there are 60 to 70 working particles on the conditioner provided in Embodiment 1 of the present invention when the height difference is about 10 μm ; in comparison, comparative example 1 and comparative example 2 require a larger tip height difference in order to provide more working particles, and even on the conditioner provided in comparative example 1, more than 40 μm of height difference of abrasive particles is required to obtain more than 100 working particles. Thus, it can be seen that within the same height difference, the conditioner provided by the present invention actually has a much higher number of working abrasive particles than the prior art conditioners do.

FIG. 4 and FIG. 5 respectively show a comparison diagram of the height difference between the first highest tip and the second highest tip (μm) and number of scratches, and a comparison diagram of number of scratches and removal rate among the composite conditioner manufactured in the foregoing preparation example 2 (Embodiment 1, wherein the crystal surface coverage rate of the diamond particles used is approximately 60% to 80%, i.e., PDA 878 manufactured by Element Six; Embodiment 2, wherein the crystal surface coverage rate of the diamond particles used is approximately 40% to 60%, i.e., PDA 657 manufactured by Element Six) and the conditioner manufactured by the brazing method (comparative example 2).

From FIG. 4, it can be known that for the conditioners provided in Embodiments 1 & 2 of the present invention, when the height difference between the first highest tip and the second highest tip is approximately 0 μm , the number of scratches after polishing is 100 to 150, which means that the conditioners provided in Embodiments 1 & 2 have good quality and the quality is stable during polishing; on the contrary, for the conditioner provided in comparative example 2, the highest tips of abrasive particles are uneven and the number of scratches is only less than 50 to less than 100, which means the conditioner provided in comparative example 2 has uneven quality, and the quality is not stable during polishing.

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In a further aspect, from FIG. 5, it can be known that the conditioners provided in Embodiment 2 of the present invention have a polishing removal rate of approximately 250 to 300 μm per hour, and approximately 100 to 150 scratches, and the conditioners provided in Embodiment 1 of the present invention have a polishing removal rate of approximately 150 to 200 μm per hour, and approximately 125 to 150 scratches, which means the conditioners provided in Embodiments 1 & 2 of the present invention are highly stable and their quality can be easily controlled; on the contrary, the conditioner provided in comparative example 2 has a polishing removal rate of approximately 125 to 225 μm per hour, and approximately 50 to 75 scratches, which means the conditioner provided in comparative example 2 not only has fewer scratches but also has unstable quality.

FIG. 6 shows a comparison diagram of conditioner service time and removal rate among the composite conditioners manufactured in the foregoing preparation example 2 (Embodiment 1 and Embodiment 2), the conditioner manufactured by the prior art brazing method (comparative example 2) and the conditioner manufactured by the prior art electroplating method (comparative example 3). From FIG. 6, it can be known that for the conditioners provided in Embodiments 1 & 2 of the present invention, during polishing, the removal rate decreases slowly with the increase of service time, which means the conditioners provided by the present invention have the fastest conditioning rate and the longest service life due to well-controlled flatness; on the contrary, the removal rate of the conditioner provided in comparative example 2 fluctuates and is unstable, thereby causing a problem in quality control, while the removal rate of the conditioner provided in comparative example 3 is poor, and cannot save the time and cost of the polishing process.

FIG. 7 is a comparison diagram of the number of polished wafers and removal rate between the composite conditioner manufactured in the foregoing preparation example 2 (Embodiment 2) and the conditioner manufactured by the brazing method (comparative example 2). From FIG. 7, it can be known that compared with comparative example 2, the conditioner provided in Embodiment 2 of the present invention can be used in the CMP process to polish more wafers.

Application Example

FIG. 8 is a schematic view of CMP (chemical-mechanical planarization) process. As

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shown in FIG. 8, generally a wafer 4 is placed on the surface of the polishing pad 6, and polishing slurry is provided via a pipeline 8 so that the slurry and the polishing pad 6 polish each other. A conditioner 2 is arranged in another blank portion on the surface of the polishing pad 6 to remove debris after polishing of the wafer. Here, the conditioner used can be a conditioner manufactured in the foregoing preparation example of the present invention.

In summary, the highest polishing apex of the existing whole-piece brazed diamond conditioner often protrudes over 20 μm more than the second highest apex, and the protruding range of the top 10 highest abrasive particles is only 50 μm ; on the contrary, when the foregoing method of the present invention is used to manufacture a composite conditioner by the inverse and flush manufacturing method, the difference between the highest polishing apex and the second highest apex can be reduced to below 10 μm , so the proportion of polishing tips that work effectively on the polishing units can be raised and the removal rate and service life can be increased.

The foregoing embodiments are merely examples for the convenience of description, and the scope of the claimed rights of the present invention should be subject to the scope of claims, rather than be limited to the foregoing embodiments.

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIG. 1A to FIG. 1G are schematic views of a flow for manufacturing a composition conditioner in preparation example 1 of the present invention.

FIG. 2A to FIG. 2G are schematic views of a flow for manufacturing a composition conditioner in preparation example 2 of the present invention.

FIG. 3 is a comparison diagram of tip height difference and number of working particles between the present invention and a prior art conditioner.

FIG. 4 is a comparison diagram of the height difference between the first highest tip and the second highest tip (μm) and number of scratches between the present invention and a prior art conditioner.

FIG. 5 is a comparison diagram of the number of scratches and removal rate between the

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present invention and a prior art conditioner.

FIG. 6 is a comparison diagram of conditioner service time and removal rate between the present invention and a prior art conditioner.

FIG. 7 is a comparison diagram of the number of polished wafers and removal rate between the present invention and a prior art conditioner.

FIG. 8 is a schematic view of the CMP process of the present invention.

FIG. 9 is a schematic view of an abrasive particle.

[DESCRIPTION OF REFERENCE SIGNS OF MAIN COMPONENTS]

first mold 10	base plate 24
opening 101	adhesive layer of which thickness is adjustable 23
temporary adhesive layer 11	composite conditioner 2
second mold 12	metal covering layer 212
orifice 121	protective layer 211
polishing unit 20	mold sealing layer 25
polishing tip 221	wafer 4
unit substrate 21	polishing pad 6
bonding layer 213	pipeline 8

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No. 101112625 Amendment Page

Seal: Amendment Supplement January 7, 2015

Seal: January 7, 2015 Amendment

VII. Claims:

1. A composite conditioner, comprising:

a base plate;

a plurality of polishing units, placed on the base plate and each polishing unit including a bonding layer and a plurality of polishing tips that are bonded by the bonding layer; and

an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate,

wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm ;

wherein of the 100 highest polishing tips, more than 50% have a crystal surface coverage rate of less than 80%.

2. The composite conditioner according to claim 1, wherein the polishing tips used to condition a polishing pad account for above 1% of all polishing tips.

3. The composite conditioner according to claim 1, wherein the area of the base plate covered by the polishing units accounts for less than 40% of the total area of a surface of the base plate.

4. The composite conditioner according to claim 1, wherein the polishing units are arranged in a single circle, double circles, multiple circles, a radial shape or a spiral shape on the base plate.

5. The composite conditioner according to claim 1, wherein during conditioning, at least more than 1,000 polishing tips will contact a polishing pad.

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6. The composite conditioner according to claim 1, wherein the material of the polishing tips is diamond, cubic boron nitride (CBN) or a combination thereof.

7. The composite conditioner according to claim 6, wherein the diamond is chemically deposited diamond, polycrystalline diamond, or a combination thereof.

8. The composite conditioner according to claim 1, wherein of the 100 highest polishing tips, more than 50% have a crystal surface coverage rate of less than 50%.

9. The composite conditioner according to claim 1, wherein each polishing unit further comprises a unit substrate, and the bonding layer is arranged between the surface of the unit substrate and the polishing tips.

10. The composite conditioner according to claim 1, wherein the bonding layer is a solder layer, an electroplated layer, a sintered layer, or a resin layer.

11. The composite conditioner according to claim 10, wherein each polishing unit further comprises a metal covering layer, which covers the surface of the bonding layer and of which material is at least one selected from a group consisting of Ni, Cr, Pd, Co, Pt, Au, Ti, Cu, W and alloy thereof.

12. The composite conditioner according to claim 11, wherein each polishing unit further comprises a protective layer, which covers the surface of the metal covering layer, and of which material is Pd, Pt, silicon carbide, aluminum nitride, aluminum oxide, zirconia, diamond-like carbon (DLC) or a combination thereof.

13. The composite conditioner according to claim 10, wherein the solder layer contains more than 1 wt% of at least one selected from a group consisting of Cr, B, P, Ti and alloy thereof, more than 50 wt% of at least one selected from a group consisting of Ni, Cu and alloy thereof, or a combination thereof.

14. The composite conditioner according to claim 1, wherein the polishing units can be disc-shaped, radial or polygonal.

15. The composite conditioner according to claim 14, wherein the diameter of the disc-shaped polishing units is in the range of 5 to 30 mm.

16. The composite conditioner according to claim 1, wherein the base plate is disc-shaped and its diameter is in the range of 80 to 120 mm.

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17. The composite conditioner according to claim 1, wherein the diameter of the polishing tips is in the range of 100 to 500 μm .

18. The composite conditioner according to claim 1, wherein the material of the adhesive layer of which thickness is adjustable is an organic adhesive.

19. The composite conditioner according to claim 1, wherein the polishing tips can be patterned and arranged on the unit substrate, or the polishing tips form a plurality of clusters, and the clusters are patterned and arranged on the unit substrate, and each cluster is composed of two to six polishing tips.

20. The composite conditioner according to claim 1, wherein the space between the polishing units is not less than 0.1 mm.

21. The composite conditioner according to claim 20, wherein the space is greater than 0.5 mm.

22. The composite conditioner according to claim 1, wherein the thickness of the adhesive layer on the bottom surface of the polishing units is in the range of below 0.6 mm.

23. The composite conditioner according to claim 22, wherein the top surface of the polishing units is over 1 mm higher than the surface of the adhesive layer of which thickness is adjustable.

24. A method for manufacturing a composite conditioner, comprising the following steps:

arranging a second mold on a first mold, wherein the second mold has a plurality of orifices;

arranging a polishing unit in each orifice of the second mold, wherein each polishing unit comprises a bonding layer and a plurality of polishing tips that are bonded by the bonding layer;

forming an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate; and

removing the first mold and the second mold to form a composite conditioner,

wherein a height difference between the first and second highest tips, between the first

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and tenth highest tips, and between the first and 100th highest tips among the polishing tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm ; and

wherein prior to arranging the second mold on the first mold, the following steps are further comprised: forming a temporary adhesive layer on the surface of the first mold, and arranging the second mold on the surface of the temporary adhesive layer, so that the temporary adhesive layer is sandwiched between the second mold and the first mold.

25. The method for manufacturing a composite conditioner according to claim 24, wherein after removing the second mold, the following steps are further comprised: removing the temporary adhesive layer.

26. The method for manufacturing a composite conditioner according to claim 24, wherein one side of the polishing units has the polishing tips, and the adhesive layer of which thickness is adjustable is arranged on the opposite side of the side.

27. The method for manufacturing a composite conditioner according to claim 26, wherein the polishing units arranged in the orifices are in contact with the first mold by means of the polishing tips.

28. The method for manufacturing a composite conditioner according to claim 27, wherein after removing the second mold and the first mold, the following steps are further comprised: forming a mold sealing layer to secure the polishing units.

29. The method for manufacturing a composite conditioner according to claim 24, wherein the orifices of the second mold are arranged on the outer ring of the second mold.

30. The method for manufacturing a composite conditioner according to claim 29, wherein the orifices of the second mold are 12 orifices formed with the outer ring of the second mold.

31. A chemical-mechanical planarization (CMP) process, comprising the following steps:

providing a polishing pad;

placing a wafer on the surface of the polishing pad and polishing the wafer and the polishing pad with each other; and

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using a conditioner arranged on the surface of the polishing pad to remove debris after polishing of the wafer, wherein the conditioner is the composite conditioner as in claim 1.

32. The CMP process according to claim 31, applicable to the production of logic devices, dynamic random access memories (DRAMs), caches (flash memories) or hard drives.

33. The CMP process according to claim 31, wherein the diameter of the wafer is 200 mm, 300 mm or 450 mm.

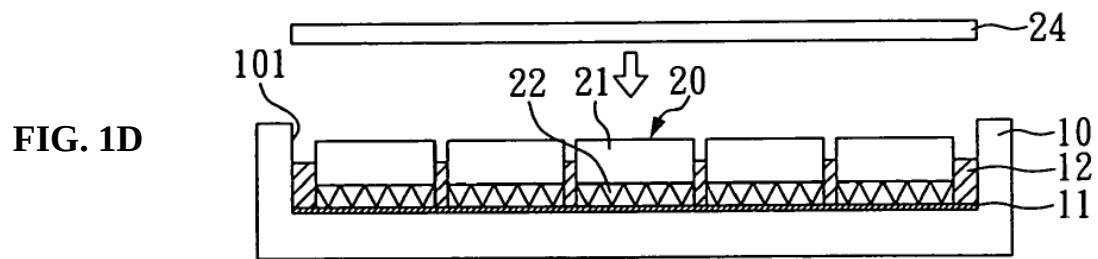
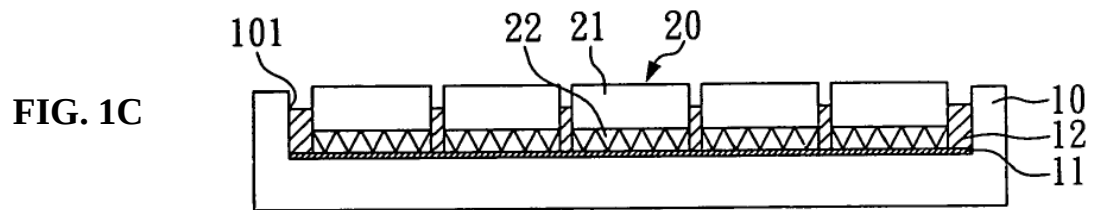
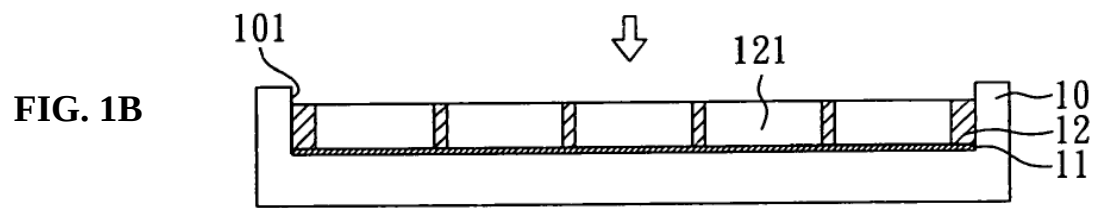
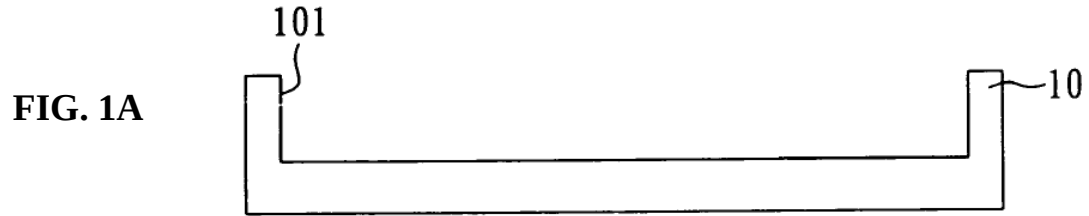
34. The CMP process according to claim 31, wherein the line width of ICs on the surface of the wafer is smaller than or equal to 45 nm.

35. The CMP process according to claim 34, wherein the line width of ICs on the surface of the wafer is smaller than or equal to 28 nm.

36. The CMP process according to claim 35, wherein the line width of ICs on the surface of the wafer is smaller than or equal to 22 nm.

VIII. Drawings (See next page):

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FIG. 1E

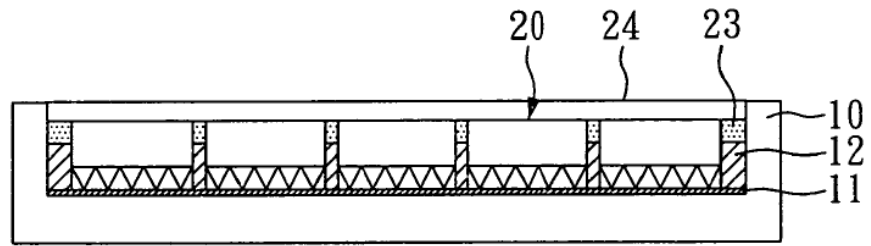


FIG. 1F

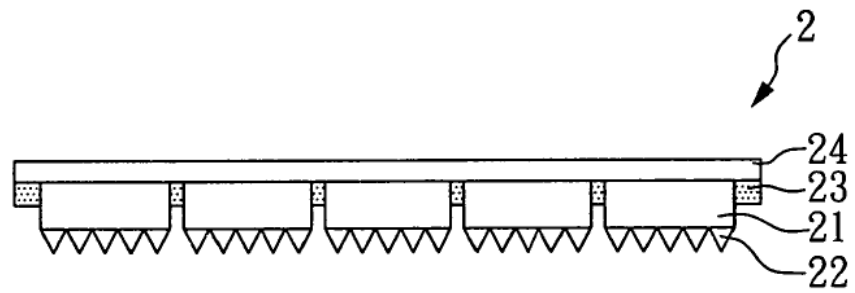
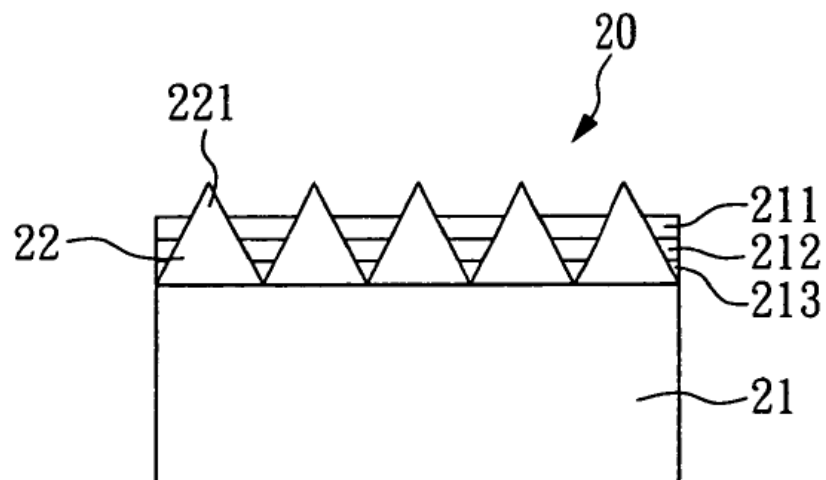


FIG. 1G



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FIG. 2A

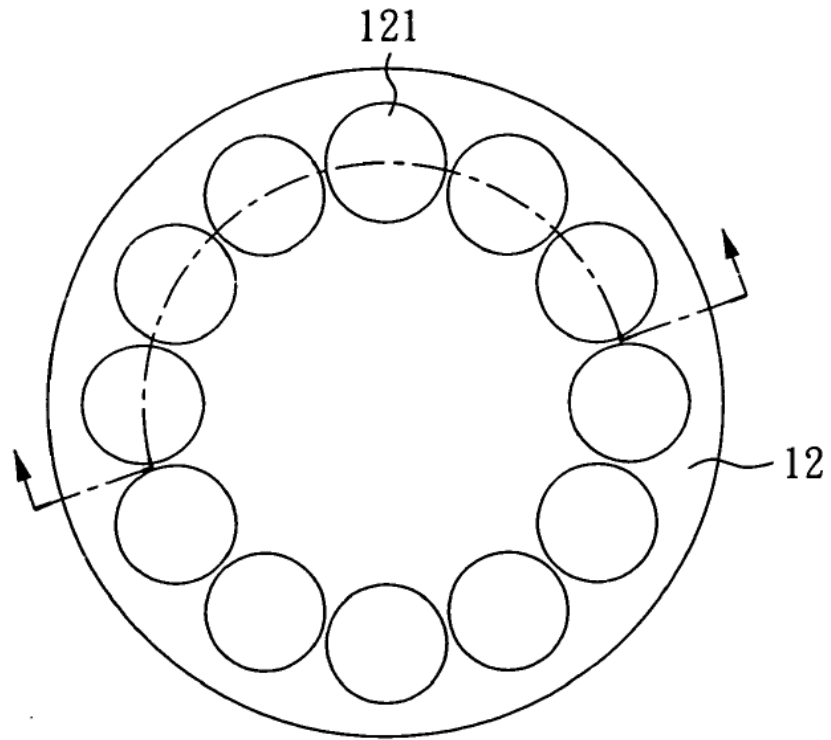


FIG. 2B

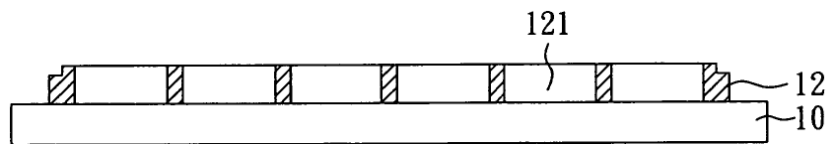


FIG. 2C

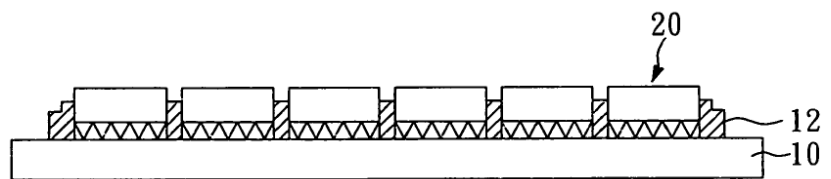
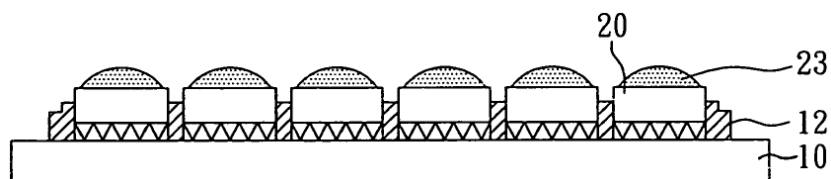
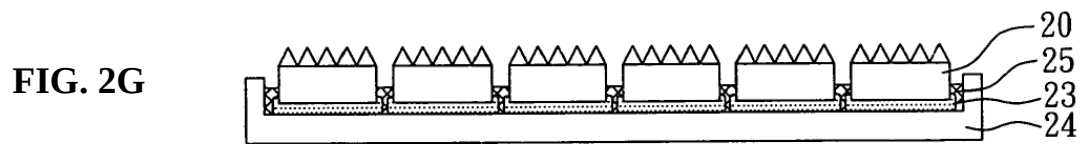
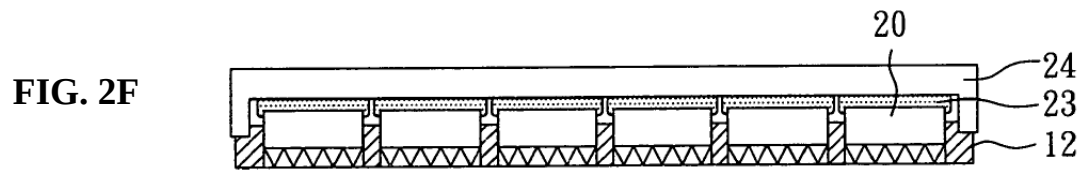
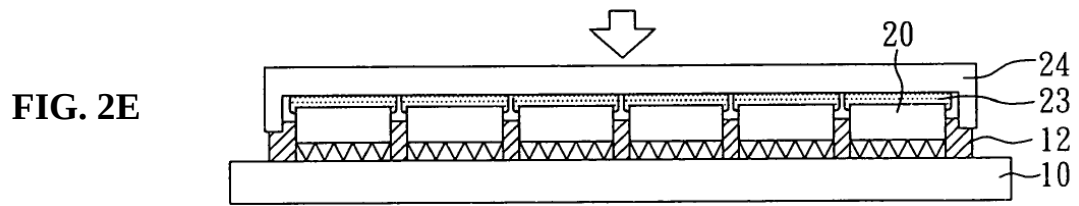


FIG. 2D



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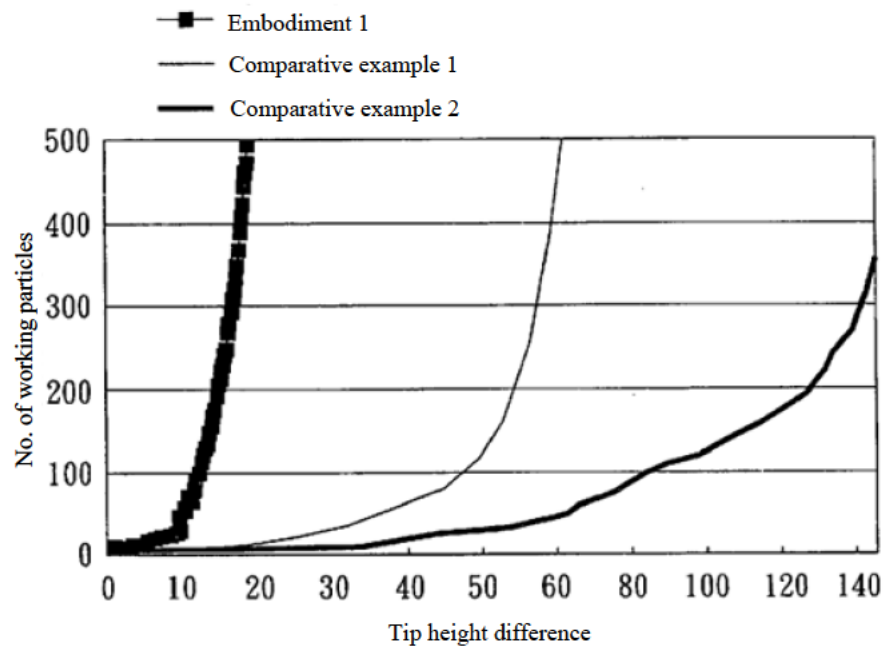


FIG. 3

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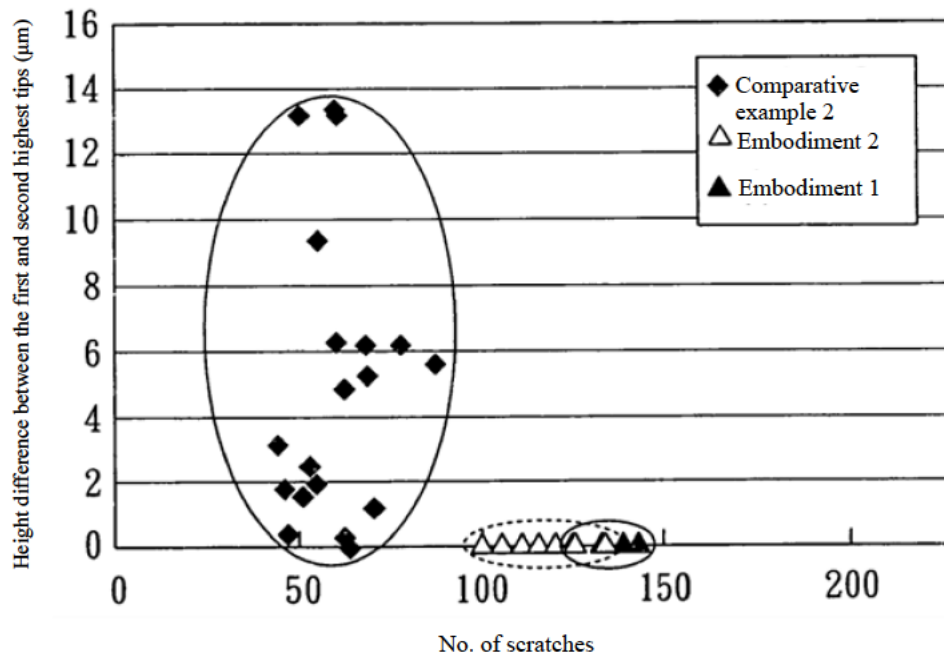


FIG. 4

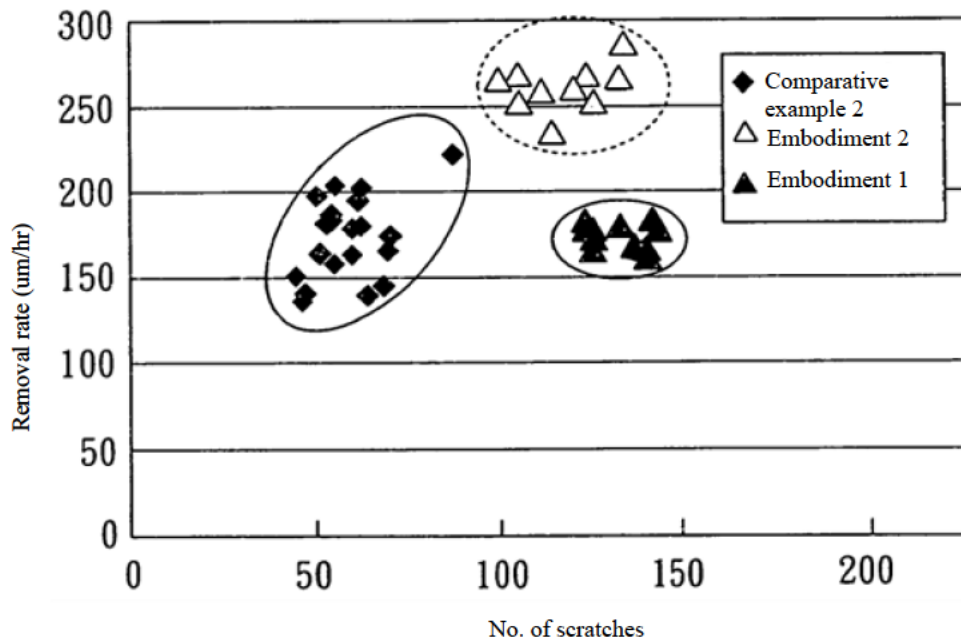


FIG. 5

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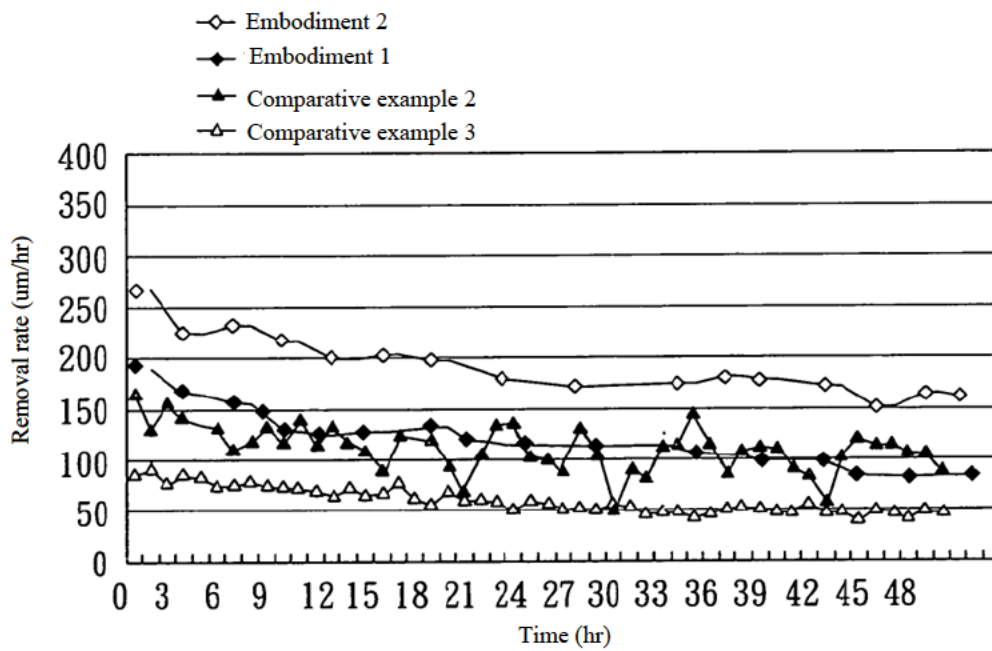


FIG. 6

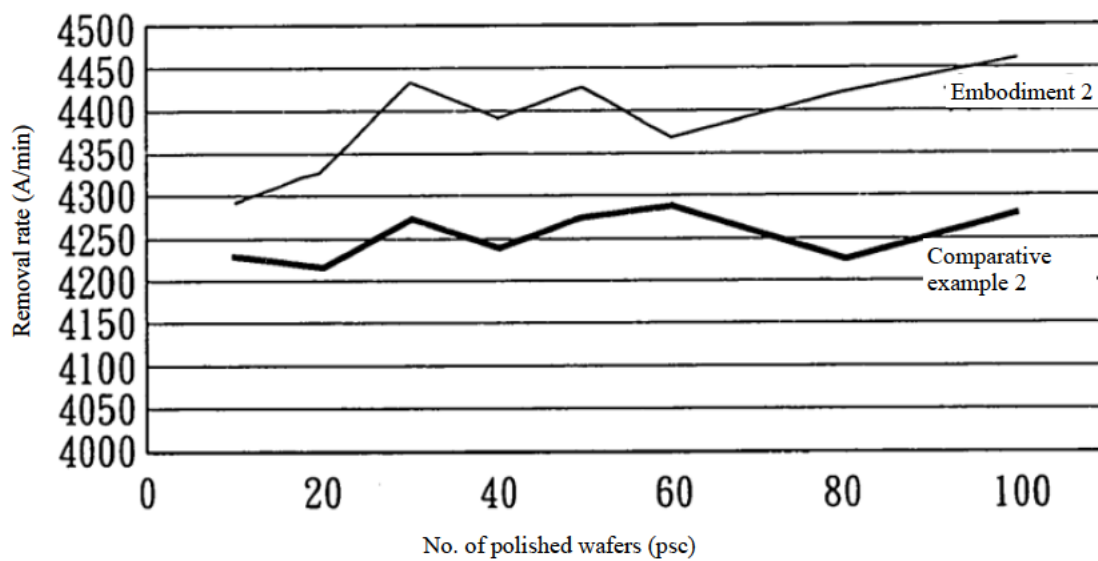


FIG. 7

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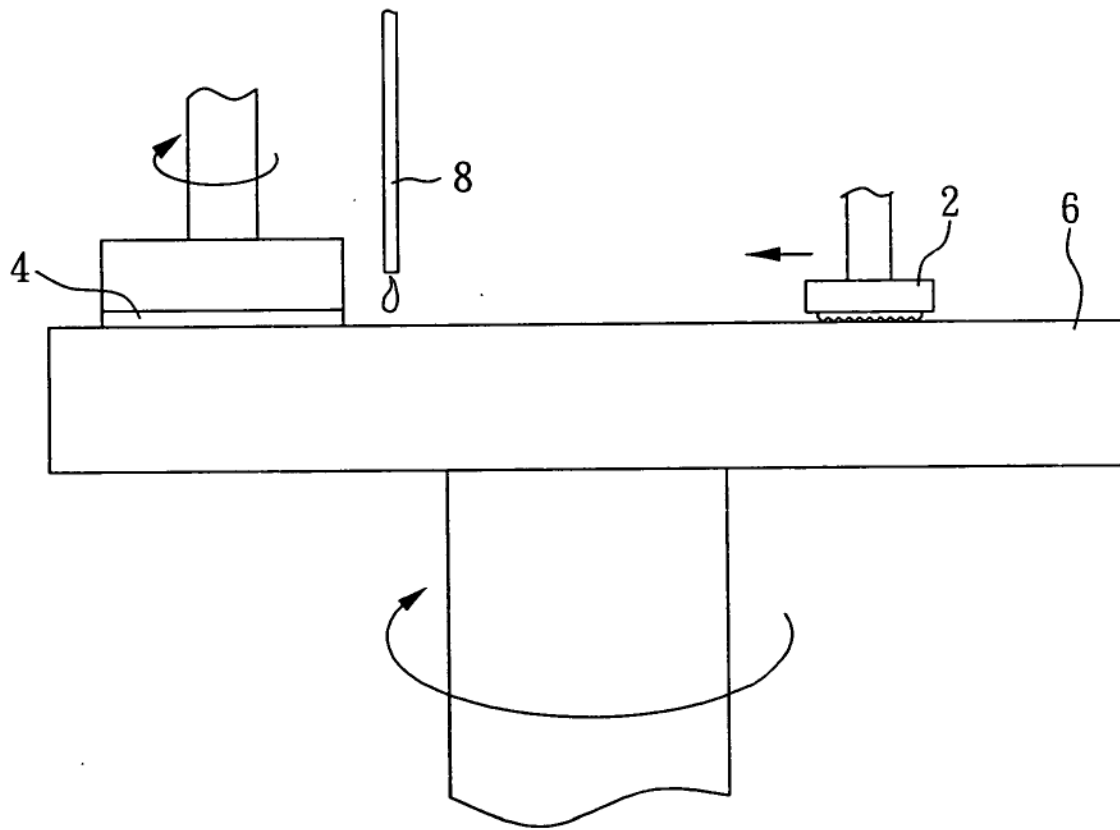


FIG. 8

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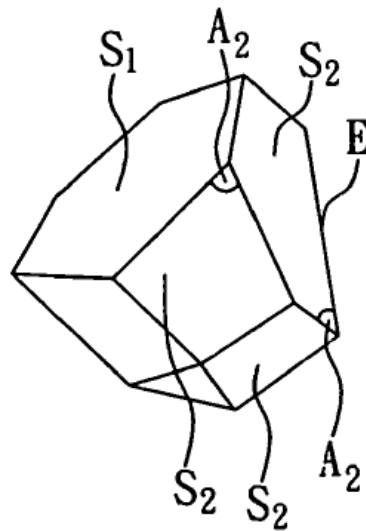
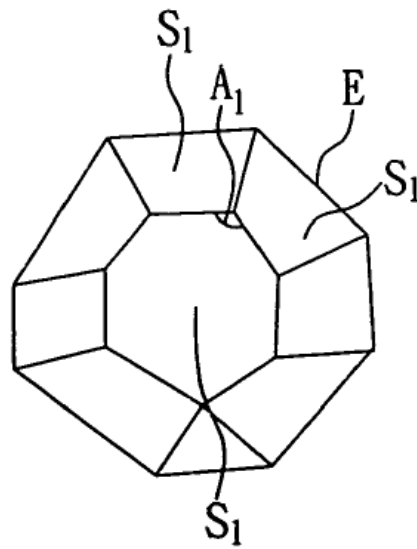


FIG. 9

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H01L 21/304 (2006. 01)

H01L 21/306 (2006. 01)

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(74) Agent: HUANG, CHIH YANG

(56) References:

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KR 10-2010-0110989A

Examiner: TSAI, FENG CHIN

Claims: 36 Drawings: 9 37 pages in total

(54) Title of Invention

COMPOSITE CONDITIONER AND METHOD FOR MANUFACTURING THE SAME
AND CMP APPLICATION THEREOF

(57) Abstract

A composite conditioner includes: a base plate; a plurality of polishing units placed on the base plate and each polishing unit including a bonding layer and a plurality of polishing tips that are bonded in plane by the bonding layer; and an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm . The present invention also relates to a method for manufacturing the conditioner and application thereof.

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Designated representative image:

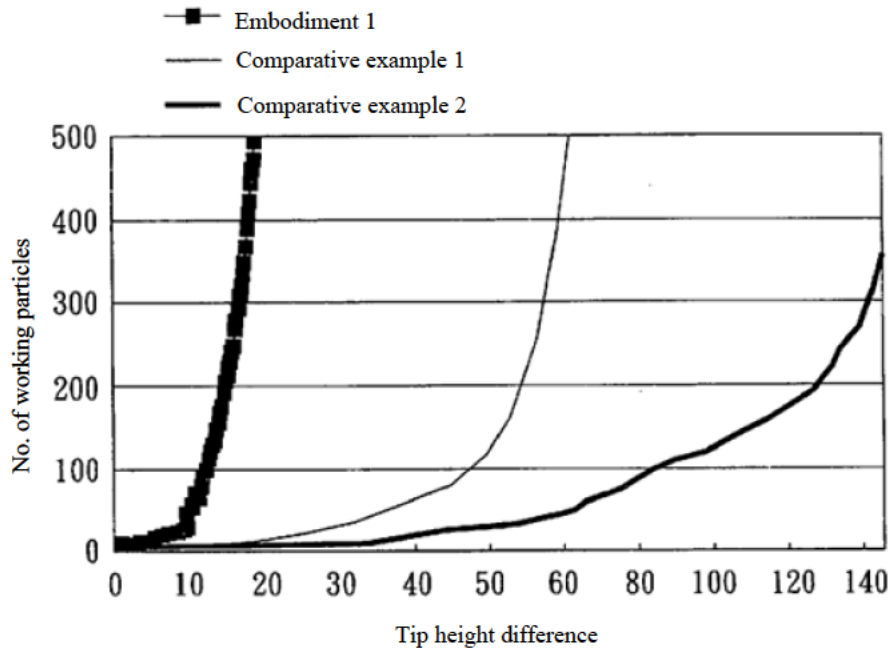


FIG. 3

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Publication

Invention Patent Specification

(Please do not change the format and order of this specification arbitrarily, ※ Please do not fill in the marked part)

※ **Application Number: 101112625**

※ **Application Date: April 10, 2015**

※ **IPC: B24B 37/04 (2006. 01)**

H01L 21/304 (2006. 01)

H01L 21/306 (2006. 01)

I. Title of the Invention: (Chinese/English)

組合式修整器及其製法與化學機械平坦化應用

COMPOSITE CONDITIONER AND METHOD FOR MANUFACTURING THE SAME
AND CMP APPLICATION THEREOF

II. Abstract of the Invention in Chinese:

本發明係有關於一種組合式修整器，包括：一底部基板；複數個研磨單元，係設置於該底部基板之表面，每一研磨單元包括複數個研磨尖點，以及一固定該些研磨尖點之結合劑層；以及一厚度可調節之黏著劑層，係固定該些研磨單元於該底部基板之表面，其中，該些研磨尖點中突出一預定平面之第一高點與第二高點之高度差小於 10 微米，第一高點與第十高點之高度差小於 20 微米，第一高點與第一百高點之高度差小於 40 微米，且該第一高點突出該結合劑層之高度大於 50 微米。本發明亦關於該組合式修整器之製造方法與應用。

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III. Abstract of the Invention in English:

A composite conditioner includes: a base plate; a plurality of polishing units placed on the base plate and each polishing unit including a bonding layer and a plurality of polishing tips that are bonded in plane by the bonding layer; and an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm . The present invention also relates to a method for manufacturing the conditioner and application thereof.

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IV. Designated Representative Image:

- (I) Designated representative image of the present application: FIG. (3).
- (II) Description of reference signs of components in the representative image:
No

V. If there are chemical formulae in the present application, please reveal the chemical formula that best shows the characteristics of the invention:

「No」

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VI. Invention Specification:

[TECHNICAL FIELD]

The present invention relates to a composite conditioner, a method for manufacturing the same and a chemical-mechanical planarization (CMP) process using the same, particularly to a composite conditioner suitable for planarization of semiconductor wafer surface, a method for manufacturing the same and a chemical-mechanical planarization (CMP) process using the same.

[PRIOR ART]

The oxide film dielectric layers of the copper circuits or interlayer tungsten circuits, even insulation circuits on the silicon wafer surface all must be surface-flattened through a planarization process to facilitate subsequent process steps. At present, in the process of manufacturing Interconnected Circuits (ICs) on semiconductor wafers, the most eye-catching planarization technology is chemical-mechanical planarization (CMP), in which the wafer is pressed on a rotating polishing pad to polish and flatten its surface.

In the CMP process, slurry is stably and evenly delivered between the wafer and the polishing pad, so that the surface of the polishing pad is impregnated with the slurry. The slurry contains chemical agents (such as acid and oxidizer) to erode the thin film on the wafer surface, and the slurry also contains countless nano-ceramic (such as SiO_2 , Al_2O_3 and CeO_2) abrasive particles, which can cut into and scrape away micro-films and at the same time, perform chemical etching and mechanical grinding to remove the protruding deposited layer on the chip, thereby polishing the surface of the wafer and achieving the purpose of planarization.

Conditioner is a necessary consumable for CMP, and its function is to condition the polishing pad. The so-called conditioning includes shaving the surface of the polishing pad and removing the waste accumulated on the surface of the polishing pad, thereby maintaining the surface roughness of the polishing pad. Further, the conditioner can also generate a small quantity of bumps and depressions on the surface, which are the height differences of so-called asperities, so that the contacted and pressed area of the polishing pad can be reduced significantly. The smaller the contact area is, the greater the contact

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pressure will be so that the slurry at the contact points can squeeze the protruding parts of the wafer, and the chemical agent (such as H_2O_2) in the slurry will be oxidized to soften or corrode the wafer.

However, the waste generated in the CMP process, including abrasive dust of wafers, such as copper wires, tungsten pore fillings, oxide films, slurry, abrasive particles, and polishing pad debris, will typically be accumulated on the surface of the polishing pad and squeezed into a glaze. Once the glaze is formed, the polishing pad will become slippery and can hardly maintain a polishing force. Therefore, it is often necessary to use a conditioner to polish each wafer to achieve the polishing efficiency (e.g., polishing speed) and flatness (e.g., the thickness distribution of the wafer coating) of the process, thereby stabilizing the quality of the wafers.

However, the prior art diamond conditioner typically secures diamond particles on the surface of a metal tray with a bonding agent. Although it is suitable for conditioning the polishing pad, for more precise CMP processes, such as CMP processes with a line width of less than 45 nm, it is more liable to scratches, local dishing, erosion and thickness non-uniformity of the wafers due to rough asperities of the polishing pad. The requirements for line width of IC are declining, while the demand for wafer surface flatness rises, and the requirements for the conditioner increase, too, making the prior art diamond conditioner unable to meet the advanced requirements for the CMP processes of below 45 nm.

For this purpose, the prior patent publication TW 201038362 A1 and TW 201100198 disclose a composite conditioner and manufacturing method thereof respectively, wherein the sharp angles of the polishing tips of polishing units in various sizes, shapes and materials cut into a polishing pad, then pressure is applied to the other side of the polishing units and resin is filled to secure the polishing units so that the height difference between polishing tip apexes of the polishing units is within 20 μm .

However, the polishing tips used in the foregoing patent application need to use diamond abrasive particles with high shape regularity, and the crystal surface coverage rate of such crystal form is very high (for example, more than 50% of the surface is crystal growth surface). Otherwise, when sharp diamonds with a low crystal surface coverage rate are used, an excessive height difference will be caused. Further, the diamond that cuts into the polishing pad the deepest, the so-called "killer diamond", has no standard for the

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difference in height from the top pads of other diamonds. In order to meet the process requirements of a smaller line width, it is necessary to continuously improve the conditioner so that when sharper polishing tips are used, the flatness of the sharp angle heights (e.g., the height difference of the sharp angles of the polishing tips) can still be maintained, and the conditioner can form finer and more uniform scores on the polishing pad, and at the same time raises the removal rate of the polishing pad. Only in this way, can the glaze be effectively removed, the asperities on the polishing pad be restored and the coating on the wafer be polished quickly.

[SUMMARY OF THE INVENTION]

A main object of the present invention is to provide a composite conditioner, wherein sharp polishing tips are used, and can still maintain tip height distribution and avoid existence of “killer diamonds”, thereby raising the ratio of polishing tips that work effectively on the polishing units, and increasing the wafer removal rate and conditioner service life.

To achieve the foregoing object, one example of the present invention provides a composite conditioner, comprising: a base plate; a plurality of polishing units placed on the base plate and each polishing unit including a bonding layer and a plurality of polishing tips that are bonded by the bonding layer (which can be made of metal, ceramics or resin); and an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm .

As CMP is plane polishing, the contact distribution between the highest tips of the wafer and the highest tips of the polishing pad determines the quality (e.g., yield) and efficiency (e.g., capacity) of CMP. If the highest tips of the asperities of the polishing pad are not uniformly distributed, the removal rate of different parts of the wafer will be different, and the surface of the wafer will not be flat. What is more, the polishing may be excessive at some locations, causing dishing in the same layer or erosion in multiple layers; or, polishing is inadequate at some locations, causing residue. If the wafer thickness is not

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uniform after polishing (Within Wafer Non-Uniformity or WIWUU), the CMP effect will be unobvious. For this reason, the present invention modified the conditioner based on the data of many tests and experiments, particularly adjusted the heights of working polishing tips through an adhesive layer of which thickness is adjustable to compensate the difference in thickness of the polishing units, thereby achieving the foregoing height distribution of the highest tips, avoiding generation of killer diamonds and raising the ratio of effectively working polishing tips on the polishing units.

In the foregoing composite conditioner of the present invention, the material of the adhesive layer of which thickness is adjustable can be an organic adhesive. Each polishing unit may further comprise a unit substrate, and the bonding layer is arranged between the surface of the unit substrate and the polishing tips, and for example can be a solder layer, an electroplated layer, a sintered layer, or a resin layer. The foregoing polishing tips refer to terminal points that can achieve a polishing effect on abrasive particles contained in a plurality of polishing units, and are exposed to the bonding layer, in other words, the heights of polishing tips refer to the protrusion heights of the polishing tips above the bonding layer.

The heights of the polishing tips can be measured with an optical detection system, such as a surface detector produced by German FRT (Fries Research & Technology GmbH), which measures the heights of all polishing tips of the conditioner (more than 10,000 for example), i.e., the protrusion heights of the polishing tips above the bonding layer. Then from the obtained height data, the least square method is used to calculate an assumed plane constituted by sharp angles of the polishing tips. This assumed plane is the foregoing predetermined plane. The first highest tip refers to the height of the one of the polishing tips that protrudes the most from the predetermined plane, the second highest tip refers to the height of the one of the polishing tips that protrudes the second most from the predetermined plane, and the same goes for other highest tips.

The polishing positions of the wafer mostly depend on the distribution of the apexes of the polishing pad, which is determined by the heights of the polishing tips of the conditioner. The conditioner can be disc-shaped (applicable to Applied Materials machine for example) or ring-shaped (applicable to Ebara machine for example). The diameter of the disc is generally about 100 mm, while the ring can be as large as 250 mm or more. Typically, tens of thousands of polishing tips (e.g., diamond particles) are distributed on the conditioner, polishing tips of 80/90 mesh, 100/120 mesh, or 120/140 mesh for example, but

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the difference in average size even under the same mesh may still be greater than 30%. Further, the size of the same polishing tip varies remarkably in different directions. For example, the distance between tips will be up to 30% larger than that between planes, and if the shape of the polishing tips is irregular, the difference will be even larger.

Therefore, the present invention adjusts the used abrasive particles so that the height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips is less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm to ensure the conditioner has numerous working tips, thereby achieving an effect of rapid and uniform removal of the thin film on the IC wafer surface. Further, it should be noted that the first highest tip and the second highest tip can be scattered in different polishing units or in the same polishing unit, so are other highest tips; in other words, the distribution of the highest tips is not concentrated in a single polishing unit.

In the foregoing composite conditioner of the present invention, the material of the polishing tips can be man-made or natural diamond, polycrystalline diamond (PCD), cubic boron nitride (CBN), polycrystalline cubic boron nitride (PCBN) or a combination thereof, and the particle size of the polishing tips can be in the range of 100 to 500 μm . The foregoing diamond can be chemically deposited diamond, polycrystalline diamond, or a combination thereof. Further, there is no special limitation to the material of the base plate. For example, it can be pure resin, metal, alloy, plastics, rubber, ceramics, glass or a combination thereof (e.g., a mixture of resin and metal).

Further, because the diamond is typically converted from graphite under the catalysis of iron-nickel alloy at a high pressure (e.g., 5GPa), it contains molten iron-nickel inclusion. The alloy catalyzes the diamond back into graphite or carbon at high temperature, during which the volume will increase substantially to burst the diamond. If the diamonds are secured on a diamond disc by brazing, many diamonds will burst due to the high process temperature, the diamond tips that cut deep into the polishing pad in the CMP process may be disintegrated along the microcrack surface, and the diamond debris may scratch expensive wafers. In view of this, diamonds containing much inclusion are often separated by magnetic separator. Even so, more or less residual iron-nickel alloy is still contained in the diamonds. If there are undetectable cracks inside the diamonds, the diamonds may be broken and disintegrated with debris in the CMP process, causing scratches of the wafer. In

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view of this, high temperature brazing should choose a solder with a lower melting point.

In the present invention, when a solder is used as the material of the bonding layer, the solder layer may contain more than 1wt% of at least one selected from a group consisting of Cr, B, P, Ti and alloy thereof, more than 50wt% of at least one selected from a group consisting of Ni, Cu and alloy thereof, or a combination thereof, wherein materials such as Cr, B, P and Ti are used to activate the solder layer. Specifically, the solder is typically Ni-Cr-B, Ni-Cr-P, or Cu-Sn-Ti alloy, with a melting point (Solidus) of 800°C to 1,000°C.

Further, each polishing unit optionally further comprises: a metal covering layer, which covers the surface of the bonding layer and of which material is at least one selected from a group consisting of Ni, Cr, Pd, Co, Pt, Au, Ti, Cu, W and alloy thereof, so that the polishing tips are more stably attached to the unit substrate of the polishing unit. Further, each polishing unit optionally further comprises: a protective layer, which is a thin-layer inert material and covers the surface of the metal covering layer, and of which material may be a metal material such as Pd or Pt, or a nonmetal material such as a ceramic film (e.g., silicon carbide, silicon nitride, aluminum nitride, aluminum oxide and zirconia), diamond-like carbon (DLC) film, organic film (e.g. Teflon) or a combination thereof, to avoid the erosion of the solder by the polishing slurry (e.g., pH=3 tungsten process slurry).

Generally speaking, the height of the apex of the diamond determines the strength of pressing into the polishing pad, but its sharpness affects the cutting depth. Typically, the sharper the diamond is, the smaller the elastic and plastic deformation of the polishing pad will be, and the greater the depth of shaving will be. Because the diamond abrasive particles formed on the surface of the conditioner have different shapes and various directions, generally only the highest hundreds of them can come into contact with the polishing pad. If the shape of the diamond is regular and symmetric, it will be at an obtuse angle and will not cut into the polishing pad easily, but will push the surface of the polishing pad, forming bulging plastic deformation on both sides; on the contrary, if the diamond has a broken surface, e.g., an irregular shape, it may cut into the polishing pad, shave the surface of the polishing pad, and meanwhile remove waste.

Therefore, in the foregoing composite conditioner of the present invention, of the 100 highest polishing tips, more than 50% have a crystal surface coverage rate of less than 80%, preferably a crystal surface coverage rate of less than 50%. When the crystal surface

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coverage rate of the polishing tips is lower, it means that the polishing tips have more broken surfaces (i.e., sharp surfaces), and it also means that the polishing tips on the working surface of the polishing units contain sharp angles and ridges, a majority of the ridges have an included angle of less than 45 degrees (i.e., the angle between the two crystal surfaces that constitute a ridge), or a majority of the sharp angles are in a state of less than 90 degrees, so the removal rate is high to the polishing pad. Refer to FIG. 9, which is a schematic view of an abrasive particle, where A, E, and S represent a sharp angle, a ridge and a surface respectively, S_1 is a crystal surface, A_1 is an included angle between crystal surfaces, S_2 is a broken surface, and A_2 is an included angle formed by at least one broken surface. It can be seen that A_1 and A_2 are two different sharp angles. The angle of A_1 is greater than 90 degrees (i.e., an obtuse angle), and the angle of A_2 is less than 90 degrees (i.e., an acute angle), which means that when A_2 is used as a polishing tip, its removal efficiency will be greater than that of A_1 .

The polishing tips can be patterned and arranged on the unit substrate, or the polishing tips form a plurality of clusters, and the clusters are patterned and arranged on the unit substrate. For example, each cluster is composed of two to six polishing tips.

Further, the polishing units can be arranged in a single circle, double circles, multiple circles, a radial shape or a spiral shape on the base plate, and can be disc-shaped, blade-shaped or polygonal. If the polishing units are disc-shaped, their diameter is in the range of 5 to 30 mm, preferably not more than 20 mm. The base plate can also be disc-shaped and its diameter is in the range of 80 to 120 mm, and alternatively, the polishing units can be fixed on a ring-shaped substrate of 250 to 270 mm. Further, if the disc-shaped polishing units are located inside, they are often blocked by the external polishing units during conditioning of the polishing pad, making it difficult to play an effect. Therefore, preferably, the polishing units can be arranged on the outer periphery of the surface of the disc-shaped base plate to produce a cliff effect of periphery conditioning in the CMP process, which will increase the number of working particles and is suitable for the CMP process to be applied to an 18-inch wafer or 22-nanometer process.

In the foregoing composite conditioner of the present invention, the space between the polishing units is not less than 0.1 mm, preferably greater than 0.5 mm, so as to ensure that the slurry can smoothly enter and exit the gaps between the polishing units in the CMP process and will not remain in them, causing defects, such as scratches on the chip. Further,

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the thickness of the adhesive layer on the bottom surface of the polishing units is in the range of below 0.6 mm, so that the polishing tips of each polishing unit can be fully adjusted to the same plane to effectively increase the number of working diamond particles.

It is known that due to the large difference in tip height, the number of tips used by a conventional conditioner (and the number of tips cutting into the polishing pad) accounts for less than 1% of the total number of tips, and the diamond coverage area of the conventional conditioner exceeds 40% of the total; on the contrary, in the foregoing composite conditioner of the present invention, the polishing tips used to condition a polishing pad can account for above 1% of all polishing tips; further, the area of the base plate covered by the polishing units can account for less than 40% of the total area of the surface of the base plate, so that the best removal rate can be achieved while reducing costs.

Another object of the present invention is to provide a method for manufacturing a composite conditioner, wherein polishing units with sharp polishing tips are used, a couple of the highest tips of each polishing unit are used as a plane reference by the inversion method, and the thickness of the adhesive material under each polishing unit is adjusted before fixation onto the substrate, so that a couple of the highest tips on the polishing unit will not protrude very much and form destructive “killer diamonds”. The use of a co-plane forces the highest tips of each polishing unit to reach a common height and can also increase the ratio of polishing tips that work effectively, thereby increasing the removal efficiency and service life of the conditioner.

In order to achieve the foregoing object, another example of the present invention provides a method for manufacturing a composite conditioner, comprising the following steps: arranging a second mold on a first mold, wherein the second mold has a plurality of orifices; arranging a polishing unit in each orifice of the second mold, wherein each polishing unit comprises a bonding layer and a plurality of polishing tips that are bonded by the bonding layer; forming an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate; and removing the first mold and the second mold to form a composite conditioner, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm .

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A general diamond conditioner is manufactured by the additive method, that is, the diamond abrasive particles are arranged flatwise (e.g., matrix distribution) on a flat substrate (e.g., stainless steel 316). According to the prior art, the height difference of diamond apexes on a single conditioner surface is typically more than 50 μm and the diamond abrasive particles can be secured by electroplating (EDD) and nickel, or by brazing (BDD) to retain them by solidifying molten alloy. The diamond plane of the former is typically upward, while the tips or ridges of the latter are often more prominent, and the diamonds with the plane facing upwards cannot cut into the polishing pad easily, and the diamonds with tips or ridges can shave the polishing pad more easily. In comparison, the present invention first uses the brazing method to form polishing units, and then uses an organic elastic material to bond and compensate a plurality of polishing units to arrange the polishing units on a base plate, so in addition to the advantages of the brazing method, it can also avoid its shortcomings, and make the formed conditioner have the highest tips of the same height. Therefore, when the diamond conditioner is conditioning the polishing pad, the protruding diamond apexes can contact and cut into the polishing pad, but there will be no overly protruding polishing tips, so no polishing tips will cut into the polishing pad too deep, resulting in excessive height difference between asperities, thereby avoiding asperities “as if big frogs in a small pond” being smeared with too much slurry, which causes the nano abrasive particles in the slurry to excessively cut into the surface of the wafer, resulting in excessive polishing, and even scratching of the wafer.

In the method for manufacturing the foregoing composite conditioner of the present invention, the adhesive layer of which thickness is adjustable can be formed after the highest tips of the polishing units are leveled with another flat plate, or after forming the adhesive layer with adjustable thickness, or before the adhesive layer of which thickness is adjustable is cured, the base plate is used to level the highest tips of the polishing units.

The adhesive layer of which thickness is adjustable can be composed of an organic adhesive, for example, a plastic material, a rubber material, a hot melt adhesive or a combination thereof; further, the orifices of the second mold are arranged on the outer ring of the second mold, thereby setting the positions of the polishing units on the outer ring of the base plate. Specifically, the orifices of the second mold are formed with the outer ring of the second mold, for example, 12 orifices. In addition, in the composite conditioner, the polishing units can also be arranged on the inner and outer rings, and generally, the smaller

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the area of the polishing units is, the larger the number of working particles will be during polishing, but the manufacturing cost will be higher, so making a conditioner with an appropriate number of polishing units can balance effect and cost.

In the method for manufacturing the foregoing composite conditioner of the present invention, prior to arranging the second mold on the first mold, the following steps are further comprised: forming a temporary adhesive layer on the surface of the first mold, and arranging the second mold on the surface of the temporary adhesive layer, so that the temporary adhesive layer is sandwiched between the second mold and the first mold, and after removing the second mold, the following steps are further comprised: removing the temporary adhesive layer. In a preferred embodiment of the present invention, the temporary adhesive layer is a double-sided adhesive tape.

In an alternative preferred embodiment of the present invention, one side of the polishing units has the polishing tips, and the adhesive layer of which thickness is adjustable is arranged on the opposite side of the side, and the polishing units arranged in the orifices are in contact with the first mold by means of the polishing tips. Further, after removing the second mold and the first mold, the following steps are further comprised: forming a mold sealing layer to secure the polishing units. It can be seen from the above that by pressing the polishing units on the side with the polishing tips, the polishing units are flatly arranged on the same plane.

The method for manufacturing the foregoing composite conditioner of the present invention may optionally further comprise the following steps: removing the second mold after removing the first mold. In other words, it means that the conditioner may comprise a second mold.

A further object of the present invention is to provide a CMP (chemical-mechanical Planarization) process, wherein sharp polishing tips are used, and can still maintain the planarity of the working surface, thereby raising the ratio of polishing tips that work efficiently on the polishing units, and increasing the removal rate and service life.

In order to achieve the foregoing object, a further example of the present invention provides a CMP process, comprising the following steps: providing a polishing pad; placing a wafer on the surface of the polishing pad and polishing the wafer and the polishing pad with each other; and using a conditioner arranged on the surface of the polishing pad to

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remove debris after polishing of the wafer, wherein the conditioner is the foregoing composite conditioner of the present invention.

The Moore's law mentions that the number of transistors accommodated on the same chip of a single size will be doubled every eighteen months due to the improvement of the process technology, thereby increasing the speed of operation performed by the chip. Owing to the continuous progress as mentioned in the Moore's Law, the line width and line distance of integrated circuits (ICs) also gradually break through the limit of 32 nanometers. However, it also faces the difficulty for CMP process to overcome the bottleneck, so it is impossible to enter a process of even smaller line width and line distance. On the contrary, as the foregoing CMP process of the present invention uses a modified conditioner, the CMP process of the present invention can use a wafer with a diameter of 200 mm, 300 mm or 450 mm, and the line width of ICs on the surface of the wafer can be smaller than or equal to 45 nm, 28 nm or 22 nm. Therefore, if the technology of the present invention is adopted in the related technologies, for example, the CMP process of the present invention is applied to the production of logic devices, dynamic random access memories (DRAMs), caches (flash memories) or hard drives, it will improve the operation execution speed of the foregoing devices as described in the Moore's Law.

[DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS]

Generally speaking, as the diamonds differ in size, shape and direction and the distance of the highest tips is random, the ploughing and shaving forms of the polishing pad are diverse, resulting in uneven heights of the polishing pad after conditioning, which makes it difficult to control the positions of the highest tips in contact with the wafer, and the area and pressure of each contact point, so that the polishing rate and uniformity of the CMP process have extremely high variability. When the wafer changes greatly (such as 8 inches to 12 inches or even 18 inches in the future), the variability of polishing rate and uniformity will be enlarged, reducing the quality and efficiency of the CMP process. More than that, when the wire width becomes narrower (e.g., 45 nm to 32 nm or even 22 nm in the future), the highest tips of the polishing pad are more likely to cause damage. When the circuits become narrower, the dielectric material between them must be more hollow to avoid electric leakage, but the hollow dielectric layer becomes fragile, so the contact pressure of

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the CMP process needs to be even smaller, but after the contact pressure is adjusted down, it will lead to a reduced polishing speed of the wafer, resulting in poor productivity.

The current diamond conditioner is typically manufactured by a method of planar addition of diamonds, so it is difficult to control the heights of apexes. Further, under high temperature manufacturing (e.g., brazing), the substrate is distorted and deformed, which makes the heights of the diamond apexes more uneven, and also greatly reduces the number of working particles, to only a few hundred though there are tens of thousands of diamonds on the conditioner.

Because the diamond conditioner is manufactured by the additive method (pressing and leveling from the top with diamond abrasive particles), it is difficult to control the size, shape and direction of the diamonds and the number, position and cutting depth of the diamonds on the working surface are also elusive, significantly reducing the predictability of the effect of the CMP process. Although the industry continues to strictly control the flatness of the conditioner substrate and the shape of the diamonds, the improvement effect is limited.

Considering that it is difficult to make the heights of the diamond apexes even, the present invention adopts the method of reverse combination. Diamond polishing units are manufactured at first, and then are placed upside down on a plane so that the polishing tips are flush. Now, an adhesive layer of which thickness is adjustable is placed on the opposite side of the polishing tips, and finally a mold sealing layer (e.g., resin) is injected to secure all the polishing units. Such inverse and flush manufacturing method can avoid “Killer Diamonds” that often exist on the diamond disc - i.e., the protruding diamonds like big frogs in a small pond. If the Diamond Killer is too sharp, it can easily cut into the polishing pad deeply and therefore is pulled apart, thereby forming Killer Asperities on the surface of the polishing pad, causing scratches and damage of the wafer.

Below the implementation manner of the present invention is described by referring to specific embodiments. Those skilled in the art can easily understand other advantages and effects of the present invention from the content disclosed in the Description. Alternatively, the present invention can be implemented or applied through other different specific embodiments, and various modifications and changes can be made to the details of the Description based on different views and application under the precondition of not departing from the spirit of the present invention.

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The figures in the embodiments of the present invention are all simplified schematic views. However, these reference signs only display the components related to the present invention, and the components displayed are not examples of actual implementation. The number, shape and other proportions of the components during actual implementation are a selective design, and the layout type of the components may be more complex.

Preparation Example 1

FIG. 1A to FIG. 1G are schematic views of a flow for manufacturing a composite conditioner.

Firstly, as shown in FIG. 1A, a first mold 10 is provided, which has an opening 101. Then, as shown in FIG. 1B, a temporary adhesive layer 11 is formed on the surface of the opening 101 of the first mold 10, and then a second mold 12 is arranged on the surface of the temporary adhesive layer 11, so that the second mold 12 is arranged inside the opening 101 of the first mold 10. Therefore, the temporary adhesive layer 11 is sandwiched between the second mold 12 and the first mold 10, wherein the second mold 12 has a plurality of orifices 121. In this preparation example, the temporary adhesive layer 11 is a double-sided adhesive tape.

As shown in FIG. 1C and FIG. 1G, a polishing unit 20 is arranged in each orifice 121 of the second mold 12, wherein each polishing unit 20 comprises a plurality of abrasive particles 22 (each abrasive particle 22 has at least one polishing tip 221), a unit substrate 21 and a bonding layer 213 arranged between the surface of the unit substrate 21 and the polishing tips 221. These polishing units 20 are manufactured by a common brazing method, and the manufacturing method is briefly described as follows: spot weld a solder pad (BNi_2) on a unit substrate 21 with a diameter of 20 mm and a thickness of 4 mm, and then use a template to arrange approximately 150 μm abrasive particles (e.g., diamond particles) on the solder pad coated with adhesive, and then put it in a vacuum furnace for vacuumizing to a vacuum degree of about 5 to 10 torr, and heat it to maximum temperature of 1,020°C and maintain this temperature for 12 minutes (in this period, the adhesive has been evaporated) to melt the solder of the solder pad into a liquid to weld the diamond particles firmly.

As the diamonds are originally located on the fixing solder, when the solder is melted

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to form a liquid, the carbide elements (e.g., Cr) in the solder will diffuse to the diamond surface. As a result, the solder will sink the diamonds by capillary force, and will also climb up to the diamond surface under the capillary force to form a slope. The diamonds were originally stuck to the surface of the solder pad on a flat surface, but now because the diamonds rotate in the liquid, their sharp angles often face upward.

Then, as shown in FIG. 1D and FIG. 1E, the polishing units 20 are leveled with a base plate 24, and an adhesive layer 23 of which thickness is adjustable is filled in to secure the polishing units 20. Then, as shown in FIG. 1F, the first mold 10, the temporary adhesive layer 11, and the second mold 12 are removed to form a composite conditioner 2.

The composite conditioner 2 includes: a base plate 24; a plurality of polishing units 20 placed on the base plate 24 and each polishing unit 20 including a plurality of polishing tips 221; and an adhesive layer 23 of which thickness is adjustable and used to secure the polishing units 20 on the base plate 24, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips 221 based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer 213 is greater than 50 μm .

FIG. 1G is an enlarged view of the polishing units of the present invention. Each polishing unit 20 comprises a plurality of abrasive particles 22 (each abrasive particle has at least one polishing tip 221), a unit substrate 21, a bonding layer 213 arranged between the surface of the unit substrate 21 and the polishing tips 221, a metal covering layer 212 covering the surface of the bonding layer 213, and a protective layer 211 covering the surface of the metal covering layer 212.

The bonding layer 213 can be a solder layer, an electroplated layer, a sintered layer, or a resin layer. If the bonding layer 213 is the solder layer, it contains more than 1 wt% of at least one selected from a group consisting of Cr, B, P, Ti and alloy thereof, more than 50 wt% of at least one selected from a group consisting of Ni, Cu and alloy thereof, or a combination thereof.

The metal covering layer 212 can be formed by means of electroplating, and its material may be at least one selected from a group consisting of Ni, Cr, Pd, Co, Pt, Au, Ti, Cu, W and alloy thereof; the material of the protective layer 211 can be Pd, Pt, silicon

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carbide, aluminum nitride, aluminum oxide, zirconia, diamond-like carbon (DLC) or a combination thereof.

Preparation Example 2

FIG. 2A to FIG. 2G are schematic views of a flow for manufacturing a composite conditioner.

Firstly, as shown in FIG. 2A, a second mold 12 is provided, which has 12 orifices 121, arranged on the outer ring of the second mold 12. Then, as shown in FIG. 2B, the second mold 12 is arranged on the surface of a first mold 10.

As shown in FIG. 2C, a polishing unit 20 is arranged in each orifice 121 of the second mold 12, wherein the working surface of the polishing unit 20 (the surface having polishing tips) faces the surface of the first mold 10. In this preparation example, the polishing units 20 are as similarly described in preparation example 1. Then, as shown in FIG. 2D, adhesive is dispensed on a side opposite to the polishing tips of each polishing unit 20 to form an adhesive layer 23 of which thickness is adjustable. Then, as shown in FIG. 2E, a base plate 24 presses flatly on the adhesive layer 23 of which thickness is adjustable, wherein the base plate 24 has a groove, which makes the base plate 24 in a “ $\square$ ” shape, and the groove of the base plate 24 flatly presses the adhesive layer 23 of which thickness is adjustable.

As shown in FIG. 2F, remove the first mold 10. Then, as shown in FIG. 2G, inverse the structure shown in FIG. 2F, remove the second mold 12 and form a mold sealing layer 25, reinforce the polishing units 20 and secure them to the base plate 24 to form a composite conditioner.

Although the polishing units manufactured by the brazing method may have killer diamonds, different polishing units with killer diamonds of similar heights can be used in combination with the foregoing method of the present invention to make the polishing tips flush. Therefore, the heights of the killer diamonds are close to the heights of other protruding diamond tips on the polishing units.

Test Example

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FIG. 3 is a comparison diagram of tip height difference and the number of working particles among the composite conditioner manufactured in the foregoing preparation example 2 (Embodiment 1, wherein the crystal surface coverage rate of the diamond particles used is approximately 60% to 80%, i.e., PDA 878 manufactured by Element Six), a conditioner manufactured by the prior art ceramic sintering method (comparative example 1) and the conditioner manufactured by the brazing method (comparative example 2). From FIG. 3, it can be known that during polishing, there are 60 to 70 working particles on the conditioner provided in Embodiment 1 of the present invention when the height difference is about 10 μm ; in comparison, comparative example 1 and comparative example 2 require a larger tip height difference in order to provide more working particles, and even on the conditioner provided in comparative example 1, more than 40 μm of height difference of abrasive particles is required to obtain more than 100 working particles. Thus, it can be seen that within the same height difference, the conditioner provided by the present invention actually has a much higher number of working abrasive particles than the prior art conditioners do.

FIG. 4 and FIG. 5 respectively show a comparison diagram of the height difference between the first highest tip and the second highest tip (μm) and number of scratches, and a comparison diagram of number of scratches and removal rate among the composite conditioner manufactured in the foregoing preparation example 2 (Embodiment 1, wherein the crystal surface coverage rate of the diamond particles used is approximately 60% to 80%, i.e., PDA 878 manufactured by Element Six; Embodiment 2, wherein the crystal surface coverage rate of the diamond particles used is approximately 40% to 60%, i.e., PDA 657 manufactured by Element Six) and the conditioner manufactured by the brazing method (comparative example 2).

From FIG. 4, it can be known that for the conditioners provided in Embodiments 1 & 2 of the present invention, when the height difference between the first highest tip and the second highest tip is approximately 0 μm , the number of scratches after polishing is 100 to 150, which means that the conditioners provided in Embodiments 1 & 2 have good quality and the quality is stable during polishing; on the contrary, for the conditioner provided in comparative example 2, the highest tips of abrasive particles are uneven and the number of scratches is only less than 50 to less than 100, which means the conditioner provided in comparative example 2 has uneven quality, and the quality is not stable during polishing.

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In a further aspect, from FIG. 5, it can be known that the conditioners provided in Embodiment 2 of the present invention have a polishing removal rate of approximately 250 to 300 μm per hour, and approximately 100 to 150 scratches, and the conditioners provided in Embodiment 1 of the present invention have a polishing removal rate of approximately 150 to 200 μm per hour, and approximately 125 to 150 scratches, which means the conditioners provided in Embodiments 1 & 2 of the present invention are highly stable and their quality can be easily controlled; on the contrary, the conditioner provided in comparative example 2 has a polishing removal rate of approximately 125 to 225 μm per hour, and approximately 50 to 75 scratches, which means the conditioner provided in comparative example 2 not only has fewer scratches but also has unstable quality.

FIG. 6 shows a comparison diagram of conditioner service time and removal rate among the composite conditioners manufactured in the foregoing preparation example 2 (Embodiment 1 and Embodiment 2), the conditioner manufactured by the prior art brazing method (comparative example 2) and the conditioner manufactured by the prior art electroplating method (comparative example 3). From FIG. 6, it can be known that for the conditioners provided in Embodiments 1 & 2 of the present invention, during polishing, the removal rate decreases slowly with the increase of service time, which means the conditioners provided by the present invention have the fastest conditioning rate and the longest service life due to well-controlled flatness; on the contrary, the removal rate of the conditioner provided in comparative example 2 fluctuates and is unstable, thereby causing a problem in quality control, while the removal rate of the conditioner provided in comparative example 3 is poor, and cannot save the time and cost of the polishing process.

FIG. 7 is a comparison diagram of the number of polished wafers and removal rate between the composite conditioner manufactured in the foregoing preparation example 2 (Embodiment 2) and the conditioner manufactured by the brazing method (comparative example 2). From FIG. 7, it can be known that compared with comparative example 2, the conditioner provided in Embodiment 2 of the present invention can be used in the CMP process to polish more wafers.

Application Example

FIG. 8 is a schematic view of CMP (chemical-mechanical planarization) process. As

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shown in FIG. 8, generally a wafer 4 is placed on the surface of the polishing pad 6, and polishing slurry is provided via a pipeline 8 so that the slurry and the polishing pad 6 polish each other. A conditioner 2 is arranged in another blank portion on the surface of the polishing pad 6 to remove debris after polishing of the wafer. Here, the conditioner used can be a conditioner manufactured in the foregoing preparation example of the present invention.

In summary, the highest polishing apex of the existing whole-piece brazed diamond conditioner often protrudes over 20 μm more than the second highest apex, and the protruding range of the top 10 highest abrasive particles is only 50 μm ; on the contrary, when the foregoing method of the present invention is used to manufacture a composite conditioner by the inverse and flush manufacturing method, the difference between the highest polishing apex and the second highest apex can be reduced to below 10 μm , so the proportion of polishing tips that work effectively on the polishing units can be raised and the removal rate and service life can be increased.

The foregoing embodiments are merely examples for the convenience of description, and the scope of the claimed rights of the present invention should be subject to the scope of claims, rather than be limited to the foregoing embodiments.

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIG. 1A to FIG. 1G are schematic views of a flow for manufacturing a composition conditioner in preparation example 1 of the present invention.

FIG. 2A to FIG. 2G are schematic views of a flow for manufacturing a composition conditioner in preparation example 2 of the present invention.

FIG. 3 is a comparison diagram of tip height difference and number of working particles between the present invention and a prior art conditioner.

FIG. 4 is a comparison diagram of the height difference between the first highest tip and the second highest tip (μm) and number of scratches between the present invention and a prior art conditioner.

FIG. 5 is a comparison diagram of the number of scratches and removal rate between the

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present invention and a prior art conditioner.

FIG. 6 is a comparison diagram of conditioner service time and removal rate between the present invention and a prior art conditioner.

FIG. 7 is a comparison diagram of the number of polished wafers and removal rate between the present invention and a prior art conditioner.

FIG. 8 is a schematic view of the CMP process of the present invention.

FIG. 9 is a schematic view of an abrasive particle.

[DESCRIPTION OF REFERENCE SIGNS OF MAIN COMPONENTS]

first mold 10	base plate 24
opening 101	adhesive layer of which thickness is adjustable 23
temporary adhesive layer 11	composite conditioner 2
second mold 12	metal covering layer 212
orifice 121	protective layer 211
polishing unit 20	mold sealing layer 25
polishing tip 221	wafer 4
unit substrate 21	polishing pad 6
bonding layer 213	pipeline 8

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No. 101112625 Amendment Page

Seal: Amendment Supplement January 7, 2015

Seal: January 7, 2015 Amendment

VII. Claims:

1. A composite conditioner, comprising:

a base plate;

a plurality of polishing units, placed on the base plate and each polishing unit including a bonding layer and a plurality of polishing tips that are bonded by the bonding layer; and

an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate,

wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm ;

wherein of the 100 highest polishing tips, more than 50% have a crystal surface coverage rate of less than 80%.

2. The composite conditioner according to claim 1, wherein the polishing tips used to condition a polishing pad account for above 1% of all polishing tips.

3. The composite conditioner according to claim 1, wherein the area of the base plate covered by the polishing units accounts for less than 40% of the total area of a surface of the base plate.

4. The composite conditioner according to claim 1, wherein the polishing units are arranged in a single circle, double circles, multiple circles, a radial shape or a spiral shape on the base plate.

5. The composite conditioner according to claim 1, wherein during conditioning, at least more than 1,000 polishing tips will contact a polishing pad.

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6. The composite conditioner according to claim 1, wherein the material of the polishing tips is diamond, cubic boron nitride (CBN) or a combination thereof.

7. The composite conditioner according to claim 6, wherein the diamond is chemically deposited diamond, polycrystalline diamond, or a combination thereof.

8. The composite conditioner according to claim 1, wherein of the 100 highest polishing tips, more than 50% have a crystal surface coverage rate of less than 50%.

9. The composite conditioner according to claim 1, wherein each polishing unit further comprises a unit substrate, and the bonding layer is arranged between the surface of the unit substrate and the polishing tips.

10. The composite conditioner according to claim 1, wherein the bonding layer is a solder layer, an electroplated layer, a sintered layer, or a resin layer.

11. The composite conditioner according to claim 10, wherein each polishing unit further comprises a metal covering layer, which covers the surface of the bonding layer and of which material is at least one selected from a group consisting of Ni, Cr, Pd, Co, Pt, Au, Ti, Cu, W and alloy thereof.

12. The composite conditioner according to claim 11, wherein each polishing unit further comprises a protective layer, which covers the surface of the metal covering layer, and of which material is Pd, Pt, silicon carbide, aluminum nitride, aluminum oxide, zirconia, diamond-like carbon (DLC) or a combination thereof.

13. The composite conditioner according to claim 10, wherein the solder layer contains more than 1 wt% of at least one selected from a group consisting of Cr, B, P, Ti and alloy thereof, more than 50 wt% of at least one selected from a group consisting of Ni, Cu and alloy thereof, or a combination thereof.

14. The composite conditioner according to claim 1, wherein the polishing units can be disc-shaped, radial or polygonal.

15. The composite conditioner according to claim 14, wherein the diameter of the disc-shaped polishing units is in the range of 5 to 30 mm.

16. The composite conditioner according to claim 1, wherein the base plate is disc-shaped and its diameter is in the range of 80 to 120 mm.

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17. The composite conditioner according to claim 1, wherein the diameter of the polishing tips is in the range of 100 to 500 μm .

18. The composite conditioner according to claim 1, wherein the material of the adhesive layer of which thickness is adjustable is an organic adhesive.

19. The composite conditioner according to claim 1, wherein the polishing tips can be patterned and arranged on the unit substrate, or the polishing tips form a plurality of clusters, and the clusters are patterned and arranged on the unit substrate, and each cluster is composed of two to six polishing tips.

20. The composite conditioner according to claim 1, wherein the space between the polishing units is not less than 0.1 mm.

21. The composite conditioner according to claim 20, wherein the space is greater than 0.5 mm.

22. The composite conditioner according to claim 1, wherein the thickness of the adhesive layer on the bottom surface of the polishing units is in the range of below 0.6 mm.

23. The composite conditioner according to claim 22, wherein the top surface of the polishing units is over 1 mm higher than the surface of the adhesive layer of which thickness is adjustable.

24. A method for manufacturing a composite conditioner, comprising the following steps:

arranging a second mold on a first mold, wherein the second mold has a plurality of orifices;

arranging a polishing unit in each orifice of the second mold, wherein each polishing unit comprises a bonding layer and a plurality of polishing tips that are bonded by the bonding layer;

forming an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate; and

removing the first mold and the second mold to form a composite conditioner,

wherein a height difference between the first and second highest tips, between the first

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and tenth highest tips, and between the first and 100th highest tips among the polishing tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm ; and

wherein prior to arranging the second mold on the first mold, the following steps are further comprised: forming a temporary adhesive layer on the surface of the first mold, and arranging the second mold on the surface of the temporary adhesive layer, so that the temporary adhesive layer is sandwiched between the second mold and the first mold.

25. The method for manufacturing a composite conditioner according to claim 24, wherein after removing the second mold, the following steps are further comprised: removing the temporary adhesive layer.

26. The method for manufacturing a composite conditioner according to claim 24, wherein one side of the polishing units has the polishing tips, and the adhesive layer of which thickness is adjustable is arranged on the opposite side of the side.

27. The method for manufacturing a composite conditioner according to claim 26, wherein the polishing units arranged in the orifices are in contact with the first mold by means of the polishing tips.

28. The method for manufacturing a composite conditioner according to claim 27, wherein after removing the second mold and the first mold, the following steps are further comprised: forming a mold sealing layer to secure the polishing units.

29. The method for manufacturing a composite conditioner according to claim 24, wherein the orifices of the second mold are arranged on the outer ring of the second mold.

30. The method for manufacturing a composite conditioner according to claim 29, wherein the orifices of the second mold are 12 orifices formed with the outer ring of the second mold.

31. A chemical-mechanical planarization (CMP) process, comprising the following steps:

providing a polishing pad;

placing a wafer on the surface of the polishing pad and polishing the wafer and the polishing pad with each other; and

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using a conditioner arranged on the surface of the polishing pad to remove debris after polishing of the wafer, wherein the conditioner is the composite conditioner as in claim 1.

32. The CMP process according to claim 31, applicable to the production of logic devices, dynamic random access memories (DRAMs), caches (flash memories) or hard drives.

33. The CMP process according to claim 31, wherein the diameter of the wafer is 200 mm, 300 mm or 450 mm.

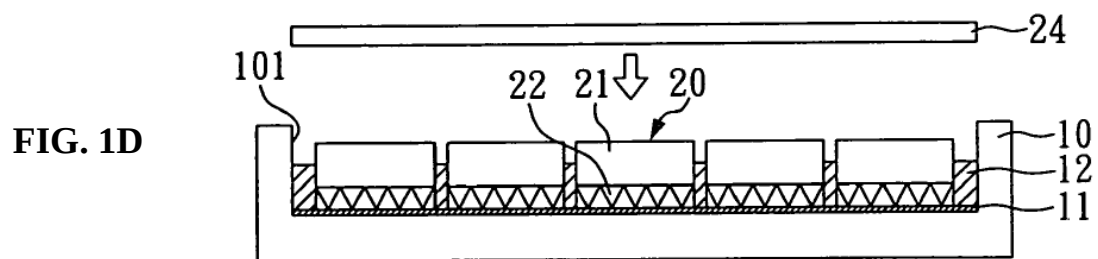
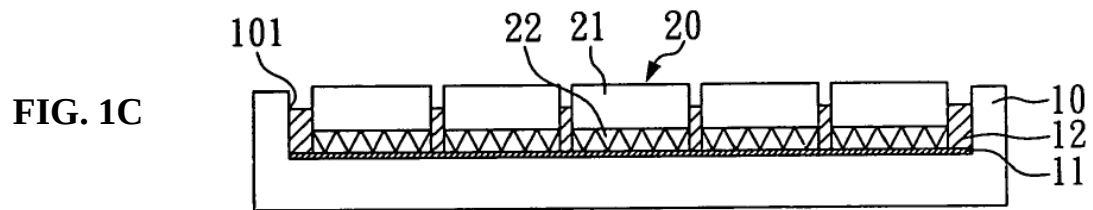
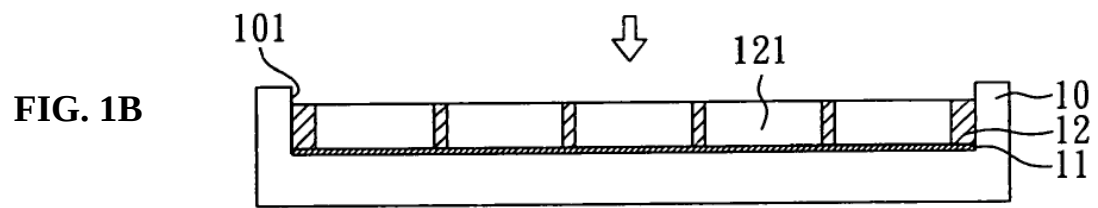
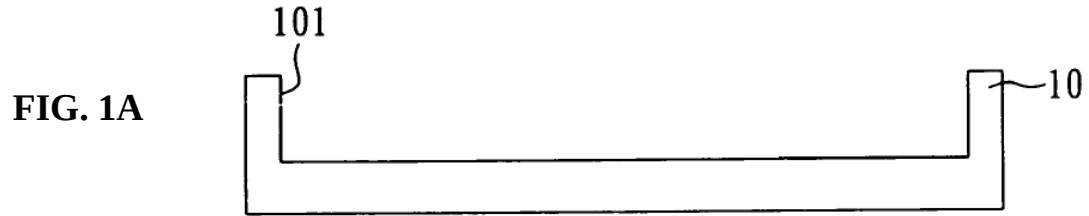
34. The CMP process according to claim 31, wherein the line width of ICs on the surface of the wafer is smaller than or equal to 45 nm.

35. The CMP process according to claim 34, wherein the line width of ICs on the surface of the wafer is smaller than or equal to 28 nm.

36. The CMP process according to claim 35, wherein the line width of ICs on the surface of the wafer is smaller than or equal to 22 nm.

VIII. Drawings (See next page):

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FIG. 1E

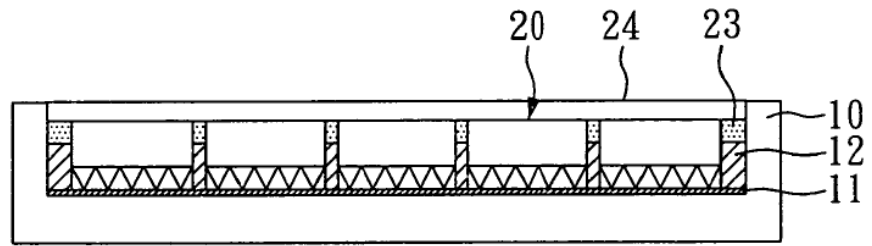


FIG. 1F

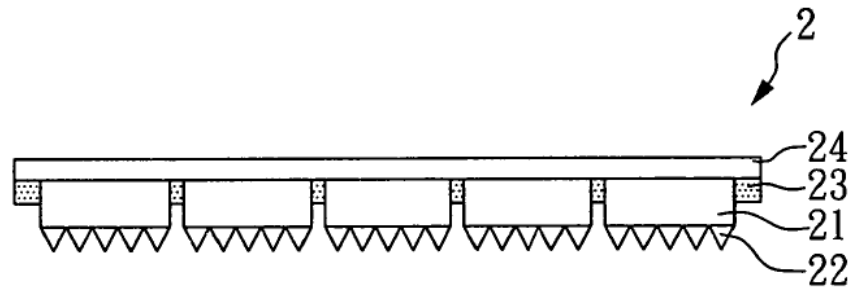
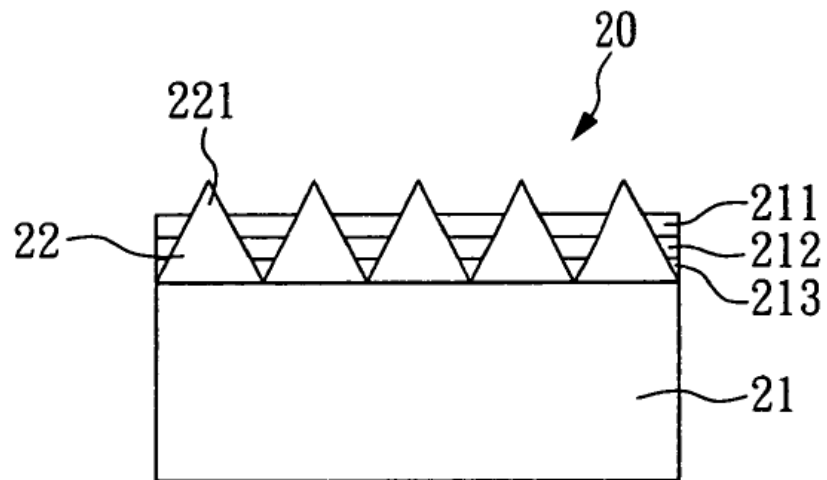


FIG. 1G



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FIG. 2A

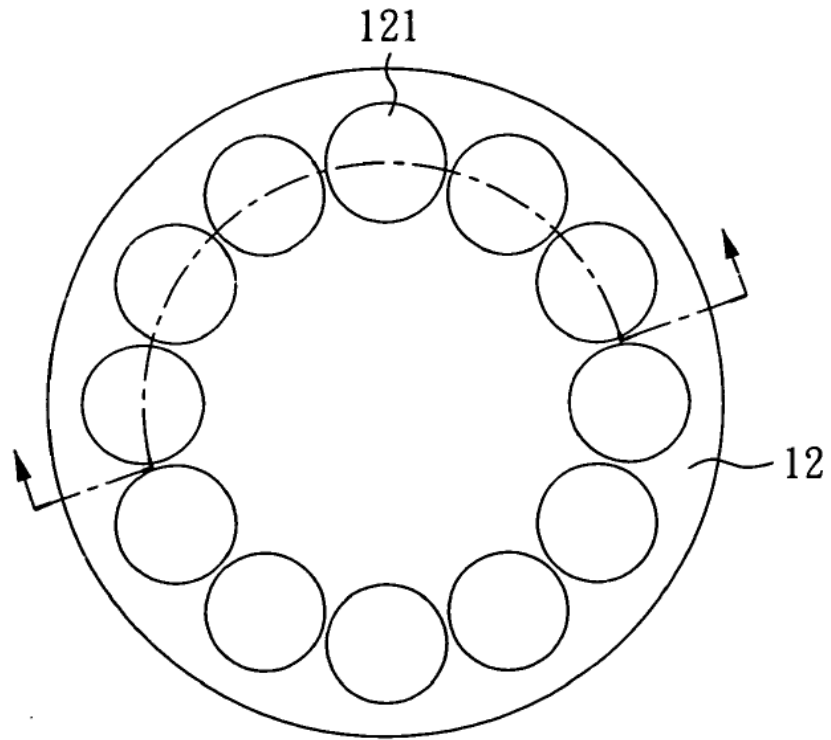


FIG. 2B

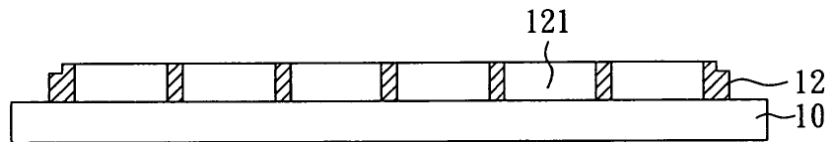


FIG. 2C

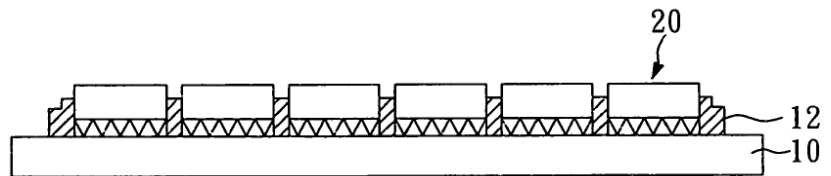
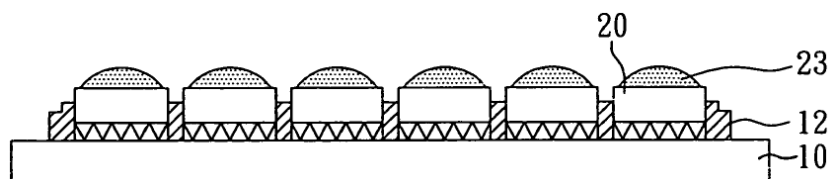
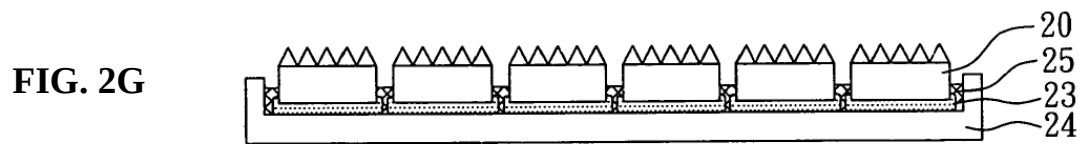
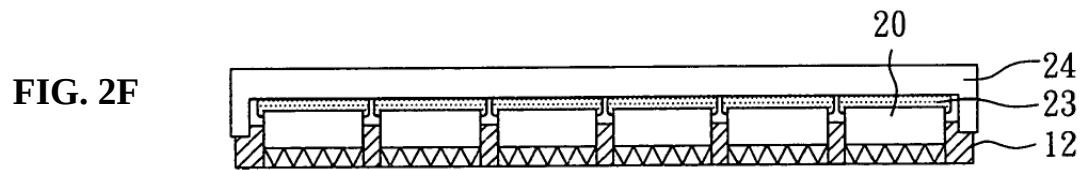
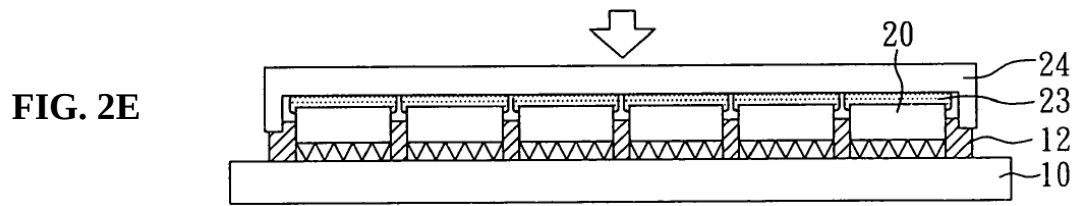


FIG. 2D



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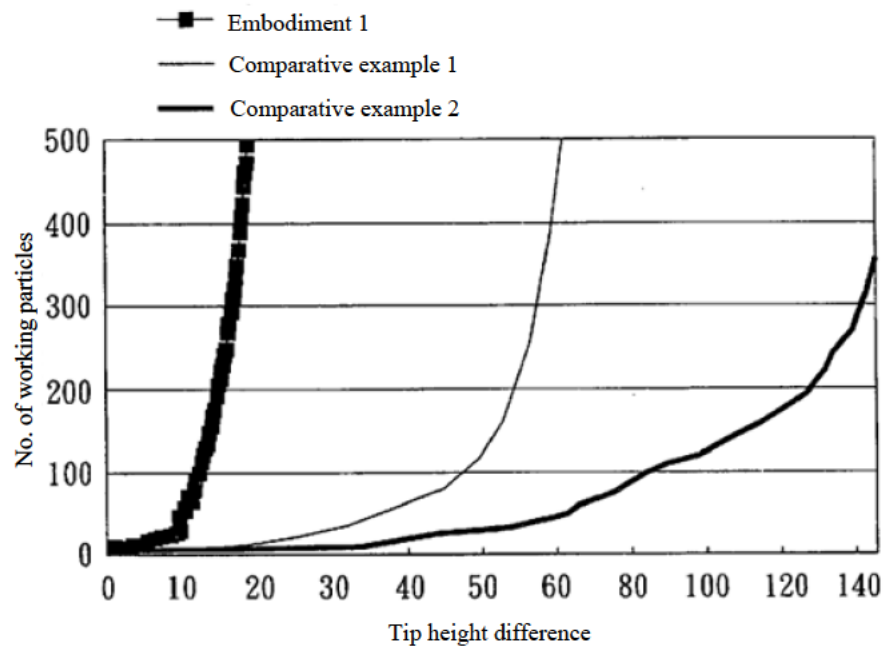


FIG. 3

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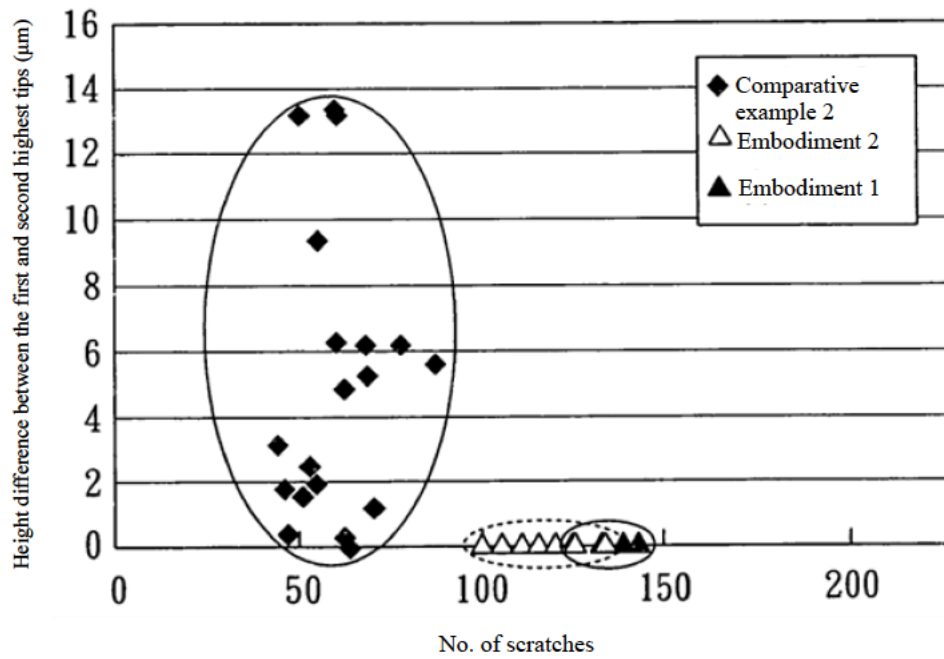


FIG. 4

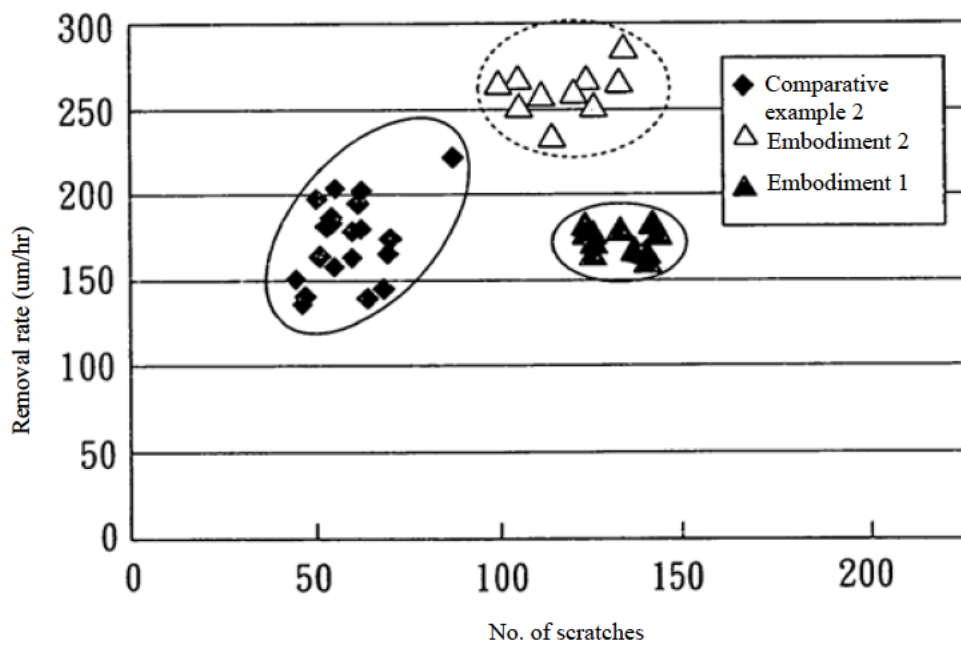


FIG. 5

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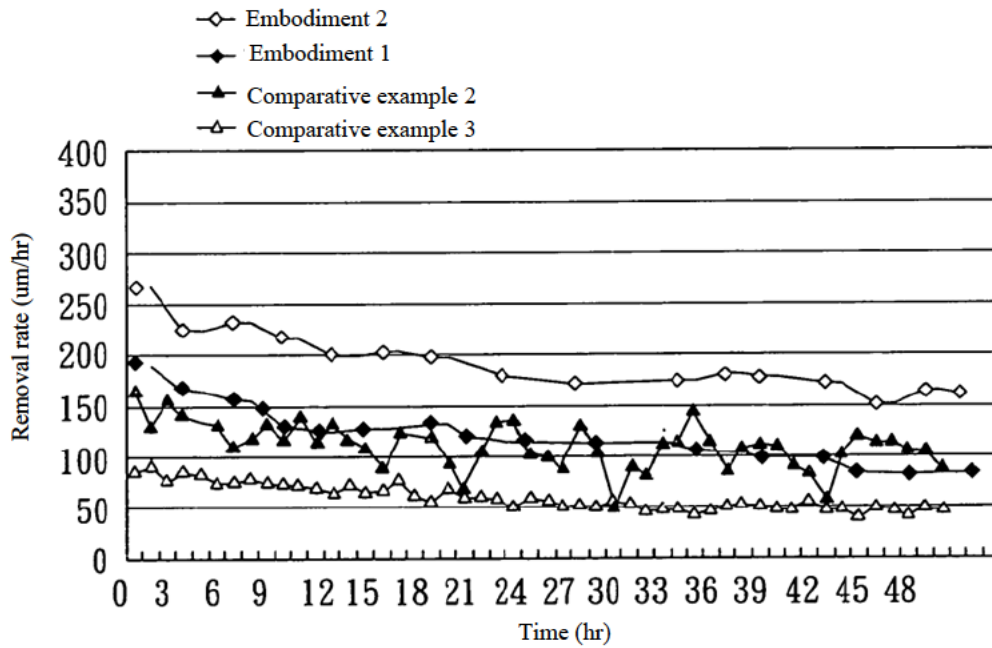


FIG. 6

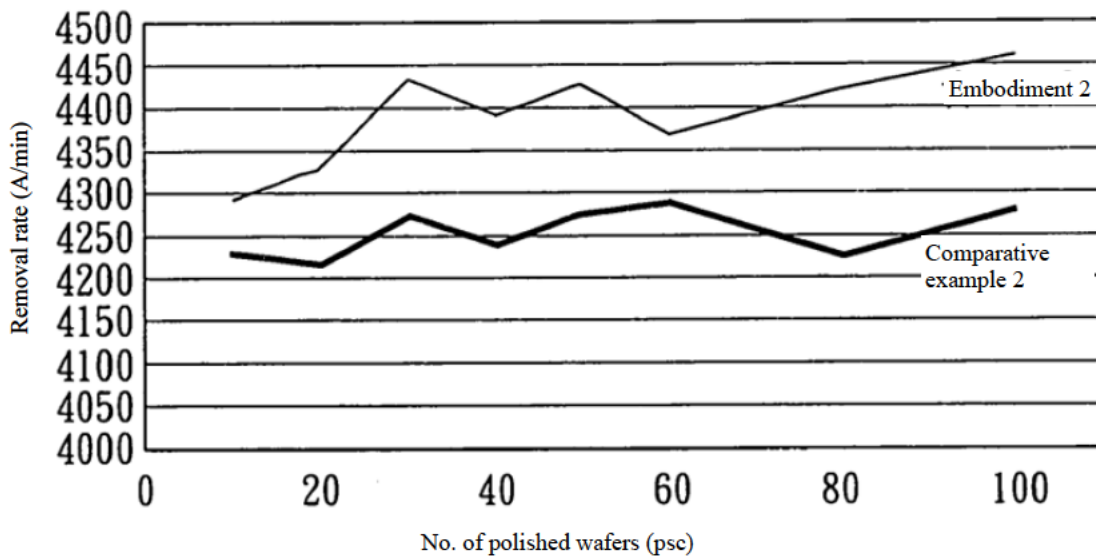


FIG. 7

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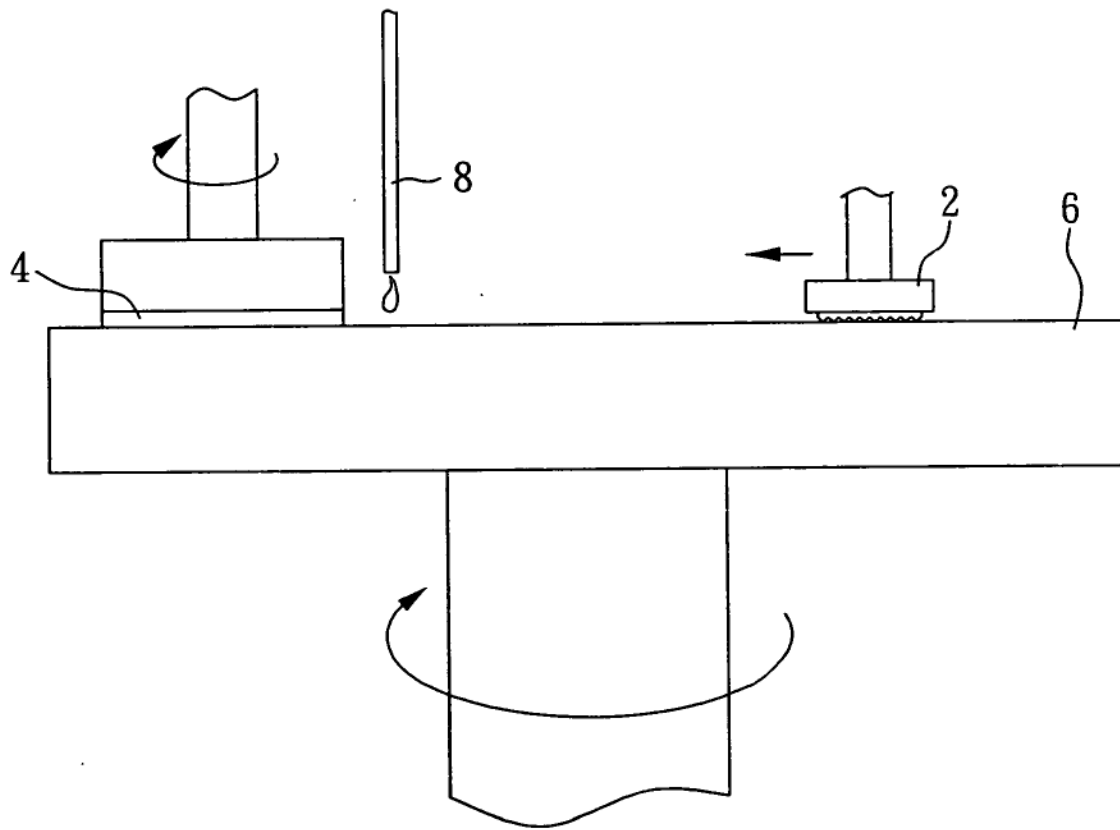


FIG. 8

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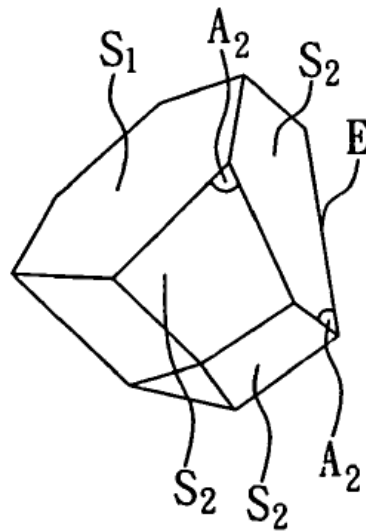
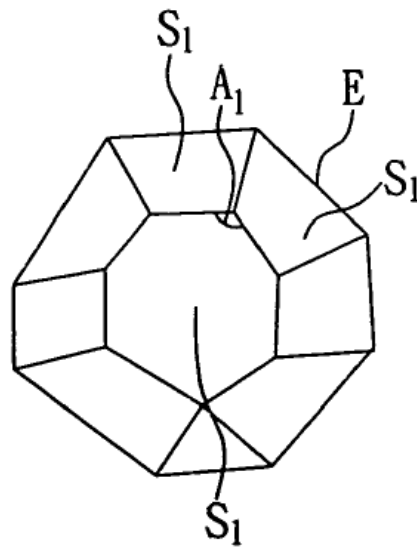


FIG. 9

EXHIBIT 7

Comparison between TW Patent I537097 (Application No. 101112625) and U.S. Patent No. 9,724,802

(New subject matter added to the '802 Patent is shown in blue)

I537097



(19) **Taiwan Intellectual Property Office**

(12) **Invention Specification Publication**

(11) **Certificate No.: TW I537097 B**

(45) **Issue Date: June 11, 2016**

(21) ~~Application Number: 101112625~~

(22) ~~Application Date: April 10, 2012~~

(51) ~~Int. Cl.: B24B 37/04 (2012. 01) H01L 21/304 (2006. 01)~~

~~H01L 21/306 (2006. 01)~~

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(72) ~~Inventor: SUNG, CHIEN MIN (TW); YEH, WEN TING (TW)~~

(74) ~~Agent: HUANG, CHIH YANG~~

(56) ~~References:~~

~~TW 562719 TW I228066~~

~~TW M406490 TW 201038362A~~

~~TW 201141663A TW 201143979A~~

~~KR 10-2010-0110989A~~

~~Examiner: TSAI, FENG CHIN~~

~~Claims: 36 Drawings: 9 37 pages in total~~

(54) Title of Invention

~~COMPOSITE CONDITIONER AND METHOD FOR MANUFACTURING THE SAME AND CMP APPLICATION THEREOF~~

(57) Abstract

~~A composite conditioner includes: a base plate; a plurality of polishing units placed on the base plate and each polishing unit including a bonding layer and a plurality of polishing tips that are bonded in plane by the bonding layer; and an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips based on a predetermined plane is respectively less than 10 μ m, 20 μ m, and 40 μ m, and the protrusion~~

Comparison between TW Patent I537097 (Application No. 101112625) and U.S. Patent No. 9,724,802

(New subject matter added to the '802 Patent is shown in blue)

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height of the first highest tip above the bonding layer is greater than 50 μm . The present invention also relates to a method for manufacturing the conditioner and application thereof.

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Designated representative image:

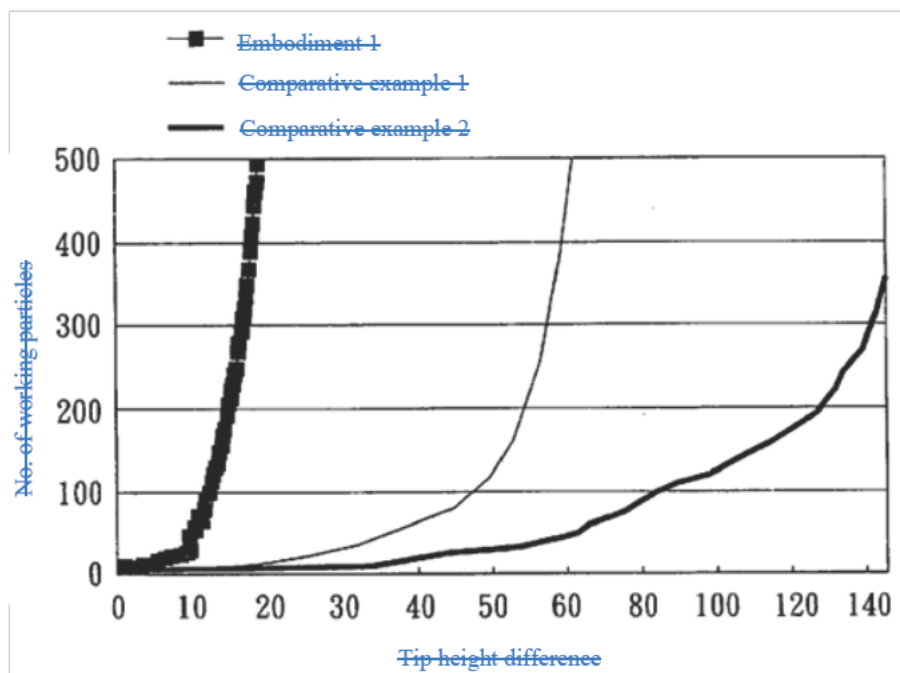


FIG. 3

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Publication

Invention Patent Specification

(Please do not change the format and order of this specification arbitrarily, ※ Please do not fill in the marked part)

※ ~~Application Number: 101112625~~

※ ~~Application Date: April 10, 2015~~ ※ ~~IPC: B24B 37/04 (2006. 01)~~

~~H01L 21/304 (2006. 01)~~

~~H01L 21/306 (2006. 01)~~

I. Title of the Invention: (Chinese/English)

組合式修整器及其製法與化學機械平坦化應用

~~COMPOSITE CONDITIONER AND METHOD FOR MANUFACTURING THE SAME
AND CMP APPLICATION THEREOF~~

II. Abstract of the Invention in Chinese:

~~本發明係有關於一種組合式修整器，包括：一底部基板；複數個研磨單元，係設置於該底部基板之表面，每一研磨單元包括複數個研磨尖點，以及一固定該些研磨尖點之結合劑層；以及一厚度可調節之黏著劑層，係固定該些研磨單元於該底部基板之表面，其中，該些研磨尖點中突出一預定平面之第一高點與第二高點之高度差小於10微米，第一高點與第十高點之高度差小於20微米，第一高點與第一百高點之高度差小於40微米，且該第一高點突出該結合劑層之高度大於50微米。本發明亦關於該組合式修整器之製造方法與應用。~~

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III. ~~Abstract of the Invention in English:~~

~~A composite conditioner includes: a base plate; a plurality of polishing units placed on the base plate and each polishing unit including a bonding layer and a plurality of polishing tips that are bonded in plane by the bonding layer; and an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm . The present invention also relates to a method for manufacturing the conditioner and application thereof.~~

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~~IV. Designated Representative Image:~~

~~(I) Designated representative image of the present application: FIG. (3).~~

~~(II) Description of reference signs of components in the representative image:~~

~~No~~

~~V. If there are chemical formulae in the present application, please reveal the chemical formula that best shows the characteristics of the invention:~~

~~「No」~~

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~~VI. Invention Specification:~~

~~{TECHNICAL FIELD}~~

~~The present invention relates to a composite conditioner, a method for manufacturing the same and a chemical mechanical planarization (CMP) process using the same, particularly to a composite conditioner suitable for planarization of semiconductor wafer surface, a method for manufacturing the same and a chemical mechanical planarization (CMP) process using the same.~~

~~{PRIOR ART}~~

~~The oxide film dielectric layers of the copper circuits or interlayer tungsten circuits, even insulation circuits on the silicon wafer surface all must be surface flattened through a planarization process to facilitate subsequent process steps. At present, in the process of manufacturing Interconnected Circuits (ICs) on semiconductor wafers, the most eye-catching planarization technology is chemical mechanical planarization (CMP), in which the wafer is pressed on a rotating polishing pad to polish and flatten its surface.~~

~~In the CMP process, slurry is stably and evenly delivered between the wafer and the polishing pad, so that the surface of the polishing pad is impregnated with the slurry. The slurry contains chemical agents (such as acid and oxidizer) to erode the thin film on the wafer surface, and the slurry also contains countless nano-ceramic (such as SiO_2 , Al_2O_3 and CeO_2) abrasive particles, which can cut into and scrape away micro films and at the same time, perform chemical etching and mechanical grinding to remove the protruding deposited layer on the chip, thereby polishing the surface of the wafer and achieving the purpose of planarization.~~

~~Conditioner is a necessary consumable for CMP, and its function is to condition the polishing pad. The so-called conditioning includes shaving the surface of the polishing pad and removing the waste accumulated on the surface of the polishing pad, thereby maintaining the surface roughness of the polishing pad. Further, the conditioner can also generate a small quantity of bumps and depressions on the surface, which are the height differences of so-called asperities, so that the contacted and pressed area of the polishing pad can be reduced significantly. The smaller the contact area is, the greater the contact~~

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~~pressure will be so that the slurry at the contact points can squeeze the protruding parts of the wafer, and the chemical agent (such as H_2O_2) in the slurry will be oxidized to soften or corrode the wafer.~~

~~However, the waste generated in the CMP process, including abrasive dust of wafers, such as copper wires, tungsten pore fillings, oxide films, slurry, abrasive particles, and polishing pad debris, will typically be accumulated on the surface of the polishing pad and squeezed into a glaze. Once the glaze is formed, the polishing pad will become slippery and can hardly maintain a polishing force. Therefore, it is often necessary to use a conditioner to polish each wafer to achieve the polishing efficiency (e.g., polishing speed) and flatness (e.g., the thickness distribution of the wafer coating) of the process, thereby stabilizing the quality of the wafers.~~

~~However, the prior art diamond conditioner typically secures diamond particles on the surface of a metal tray with a bonding agent. Although it is suitable for conditioning the polishing pad, for more precise CMP processes, such as CMP processes with a line width of less than 45 nm, it is more liable to scratches, local dishing, erosion and thickness non-uniformity of the wafers due to rough asperities of the polishing pad. The requirements for line width of IC are declining, while the demand for wafer surface flatness rises, and the requirements for the conditioner increase, too, making the prior art diamond conditioner unable to meet the advanced requirements for the CMP processes of below 45 nm.~~

~~For this purpose, the prior patent publication TW 201038362 A1 and TW 201100198 disclose a composite conditioner and manufacturing method thereof respectively, wherein the sharp angles of the polishing tips of polishing units in various sizes, shapes and materials cut into a polishing pad, then pressure is applied to the other side of the polishing units and resin is filled to secure the polishing units so that the height difference between polishing tip apexes of the polishing units is within 20 μm .~~

~~However, the polishing tips used in the foregoing patent application need to use diamond abrasive particles with high shape regularity, and the crystal surface coverage rate of such crystal form is very high (for example, more than 50% of the surface is crystal growth surface). Otherwise, when sharp diamonds with a low crystal surface coverage rate are used, an excessive height difference will be caused. Further, the diamond that cuts into the polishing pad the deepest, the so called "killer diamond", has no standard for the~~

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~~difference in height from the top pads of other diamonds. In order to meet the process requirements of a smaller line width, it is necessary to continuously improve the conditioner so that when sharper polishing tips are used, the flatness of the sharp angle heights (e.g., the height difference of the sharp angles of the polishing tips) can still be maintained, and the conditioner can form finer and more uniform scores on the polishing pad, and at the same time raises the removal rate of the polishing pad. Only in this way, can the glaze be effectively removed, the asperities on the polishing pad be restored and the coating on the wafer be polished quickly.~~

~~[SUMMARY OF THE INVENTION]~~

~~A main object of the present invention is to provide a composite conditioner, wherein sharp polishing tips are used, and can still maintain tip height distribution and avoid existence of “killer diamonds”, thereby raising the ratio of polishing tips that work effectively on the polishing units, and increasing the wafer removal rate and conditioner service life.~~

~~To achieve the foregoing object, one example of the present invention provides a composite conditioner, comprising: a base plate; a plurality of polishing units placed on the base plate and each polishing unit including a bonding layer and a plurality of polishing tips that are bonded by the bonding layer (which can be made of metal, ceramics or resin); and an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm .~~

~~As CMP is plane polishing, the contact distribution between the highest tips of the wafer and the highest tips of the polishing pad determines the quality (e.g., yield) and efficiency (e.g., capacity) of CMP. If the highest tips of the asperities of the polishing pad are not uniformly distributed, the removal rate of different parts of the wafer will be different, and the surface of the wafer will not be flat. What is more, the polishing may be excessive at some locations, causing dishing in the same layer or erosion in multiple layers; or, polishing is inadequate at some locations, causing residue. If the wafer thickness is not~~

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~~uniform after polishing (Within Wafer Non Uniformity or WIWUU), the CMP effect will be unobvious. For this reason, the present invention modified the conditioner based on the data of many tests and experiments, particularly adjusted the heights of working polishing tips through an adhesive layer of which thickness is adjustable to compensate the difference in thickness of the polishing units, thereby achieving the foregoing height distribution of the highest tips, avoiding generation of killer diamonds and raising the ratio of effectively working polishing tips on the polishing units.~~

~~In the foregoing composite conditioner of the present invention, the material of the adhesive layer of which thickness is adjustable can be an organic adhesive. Each polishing unit may further comprise a unit substrate, and the bonding layer is arranged between the surface of the unit substrate and the polishing tips, and for example can be a solder layer, an electroplated layer, a sintered layer, or a resin layer. The foregoing polishing tips refer to terminal points that can achieve a polishing effect on abrasive particles contained in a plurality of polishing units, and are exposed to the bonding layer, in other words, the heights of polishing tips refer to the protrusion heights of the polishing tips above the bonding layer.~~

~~The heights of the polishing tips can be measured with an optical detection system, such as a surface detector produced by German FRT (Fries Research & Technology GmbH), which measures the heights of all polishing tips of the conditioner (more than 10,000 for example), i.e., the protrusion heights of the polishing tips above the bonding layer. Then from the obtained height data, the least square method is used to calculate an assumed plane constituted by sharp angles of the polishing tips. This assumed plane is the foregoing predetermined plane. The first highest tip refers to the height of the one of the polishing tips that protrudes the most from the predetermined plane, the second highest tip refers to the height of the one of the polishing tips that protrudes the second most from the predetermined plane, and the same goes for other highest tips.~~

~~The polishing positions of the wafer mostly depend on the distribution of the apexes of the polishing pad, which is determined by the heights of the polishing tips of the conditioner. The conditioner can be disc shaped (applicable to Applied Materials machine for example) or ring shaped (applicable to Ebara machine for example). The diameter of the disc is generally about 100 mm, while the ring can be as large as 250 mm or more. Typically, tens of thousands of polishing tips (e.g., diamond particles) are distributed on the conditioner, polishing tips of 80/90 mesh, 100/120 mesh, or 120/140 mesh for example, but~~

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~~the difference in average size even under the same mesh may still be greater than 30%. Further, the size of the same polishing tip varies remarkably in different directions. For example, the distance between tips will be up to 30% larger than that between planes, and if the shape of the polishing tips is irregular, the difference will be even larger.~~

~~Therefore, the present invention adjusts the used abrasive particles so that the height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips is less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm to ensure the conditioner has numerous working tips, thereby achieving an effect of rapid and uniform removal of the thin film on the IC wafer surface. Further, it should be noted that the first highest tip and the second highest tip can be scattered in different polishing units or in the same polishing unit, so are other highest tips; in other words, the distribution of the highest tips is not concentrated in a single polishing unit.~~

~~In the foregoing composite conditioner of the present invention, the material of the polishing tips can be man-made or natural diamond, polycrystalline diamond (PCD), cubic boron nitride (CBN), polycrystalline cubic boron nitride (PCBN) or a combination thereof, and the particle size of the polishing tips can be in the range of 100 to 500 μm . The foregoing diamond can be chemically deposited diamond, polycrystalline diamond, or a combination thereof. Further, there is no special limitation to the material of the base plate. For example, it can be pure resin, metal, alloy, plastics, rubber, ceramics, glass or a combination thereof (e.g., a mixture of resin and metal).~~

~~Further, because the diamond is typically converted from graphite under the catalysis of iron-nickel alloy at a high pressure (e.g., 5GPa), it contains molten iron-nickel inclusion. The alloy catalyzes the diamond back into graphite or carbon at high temperature, during which the volume will increase substantially to burst the diamond. If the diamonds are secured on a diamond disc by brazing, many diamonds will burst due to the high process temperature, the diamond tips that cut deep into the polishing pad in the CMP process may be disintegrated along the microcrack surface, and the diamond debris may scratch expensive wafers. In view of this, diamonds containing much inclusion are often separated by magnetic separator. Even so, more or less residual iron-nickel alloy is still contained in the diamonds. If there are undetectable cracks inside the diamonds, the diamonds may be~~

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~~broken and disintegrated with debris in the CMP process, causing scratches of the wafer. In view of this, high temperature brazing should choose a solder with a lower melting point.~~

~~In the present invention, when a solder is used as the material of the bonding layer, the solder layer may contain more than 1wt% of at least one selected from a group consisting of Cr, B, P, Ti and alloy thereof, more than 50wt% of at least one selected from a group consisting of Ni, Cu and alloy thereof, or a combination thereof, wherein materials such as Cr, B, P and Ti are used to activate the solder layer. Specifically, the solder is typically Ni-Cr-B, Ni-Cr-P, or Cu-Sn-Ti alloy, with a melting point (Solidus) of 800°C to 1,000°C.~~

~~Further, each polishing unit optionally further comprises: a metal covering layer, which covers the surface of the bonding layer and of which material is at least one selected from a group consisting of Ni, Cr, Pd, Co, Pt, Au, Ti, Cu, W and alloy thereof, so that the polishing tips are more stably attached to the unit substrate of the polishing unit. Further, each polishing unit optionally further comprises: a protective layer, which is a thin layer inert material and covers the surface of the metal covering layer, and of which material may be a metal material such as Pd or Pt, or a nonmetal material such as a ceramic film (e.g., silicon carbide, silicon nitride, aluminum nitride, aluminum oxide and zirconia), diamond-like carbon (DLC) film, organic film (e.g., Teflon) or a combination thereof, to avoid the erosion of the solder by the polishing slurry (e.g., pH=3 tungsten process slurry).~~

~~Generally speaking, the height of the apex of the diamond determines the strength of pressing into the polishing pad, but its sharpness affects the cutting depth. Typically, the sharper the diamond is, the smaller the elastic and plastic deformation of the polishing pad will be, and the greater the depth of shaving will be. Because the diamond abrasive particles formed on the surface of the conditioner have different shapes and various directions, generally only the highest hundreds of them can come into contact with the polishing pad. If the shape of the diamond is regular and symmetric, it will be at an obtuse angle and will not cut into the polishing pad easily, but will push the surface of the polishing pad, forming bulging plastic deformation on both sides; on the contrary, if the diamond has a broken surface, e.g., an irregular shape, it may cut into the polishing pad, shave the surface of the polishing pad, and meanwhile remove waste.~~

~~Therefore, in the foregoing composite conditioner of the present invention, of the 100 highest polishing tips, more than 50% have a crystal surface coverage rate of less than 80%;~~

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~~preferably a crystal surface coverage rate of less than 50%. When the crystal surface coverage rate of the polishing tips is lower, it means that the polishing tips have more broken surfaces (i.e., sharp surfaces), and it also means that the polishing tips on the working surface of the polishing units contain sharp angles and ridges, a majority of the ridges have an included angle of less than 45 degrees (i.e., the angle between the two crystal surfaces that constitute a ridge), or a majority of the sharp angles are in a state of less than 90 degrees, so the removal rate is high to the polishing pad. Refer to FIG. 9, which is a schematic view of an abrasive particle, where A, E, and S represent a sharp angle, a ridge and a surface respectively, S_1 is a crystal surface, A_1 is an included angle between crystal surfaces, S_2 is a broken surface, and A_2 is an included angle formed by at least one broken surface. It can be seen that A_1 and A_2 are two different sharp angles. The angle of A_1 is greater than 90 degrees (i.e., an obtuse angle), and the angle of A_2 is less than 90 degrees (i.e., an acute angle), which means that when A_2 is used as a polishing tip, its removal efficiency will be greater than that of A_1 .~~

~~The polishing tips can be patterned and arranged on the unit substrate, or the polishing tips form a plurality of clusters, and the clusters are patterned and arranged on the unit substrate. For example, each cluster is composed of two to six polishing tips.~~

~~Further, the polishing units can be arranged in a single circle, double circles, multiple circles, a radial shape or a spiral shape on the base plate, and can be disc shaped, blade-shaped or polygonal. If the polishing units are disc shaped, their diameter is in the range of 5 to 30 mm, preferably not more than 20 mm. The base plate can also be disc shaped and its diameter is in the range of 80 to 120 mm, and alternatively, the polishing units can be fixed on a ring shaped substrate of 250 to 270 mm. Further, if the disc shaped polishing units are located inside, they are often blocked by the external polishing units during conditioning of the polishing pad, making it difficult to play an effect. Therefore, preferably, the polishing units can be arranged on the outer periphery of the surface of the disc shaped base plate to produce a cliff effect of periphery conditioning in the CMP process, which will increase the number of working particles and is suitable for the CMP process to be applied to an 18 inch wafer or 22 nanometer process.~~

~~In the foregoing composite conditioner of the present invention, the space between the polishing units is not less than 0.1 mm, preferably greater than 0.5 mm, so as to ensure that the slurry can smoothly enter and exit the gaps between the polishing units in the CMP~~

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~~process and will not remain in them, causing defects, such as scratches on the chip. Further, the thickness of the adhesive layer on the bottom surface of the polishing units is in the range of below 0.6 mm, so that the polishing tips of each polishing unit can be fully adjusted to the same plane to effectively increase the number of working diamond particles.~~

~~It is known that due to the large difference in tip height, the number of tips used by a conventional conditioner (and the number of tips cutting into the polishing pad) accounts for less than 1% of the total number of tips, and the diamond coverage area of the conventional conditioner exceeds 40% of the total; on the contrary, in the foregoing composite conditioner of the present invention, the polishing tips used to condition a polishing pad can account for above 1% of all polishing tips; further, the area of the base plate covered by the polishing units can account for less than 40% of the total area of the surface of the base plate, so that the best removal rate can be achieved while reducing costs.~~

~~Another object of the present invention is to provide a method for manufacturing a composite conditioner, wherein polishing units with sharp polishing tips are used, a couple of the highest tips of each polishing unit are used as a plane reference by the inversion method, and the thickness of the adhesive material under each polishing unit is adjusted before fixation onto the substrate, so that a couple of the highest tips on the polishing unit will not protrude very much and form destructive “killer diamonds”. The use of a co-plane forces the highest tips of each polishing unit to reach a common height and can also increase the ratio of polishing tips that work effectively, thereby increasing the removal efficiency and service life of the conditioner.~~

~~In order to achieve the foregoing object, another example of the present invention provides a method for manufacturing a composite conditioner, comprising the following steps: arranging a second mold on a first mold, wherein the second mold has a plurality of orifices; arranging a polishing unit in each orifice of the second mold, wherein each polishing unit comprises a bonding layer and a plurality of polishing tips that are bonded by the bonding layer; forming an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate; and removing the first mold and the second mold to form a composite conditioner, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40~~

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~~μm, and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm.~~

~~A general diamond conditioner is manufactured by the additive method, that is, the diamond abrasive particles are arranged flatwise (e.g., matrix distribution) on a flat substrate (e.g., stainless steel 316). According to the prior art, the height difference of diamond apexes on a single conditioner surface is typically more than 50 μm and the diamond abrasive particles can be secured by electroplating (EDD) and nickel, or by brazing (BDD) to retain them by solidifying molten alloy. The diamond plane of the former is typically upward, while the tips or ridges of the latter are often more prominent, and the diamonds with the plane facing upwards cannot cut into the polishing pad easily, and the diamonds with tips or ridges can shave the polishing pad more easily. In comparison, the present invention first uses the brazing method to form polishing units, and then uses an organic elastic material to bond and compensate a plurality of polishing units to arrange the polishing units on a base plate, so in addition to the advantages of the brazing method, it can also avoid its shortcomings, and make the formed conditioner have the highest tips of the same height. Therefore, when the diamond conditioner is conditioning the polishing pad, the protruding diamond apexes can contact and cut into the polishing pad, but there will be no overly protruding polishing tips, so no polishing tips will cut into the polishing pad too deep, resulting in excessive height difference between asperities, thereby avoiding asperities “as if big frogs in a small pond” being smeared with too much slurry, which causes the nano abrasive particles in the slurry to excessively cut into the surface of the wafer, resulting in excessive polishing, and even scratching of the wafer.~~

~~In the method for manufacturing the foregoing composite conditioner of the present invention, the adhesive layer of which thickness is adjustable can be formed after the highest tips of the polishing units are leveled with another flat plate, or after forming the adhesive layer with adjustable thickness, or before the adhesive layer of which thickness is adjustable is cured, the base plate is used to level the highest tips of the polishing units.~~

~~The adhesive layer of which thickness is adjustable can be composed of an organic adhesive, for example, a plastic material, a rubber material, a hot melt adhesive or a combination thereof; further, the orifices of the second mold are arranged on the outer ring of the second mold, thereby setting the positions of the polishing units on the outer ring of the base plate. Specifically, the orifices of the second mold are formed with the outer ring~~

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~~of the second mold, for example, 12 orifices. In addition, in the composite conditioner, the polishing units can also be arranged on the inner and outer rings, and generally, the smaller the area of the polishing units is, the larger the number of working particles will be during polishing, but the manufacturing cost will be higher, so making a conditioner with an appropriate number of polishing units can balance effect and cost.~~

~~In the method for manufacturing the foregoing composite conditioner of the present invention, prior to arranging the second mold on the first mold, the following steps are further comprised: forming a temporary adhesive layer on the surface of the first mold, and arranging the second mold on the surface of the temporary adhesive layer, so that the temporary adhesive layer is sandwiched between the second mold and the first mold, and after removing the second mold, the following steps are further comprised: removing the temporary adhesive layer. In a preferred embodiment of the present invention, the temporary adhesive layer is a double-sided adhesive tape.~~

~~In an alternative preferred embodiment of the present invention, one side of the polishing units has the polishing tips, and the adhesive layer of which thickness is adjustable is arranged on the opposite side of the side, and the polishing units arranged in the orifices are in contact with the first mold by means of the polishing tips. Further, after removing the second mold and the first mold, the following steps are further comprised: forming a mold sealing layer to secure the polishing units. It can be seen from the above that by pressing the polishing units on the side with the polishing tips, the polishing units are flatly arranged on the same plane.~~

~~The method for manufacturing the foregoing composite conditioner of the present invention may optionally further comprise the following steps: removing the second mold after removing the first mold. In other words, it means that the conditioner may comprise a second mold.~~

~~A further object of the present invention is to provide a CMP (chemical mechanical Planarization) process, wherein sharp polishing tips are used, and can still maintain the planarity of the working surface, thereby raising the ratio of polishing tips that work efficiently on the polishing units, and increasing the removal rate and service life.~~

~~In order to achieve the foregoing object, a further example of the present invention provides a CMP process, comprising the following steps: providing a polishing pad; placing~~

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~~a wafer on the surface of the polishing pad and polishing the wafer and the polishing pad with each other; and using a conditioner arranged on the surface of the polishing pad to remove debris after polishing of the wafer, wherein the conditioner is the foregoing composite conditioner of the present invention.~~

~~The Moore's law mentions that the number of transistors accommodated on the same chip of a single size will be doubled every eighteen months due to the improvement of the process technology, thereby increasing the speed of operation performed by the chip. Owing to the continuous progress as mentioned in the Moore's Law, the line width and line distance of integrated circuits (ICs) also gradually break through the limit of 32 nanometers. However, it also faces the difficulty for CMP process to overcome the bottleneck, so it is impossible to enter a process of even smaller line width and line distance. On the contrary, as the foregoing CMP process of the present invention uses a modified conditioner, the CMP process of the present invention can use a wafer with a diameter of 200 mm, 300 mm or 450 mm, and the line width of ICs on the surface of the wafer can be smaller than or equal to 45 nm, 28 nm or 22 nm. Therefore, if the technology of the present invention is adopted in the related technologies, for example, the CMP process of the present invention is applied to the production of logic devices, dynamic random access memories (DRAMs), caches (flash memories) or hard drives, it will improve the operation execution speed of the foregoing devices as described in the Moore's Law.~~

~~[DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS]~~

~~Generally speaking, as the diamonds differ in size, shape and direction and the distance of the highest tips is random, the ploughing and shaving forms of the polishing pad are diverse, resulting in uneven heights of the polishing pad after conditioning, which makes it difficult to control the positions of the highest tips in contact with the wafer, and the area and pressure of each contact point, so that the polishing rate and uniformity of the CMP process have extremely high variability. When the wafer changes greatly (such as 8 inches to 12 inches or even 18 inches in the future), the variability of polishing rate and uniformity will be enlarged, reducing the quality and efficiency of the CMP process. More than that, when the wire width becomes narrower (e.g., 45 nm to 32 nm or even 22 nm in the future), the highest tips of the polishing pad are more likely to cause damage. When the circuits~~

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~~become narrower, the dielectric material between them must be more hollow to avoid electric leakage, but the hollow dielectric layer becomes fragile, so the contact pressure of the CMP process needs to be even smaller, but after the contact pressure is adjusted down, it will lead to a reduced polishing speed of the wafer, resulting in poor productivity.~~

~~The current diamond conditioner is typically manufactured by a method of planar addition of diamonds, so it is difficult to control the heights of apexes. Further, under high temperature manufacturing (e.g., brazing), the substrate is distorted and deformed, which makes the heights of the diamond apexes more uneven, and also greatly reduces the number of working particles, to only a few hundred though there are tens of thousands of diamonds on the conditioner.~~

~~Because the diamond conditioner is manufactured by the additive method (pressing and leveling from the top with diamond abrasive particles), it is difficult to control the size, shape and direction of the diamonds and the number, position and cutting depth of the diamonds on the working surface are also elusive, significantly reducing the predictability of the effect of the CMP process. Although the industry continues to strictly control the flatness of the conditioner substrate and the shape of the diamonds, the improvement effect is limited.~~

~~Considering that it is difficult to make the heights of the diamond apexes even, the present invention adopts the method of reverse combination. Diamond polishing units are manufactured at first, and then are placed upside down on a plane so that the polishing tips are flush. Now, an adhesive layer of which thickness is adjustable is placed on the opposite side of the polishing tips, and finally a mold sealing layer (e.g., resin) is injected to secure all the polishing units. Such inverse and flush manufacturing method can avoid "Killer Diamonds" that often exist on the diamond disc i.e., the protruding diamonds like big frogs in a small pond. If the Diamond Killer is too sharp, it can easily cut into the polishing pad deeply and therefore is pulled apart, thereby forming Killer Asperities on the surface of the polishing pad, causing scratches and damage of the wafer.~~

~~Below the implementation manner of the present invention is described by referring to specific embodiments. Those skilled in the art can easily understand other advantages and effects of the present invention from the content disclosed in the Description. Alternatively, the present invention can be implemented or applied through other different specific embodiments, and various modifications and changes can be made to the details of the~~

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~~Description based on different views and application under the precondition of not departing from the spirit of the present invention.~~

~~The figures in the embodiments of the present invention are all simplified schematic views. However, these reference signs only display the components related to the present invention, and the components displayed are not examples of actual implementation. The number, shape and other proportions of the components during actual implementation are a selective design, and the layout type of the components may be more complex.~~

Preparation Example 1

~~FIG. 1A to FIG. 1G are schematic views of a flow for manufacturing a composite conditioner.~~

~~Firstly, as shown in FIG. 1A, a first mold 10 is provided, which has an opening 101. Then, as shown in FIG. 1B, a temporary adhesive layer 11 is formed on the surface of the opening 101 of the first mold 10, and then a second mold 12 is arranged on the surface of the temporary adhesive layer 11, so that the second mold 12 is arranged inside the opening 101 of the first mold 10. Therefore, the temporary adhesive layer 11 is sandwiched between the second mold 12 and the first mold 10, wherein the second mold 12 has a plurality of orifices 121. In this preparation example, the temporary adhesive layer 11 is a double-sided adhesive tape.~~

~~As shown in FIG. 1C and FIG. 1G, a polishing unit 20 is arranged in each orifice 121 of the second mold 12, wherein each polishing unit 20 comprises a plurality of abrasive particles 22 (each abrasive particle 22 has at least one polishing tip 221), a unit substrate 21 and a bonding layer 213 arranged between the surface of the unit substrate 21 and the polishing tips 221. These polishing units 20 are manufactured by a common brazing method, and the manufacturing method is briefly described as follows: spot weld a solder pad (BNi_{12}) on a unit substrate 21 with a diameter of 20 mm and a thickness of 4 mm, and then use a template to arrange approximately 150 μm abrasive particles (e.g., diamond particles) on the solder pad coated with adhesive, and then put it in a vacuum furnace for vacuumizing to a vacuum degree of about 5 to 10 torr, and heat it to maximum temperature of 1,020°C and maintain this temperature for 12 minutes (in this period, the adhesive has been evaporated) to melt the solder of the solder pad into a liquid to weld the diamond particles firmly.~~

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~~As the diamonds are originally located on the fixing solder, when the solder is melted to form a liquid, the carbide elements (e.g., Cr) in the solder will diffuse to the diamond surface. As a result, the solder will sink the diamonds by capillary force, and will also climb up to the diamond surface under the capillary force to form a slope. The diamonds were originally stuck to the surface of the solder pad on a flat surface, but now because the diamonds rotate in the liquid, their sharp angles often face upward.~~

~~Then, as shown in FIG. 1D and FIG. 1E, the polishing units 20 are leveled with a base plate 24, and an adhesive layer 23 of which thickness is adjustable is filled in to secure the polishing units 20. Then, as shown in FIG. 1F, the first mold 10, the temporary adhesive layer 11, and the second mold 12 are removed to form a composite conditioner 2.~~

~~The composite conditioner 2 includes: a base plate 24; a plurality of polishing units 20 placed on the base plate 24 and each polishing unit 20 including a plurality of polishing tips 221; and an adhesive layer 23 of which thickness is adjustable and used to secure the polishing units 20 on the base plate 24, wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips 221 based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer 213 is greater than 50 μm .~~

~~FIG. 1G is an enlarged view of the polishing units of the present invention. Each polishing unit 20 comprises a plurality of abrasive particles 22 (each abrasive particle has at least one polishing tip 221), a unit substrate 21, a bonding layer 213 arranged between the surface of the unit substrate 21 and the polishing tips 221, a metal covering layer 212 covering the surface of the bonding layer 213, and a protective layer 211 covering the surface of the metal covering layer 212.~~

~~The bonding layer 213 can be a solder layer, an electroplated layer, a sintered layer, or a resin layer. If the bonding layer 213 is the solder layer, it contains more than 1 wt% of at least one selected from a group consisting of Cr, B, P, Ti and alloy thereof, more than 50 wt% of at least one selected from a group consisting of Ni, Cu and alloy thereof, or a combination thereof.~~

~~The metal covering layer 212 can be formed by means of electroplating, and its material may be at least one selected from a group consisting of Ni, Cr, Pd, Co, Pt, Au, Ti,~~

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~~Cu, W and alloy thereof; the material of the protective layer 211 can be Pd, Pt, silicon carbide, aluminum nitride, aluminum oxide, zirconia, diamond-like carbon (DLC) or a combination thereof.~~

Preparation Example 2

~~FIG. 2A to FIG. 2G are schematic views of a flow for manufacturing a composite conditioner.~~

~~Firstly, as shown in FIG. 2A, a second mold 12 is provided, which has 12 orifices 121, arranged on the outer ring of the second mold 12. Then, as shown in FIG. 2B, the second mold 12 is arranged on the surface of a first mold 10.~~

~~As shown in FIG. 2C, a polishing unit 20 is arranged in each orifice 121 of the second mold 12, wherein the working surface of the polishing unit 20 (the surface having polishing tips) faces the surface of the first mold 10. In this preparation example, the polishing units 20 are as similarly described in preparation example 1. Then, as shown in FIG. 2D, adhesive is dispensed on a side opposite to the polishing tips of each polishing unit 20 to form an adhesive layer 23 of which thickness is adjustable. Then, as shown in FIG. 2E, a base plate 24 presses flatly on the adhesive layer 23 of which thickness is adjustable, wherein the base plate 24 has a groove, which makes the base plate 24 in a “□” shape, and the groove of the base plate 24 flatly presses the adhesive layer 23 of which thickness is adjustable.~~

~~As shown in FIG. 2F, remove the first mold 10. Then, as shown in FIG. 2G, inverse the structure shown in FIG. 2F, remove the second mold 12 and form a mold sealing layer 25, reinforce the polishing units 20 and secure them to the base plate 24 to form a composite conditioner.~~

~~Although the polishing units manufactured by the brazing method may have killer diamonds, different polishing units with killer diamonds of similar heights can be used in combination with the foregoing method of the present invention to make the polishing tips flush. Therefore, the heights of the killer diamonds are close to the heights of other protruding diamond tips on the polishing units.~~

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Test Example

FIG. 3 is a comparison diagram of tip height difference and the number of working particles among the composite conditioner manufactured in the foregoing preparation example 2 (Embodiment 1, wherein the crystal surface coverage rate of the diamond particles used is approximately 60% to 80%, i.e., PDA 878 manufactured by Element Six), a conditioner manufactured by the prior art ceramic sintering method (comparative example 1) and the conditioner manufactured by the brazing method (comparative example 2). From FIG. 3, it can be known that during polishing, there are 60 to 70 working particles on the conditioner provided in Embodiment 1 of the present invention when the height difference is about 10 μm ; in comparison, comparative example 1 and comparative example 2 require a larger tip height difference in order to provide more working particles, and even on the conditioner provided in comparative example 1, more than 40 μm of height difference of abrasive particles is required to obtain more than 100 working particles. Thus, it can be seen that within the same height difference, the conditioner provided by the present invention actually has a much higher number of working abrasive particles than the prior art conditioners do.

FIG. 4 and FIG. 5 respectively show a comparison diagram of the height difference between the first highest tip and the second highest tip (μm) and number of scratches, and a comparison diagram of number of scratches and removal rate among the composite conditioner manufactured in the foregoing preparation example 2 (Embodiment 1, wherein the crystal surface coverage rate of the diamond particles used is approximately 60% to 80%, i.e., PDA 878 manufactured by Element Six; Embodiment 2, wherein the crystal surface coverage rate of the diamond particles used is approximately 40% to 60%, i.e., PDA 657 manufactured by Element Six) and the conditioner manufactured by the brazing method (comparative example 2).

From FIG. 4, it can be known that for the conditioners provided in Embodiments 1 & 2 of the present invention, when the height difference between the first highest tip and the second highest tip is approximately 0 μm , the number of scratches after polishing is 100 to 150, which means that the conditioners provided in Embodiments 1 & 2 have good quality and the quality is stable during polishing; on the contrary, for the conditioner provided in comparative example 2, the highest tips of abrasive particles are uneven and the number of scratches is only less than 50 to less than 100, which means the conditioner provided in

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comparative example 2 has uneven quality, and the quality is not stable during polishing. In a further aspect, from FIG. 5, it can be known that the conditioners provided in Embodiment 2 of the present invention have a polishing removal rate of approximately 250 to 300 μm per hour, and approximately 100 to 150 scratches, and the conditioners provided in Embodiment 1 of the present invention have a polishing removal rate of approximately 150 to 200 μm per hour, and approximately 125 to 150 scratches, which means the conditioners provided in Embodiments 1 & 2 of the present invention are highly stable and their quality can be easily controlled; on the contrary, the conditioner provided in comparative example 2 has a polishing removal rate of approximately 125 to 225 μm per hour, and approximately 50 to 75 scratches, which means the conditioner provided in comparative example 2 not only has fewer scratches but also has unstable quality.

FIG. 6 shows a comparison diagram of conditioner service time and removal rate among the composite conditioners manufactured in the foregoing preparation example 2 (Embodiment 1 and Embodiment 2), the conditioner manufactured by the prior art brazing method (comparative example 2) and the conditioner manufactured by the prior art electroplating method (comparative example 3). From FIG. 6, it can be known that for the conditioners provided in Embodiments 1 & 2 of the present invention, during polishing, the removal rate decreases slowly with the increase of service time, which means the conditioners provided by the present invention have the fastest conditioning rate and the longest service life due to well controlled flatness; on the contrary, the removal rate of the conditioner provided in comparative example 2 fluctuates and is unstable, thereby causing a problem in quality control, while the removal rate of the conditioner provided in comparative example 3 is poor, and cannot save the time and cost of the polishing process.

FIG. 7 is a comparison diagram of the number of polished wafers and removal rate between the composite conditioner manufactured in the foregoing preparation example 2 (Embodiment 2) and the conditioner manufactured by the brazing method (comparative example 2). From FIG. 7, it can be known that compared with comparative example 2, the conditioner provided in Embodiment 2 of the present invention can be used in the CMP process to polish more wafers.

Application Example

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~~FIG. 8 is a schematic view of CMP (chemical mechanical planarization) process. As shown in FIG. 8, generally a wafer 4 is placed on the surface of the polishing pad 6, and polishing slurry is provided via a pipeline 8 so that the slurry and the polishing pad 6 polish each other. A conditioner 2 is arranged in another blank portion on the surface of the polishing pad 6 to remove debris after polishing of the wafer. Here, the conditioner used can be a conditioner manufactured in the foregoing preparation example of the present invention.~~

~~In summary, the highest polishing apex of the existing whole piece brazed diamond conditioner often protrudes over 20 μm more than the second highest apex, and the protruding range of the top 10 highest abrasive particles is only 50 μm ; on the contrary, when the foregoing method of the present invention is used to manufacture a composite conditioner by the inverse and flush manufacturing method, the difference between the highest polishing apex and the second highest apex can be reduced to below 10 μm , so the proportion of polishing tips that work effectively on the polishing units can be raised and the removal rate and service life can be increased.~~

~~The foregoing embodiments are merely examples for the convenience of description, and the scope of the claimed rights of the present invention should be subject to the scope of claims, rather than be limited to the foregoing embodiments.~~

~~[BRIEF DESCRIPTION OF THE DRAWINGS]~~

~~FIG. 1A to FIG. 1G are schematic views of a flow for manufacturing a composition conditioner in preparation example 1 of the present invention.~~

~~FIG. 2A to FIG. 2G are schematic views of a flow for manufacturing a composition conditioner in preparation example 2 of the present invention.~~

~~FIG. 3 is a comparison diagram of tip height difference and number of working particles between the present invention and a prior art conditioner.~~

~~FIG. 4 is a comparison diagram of the height difference between the first highest tip and the second highest tip (μm) and number of scratches between the present invention and a prior art conditioner.~~

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~~FIG. 5 is a comparison diagram of the number of scratches and removal rate between the present invention and a prior art conditioner.~~

~~FIG. 6 is a comparison diagram of conditioner service time and removal rate between the present invention and a prior art conditioner.~~

~~FIG. 7 is a comparison diagram of the number of polished wafers and removal rate between the present invention and a prior art conditioner.~~

~~FIG. 8 is a schematic view of the CMP process of the present invention.~~

~~FIG. 9 is a schematic view of an abrasive particle.~~

~~[DESCRIPTION OF REFERENCE SIGNS OF MAIN COMPONENTS]~~

~~first mold 10~~	~~base plate 24~~
~~opening 101~~	~~adhesive layer of which thickness is adjustable 23~~
~~temporary adhesive layer 11~~	~~composite conditioner 2~~
~~second mold 12~~	~~metal covering layer 212~~
~~orifice 121~~	~~protective layer 211~~
~~polishing unit 20~~	~~mold sealing layer 25~~
~~polishing tip 221~~	~~wafer 4~~
~~unit substrate 21~~	~~polishing pad 6~~
~~bonding layer 213~~	~~pipeline 8~~

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~~No. 101112625 Amendment Page~~

~~Seal: Amendment Supplement January 7, 2015~~

~~Seal: January 7, 2015 Amendment~~

~~VII. Claims:~~

~~1. A composite conditioner, comprising:~~

~~a base plate;~~

~~a plurality of polishing units, placed on the base plate and each polishing unit including a bonding layer and a plurality of polishing tips that are bonded by the bonding layer; and~~

~~an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate,~~

~~wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm ;~~

~~wherein of the 100 highest polishing tips, more than 50% have a crystal surface coverage rate of less than 80%.~~

~~2. The composite conditioner according to claim 1, wherein the polishing tips used to condition a polishing pad account for above 1% of all polishing tips.~~

~~3. The composite conditioner according to claim 1, wherein the area of the base plate covered by the polishing units accounts for less than 40% of the total area of a surface of the base plate.~~

~~4. The composite conditioner according to claim 1, wherein the polishing units are arranged in a single circle, double circles, multiple circles, a radial shape or a spiral shape on the base plate.~~

~~5. The composite conditioner according to claim 1, wherein during conditioning, at least more than 1,000 polishing tips will contact a polishing pad.~~

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~~6.—The composite conditioner according to claim 1, wherein the material of the polishing tips is diamond, cubic boron nitride (CBN) or a combination thereof.~~

~~7.—The composite conditioner according to claim 6, wherein the diamond is chemically deposited diamond, polycrystalline diamond, or a combination thereof.~~

~~8.—The composite conditioner according to claim 1, wherein of the 100 highest polishing tips, more than 50% have a crystal surface coverage rate of less than 50%.~~

~~9.—The composite conditioner according to claim 1, wherein each polishing unit further comprises a unit substrate, and the bonding layer is arranged between the surface of the unit substrate and the polishing tips.~~

~~10.—The composite conditioner according to claim 1, wherein the bonding layer is a solder layer, an electroplated layer, a sintered layer, or a resin layer.~~

~~11.—The composite conditioner according to claim 10, wherein each polishing unit further comprises a metal covering layer, which covers the surface of the bonding layer and of which material is at least one selected from a group consisting of Ni, Cr, Pd, Co, Pt, Au, Ti, Cu, W and alloy thereof.~~

~~12.—The composite conditioner according to claim 11, wherein each polishing unit further comprises a protective layer, which covers the surface of the metal covering layer, and of which material is Pd, Pt, silicon carbide, aluminum nitride, aluminum oxide, zirconia, diamond like carbon (DLC) or a combination thereof.~~

~~13.—The composite conditioner according to claim 10, wherein the solder layer contains more than 1 wt% of at least one selected from a group consisting of Cr, B, P, Ti and alloy thereof, more than 50 wt% of at least one selected from a group consisting of Ni, Cu and alloy thereof, or a combination thereof.~~

~~14.—The composite conditioner according to claim 1, wherein the polishing units can be disc shaped, radial or polygonal.~~

~~15.—The composite conditioner according to claim 14, wherein the diameter of the disc shaped polishing units is in the range of 5 to 30 mm.~~

~~16.—The composite conditioner according to claim 1, wherein the base plate is disc-shaped and its diameter is in the range of 80 to 120 mm.~~

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~~17.—The composite conditioner according to claim 1, wherein the diameter of the polishing tips is in the range of 100 to 500 μm .~~

~~18.—The composite conditioner according to claim 1, wherein the material of the adhesive layer of which thickness is adjustable is an organic adhesive.~~

~~19.—The composite conditioner according to claim 1, wherein the polishing tips can be patterned and arranged on the unit substrate, or the polishing tips form a plurality of clusters, and the clusters are patterned and arranged on the unit substrate, and each cluster is composed of two to six polishing tips.~~

~~20.—The composite conditioner according to claim 1, wherein the space between the polishing units is not less than 0.1 mm.~~

~~21.—The composite conditioner according to claim 20, wherein the space is greater than 0.5 mm.~~

~~22.—The composite conditioner according to claim 1, wherein the thickness of the adhesive layer on the bottom surface of the polishing units is in the range of below 0.6 mm.~~

~~23.—The composite conditioner according to claim 22, wherein the top surface of the polishing units is over 1 mm higher than the surface of the adhesive layer of which thickness is adjustable.~~

~~24.—A method for manufacturing a composite conditioner, comprising the following steps:~~

~~arranging a second mold on a first mold, wherein the second mold has a plurality of orifices;~~

~~arranging a polishing unit in each orifice of the second mold, wherein each polishing unit comprises a bonding layer and a plurality of polishing tips that are bonded by the bonding layer;~~

~~forming an adhesive layer of which thickness is adjustable and used to secure the polishing units on the base plate; and~~

~~removing the first mold and the second mold to form a composite conditioner;~~

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~~wherein a height difference between the first and second highest tips, between the first and tenth highest tips, and between the first and 100th highest tips among the polishing tips based on a predetermined plane is respectively less than 10 μm , 20 μm , and 40 μm , and the protrusion height of the first highest tip above the bonding layer is greater than 50 μm ; and~~

~~wherein prior to arranging the second mold on the first mold, the following steps are further comprised: forming a temporary adhesive layer on the surface of the first mold, and arranging the second mold on the surface of the temporary adhesive layer, so that the temporary adhesive layer is sandwiched between the second mold and the first mold.~~

~~25.—The method for manufacturing a composite conditioner according to claim 24, wherein after removing the second mold, the following steps are further comprised: removing the temporary adhesive layer.~~

~~26.—The method for manufacturing a composite conditioner according to claim 24, wherein one side of the polishing units has the polishing tips, and the adhesive layer of which thickness is adjustable is arranged on the opposite side of the side.~~

~~27.—The method for manufacturing a composite conditioner according to claim 26, wherein the polishing units arranged in the orifices are in contact with the first mold by means of the polishing tips.~~

~~28.—The method for manufacturing a composite conditioner according to claim 27, wherein after removing the second mold and the first mold, the following steps are further comprised: forming a mold sealing layer to secure the polishing units.~~

~~29.—The method for manufacturing a composite conditioner according to claim 24, wherein the orifices of the second mold are arranged on the outer ring of the second mold.~~

~~30.—The method for manufacturing a composite conditioner according to claim 29, wherein the orifices of the second mold are 12 orifices formed with the outer ring of the second mold.~~

~~31.—A chemical mechanical planarization (CMP) process, comprising the following steps:~~

~~providing a polishing pad;~~

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~~placing a wafer on the surface of the polishing pad and polishing the wafer and the polishing pad with each other; and~~

~~using a conditioner arranged on the surface of the polishing pad to remove debris after polishing of the wafer, wherein the conditioner is the composite conditioner as in claim 1.~~

~~32.—The CMP process according to claim 31, applicable to the production of logic devices, dynamic random access memories (DRAMs), caches (flash memories) or hard drives.~~

~~33.—The CMP process according to claim 31, wherein the diameter of the wafer is 200 mm, 300 mm or 450 mm.~~

~~34.—The CMP process according to claim 31, wherein the line width of ICs on the surface of the wafer is smaller than or equal to 45 nm.~~

~~35.—The CMP process according to claim 34, wherein the line width of ICs on the surface of the wafer is smaller than or equal to 28 nm.~~

~~36.—The CMP process according to claim 35, wherein the line width of ICs on the surface of the wafer is smaller than or equal to 22 nm.~~

~~VIII. Drawings~~ (See next page):

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FIG. 1A

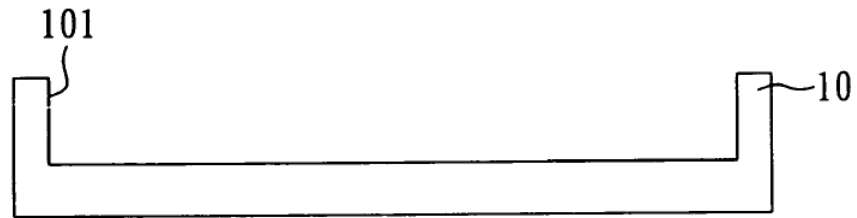


FIG. 1B

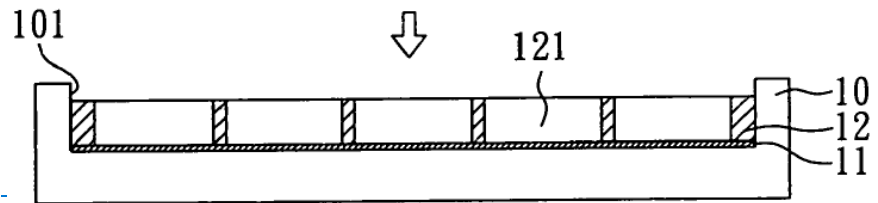


FIG. 1C

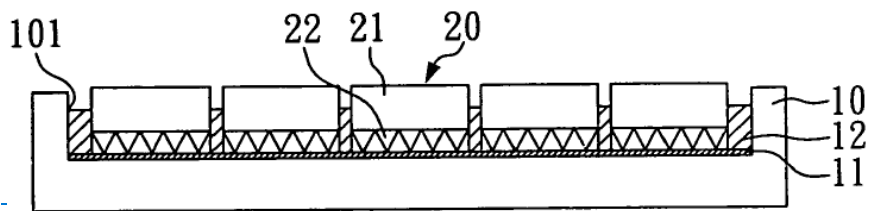
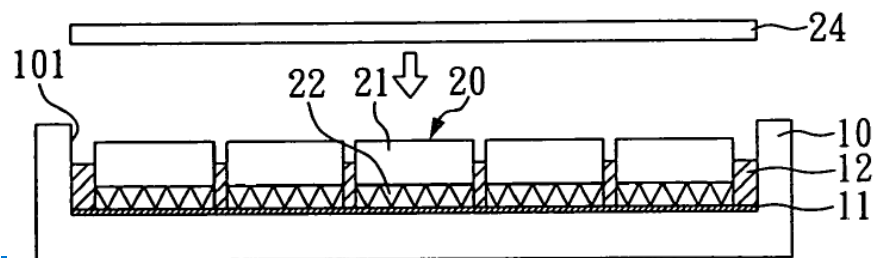


FIG. 1D



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FIG. 1E

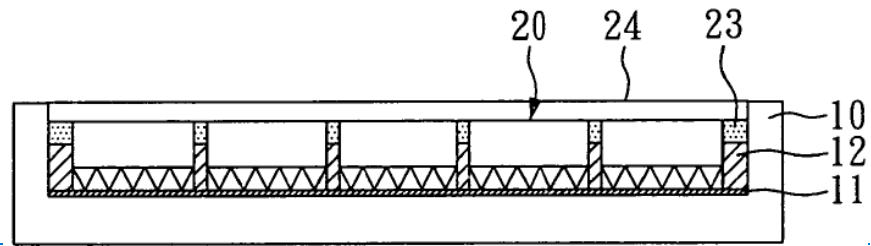


FIG. 1F

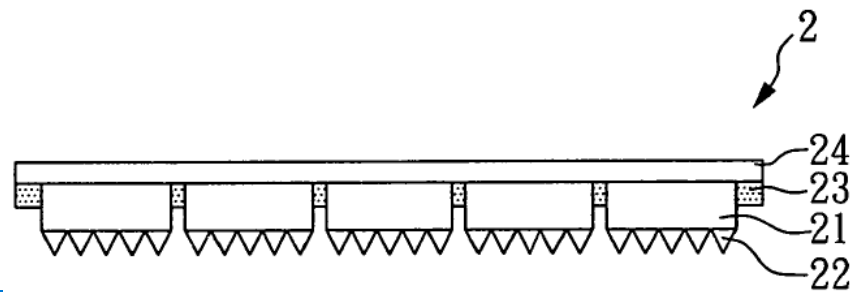
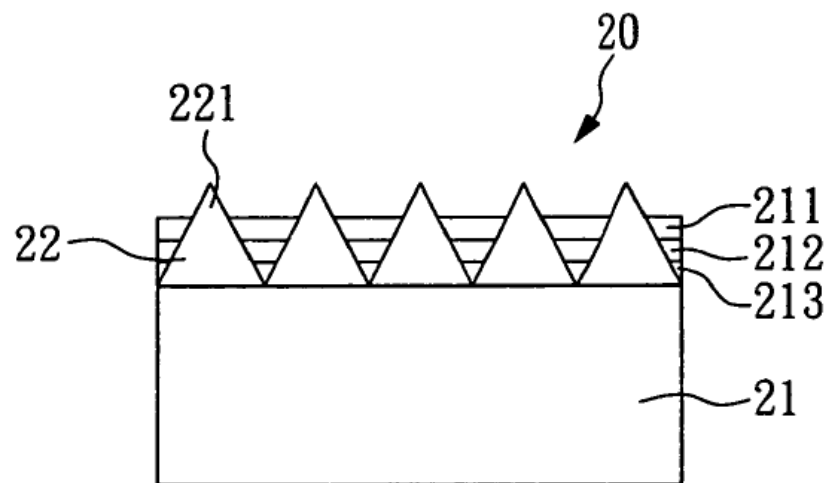


FIG. 1G



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FIG. 2A

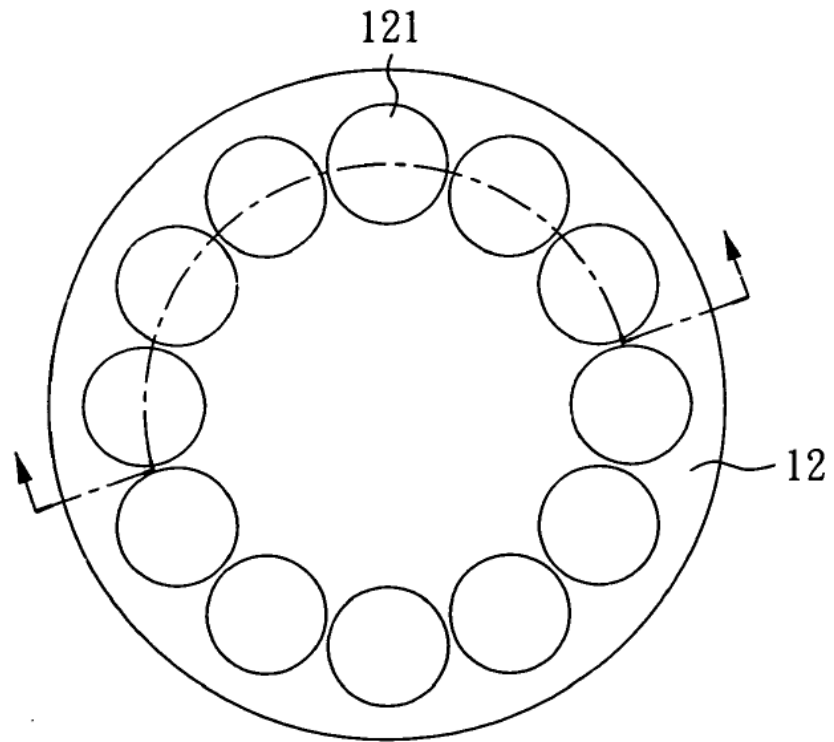


FIG. 2B

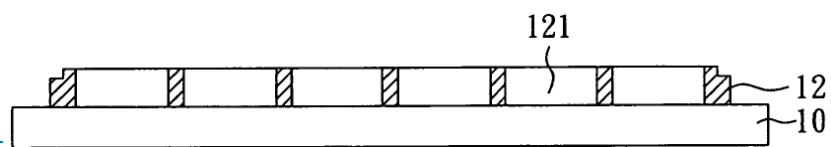


FIG. 2C

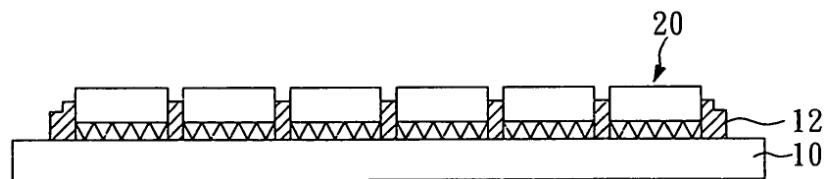
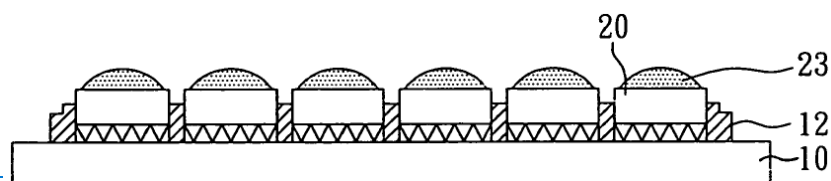


FIG. 2D



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FIG. 2E

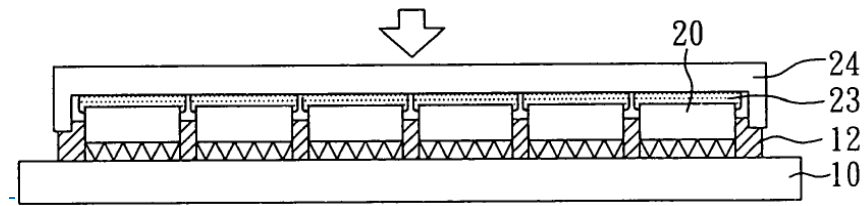


FIG. 2F

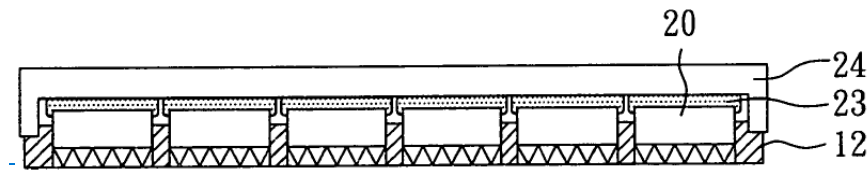
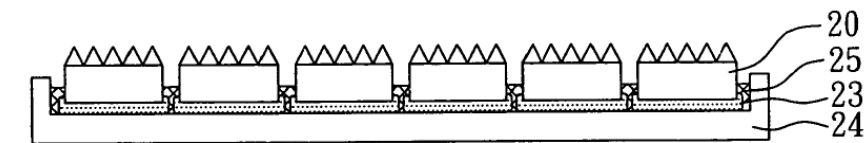


FIG. 2G



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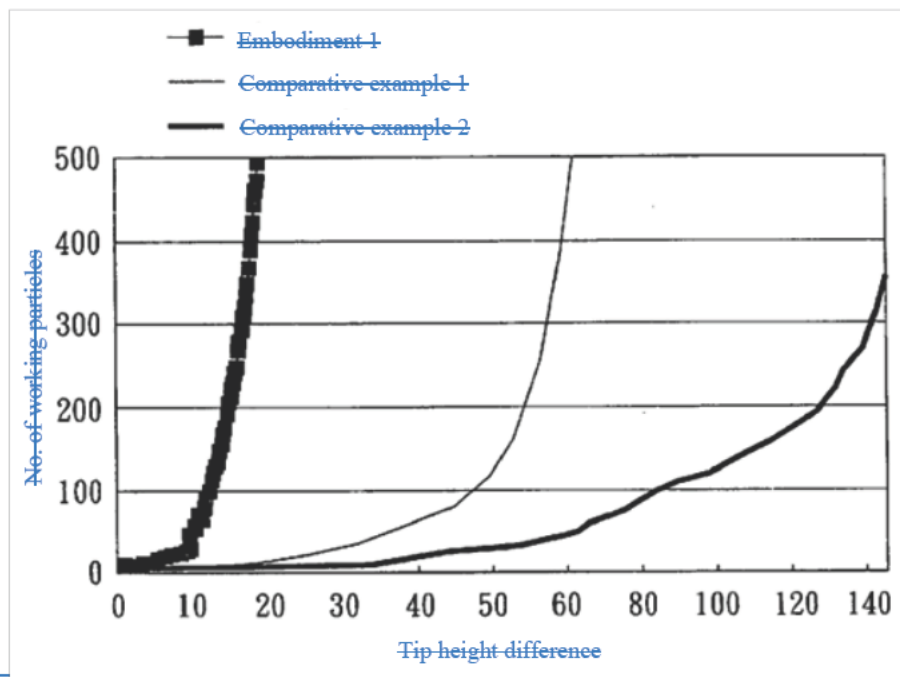


FIG. 3

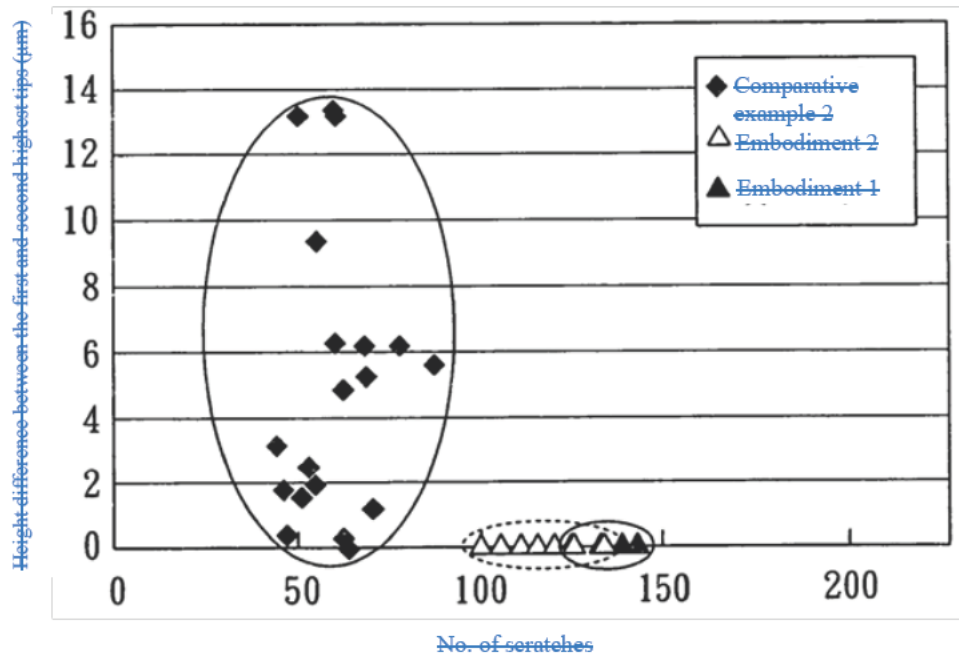


FIG. 4

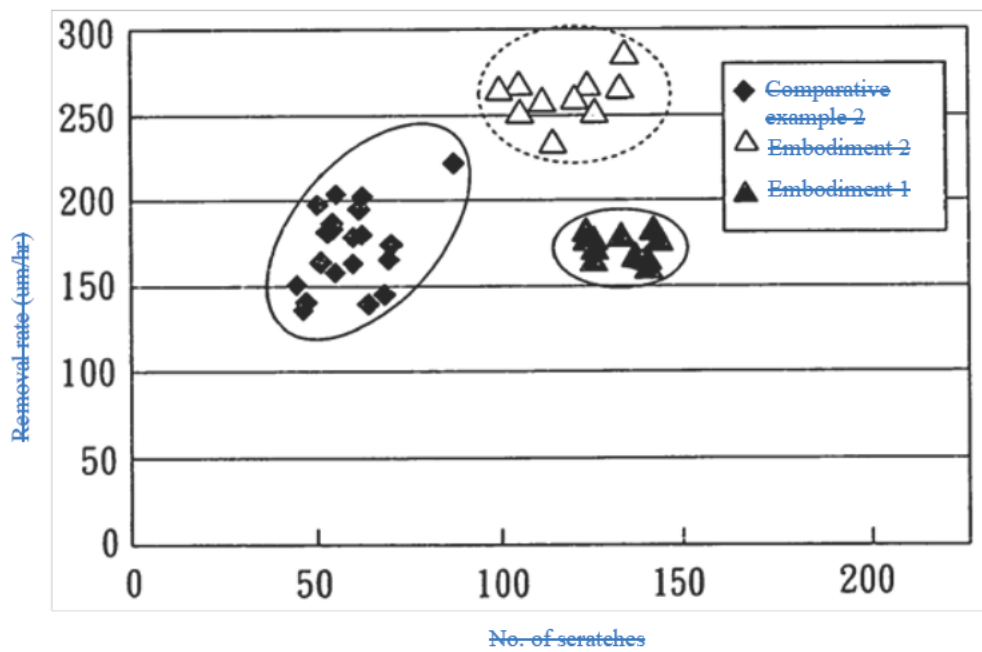


FIG. 5

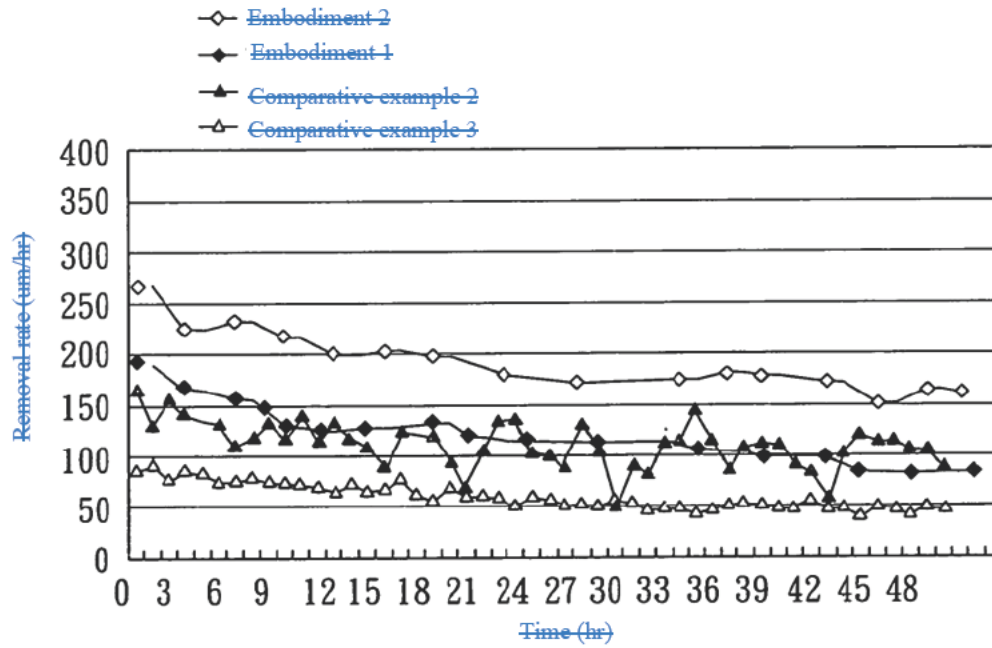


FIG. 6

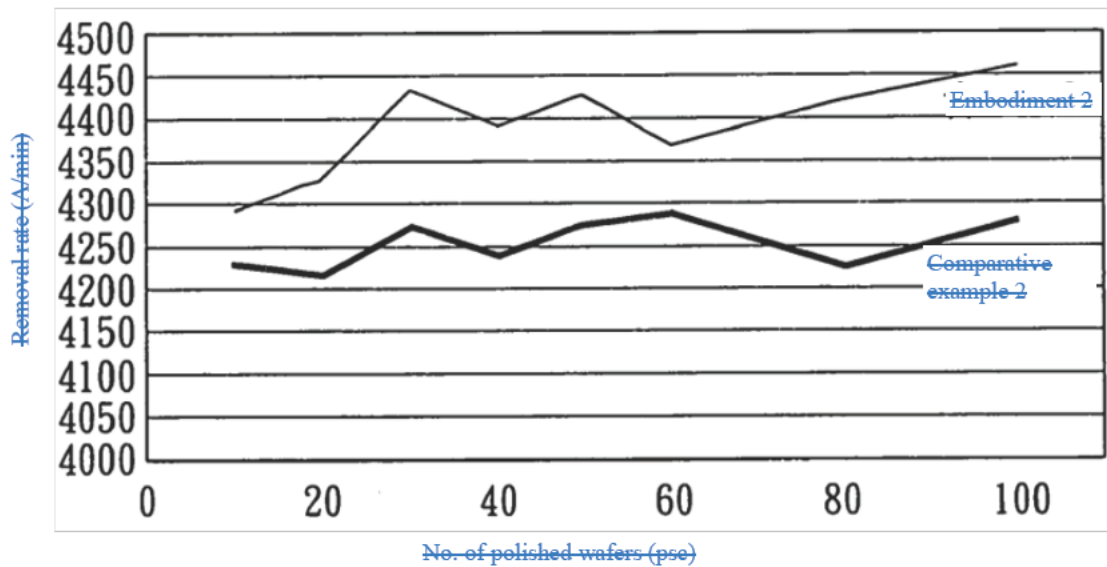


FIG. 7

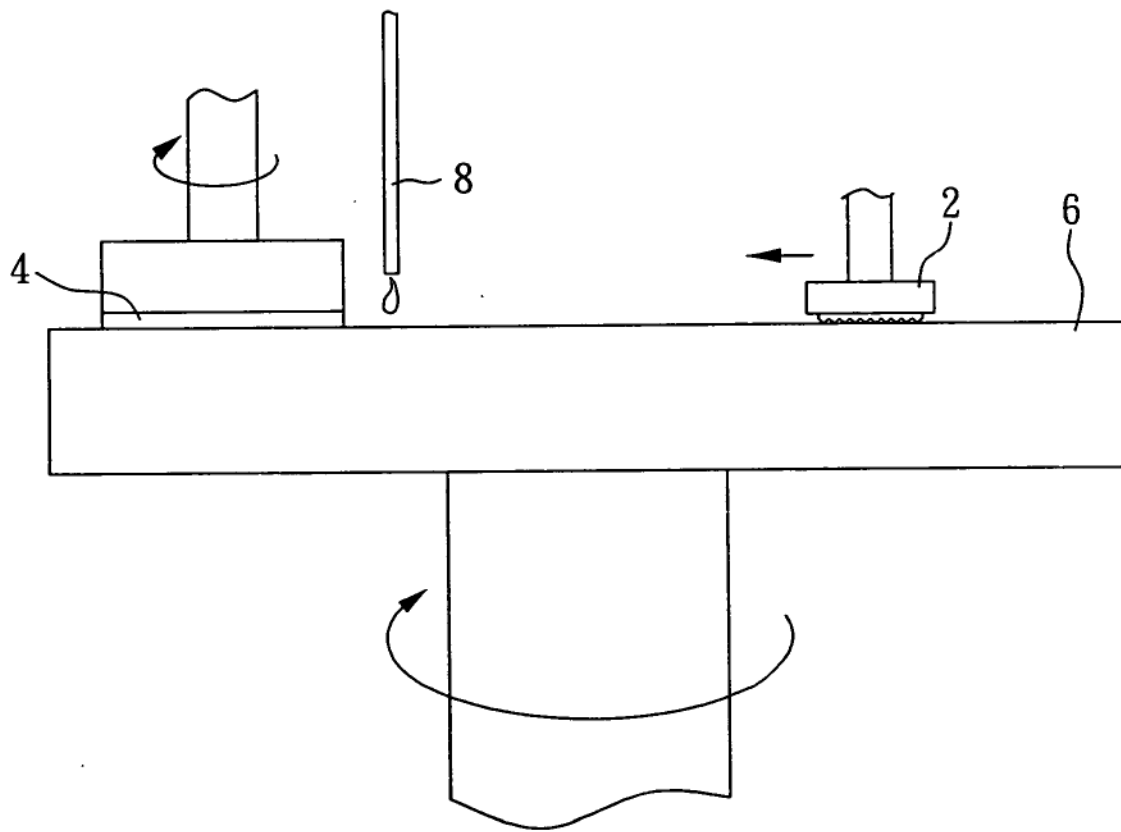


FIG. 8

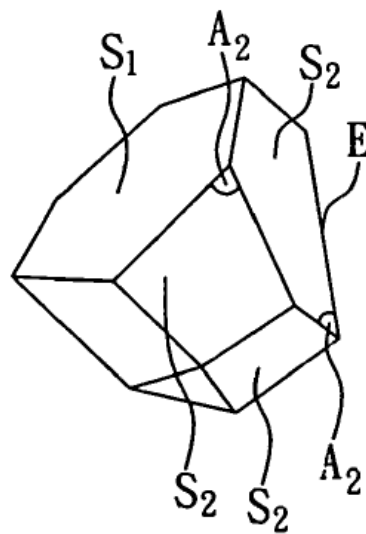
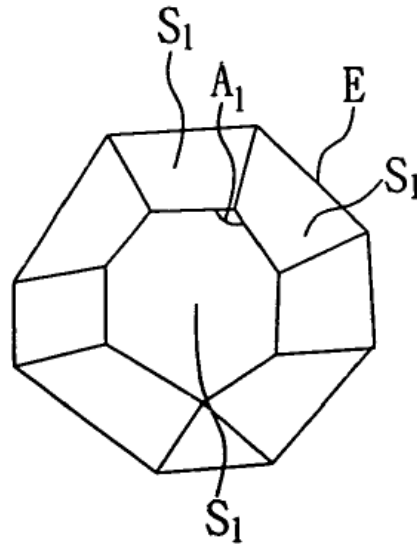


FIG. 9 Description:

BACKGROUND OF THE INVENTION

The semiconductor industry currently spends in excess of one billion U.S. dollars each year manufacturing silicon wafers that must exhibit very flat and smooth surfaces. Known techniques to manufacture smooth and even-surfaced silicon wafers are plentiful. The most common of these involves the process known as Chemical Mechanical Polishing (CMP) which includes the use of a polishing pad in combination with an abrasive slurry. Of central importance in a CMP process is the attainment of high performance even in aspects such as uniformity of polished wafer, smoothness of the IC circuitry, removal rate for productivity, longevity of consumables for CMP economics, etc.

SUMMARY OF THE INVENTION

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The present disclosure provides CMP pad dressers and associated methods, including without limitation, methods directed to the manufacture and use of such dressers. In one aspect, for example, a CMP pad dresser can include a support substrate and a plurality of superabrasive particles secured to the support substrate with each superabrasive particle extending away from the support substrate to a protrusion distance. The plurality of superabrasive particles can be positioned such that the highest protruding tip of each of the plurality of superabrasive particles is along a designated profile with a tip variation of from about 5 microns to about 100 microns. In another aspect, the highest protruding tip of each of the plurality of superabrasive particles is along the designated profile with a tip variation of from about 10 microns to about 50 microns. In yet another aspect, the highest protruding tip of each of the plurality of superabrasive particles is along the designated profile with a tip variation of from about 20 microns to about 40 microns. In a further aspect, the highest protruding tip of each of the plurality of superabrasive particles is along the designated profile with a tip variation of less than about 20 microns. The designated profile can include any geometric configuration that can be useful in dressing a CMP pad, and any such configuration is considered to be within the present scope. Non-limiting examples can include a plane, a slope, a curved shape, a dome shape, and the like, including appropriate combinations thereof.

The positioning of superabrasive particles relative to the support substrate can also be described in terms of the depths that the superabrasive particles cut into a CMP pad when used to abrade the CMP pad. In one aspect, for example, the protrusions of the plurality of superabrasive particles produce cutting depths of less than about 20 microns when used to abrade a CMP pad. In another aspect, the protrusions of the plurality of superabrasive particles produce cutting depths of from about 1 micron to about 20 microns when used to abrade a CMP pad. In yet another aspect, the protrusions of the plurality of superabrasive particles produce cutting depths of from about 10 microns to about 20 microns when used to abrade a CMP pad.

As another exemplary aspect of the present disclosure, a CMP pad dresser can include a rigid support substrate and a monolayer of a plurality of superabrasive particles coupled to the support substrate, where each superabrasive particle in the monolayer extends from the support substrate to a protrusion distance. In one aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 50 microns, and the difference in protrusion distance between the highest 1% of the protruding tips of the monolayer of superabrasive particles is within about 80 microns or less. In another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In a further aspect, the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns.

As yet another exemplary aspect of the present disclosure, a CMP pad dresser can include a rigid support substrate and a monolayer of a plurality of superabrasive particles coupled to the support substrate, where the plurality of superabrasive particles includes a plurality of working superabrasive particles, such that rotating the dresser against a CMP pad cuts asperities into the CMP pad having a cutting depth of less than or equal to about 50 microns. In another aspect, the cutting depth is from about 10 microns to about 50 microns. In yet another aspect, the plurality of working superabrasive particles includes at least 100 working superabrasive particles. In a further aspect, the plurality of working superabrasive particles includes at least 1000 working superabrasive particles. In yet another aspect, the plurality of working superabrasive particles includes from about 1000 to about 6000 working superabrasive particles. In another aspect, the plurality of working superabrasive particles includes from about 2000 to about 5000 working superabrasive particles. In a further aspect, the plurality of working superabrasive particles include at least about 1000 working superabrasive particles that protrude from the rigid support substrate to distances within about 30 microns of one another.

As another exemplary aspect of the present disclosure, a method of dressing a CMP pad can include applying a CMP pad dresser to a CMP pad, and moving at least one of the CMP pad or the CMP pad dresser with respect to one another to cut asperities into the CMP pad having a cutting depth of from about 10 microns to about 50 microns.

As a further exemplary aspect of the present disclosure, a CMP pad dresser is provided including a support substrate and a plurality of superabrasive particles secured to the support substrate and positioned to engage and dress a CMP pad, where the plurality of superabrasive particles cut to depths of less than 50 microns into a CMP pad during a dressing procedure.

There has thus been outlined, rather broadly, various features of the invention so that the detailed description thereof that follows may be better understood, and so that the present contribution to the art may be better appreciated. Other features of the present invention will become clearer from the following detailed description of the invention, taken with the accompanying claims, or may be learned by the practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

S

FIG. 1 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present disclosure;

FIG. 2 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present disclosure;

FIG. 3 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present disclosure;
and

FIG. 4 is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present disclosure.

It will be understood that the above figures are merely for illustrative purposes in furthering an understanding of the invention. Further, the figures are not drawn to scale, thus dimensions, proportions, and other aspects may, and generally are, exaggerated to make illustrations thereof clearer. Therefore, departure can be made from the specific dimensions and aspects shown in the figures in order to produce the heat spreaders of the present invention.

DETAILED DESCRIPTION

Before the present invention is disclosed and described, it is to be understood that this invention is not limited to the particular structures, method steps, or materials disclosed herein, but is extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular embodiments only and is not intended to be limiting.

It must be noted that, as used in this specification and the appended claims, the singular forms "a," "an" and, "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a diamond particle" includes one or more of such particles and reference to "the layer" includes reference to one or more of such layers.

DEFINITIONS

In describing and claiming the present invention, the following terminology will be used in accordance with the definitions set forth below.

As used herein, the terms "conditioner" and "dresser" can be used interchangeably, and refer to a tool used to condition or dress a pad, such as a CMP pad.

As used herein, "superabrasive" may be used to refer to any crystalline, or polycrystalline material, or mixture of such materials that has a Mohr's hardness of about 8 or greater. In some aspects, the Mohr's hardness may be about 9.5 or greater. In other aspects, superabrasive materials can be materials having a Vickers hardness of about 4000 Kg/mm² or greater. Suitable superabrasive materials examples can include, without limitation, diamond, polycrystalline diamond (PCD), cubic boron nitride (cBN), polycrystalline cubic boron nitride (PcBN), corundum and sapphire, as well as other superabrasive materials known to those skilled in the art. Superabrasive materials may be incorporated into various tools in a variety of forms including particles, grains, films, layers, pieces, segments, etc. While superabrasive materials are very inert and thus difficult to form chemical bonds with, it is known that certain reactive elements, such as chromium and titanium are capable of chemically reacting with superabrasive materials at certain temperatures.

As used herein, "particle" refers, when used in connection with superabrasive particles, to a particulate form of superabrasive particle. Such particles may take a variety of shapes, including round, oblong, square, euhedra, etc., can be either single crystalline or polycrystalline, and can have a number of mesh sizes. As is known in the art, "mesh" refers to the number of holes per unit area, as in the case of U.S. meshes. A mesh size referred to herein is U.S. mesh unless otherwise indicated. Further, mesh sizes are generally understood to indicate an average mesh size of a given collection of particles since each particle with a particular "mesh size" may actually vary over a small distribution of sizes, unless noted otherwise.

As used herein, "working superabrasive particles" are superabrasive particles that cut or otherwise deform a CMP pad during a dressing or conditioning procedure. This action can remove debris from the surface, it can deform the surface either elastically or plastically, or it can create a groove or asperity in the surface of the CMP pad. In one specific aspect, a working superabrasive particle can cut deeper than about 10 microns into a CMP pad during a dressing procedure.

As used herein, "non-working superabrasive particles" are superabrasive particles in a CMP pad dresser that do not significantly cut or deform the pad sufficient to remove debris from the surface, deform the surface, or create grooves in the surface.

As used herein, "overly-aggressive superabrasive particles" are superabrasive particles in a CMP pad dresser that aggressively dress or condition a CMP pad. In one aspect, aggressive superabrasive particles are superabrasive particles that cut deeper than about 50 microns into a CMP pad during a dressing procedure. In another aspect, aggressive superabrasive particles are superabrasive particles that remove at least 1/5 of the material from the CMP pad. In yet another aspect, aggressive superabrasive particles are superabrasive particles that remove at least 1/2 of the material from the CMP pad.

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As used here n, “work ng end” refers to an end of a part c e that s or ented towards the CMP pad and that dur ng a dress ng operat on makes contact w th the pad. In many cases the work ng end of a part c e w be d sta from a substrate to wh ch the part c e s attached.

As used here n, cutt ng “t p” refers to a port on of a cutt ng e ement or part c e that protrudes the greatest d stance from the support substrate, e.g., that s the frst port on of the cutt ng e ement that contacts a CMP pad when n use. It s to be understood that a cutt ng “t p” can ncude a p anar surface, a po nted surface, or an edge; so ong as the p anar surface, po nted surface or edge of the cutt ng e ement s the frst port on of the cutt ng e ement that contacts a CMP pad from wh ch materia s to be removed.

As used here n, “sharp port on” refers to any narrow port on to wh ch a crista or part c e may converge, ncud ng but not m ted to corners, apexes, r dges, edges, obe sks, and other protrus ons. In some cases, corners and/or apexes are formed at the convergence of more than two faces of the part c e or crista , or other body, d sposed n ntersect ng p anes. In other aspects, edges and/or r dges may be formed at the convergence of two or at east two faces of the part c e or crista , or other body, d sposed n ntersect ng p anes. In some aspects, “sharp port on” can ncude a port on that s broken, ch pped, cracked, agged, and the ke. In some aspects, degrees of sharpness can be corre ated w th the geometr c ang e formed by the part c e, crista , or other body, at the ocat on n quest on. In some aspects, an ang e of 90 degrees or ess can be cons dered sharp. In other aspects, an ang e of 60 degrees or ess can be cons dered sharp. In yet other aspects, and ang e of 45 degrees or ess, or 30 degrees or ess can be cons dered to be sharp.

As used here n, cutt ng “edge” refers to a port on of a cutt ng e ement or part c e that ncudes some measurab e wd th across a port on that contacts and removes materia from a workp ece. As an exemp ary ustrat on, a typ ca kn fe b ade has a cutt ng edge that extends ong tud na y a ong the kn fe b ade, and the kn fe b ade wou d have to be or ented transverse y to a workp ece to scrape or p ane materia from the workp ece n order for the cutt ng “edge” of the kn fe b ade to remove materia from the workp ece.

As used here n, “per phera y ocat ed,” “per phera ocat on,” and the ke, refer to any part c e or other cutt ng e ement of a dresser that s ocat ed n an area that or g nates at the ead ng edge or outer rm of a dresser and extends nward y towards the center for up to about 90% of the rad us of the dresser. In some aspects, the area may extend nward y from about 20% to 90% of the rad us. In other aspects, the area may extend n to about 50% of the rad us. In yet another aspect, the area may extend n to about 33% of the rad us of a dresser (.e. 66% away from the center).

As used here n, “centra y ocat ed part c e,” “part c e n a centra ocat on,” and the ke refer to any part c e or other cutt ng e ement of a too that s ocat ed n an area of the too that or g nates at a center po nt of the too and extends outward y towards the too 's edge for up to about 90% of the rad us of the too . In some aspects, the area may extend outward y from about 20% to about 90% of the rad us. In other aspects, the area may extend out to about 50% of the rad us. In yet another aspect, the area may extend out to about 33% of the rad us of a too .

As used here n, “att tude” refers to the pos t on or arrangement of a superabras ve part c e n re at on to a def ned surface, such as a substrate to wh ch t s attached, or a CMP pad to wh ch t s to be app ed dur ng a work operat on. For examp e, a superabras ve part c e can have an att tude that prov des a spec f c port on of the part c e n or entat on toward a CMP pad.

As used here n, “ead ng edge” refers to the edge of a CMP pad dresser that s a fronta edge based on the d rect on that the CMP pad s mov ng, or the d rect on that the pad s mov ng, or both. Notab y, n some aspects, the ead ng edge may be cons dered to encompass not on y the area spec f ca y at the edge of a dresser, but may a so ncude port ons of the dresser wh ch extend s ght y nward from the actua edge. In one aspect, the ead ng edge may be ocat ed a ong an outer edge of the CMP pad dresser. In another aspect, the CMP pad dresser may be conf gured w th a pattern of abras ve part c es that prov des at east one effect ve ead ng edge on a centra or nner port on of the CMP pad dresser work ng surface. In other words, a centra or nner port on of the dresser may be conf gured to prov de a funct ona effect s m ar to that of a ead ng edge on the outer edge of the dresser.

As used here n, the term “prof e” and “geometr c prof e” can be used nterchangeab y, and refer to a predeterm ned contour above a support substrate to wh ch a p ura ty of superabras ve part c es or other cutt ng e ements are ntended to a gn. Examp es of such prof es may ncude, w thout m tat on, fat or p anar prof es, curved prof es, wavy prof es, convex prof es, concave prof es, mu t-tered prof es, and the ke, ncud ng comb nat ons thereof.

As used here n, “geometr c conf gurat on” refers to a shape that s capab e of be ng descr bed n read y understood and recogn zed mathemat ca terms. Examp es of shapes qua fy ng as “geometr c conf gurat ons” ncude, w thout m tat on, cub c shapes, po yhedra (ncud ng regu ar po yhedra) shapes, tr angu ar shapes (ncud ng equ atera tr ang es, sosce es tr ang es and three-d mens ona tr angu ar shapes), pyram da shapes, spheres, rectang es, “p e” shapes, wedge shapes, octagona shapes, c rc es, etc.

As used here n, "dress ng segment" refers to a dress ng or cond t on ng e ement of a CMP pad dresser. In one aspect, dress ng segments are ut zed to carry superabras ve part c es hav ng eve ed t ps. Thus, n some cases superabras ve part c es can be ntroduced nto a CMP pad dresser by the ncorporat on of mu t p e dress ng segments. It shou d be noted that a var ety of techn ques of attach ng the dress ng segments to the substrates, and a var ety of techn ques of attach ng the superabras ve part c es to the dress ng segments, are poss b e, a of wh ch are considered to be w th n the present scope. It s to be understood that a of these var ous attachment mechan sms can be used nterchangeab y here n: that s, f a method of attach ng a dress ng segment to a substrate s d scussed here n, the method of attachment d scussed can a so be used to attach superabras ve part c es to a dress ng segment. For any part cu ar CMP pad dresser be ng d scussed, however, t s understood that attachment methods of the superabras ve part c es to the dress ng segments can d ffer from, or can be the same as, the method used to attach the dress ng segments to the pad cond t oner substrate.

As used here n, "cutt ng e ement" descr bes a var ety of structures capab e of remov ng (e.g., cutt ng) mater a from a CMP pad. A cutt ng e ement can be a mass hav ng severa cutt ng po nts, r dges or mesas formed thereon or there n. It s notab e that such cutt ng po nts, r dges or mesas may be from a mu t p c ty of protrus ons or asper t es ncuded n the mass. Furthermore, a cutt ng e ement can a so refer an nd v dua part c e that may have on y one cutt ng po nt, r dge or mesa formed thereon or there n.

As used here n, "organ c mater a " refers to a sem so d or so d comp ex or m x of organ c compounds. "Organ c mater a ayer" and "organ c matr x" may be used nterchangeab y, and refer to a ayer or mass of a sem so d or so d comp ex or m x of organ c compounds, ncud ng res ns, po ymers, gums, etc. The organ c mater a can be a po ymer or copo ymer formed from the po ymer zat on of one or more monomers. In some cases, such organ c mater a can be adhes ve.

As used here n, the process of "braz ng" s ntended to refer to the creat on of chem ca bonds between the carbon atoms of the superabras ve part c es/mater a s and the braze mater a . Further, "chem ca bond" means a cova ent bond, such as a carb de or bor de bond, rather than mechan ca or weaker nter-atom attract ve forces. Thus, when "braz ng" s used n connect on w th superabras ve part c es a true chem ca bond s be ng formed. However, when "braz ng" s used n connect on w th meta to meta bond ng the term s used n the more trad t ona sense of a meta urg ca bond. Therefore, braz ng of a superabras ve segment to a too body does not necessar y requ re the presence of a carb de former.

As used here n, "mechan ca bond" and "mechan ca bond ng" may be used nterchangeab y, and refer to a bond nterface between two ob ects or ayers formed pr mar y by fr ct ona forces. In some cases the fr ct ona forces between the bonded ob ects may be ncreased by expand ng the contact ng surface areas between the ob ects, and by mpos ng other spec f c geometr ca and phys ca conf gurat ons, such as substant a y surround ng one ob ect w th another.

As used here n, "s nter ng" refers to the o n ng of two or more nd v dua part c es to form a cont nuous so d mass. The process of s nter ng nvo ves the conso dat on of part c es to at east part a y e m nate vo ds between part c es. S nter ng may occur n e ther meta or carbonaceous part c es, such as d amond. S nter ng of meta part c es occurs at var ous temperatures depend ng on the compos t on of the mater a . S nter ng of d amond part c es genera y requ res u trah gh pressures and the presence of a carbon so vent as a d amond s nter ng a d. S nter ng a ds are often present to a d n the s nter ng process and a port on of such may rema n n the f na product.

The term "meta c" refers to both meta s and meta o ds. Meta s ncude those compounds typ ca y considered meta s found w th n the trans t on meta s, a ka and a ka earth meta s. Examp es of meta s are Ag, Au, Cu, A , and Fe. Meta o ds ncude spec f ca y S , B, Ge, Sb, As, and Te. Meta c mater a s a so ncude a oys or m xtures that ncude meta c mater a s. Such a oys or m xtures may further ncude add t ona add t ves. In the present nvent on, carb de formers and carbon wett ng agents may be ncuded as a oys or m xtures, but are not ant c pated to be the on y meta c component. Examp es of such carb de formers are Sc, Y, T , Zr, Hf, V, Nb, Cr, Mo, Mn, Ta, W, and Tc. Examp es of carbon wett ng agents are Co, N , Mn, and Cr.

As used here n, "nf trat ng" refers to a s tuat on where a mater a s heated to ts me t ng po nt and then f ows as a qu d through the nterst t a vo ds between part c es.

As used here n, the terms "substrate" and "support substrate" can be used nterchangeab y, and refer a port on of a pad cond t oner that supports superabras ve mater a s, and to wh ch abras ve mater a s and/or superabras ve segments that carry abras ve mater a s may be aff xed. Substrates can have a var ety of shapes, th cknesses, and/or mater a s that are capab e of support ng abras ve mater a s n a manner that s suff c ent to prov de a CMP pad dresser usefu for ts ntended purpose. Substrates may be of a so d mater a , a powdered mater a that becomes so d when processed, or a f ex b e mater a . Examp es of typ ca substrate mater a s ncude w thout m tat on, meta s, meta a oys, ceram cs, re at ve y hard po ymers or other organ c mater a s, g asses, and m xtures thereof. Further, the

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substrate may include a material that adheres to the substrate, including, without limitation, brazing a solder material, soldering a die and the like.

As used herein, the term “substantially” refers to the complete or nearly complete extent or degree of an action, characteristic, property, state, structure, item, or result. For example, an object that is “substantially” enclosed would mean that the object is either completely enclosed or nearly completely enclosed. The exact allowable degree of deviation from absolute completeness may in some cases depend on the specific context. However, generally speaking the nearness of completion will be so as to have the same overall result as if absolute and total completion were obtained.

The use of “substantially” is equally applicable when used in a negative connotation to refer to the complete or nearly complete lack of an action, characteristic, property, state, structure, item, or result. For example, a composition that is “substantially free of” parts would either completely lack parts, or so nearly completely lack parts that the effect would be the same as if completely lacking parts. In other words, a composition that is “substantially free of” an ingredient or element may still actually contain such item as long as there is no measurable effect thereof.

As used herein, the term “about” is used to provide flexibility to a numerical range endpoint by providing that a given value may be “at least above” or “at least below” the endpoint. However, it is to be understood that even when the term “about” is used in the present specification in connection with a specific numerical value, that support for the exact numerical value recited apart from the “about” terminology is also provided.

In this disclosure, “comprises,” “comprising,” “containing” and “having” and the like can have the meaning ascribed to them in U.S. Patent law and can mean “includes,” “including,” and the like, and are generally interpreted to be open ended terms. The terms “consisting of” or “consists of” are closed terms, and include only the components, structures, steps, or the like specifically stated in conjunction with such terms, as well as that which is in accordance with U.S. Patent law. “Consisting essentially of” or “consists essentially of” have the meaning generally ascribed to them by U.S. Patent law. In particular, such terms are generally closed terms, with the exception of allowing inclusion of additional items, materials, components, steps, or elements, that do not materially affect the basic and novel characteristics or function of the item(s) used in connection therewith. For example, trace elements present in a composition, but not affecting the composition's nature or characteristics would be permissible present under the “consisting essentially of” language, even though not expressly recited in a list of items following such terminology. When using an open ended term, like “comprising” or “including,” it is understood that direct support should be afforded as to “consisting essentially of” language as well as “consisting of” language as if stated explicitly and vice versa.

As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these items should be construed as though each member of the list is individually defined as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on the representation in a common group without indications to the contrary.

Concentrations, amounts, and other numerical data may be expressed or presented herein in a range format. It is to be understood that such a range format is used merely for convenience and brevity and thus should be interpreted flexibly to include not only the numerical values explicitly recited as the limits of the range, but also to include the individual numerical values or sub-ranges encompassed within that range as if each numerical value and sub-range is explicitly recited. As an illustration, a numerical range of “about 1 to about 5” should be interpreted to include not only the explicitly recited values of about 1 to about 5, but also to include individual values and sub-ranges within the indicated range. Thus, included within this numerical range are individual values such as 2, 3, and 4 and sub-ranges such as from 1-3, from 2-4, and from 3-5, etc., as well as 1, 2, 3, 4, and 5, individually. The same principle applies to ranges reciting only one numerical value as a minimum or a maximum. Furthermore, such an interpretation should apply regardless of the breadth of the range or the characteristics being described.

The Invention

The present disclosure generally provides CMP pad dressers, methods associated with pad conditioning (e.g., smoothing, polishing, dressing), and the CMP polishing of a workpiece. Pad conditioners according to aspects of the present disclosure can be advantageously utilized, for example, in dressing CMP pads that are used in polishing, finishing or otherwise affecting semiconductor materials. Specifically, in some aspects the present disclosure concerns CMP pad dressers having superabrasive particles with substantially evened tips. In other aspects, the present CMP pad dressers can have superabrasive particles that are aligned across a designated profile, and as such, are “evened” with respect to that profile. Traditional CMP pad dresser manufacturing methods, even many of those describing techniques for evening superabrasive particle tips prior to fixation, generally contain significant variation in tip height across the surface of the dresser that is not accounted for by an intended tip alignment profile. Often, the superabrasive particles are affixed to the CMP pad dresser support in a manner that disrupts any even

that has occurred. For example, factors that utilize high heat and/or pressure can cause warping of the dresser support as the dresser cools. Thus, unnecessary steps are taken to avoid such warpage, superabrasive particles are not maintained in the revised state following cooling of the dresser. This can be particularly problematic with brazing techniques.

A CMP pad dresser can be used to dress or condition a CMP pad by removing dirt and debris (i.e. degazing the pad), as well as opening up asperities on the pad surface to capture and hold chemicals during a polishing procedure. As has been described, due to difficulties associated with superabrasive particle embedding in many traditional manufacturing processes, only a small percentage of superabrasive particles in a typical CMP pad dresser are positioned so as to penetrate or cut into a CMP pad. As this small percentage of superabrasive particles become worn, plastic deformation of the CMP pad becomes a large relative to the amount of CMP of pad that is cut. Consequently, the pad becomes highly deformed and accumulated with dirt. As a result the polishing rate of the CMP pad decreases, and the scratch rate of the wafer or work piece increases.

CMP pads are typically made of a relatively soft polymer, such as, for example, polyurethane. As the CMP pad is engaged by the CMP pad dresser, the polymer material is deformed first by elastic strain and then by plastic strain. Eventually, the strain energy in the deformed material exceeds the bond energy density (i.e. the hardness of the pad) and the polymer material ruptures. Thus, the function of superabrasive particles in the CMP pad dresser is to dress the CMP pad material by breaking polymer bonds through this deformation process. It should be noted that sharp superabrasive particle tips can penetrate the CMP pad material without causing excessive deformation. As such, the sharpness of a superabrasive particle can be defined as being inverse to the deformed volume prior to rupture. In other words, the smaller the volume of deformation prior to cutting, the sharper the cutting tip. This deformation information can be used to determine the sharpness of superabrasive particles in the CMP pad dresser.

Additionally, a superabrasive particle having a tip with smaller tip radius, such as would be the case with a broken corner, can cut more cleanly through the CMP pad with less deformation as compared to a superabrasive particle having a larger tip radius. Consequently, an irregularly shaped superabrasive particle can be sharper than a euhedral superabrasive corner having an obtuse angle relative to the CMP pad. This also applies to the difference between a superabrasive particle corner as compared with a superabrasive particle face.

It is thus noted that sharp superabrasive particle tips can cut CMP pad material with less deformation and material strain. Conversely, a dull superabrasive particle may deform but not cut the CMP pad material because the strain energy does not exceed the bond energy density of the polymer material. As the tips of such particles are worn, the contact area between the polymer material and the particles increase. This increase in contact area results in an increase in the deformation volume of the pad. Due to the increased strain energy required for the polymer material to rupture with such an increased deformation volume, the number of superabrasive particles cutting the polymer material will decrease in relation to the degree of dulling during a CMP process.

CMP pad dressing can also be affected by the proportion of superabrasive particles in the CMP pad dresser that are working and the proportion that are over-aggressively cutting. As an example, a typical CMP pad dresser can have greater than 10,000 superabrasive particles. Of these 10,000 particles, in some cases there may only be a few working superabrasive particles that are actually able to cut the CMP pad. Additionally, out of these few working superabrasive particles, there may be a smaller proportion of over-aggressive superabrasive particles that cut over 50% of the entire pad that is consumed during conditioning, and in some cases can remove more than 25% of the total pad material. This uneven workload distribution can cause erratic CMP performance, and can result in over consumption of the CMP pad, chipping of the over-aggressive superabrasive particles that can scratch the wafer, unpredictable wafer removal rates, uneven wafer surface planarization, shortened CMP pad dresser life, compact on of the CMP pad with debris, and the like. Such effects can greatly lower the yield of wafers or work pieces processed under these conditions. A more effective normalization of workload distribution across the surface of the CMP pad dresser can lead to a more uniformly degazed pad and more uniform pad asperities.

The present CMP pad dressers include a layer of superabrasive particles having substantial evenly distributed tips across the working surface of the finished CMP pad dresser. A variety of techniques can be utilized to maintain tip embedding, and any such techniques considered to be within the present scope. A few non-limiting examples of such techniques are described below. It is intended that the term "embedding" with respect to superabrasive particles can refer to superabrasive particles that are embedded with respect to a planar profile, as well as to superabrasive particles that are aligned along a designated profile that is non-planar. In the latter case, "embedding" would thus describe the alignment of the superabrasive particles along the designated profile. So in the case of a profile having a dome-shape, embedded superabrasive particles would be particles that were in alignment with the profile.

Furthermore, superabrasive tip alignment can additionally be described in terms of height distribution, or in some cases protrusion distance from the support substrate that is represented by a height distribution across the purity of superabrasive particles. An even height distribution of superabrasive particles may function to more effectively preserve the integrity of the CMP pad dresser as compared to CMP pad dressers lacking such an even height

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d str but on. S m ar y, a p ura ty of superabras ve part c es can be descr bed as extend ng away from a support substrate to a predeterm ned he ght, represented by a protrus on d stance from the substrate, where the predeterm ned he ghts of the part c es a gn a ong a des gnated prof e. Thus, the actua d str but on of protrus on d stances across the p ura ty of superabras ve part c es n a f n shed dresser can be compared aga nst the des gnated prof e to determ ne the var ance, or degree of “ eve ng” ach eved.

In one aspect, for examp e, a CMP pad dresser s prov ded nc ud ng a support substrate and a p ura ty of superabras ve part c es secured to the support substrate, w th each superabras ve part c e extend ng away from the support substrate to a protrus on d stance, where the h ghest protrud ng t p of each of the p ura ty of superabras ve part c es a gn a ong a des gnated prof e. Wh e t s ntended that the t ps of the superabras ve part c es a gn a ong the des gnated prof e, some eve of dev at on may occur. These dev at ons may be a resu t of the des gn or manufactur ng process of the too . G ven the w de var ety of s zes of superabras ve part c es that may potent a y be ut zed n a g ven too , such dev at ons may be h gh y dependent on a part cu ar app cat on. A so, when referr ng to the des gnated prof e, t shou d be noted that the term “t p” s ntended to nc ude the h ghest protrud ng po nt of a superabras ve part c e, whether that po nt be an apex, an edge, or a face.

As such, n one aspect the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 1 m cron to about 150 m crons. In another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 5 m crons to about 100 m crons. In yet another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 10 m crons to about 75 m crons. In a further aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 10 m crons to about 50 m crons. In another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 50 m crons to about 150 m crons. In yet another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 20 m crons to about 100 m crons. In a further aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 20 m crons to about 50 m crons. In another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by from about 20 m crons to about 40 m crons. Add tona y, n one aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by ess than about 20 m crons. In another aspect the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by ess than about 10 m crons. In yet another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by ess than about 5 m crons. In yet another aspect, the p ura ty of superabras ve part c es are arranged such that the r t ps vary from the des gnated prof e by ess than about 1 m cron. In a further aspect, a ma or ty of the p ura ty of superabras ve part c es are arranges such that the r t ps vary from the des gnated prof e to ess than about 10% of the average s ze of the superabras ve part c es.

In another aspect, each of the p ura ty of superabras ve part c es can be def ned by a protrus on d stance from an exposed surface of a b nd ng mater a from wh ch they protrude to a predeterm ned he ght. Though the predeterm ned he ght may vary between too app cat ons, n one aspect the predeterm ned he ght may be greater than about 20 m crons. In another aspect the var at on from the predeterm ned he ght may be from about 1 m cron to about 20 m crons. In yet another aspect the var at on from the predeterm ned he ght may be from about 5 m crons to about 20 m crons. In a further aspect the var at on from the predeterm ned he ght may be from about 10 m crons to about 20 m crons. Superabras ve part c es may a so be arranged w th respect to arrangement or d str but on, att tude, s ze, etc. Furthermore, the d str but on of protrus on of the p ura ty of superabras ve part c es s ref ected n the depth that the part c es cut nto a CMP pad.

As such, n one spec f c aspect the predeterm ned he ght or protrus on d stance may produce a cutt ng depth of ess than about 20 m crons when used to dress a CMP pad. In another spec f c aspect, the predeterm ned he ght or protrus on d stance may produce a cutt ng depth of from about 1 m cron to about 20 m crons when used to dress a CMP pad. In yet another spec f c aspect, the predeterm ned he ght or protrus on d stance may produce a cutt ng depth of from about 10 m cron to about 20 m crons when used to dress a CMP pad. It shou d a so be noted that the eve ng of superabras ve part c es to a predeterm ned he ght may be dependent on superabras ve part c e spac ng. In other words, the farther superabras ve part c es are separated, the more the mp ng ng forces w affect each superabras ve part c e. As such, patterns w th ncreased spac ng between the superabras ve part c es may benef t from a sma er var at on from predeterm ned he ght.

In one spec f c examp e, a p ura ty of cutt ng e ements such as superabras ve part c es can protrude to a predeterm ned he ght above a b nd ng mater a such as, for examp e, a so d fed organ c mater a ayer. Though any predeterm ned he ght that wou d be usefu n an abrad ng or cutt ng too wou d be cons dered to be w th n the present y c a med scope, n one spec f c aspect the predeterm ned he ght may produce a cutt ng depth of ess than about 20 m crons when used to abrade a workp ece. In another spec f c aspect, the predeterm ned he ght may produce a cutt ng depth of from about 1 m cron to about 20 m crons when used to abrade a workp ece. In yet another

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specific aspect, the predetermined height may produce a cutting depth of from about 10 microns to about 20 microns when used to abrade a workpiece. In yet another aspect, the predetermined height may produce a depth of up to or more than 50 or 100 microns.

As a further example, it may also be beneficial for the cutting elements to protrude from the bonding material, for example, so defined organic material layer to a predetermined height or series of heights that is/are a longitudinal profile. Numerous configurations for designed profiles are possible, depending on the particular use of the abrading tool. In one aspect, the designed profile may be a plane. In planar profiles, the highest protruding points of the cutting elements are intended to be substantially even. It is important to point out that, though it is preferred that these points align with the designed profile, there may be some height deviation between cutting elements that occur due to variations inherent in the manufacturing process.

In addition to planar profiles, in another aspect the designed profile has a slope. Tools having sloping surfaces may function to more evenly spread the frictional forces imparting thereon across the cutting elements, particularly for rotating tools such as disk sanders and CMP pad dressers. The greater downward force applied by higher central portions of the tool may offset the higher rotational velocity at the periphery, thus reducing the mechanical stress experienced by cutting elements in that location. As such, the slope may be continuous from a central point of the tool to a peripheral point, or the slope may be discontinuous, and thus be present on only a portion of the tool. Similarly, a given tool may have a single slope or multiple slopes. In certain aspects, the tool may slope in a direction from a central point to a peripheral point, or it may slope from a peripheral point to a central point.

Various slopes are contemplated that may provide a benefit to so defined organic material layer tools. It is not intended that the claims of the present invention be limited as to specific slopes, as a variety of slopes in numerous different tools are possible. In one aspect, however, a CMP pad dresser may benefit from an average slope of 1/1000 from the center to the periphery.

As a variation on tools having a slope, in certain aspects the designed profile may have a curved shape. One specific example of a curved shape is a dome shape tool. Such curved profiles function in a similar manner to the sloped surfaces. Tools may include such curved profiles in order to more effectively distribute the frictional forces between a set of the cutting elements, thus reducing failures of individual parts and prolonging the life of the tool.

Furthermore, in some aspects the determination of the distance that the tips of the cutting elements extend from a binder material, such as an organic binder, can also be affected by considering how much of the cutting elements extend above the binder compared to how much of the cutting elements remain submerged beneath the binder surface. In one aspect, a ratio of an amount the cutting elements protrude above the binder to an amount submerged beneath the binder is about 4 to 1. In another aspect, about 2/3 of the cutting elements are submerged, with about 1/3 being exposed above the binder. Other ratios are also possible, from a 20 to 1 ratio to about 0.2 to 1, inclusive of ranges therebetween.

As a non-limiting example, in one aspect a CMP pad dresser can include a support substrate, such as a rigid support substrate, and a monolayer of a plurality of superabrasive particles coupled to the support substrate, where the plurality of superabrasive particles includes a plurality of working superabrasive particles. In use the dresser can be engaged against a CMP pad and cut asperities into the CMP pad having a cutting depth of less than or equal to about 50 microns. In another aspect, the cutting depth is from about 10 microns to about 50 microns. Additionally, in one aspect the plurality of working superabrasive particles includes at least 100 working superabrasive particles, at least 300 working superabrasive particles, or at least 500 working superabrasive particles. In another aspect, the plurality of working superabrasive particles includes at least 1000 working superabrasive particles. In yet another aspect, the plurality of working superabrasive particles includes from about 1000 to about 6000 working superabrasive particles. In a further aspect, the plurality of working superabrasive particles includes from about 2000 to about 5000 working superabrasive particles. In yet another aspect, the plurality of working superabrasive particles includes at least about 1000 working superabrasive particles that protrude from the rigid support substrate to distances within about 30 microns of one another.

It is noted that, in some cases, the number of working superabrasive particles can be determined by observing edge or tip wear after use in a dressing operation. As such, in one aspect a CMP pad dresser can have greater than about 300 superabrasive particles with worn tips or edges following a CMP pad dressing procedure. In another aspect, a CMP pad dresser can have greater than about 500 superabrasive particles with worn tips or edges following a CMP pad dressing procedure. In a further aspect, a CMP pad dresser can have greater than about 1000 superabrasive particles with worn tips or edges following a CMP pad dressing procedure.

In one example, superabrasive particles can be described in terms of the distance that each superabrasive particle protrudes from the bonding material, or matrix layer. The difference in protrusion distance between the highest protruding tip and the next highest protruding tip of the monolayer of superabrasive particles is described as the protrusion difference. In one aspect, the protrusion difference can be less than or equal to about 50 microns. In

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another aspect, the protrusion difference can be less than or equal to about 20 microns. In a further aspect, the protrusion difference can be less than or equal to about 10 microns. It is noted that the term "protrusion difference" can also be used to describe the difference in protrusion distance between any two or more superabrasive particles.

In another aspect, and in addition to the protrusion difference between the highest two protruding tips, the difference in protrusion distance between the highest 10 protruding tips of the mono layer of superabrasive particles are within about 30 microns or less. In yet another aspect, the difference in protrusion distance between the highest 10 protruding tips of the mono layer of superabrasive particles are within about 20 microns or less.

Additionally, in some aspects the difference in protrusion distance between the highest 1% of the protruding tips of the first mono layer of superabrasive particles can be within about 80 microns or less. In other words, for the 1% of the purity of superabrasive particles that have the highest protruding tips, the variance in protrusion distance for that 1% is less than or equal to about 80 microns. For example, the two highest protruding superabrasive particles protrude to within about 10 microns or less of each other, and in addition, the highest protruding 1% of superabrasive particles protrude to within about 80 microns or less of each other. In yet another aspect, the difference in protrusion distance between the highest 1% of the protruding tips of the mono layer of superabrasive particles are within about 60 microns or less. In yet another aspect, the difference in protrusion distance between the highest 1% of the protruding tips of the mono layer of superabrasive particles are within about 40 microns or less.

It is noted that the recited protrusion distances can include a distribution across the entire mono layer surface or a discrete area or segment of the mono layer. For example, the highest 1% of protruding tips can be located around the periphery of the mono layer. In one aspect, for example, substantially all of the asperities are cut in the CMP pad by superabrasive particles located at a peripheral location of the dresser. In another aspect, the peripheral location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 90% of the dresser radius. In yet another aspect, the peripheral location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 50% of the dresser radius. In a further aspect, the peripheral location extends from an outer edge of the dresser inwardly toward a center point of the dresser for up to about 33% of the dresser radius. Additionally, in some aspects, substantially all of the superabrasive particles are located at a peripheral location of the dresser. In other aspects, substantially all of the superabrasive particles are arranged in a uniform predetermined pattern at a peripheral location of the dresser.

In another example, discrete regions of etched superabrasive particles can be located within a larger area of superabrasive particles having a lower protrusion distance than the etched portion. It is also contemplated that the mono layer can include multiple regions or segments of superabrasive particles that are etched as described, within a larger area of superabrasive particles having a lower protrusion distance.

Thus, the relative etching of the mono layer of superabrasive particles can greatly affect the morphology and distribution of asperities cut into the CMP pad by the dresser. For example, in one aspect, the mono layer is etched such that rotating the dresser against the CMP cuts asperities having a maximum cutting depth of about 80 microns. In another aspect, the mono layer is etched such that rotating the dresser against the CMP cuts asperities having a maximum cutting depth of about 60 microns. In yet another aspect, the mono layer is etched such that rotating the dresser against the CMP cuts asperities having a maximum cutting depth of about 40 microns. By forming pointed asperities, the contact pressure between the work piece and the CMP pad is increased, thus improving the polishing characteristics of the pad. As these pointed regions begin to flatten, the contact pressure begins to decrease, and a slurry located therebetween is less effectively pressed against the work piece. In some aspects it can be beneficial for the contact area between the pad and the wafer to be less than or equal to about 1% of the total wafer surface area facing the pad. In other aspects, it can be beneficial for the contact area between the pad and the wafer to be less than or equal to about 0.1% of the total wafer surface area facing the pad. This small contact area is due to the wafer being perched on the contact points of the asperities. During the polishing process, the sharp tips of the asperities become worn, thus increasing the contact area and decreasing the contact pressure to a point whereby the slurry abrasives do not effectively abrade the wafer. At this point the removal rate of material from the wafer drops, and the pad needs to be redressed to sharpen the asperities.

Additionally, the load placed on the CMP pad by the dresser can affect the morphology of the spacers, such as, in some cases, the asperity depth. The load can be adjusted for a given dresser to adjust penetration depth. In one aspect, for example, the load can be from about 0.1 Kg to about 60 Kg. In other aspects, the load can be from about 2 Kg to about 20 Kg. In further aspects, the load may be from about 6 Kg to about 12 Kg. In some aspects the load may be Kg/m². For example, in one aspect an 11.5 Kg load can allow a material removal rate from the wafer of about 200 microns per hour for Cu layers. In a related example, an 11.5 Kg load can allow a material removal rate from the wafer of about 100 microns per hour for oxides. In many cases, a lower load can be used in order to minimize the superabrasive particle damage (e.g., less than or equal to about 2 Kg).

Furthermore, etching of the tips of the superabrasive particles in the mono layer allows differing amounts of superabrasive particles to actually cut asperities into the pad. In one aspect, for example, the tips are etched such

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that at least 100 tips of the purity of superabrasive particles cut asperities into the CMP pad as the dresser is rotated. In another aspect, the tips are evened such that at least 50 tips of the purity of superabrasive particles cut asperities into the CMP pad as the dresser is rotated. In a further aspect, the tips are evened such that at least 25 tips of the purity of superabrasive particles cut asperities into the CMP pad as the dresser is rotated.

Additionally, various methods can be utilized to measure superabrasive particle height to determine the difference in protrusion distance between tips. As such, any method for making such a determination is considered to be within the present scope. It should be noted that for the purposes of the present disclosure, the term "protrusion" refers to the height of a particle relative to some reference point. Techniques for such measurements can include direct measurements of the particle heights relative to a reference point such as, for example, the highest particle tip, a surface of a rigid support, the bottom surface of the matrix, etc. Measurements of particle height from the surface of the matrix material can be problematic, however, due to the irregular nature of such materials due to working around the superabrasive particles. In those cases whereby the matrix material is uniform, such a surface may be used to determine particle height. Additionally, a relative protrusion or height difference between two particles would be the difference in the heights between these particles measured from a common reference point. Furthermore, in some cases the superabrasive particles may have a long slope, curvature, or some other arrangement that is not parallel to the underlying support, such as, for example, a meta support layer. In these cases, the protrusion height would be normalized against the slope, curvature, or other arrangement so that the relative protrusion height difference between particles can be measured in the absence of the slope, curvature, etc. It should be noted that superabrasive particle height evening can, in some cases, be independent from the positioning or patterning of the superabrasive particles across the surface of the dresser.

One example of a direct measurement technique can include an optical scanning process to evaluate superabrasive particle positions. In one such process, an optical scanner can scan the surface of the CMP pad dresser to determine the height of the superabrasive particles relative to a fixed point. For example, the scanner can scan downward in space toward the dresser until the highest tips are located. The highest tip can then be set to the reference point, and the scanner can continue scanning in a direction toward the dresser measuring the distance from the reference point to each superabrasive particle tip across the surface of the dresser. Accordingly, the difference in protrusion distance between any of the superabrasive particles across the dresser can be directly measured.

Furthermore, measurement techniques can also include indirect measurements, such as, for example, applying the diamond monolayer to a deformable substrate that deforms relative to the protrusion distance of the particles. The diamond monolayer can be pressed into the deformable substrate and/or moved across the deformable substrate to form a scratch pattern therein. Tip height can thus be extrapolated from such indirect measurements.

Numerous configurations for designed profiles are possible depending on the particular use of the abrading tool, and such designed profiles are considered to be within the present scope. In one aspect, for example, the designed profile can be a plane. In planar profiles, the highest protruding points of the superabrasive particles are intended to be substantially even in the traditional sense. It is important to point out that, though it is preferred that these points align with the designed profile, there may be some height deviation between superabrasive particles that occur due to limitations inherent in the manufacturing process.

In addition to planar profiles, in another aspect of the present invention the designed profile has a slope. Tools having sloping surfaces may function to more evenly spread the frictional forces imparting thereon across the superabrasive particles, particularly for rotating tools such as disk sanders and CMP pad dressers. The greater downward force applied by higher central portions of the tool may offset the higher rotational velocity at the periphery, thus reducing the mechanical stress experienced by superabrasive particles in that location. As such, the slope may be continuous from a central point of the tool to a peripheral point, or the slope may be discontinuous, and thus be present on only a portion of the tool. Similarly, a given tool may have a single slope or multiple slopes. In certain aspects, the tool may slope in a direction from a central point to a peripheral point, or it may slope from a peripheral point to a central point. Various slopes are contemplated that may provide a benefit to so called organic materials. It is not intended that the claims of the present invention be limited as to specific slopes, as a variety of slopes in numerous different tools are possible. In one aspect, however, a CMP pad dresser may benefit from an average slope of 1/1000 from the center to the periphery.

Furthermore, in certain aspects the designed profile may have a curved shape. One specific example of a curved shape is a dome shape CMP pad dresser. Such curved profiles function in a similar manner to the sloped surfaces. CMP pad dressers may include such curved profiles in order to more effectively distribute the frictional forces between any of the superabrasive particles, thus reducing failures of individual particles and prolonging the life of the dresser. Also, CMP pad dressers can have designed profiles that combine any of a plane, a slope, a curved shape, a dome shape, and the like, into a variety of complex profiles.

In another aspect of the present disclosure, a CMP pad dresser can include a support substrate, such as a rigid support substrate, and a monolayer of a purity of superabrasive particles coupled to the support substrate, where

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each superabrasive part in the mono layer extends away from the support substrate to a protrusion distance, and where the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the mono layer of superabrasive parts is less than or equal to about 50 microns. Additionally, the difference in protrusion distance between the highest 1% of the protruding tips of the mono layer of superabrasive parts are within about 80 microns or less. In another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In a further aspect, the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns.

In another aspect of the present disclosure, a CMP pad dresser is provided including a support substrate and a plurality of superabrasive parts secured to the support substrate and positioned to engage and dress a CMP pad, where the plurality of superabrasive parts cut to depths of less than 50 microns into a CMP pad during a dressing procedure.

In a further aspect, a method of dressing a CMP pad is provided. Such a method can include applying a CMP pad dresser to a CMP pad, and moving at least one of the CMP pad or the CMP pad dresser with respect to one another to cut asperities into the CMP pad having a cutting depth of from about 10 microns to about 50 microns. As one non-limiting example, an exemplary CMP pad can include a support substrate and a mono layer of a plurality of superabrasive parts coupled to the support substrate, where the plurality of superabrasive parts includes a plurality of working superabrasive parts.

In one exemplary aspect, as is shown in FIG. 1, a CMP pad dresser 100 includes a mono layer of a plurality of superabrasive parts 102 coupled to a support substrate 104 with, for example, a bonding material 105. Each superabrasive part in the mono layer protrudes to a protrusion distance from the support substrate. The difference in protrusion distance 106 between the highest protruding tip 108 and the next highest protruding tip 110 of the mono layer of superabrasive parts is described as the protrusion difference. In one aspect, the protrusion difference can be less than or equal to about 50 microns. In another aspect, the protrusion difference can be less than or equal to about 20 microns. In a further aspect, the protrusion difference can be less than or equal to about 10 microns. It is noted that the term "protrusion difference" can also be used to describe the difference in protrusion distance between any two or more superabrasive parts.

A variety of materials are contemplated for use as superabrasive parts. Any superabrasive known that can be utilized in a CMP pad dresser should be considered to be within the present scope. Non-limiting examples of such materials include diamond materials, nitride materials, ceramics, and the like. In one aspect, the superabrasive parts include diamond materials. Such diamond materials can include natural or synthetic diamond, single crystals, polycrystals, and the like. In another aspect, the superabrasive parts include cubic boron nitride materials.

It is intended that the scope of the present disclosure include superabrasive parts of a conceivable sizes that would be useful in dressing a CMP pad. Aspects of the present disclosure, however, specifically allow the retention of superabrasive parts in a CMP pad dresser of sizes that have not previously been feasible for use in metal tool making using traditional techniques with parts exposed and arranged in a pattern. In one aspect, superabrasive parts may range in size from about 30 microns to about 250 microns. In another aspect, superabrasive parts may range in size from about 100 microns to about 200 microns. In yet another aspect, superabrasive parts can range from 100 microns to 150 microns. Additionally, various diamond particle sizes can be used, including mesh sizes such as 10/20, 30/40, 80/90, 90/100, 100/120, 120/140, 140/170, 170/200, 200/230, 230/270, 270/325, and 325/400.

Additionally, the plurality of the superabrasive parts can be oriented so as to affect dressing performance of a CMP pad. Orienting the superabrasive parts in a specific attitude relative to the CMP pad to be dressed creates different asperities on the pad surface, thus affecting the performance of the CMP pad. Different asperities result in different manners and thus provide a workpiece differently according to asperity depth, width, density, etc. The superabrasive parts of a CMP pad dresser can be oriented according to the desired polishing characteristics of the CMP pad. For example, if the superabrasive parts predominantly have an apex oriented towards the CMP pad, the asperities of the pad will be narrow and deep. The advantages of narrow and deep asperities are that the pad can better retain the polishing slurry, and thus the polishing rate of the wafer increases. However, the increased polishing rate may also increase the wear rate of the superabrasive parts. As such, wear rate may vary depending on the attitude of the superabrasive parts, and therefore, the orientation of each superabrasive part may be considered when designing a device with desired performance characteristics. Generally speaking, superabrasive parts attitudes that provide higher dressing rates (i.e. deeper penetration into a pad) also wear parts out at a higher rate.

In contrast, if the superabrasive particles are oriented with a face towards the pad, the resulting asperities may polish at a lower rate. The face of the particles generally thought to be more durable, but does not typically cut deep and narrow asperities in the pad, but rather asperities that are shallow and broad. Therefore the face portion of a particle will dress a CMP pad at a reduced rate compared to the apex portion of a particle, but the superabrasive particle will wear at a much lower rate.

The edge portions of a superabrasive particle have dressing and wear characteristics that are between those of the face and apex portions. It has been thought that if the edge portion is used to dress a CMP pad, the asperities are not as deep or narrow as those dressed with an apex portion, but may provide asperities having desirable intermediate characteristics. Further, the edge portion of the particle does not wear at such a high rate as that of an apex.

In one aspect, the purity of superabrasive particles are substantially configured in an attitude having either an apex portion or an edge portion oriented toward a pad to be dressed. In another aspect, the purity of superabrasive particles are substantially configured in an attitude having either an edge portion or a face portion oriented toward a pad to be dressed. In yet another aspect, the purity of superabrasive particles can be configured in an attitude having a sharp portion oriented towards a pad to be dressed. In a further aspect, the purity of superabrasive particles can be configured in an attitude having an apex portion oriented towards a pad to be dressed.

A CMP pad dresser having a substantially evened top arrangements can have a low scratch rate because superabrasive particles are essentially pulled out of the matrix layer due to the more uniform protrusion distribution compared to traditional dressers. Additionally, the more uniform protrusion distribution of such a dresser allows the condition of CMP pads in such a manner as to facilitate good polishing rates while at the same time extending the effective working life of the dresser. These benefits can be affected by, for example, uniform asperity spacing and sized distribution in the CMP pad.

CMP pad dressers having substantially evened or evened superabrasive particle tips can be made using various manufacturing techniques, and any such techniques considered to be within the present scope. The following description provides a few non-limiting descriptions of such exemplary processes.

In one aspect, for example, a CMP pad dresser can be made using a brazing process, and as such would generally include a support substrate and a purity of superabrasive particles coupled to the support substrate by a metal or metal alloy braze material. As has been described, traditional brazing techniques create warpage in the dresser as the braze material cools. As such, superabrasive particle tips that were evened prior to brazing are substantially damaged in the manufactured dresser. Therefore, steps to minimize or eliminate the warpage must be taken when using a braze process in order to maintain the evening. Various techniques to minimize or eliminate warpage are contemplated, and any such techniques considered to be within the present scope.

As one general example, a CMP pad dresser can be made in at least a two stage process, where the first stage is performed in a manner that minimizes perturbations of the evened tips in a process that would normally significantly move the superabrasive tips out of a evened arrangement, such as, for example, by brazing. The second stage of the process can further enhance the evening of superabrasive particle tips across the CMP pad dresser. Other examples may include utilizing lower temperature alloys, using slow temperature ramping in heating and/or cooling of the support substrate, using additional mechanical support to firmly hold the support substrate from moving when warpage occurs, and the like.

Warpage can also be minimized or eliminated through the structural design of the dresser. For example, in one aspect a CMP pad dresser can include a first monolayer of superabrasive particles disposed on one side of a metal support layer and a second monolayer of superabrasive particles disposed on the metal support layer on an opposite side from the first monolayer. The superabrasive particles of the second monolayer are positioned to have substantially the same distribution as the superabrasive particles of the first monolayer. A rigid support is coupled to the second monolayer of superabrasive particles opposite the first monolayer to provide support to the dresser.

As is shown in FIG. 2, for example, a first monolayer of superabrasive particles 202 is arranged on a surface of a support substrate 204. A second monolayer of superabrasive particles 206 is arranged on the support substrate 204 on a side that is opposite to the first monolayer. As is discussed further below, in some cases the first and second monolayers of superabrasive particles can be arranged such that corresponding superabrasive particles across the support layer are in substantial alignment, as is shown in FIG. 2. In other cases, the superabrasive particles of the first and second monolayers can be arranged in a substantially similar distribution, but may or may not be substantially aligned with one another across the support substrate.

The disposition of a monolayer of superabrasive particles on each side of the support substrate thus moderates the thermal shrinkage from the brazing temperature that would otherwise buckle a distribution of superabrasive particles arranged on just one side. By applying a monolayer to each side of the support substrate, warping forces such as thermal movement and pressure can be equalized or substantially equalized from both sides. As such, the warpage

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of the support substrate can be minimized. In other words, the forces responsible for warpage are applied substantially equally to each side of the support substrate and can thus at least partly cancel one another out, thus minimizing warpage that can otherwise occur. In some aspects, the superabrasive particles making up the monolayers on each side of the support substrate can have matching configurations, patterns, or orientations to one another. In this way there can be a substantially matching spatial arrangement of superabrasive particles on each side of the support substrate. In another aspect, the configurations, patterns, or orientations can be different or varied from one another, or may be partly matching. In yet another aspect, the patterned placement of the superabrasive particles on one side of the support substrate can be substantially aligned with the pattern of superabrasive particles on the other side of the support substrate so that particle locations match one another. In some aspects, there can be a direct correspondence between the spatial positioning of superabrasive particles on one side of the support substrate and the spatial positioning of superabrasive particles on the other side of the meta support substrate. In another aspect, the patterns of superabrasive particles may match or substantially match one another, but may be offset on opposite sides of the support substrate so that particle locations do not match one another.

Accordingly, minimizing the warpage of the support substrate can maintain a greater degree of evenness of superabrasive particle positions in the finished tool. When heat and/or pressure are used to make a superabrasive tool, warpage of the support substrate can cause great variations in top height even, even for those particles that were evened prior to heating and/or applying pressure. In one aspect, distributing the warpage forces equally or substantially equally on both sides of a support substrate through the arrangement of the superabrasive particles can effectively cancel forces on opposite sides and thus greatly reduce the degree of warpage occurring in the support substrate, thus also minimizing the relative height movement of the superabrasive particles relative to one another. In other aspects, CMP pad dressers can be made using processes that do not utilize high pressure and/or high temperature.

The support substrate can be any material capable of supporting the diamond monolayer during tool formation. Such materials can include, without limitation, metal materials, metal alloy materials, brazed alloy materials, ceramic materials, composites, and the like.

In one aspect, the superabrasive particles can be arranged into a predetermined pattern. Such a pattern can be a uniform distributed pattern or a non-uniform distributed pattern. Additionally, a variety of techniques are contemplated to facilitate the arrangement of superabrasive particles into a predetermined pattern. Predetermined is understood to mean a non-random pattern that has been determined prior to arranging the superabrasive particles. In one aspect, a predetermined pattern can also apply to a predetermined spacing between particles. Non-limiting examples of such techniques include arrangement by a template, arrangement using spots of adhesives, arrangement on a first substrate followed by a pattern specific transfer from the first substrate to the support substrate, and the like, including combinations thereof. The superabrasive particles from either of the monolayers can be temporarily held in position in the predetermined pattern using a variety of techniques, including without limitation, adhesives, deposited locations on the meta support matrix, a supporting compound such as, for example, a wax, and the like, including combinations thereof. In one specific aspect, the superabrasive particles can be temporarily coupled to the support substrate using an adhesive that then volatilizes away and is eliminated during construction of the dresser.

In one aspect, the predetermined pattern can be a uniform distributed grid. In another aspect, the predetermined pattern can be an annular configuration having a central region devoid of superabrasive particles. In one specific aspect, the annular configuration can include an annular ring. In another specific aspect, the annular configuration can include a portion of an annular ring. In yet another aspect, an annular configuration can include one or more concentric annular rings nested inside one another. In other aspects, the monolayer distribution can be discretized along regions, spiral regions, and the like.

In another aspect, as is shown in FIG. 3, a first monolayer of superabrasive particles 302 is arranged on a surface of a support substrate 304. A second monolayer of superabrasive particles 306 is arranged on the support substrate 304 on a side that is opposite to the first monolayer. A bonding material 308 secures the first monolayer and the second monolayer to the support substrate 304. The bonding material can be any material capable of securing the first and second monolayer to the support substrate. In one aspect, the bonding material can be the same for securing the first monolayer and the second monolayer, while in other aspects the bonding material can be different for securing the first monolayer and the second monolayer.

It is noted that the various descriptions of materials, attachment techniques, and the like, can be generally applicable to any CMP pad dresser design to which such materials, techniques, and the like are applicable. For example, a material that can be used to secure a superabrasive particle to a substrate can be used in both dual monolayer and single monolayer dresser designs.

Accordingly, the bonding material can be any material capable of securing superabrasive particles therein. Non-limiting examples of bonding materials include metal brazes, metal braze alloys, organic matrix materials, sintered materials, ectropated materials, and the like, including combinations thereof.

In one aspect, for example, the superabrasive particles can be brazed to the support substrate, and thus the bonding material can be a metal braze or metal braze alloy. Metal brazing techniques are known in the art. A green braze material can be applied to the support substrate on or around the superabrasive particles. The metal braze can be applied in any known configuration, including braze sheets, powders, pastes, sprays, and the like, including combinations thereof. Once applied to the support substrate, the braze can be heated and melted to coat at least a portion of the support substrate and to bond the superabrasive particles. The heating temperature can vary depending on the braze material used, but in one aspect can be from about 700° C. to about 1200° C.

In one non-limiting example, the superabrasive particles can be bonded to the support substrate by brazing with a nickel-based alloy containing chromium. In another example, the brazing can include pressing the superabrasive particles with a flat ceramic material that cannot be bonded to the braze in order to leave the superabrasive particles intact. Various braze alloys are contemplated, including non-limiting examples such as BN₂, BN₇, and the like.

Additionally, in one aspect superabrasive particles can be coupled to the support substrate by an electrodeposition process, and thus the bonding material can be an electrodeposited metal material. As an example of a suitable method for positioning and retaining abrasive materials prior to and during the electrodeposition process, a mold can be used that includes an insulating material that can effectively prevent the accumulation of electrodeposited material on the molding surface. Superabrasive particles can be held on the molding surface of the molding electrodeposition. As such, the accumulation of electrodeposited material can be prevented from occurring on the particles and the working surface of the pad conditioner substrate. Such techniques are described in U.S. patent application Ser. No. 11/292,938, filed Dec. 2, 2005, which is hereby incorporated herein by reference.

In another aspect, the superabrasive particles can be bonded to the support substrate by sintering, and thus the bonding material can include a sintering material. For example, the bonding of the superabrasive particles to the support substrate can include depositing a sintering compound on the support substrate in contact with the periphery of superabrasive particles, and sintering the sintering compound to bond the superabrasive particles to the support substrate. Suitable sintering methods will be readily appreciated by one of ordinary skill in the art having possession of this disclosure. Basically, a sintering compound is applied around the superabrasive particles and in contact with the support substrate. The sintering compound can be any known sintering material that can be used to secure superabrasive particles to a substrate. Non-limiting examples of such materials can include metal and metal alloy powders, ceramic powders, and the like. One specific non-limiting example of a sintering compound is cobalt powder.

Once the sintering compound has been applied around the superabrasive particles and to the support substrate, heat and in some cases pressure can be applied to cause sintering to occur. In some aspects, a braze or braze alloy can be infiltrated into the sintering compound during bonding to further strengthen the bonding material matrix.

In yet another aspect, sintering can be used to sinter the periphery of superabrasive particles into a CMP pad dresser, where the support substrate is the sintering material. In this case, the above recited procedure can be repeated without the use of a support substrate.

In another aspect, heat and pressure can be applied to bond the periphery of superabrasive particles directly into the support substrate. Thus, upon the application of heat and pressure, the support substrate can be softened or partially melted. The superabrasive particles are then pressed into the support substrate. A planar leveling surface can be used to apply pressure to the monolayer of superabrasive particles to thus maintain the level nature of the superabrasive particles as the superabrasive particles are pressed into the support substrate. Pressure can be maintained upon the support substrate and superabrasive particles until cooled, thus minimizing warping.

In yet another aspect, as is shown in FIG. 4, a dual monolayer CMP pad dresser can include a first monolayer of superabrasive particles **402** and a second monolayer of superabrasive particles **406** coupled to a support substrate **404**. The superabrasive particles can be coupled to the support substrate directly or via a bonding material. The second monolayer of superabrasive particles **406** is coupled to a second support substrate **408**. A portion of the second support substrate is shown removed in FIG. 4 to expose the second monolayer. The second support substrate **408** can facilitate handling and use of the CMP pad dresser. By bonding the superabrasive particles of the second monolayer to the second support substrate, the first monolayer of superabrasive particles remains exposed for CMP pad conditioning operations.

The second support substrate can be made from any material compatible with the abrading or dressing process. Such materials can include polymeric materials, metal materials, ceramic materials, glasses, composites, and the like. In one aspect, the second support substrate can be a polymeric material and the second monolayer of superabrasive particles can be embedded therein using heat, pressure, adhesives, etc. In some aspects, the second support substrate can be a non-polymeric material such as a metal layer. In such cases, the superabrasive particles

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can be bonded to the second support substrate by adhesive attachment, soldering, brazing, electroplating, and the like. For brazing techniques, care can be taken to minimize or eliminate warpage in the substrate during the heating and cooling process. In another aspect, one or more magnetic elements can be placed into the second support substrate to attract and hold the CMP pad dresser in place, thus forming a temporary attachment. An optional locking mechanism can be utilized to further immobilize the CMP pad dresser to the second support substrate during use. In some aspects the second support substrate can include surface features to hold the dresser in place during rotational movement against a CMP pad. The second support substrate can have approximately the same diameter as the meta support layer, a larger diameter than the meta support layer, or, in some cases, a smaller diameter than the meta support layer.

In another aspect, a CMP pad dresser can be comprised of a plurality of dressing segments having a plurality of leveled superabrasive particles, where the plurality of dressing segments are held in place by a rigid support or support substrate. Such a design allows a plurality of smaller dressing segments to be manufactured having precise leveled tops. Smaller diameter support layers in these dressing segments can be made by processes involving heat and/or pressure with less warpage due to the smaller size. For example, a 4 inch diameter meta disc can exhibit greater warpage due to brazing as compared to a 0.5 inch diameter meta disc. Thus thermal distortion and particle floating problems are decreased. A plurality of such dressing segments can then be coupled to a larger diameter support substrate by processes that do not introduce significant warpage, such as bonding in an organic material. Such dressing segments can have one or more layer(s) of superabrasive particles coupled to a support layer. In one aspect, a segment can have a single layer of superabrasive particles coupled to a support layer. In another aspect, a segment can have a layer of superabrasive particles coupled to each side of a support layer, as has been described herein. Thus, this process allows the manufacture of CMP pad dressers that can have precise protrusions to tolerances. Additionally, in one aspect, each dressing segment can have at least three superabrasive particles that protrude to the greatest extent. If the three highest protruding superabrasive particles on every dressing segment are leveled across the entire support substrate, a CMP pad dresser is made having very precise leveling across the entire surface. If, for example, ten dressing segments are used to make the CMP pad dresser, then the highest protruding thirty superabrasive particles in the too will have effectively the same protrusion distance and be substantially leveled. Various additional details regarding dressing segments are detailed in U.S. patent application Ser. No. 13/034,213, filed Feb. 24, 2011, which is hereby incorporated herein by reference.

Various organic materials are contemplated for use as a support substrate, and/or to secure a second monolayer of superabrasive particles and/or the dressing segments to the support substrate. Examples of suitable organic materials include, without limitation, amorphous resins, acrylic resins, polyether resins, polyamide resins, polyimide resins, polyurethane resins, phenolic resins, phenolic/atex resins, epoxy resins, isocyanate resins, isocyanurate resins, polysiloxane resins, reactive vinyl resins, polyethylene resins, polypropylene resins, polystyrene resins, phenoxypolymer resins, polyimide resins, polyurethane resins, acrylic resin-butadiene-styrene resins, acrylic resins, polycarbonate resins, polyimide resins, and mixtures thereof. In one specific aspect, the organic material can be an epoxy resin. In another aspect, the organic material can be a polyimide resin. In yet another aspect, the organic material can be a polyurethane resin.

Additionally, so-called "reverse casting" methods can be used to accurately orient and attach the dressing segments to the support substrate. Such methods can include creating a security of dressing segments to a substrate using a "mask" material. The portions of the dressing segments protruding from the mask material can then be attached to the rigid support using the methods discussed herein, after which (or during which), the mask material can be removed.

When an organic material is utilized, methods of curing the organic material can be a variety of processes known to one skilled in the art that cause a phase transition in the organic material from at least a pliable state to at least a rigid state. Curing can occur, without limitation, by exposing the organic material to energy in the form of heat, electromagnetic radiation, such as ultraviolet, infrared, and microwave radiation, particle bombardment, such as an electron beam, organocatalysts, inorganocatalysts, or any other curing method known to one skilled in the art.

In one aspect of the present invention, the organic material can be a thermoplastic material. Thermoplastic materials can be reversibly hardened and softened by cooling and heating respectively. In another aspect, the organic material layer may be a thermosetting material. Thermosetting materials cannot be reversibly hardened and softened with the thermoplastic materials. In other words, once curing has occurred, the process can be essentially irreversible, if desired.

As a more detailed list of what is described above, organic materials that may be useful in embodiments of the present invention include, but are not limited to: amorphous resins including akyated urea-formaldehyde resins, melamine-formaldehyde resins, and akyated benzoguanamine-formaldehyde resins; acrylic resins including vinyl acrylates, acrylic epoxies, acrylic urethanes, acrylic polyethers, acrylic polyethers, vinyl ethers, acrylic oxides, acrylic siloxanes, and associated methacrylates; akyated resins such as urethane akyated resins; polyether resins; polyamide resins; polyimide resins; reactive urethane resins; polyurethane resins; phenolic resins

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such as resorcinol and novolac resins; phenolic/atex resins; epoxy resins such as bisphenol epoxy resins; isocyanate resins; isocyanurate resins; polyoxane resins; including a polyarylate resins; reactive vinyl resins; resins marketed under the Bake-It™ trade name, including polyethylene resins, polypropylene resins, epoxy resins, phenolic resins, polystyrene resins, phenoxyl resins, perylene resins, polysulfone resins, ethylene copolymer resins, acrylonitrile-butadiene-styrene (ABS) resins, acrylic resins, and vinyl resins; acrylic resins; polycarbonate resins; and mixtures and combinations thereof. In one aspect of the present invention, the organochemical material may be an epoxy resin. In another aspect, the organochemical material may be a polyimide resin. In yet another aspect, the organochemical material may be a polyurethane resin.

Numerous additives may be included in the organochemical material to facilitate its use. For example, additional crosslinking agents and fillers may be used to improve the cured characteristics of the organochemical material. Additives, sovents may be utilized to alter the characteristics of the organochemical material in the uncured state. Also, a reinforcing material may be disposed within at least a portion of the solidified organochemical material. Such reinforcing material may function to increase the strength of the organochemical material, and thus further improve the retention of the individual abrasive segments. In one aspect, the reinforcing material may include ceramics, metals, or combinations thereof. Examples of ceramics include alumina, aluminum carbide, silica, silicon carbide, zirconia, zirconium carbide, and mixtures thereof.

Additives, in one aspect a coupling agent or an organometallic compound may be coated onto the surface of a superabrasive material to facilitate the retention of the superabrasive particles in the organochemical material via chemical bonding. A wide variety of organochemical and organometallic compounds is known to those of ordinary skill in the art and may be used. Organometallic coupling agents can form chemical bonds between the superabrasive materials and the organochemical material, thus increasing the retention of the superabrasive materials therein. In this way, the organometallic coupling agent can serve as a bridge to form bonds between the organochemical material and the surface of the superabrasive material. In one aspect of the present invention, the organometallic coupling agent can be a titanate, zirconate, silane, or mixture thereof. The amount of organometallic coupling agent used can depend upon the coupling agent and on the surface area of the superabrasive material. Often times, 0.05% to 10% by weight of the organochemical material may be sufficient.

Specific non-mitting examples of silanes suitable for use in the present invention include: 3-glycidypropyltrimethoxysilane (available from Dow Corning as Z-6040); γ-methacryloxypropyltrimethoxysilane (available from Union Carbide Chemicals Company as A-174); β-(3,4-epoxycyclohexyl)ethyltrimethoxysilane, γ-aminopropyltriethoxysilane, N-(β-aminooethyl)-γ-aminopropylmethyldimethoxysilane (available from Union Carbide, Shin-etsu Kagaku Kogyo K.K., etc.). Specific non-mitting examples of titanate coupling agents include: isopropyltriisostearoyltitanate, dicumylphenylateoxyacetate titanate, 4-aminobenzenesulfonate dodecyl benzenesulfonate titanate, tetraoctylbis(ditridecyl phosphite) titanate, isopropyltri(N-ethylammonioethyl)titanate (available from Kenrich Petrochemicals, Inc.), neosilyl titanates such as LICA-01, LICA-09, LICA-28, LICA-44 and LICA-97 (also available from Kenrich), and the like. Specific non-mitting examples of aluminum coupling agents include acetoxysilane aluminum diisopropylate (available from A. Nomoto K.K.), and the like. Specific non-mitting examples of zirconate coupling agents include: neosilyl zirconates, LZ-01, LZ-09, LZ-12, LZ-38, LZ-44, LZ-97 (also available from Kenrich Petrochemicals, Inc.), and the like. Other known organometallic coupling agents, e.g., thiolate based compounds, can be used in the present invention and are considered within the scope of the present invention.

In other aspects of the present disclosure, superabrasive particles can be leveled by reducing the protrusions of particles that are outside of the desired tolerance range. Once such particles are identified, various techniques can be utilized to reduce such protrusions. In one aspect, for example, mechanical abrasion of the dresser can reduce the protruding particles. In another aspect, a vibratory tumbler can be used to individually break such particles. In yet another aspect, a laser such as a Nd:YAG laser can be used to disrupt such particles.

In yet a further aspect of the present disclosure, a CMP pad dresser can include a plurality of superabrasive particles arranged as a working surface, where the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the first mono layer of superabrasive particles is less than or equal to about 20 microns, and where the difference in protrusion distance between the highest 1% of the protruding tips of the first mono layer of superabrasive particles, excluding the highest protruding tip, are within about 80 microns.

In another aspect, a CMP pad dresser can include a plurality of superabrasive particles arranged as a working surface, where the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns, the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns, the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns, and the highest protruding tip has a protrusion distance of greater than or equal to about 50 microns.

It is noted that, while the above disclosure refers primarily to CMP pad dressers, other processes on grinding and/or abrading tools are considered to be within the present scope. As such, the techniques and teaching disclosed herein can additionally be applied to such tools.

Additionally, it is noted that traditional CMP processing techniques, including pad dressing, has limited the critical dimensions of integrated circuits. The presently disclosed CMP dressing devices and techniques can, however, allow processing of wafers having integrated circuit critical dimensions of less than or equal to 45 nm, 32 nm, 28 nm, 22 nm, or less.

Of course, it is to be understood that the above-described arrangements are only illustrative of the application of the principles of the present invention. Numerous modifications and alternative arrangements may be devised by those skilled in the art without departing from the spirit and scope of the present invention and the appended claims are intended to cover such modifications and arrangements. Thus, while the present invention has been described above with particularity and detail in connection with what is presently deemed to be the most practical and preferred embodiments of the invention, it will be apparent to those of ordinary skill in the art that numerous modifications, including, but not limited to, variations in size, materials, shape, form, function and manner of operation, assembly and use may be made without departing from the principles and concepts set forth herein.

Claims:

What is claimed is:

1. A CMP pad dresser, comprising: a rigid support substrate; and a monolayer of a plurality of superabrasive particles coupled to the support substrate, wherein each superabrasive particle in the monolayer extends away from the support substrate to a protrusion distance, wherein a top of each of the plurality of superabrasive particles engages a designated profile with a top variation of from about 5 microns to about 100 microns, and wherein the difference in protrusion distance between the highest protruding top and the second highest protruding top of the monolayer of superabrasive particles is less than or equal to about 50 microns, and the difference in protrusion distance between the highest 1% of the protruding tops of the monolayer of superabrasive particles are within about 80 microns or less.
2. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding top and the second highest protruding top is less than or equal to about 10 microns.
3. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding top and the second highest protruding top is less than about 10 microns.
4. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding top and the 10th highest protruding top is less than or equal to about 20 microns.
5. The dresser of claim 1, wherein the difference in protrusion distance between the highest protruding top and the 100th highest protruding top is less than or equal to about 40 microns.
6. The dresser of claim 1, wherein the plurality of superabrasive particles includes a plurality of working superabrasive particles, such that rotating the dresser against a CMP pad cuts asperities into the CMP pad having a cutting depth of less than or equal to about 50 microns.
7. The dresser of claim 6, wherein the cutting depth is from about 10 microns to about 50 microns.
8. The dresser of claim 6, wherein the plurality of working superabrasive particles includes at least 100 working superabrasive particles.
9. The dresser of claim 6, wherein the plurality of working superabrasive particles includes at least 1000 working superabrasive particles.
10. The dresser of claim 6, wherein the plurality of working superabrasive particles includes from about 1000 to about 6000 working superabrasive particles.
11. The dresser of claim 6, wherein the plurality of working superabrasive particles includes from about 2000 to about 5000 working superabrasive particles.
12. The dresser of claim 6, wherein the plurality of working superabrasive particles include at least about 1000 working superabrasive particles that protrude from the rigid support substrate to distances within about 30 microns of one another.

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13. The dresser of claim 1, wherein the highest protruding tip of each of the plurality of superabrasive particles along the designated profile with a tip variation of from about 10 microns to about 50 microns.

14. The dresser of claim 1, wherein the highest protruding tip of each of the plurality of superabrasive particles along the designated profile with a tip variation of from about 20 microns to about 40 microns.

15. The dresser of claim 1, wherein the highest protruding tip of each of the plurality of superabrasive particles along the designated profile with a tip variation of less than about 20 microns.

16. The dresser of claim 1, wherein the protrusions of the plurality of superabrasive particles produce cutting depths of less than about 20 microns when used to abrade a CMP pad.

17. The dresser of claim 1, wherein the protrusions of the plurality of superabrasive particles produce cutting depths of from about 1 micron to about 20 microns when used to abrade a CMP pad.

18. The dresser of claim 1, wherein the protrusions of the plurality of superabrasive particles produce cutting depths of from about 10 microns to about 20 microns when used to abrade a CMP pad.

19. The dresser of claim 1, wherein the designated profile includes a configuration selected from the group consisting of a plane, a slope, a curved shape, a dome shape, and combinations thereof.

20. The dresser of claim 1, wherein the plurality of superabrasive particles is arranged across the support substrate in a predetermined pattern.

21. The dresser of claim 20, wherein the predetermined pattern includes an even distribution of the plurality of superabrasive particles spaced at a distance of from about 100 microns to about 800 microns.

EXHIBIT 8

Comparison between U.S. Pub. No. 2014/0120724 and U.S. Patent No. 9,724,802
(New subject matter added to the '802 Patent is shown in red)

Description:

PRIORITY DATA

This application is a continuation-in-part of U.S. patent application Ser. No. 12/726,786, filed on Mar. 18, 2010, which is a continuation-in-part of U.S. patent application Ser. No. 12/255,823, filed Oct. 22, 2008, which is a continuation-in-part of U.S. patent application Ser. No. 12/168,110, filed on Jun. 5, 2008, which claims the benefit of U.S. Provisional Patent Application Ser. No. 60/976,198, filed Sep. 28, 2007, and which is a so-called continuation-in-part of U.S. patent application Ser. No. 11/560,817, filed Nov. 16, 2006, which is a continuation-in-part of U.S. patent application Ser. No. 11/357,713, filed Feb. 17, 2006, which claims the benefit of U.S. Provisional Patent Application Ser. No. 60/681,798, filed May 16, 2005. This application is additionally a continuation-in-part of U.S. patent application Ser. No. 12/628,859, filed Dec. 1, 2009, which is a continuation of U.S. patent application Ser. No. 11/804,221, filed May 16, 2007, which is a continuation of U.S. patent application Ser. No. 11/223,786, filed Sep. 9, 2005. This application is a so-called continuation-in-part of U.S. patent application Ser. No. 12/850,747, filed Aug. 5, 2010, which claims the benefit of U.S. Provisional Patent Application Ser. No. 61/246,816, filed on Sep. 29, 2009. This application is further a continuation-in-part of U.S. patent application Ser. No. 13/034,213, filed Feb. 24, 2011, which claims the benefit of U.S. Provisional Patent Application Ser. No. 61/333,162, filed on May 10, 2010. Each of these applications is incorporated herein by reference. This application also claims the benefit of Taiwan Patent Application Ser. No. 101112625, filed on Apr. 10, 2012, which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

For the tiny copper circuit or the interlayer tungsten circuit on the silicon wafer surface, even for the oxide film electrode layer of the insulated circuit, making the surface flat through the planarization process to facilitate the subsequent process steps is necessary. Currently, with the process of manufacture integrated circuits (IC) on the semiconductor wafer, the most outstanding planarization technology is the chemical-mechanical planarization (CMP), which flattens a surface by pressing the wafer grinding on a rotating polishing pad.

The chemical-mechanical planarization is processed by transferring the slurry between the wafer and the polishing pad stably and evenly to soak the polishing pad surface with slurry which contains chemical (for instance, acid and oxidant) to erode the film on the wafer surface. The myriad of nano-ceramics abrasives (ex. SiO₂, Al₂O₃ and CeO₂) in the slurry further pierce and scrape trace film, and simultaneously conduct chemical etching and mechanical grinding to remove the protruding deposit layer on the wafer. The purpose of planarization can be achieved by polishing the wafer surface.

A conditioner, whose function is to polish pad, is a necessary supply for chemical-mechanical planarization. The so-called conditioner is directed to shaving polishing pad surface and removing the waste accumulated on the polishing pad surface to maintain the roughness of the polishing pad surface. In addition, a conditioner could also produce tiny up-fit and compress on the surface, and it is known as the height difference of the asperities. Accordingly, the contact area on the polishing pad would be reduced significantly. Once the contact area becomes smaller, the contact pressure becomes greater to make the slurry at the contact point extrude on the protruding part of the wafer and the chemicals (ex. H₂O₂) in the slurry would be oxidized to soften or erode the wafer.

However, the waste produced in the process of the chemical-mechanical planarization, including the debris of the wafer, ex. copper wires, tungsten feed holes, oxidized film, slurry, abrasives and polishing pad scrap etc, the debris usually accumulates on the polishing pad surface and is pressed to become gase. Once the gase is formed, polishing pad would become slippery and difficult to maintain grinding power. Therefore, after polishing each wafer, it is necessary to utilize a conditioner to achieve the grinding efficiency of the process (ex. polishing speed) and flatness (ex. the thickness distributed of the wafer coating) as to stabilize the wafer quality.

However, previous diamond conditioner is usually secured the diamond on the metal tab surface by binder. Although it is adapted for conditioning the polishing pad, with regard to the more accurate chemical-mechanical planarization process, scratch, particle shedding, erosion and thickness non-uniformity of the wafer would cause easily by the rough asperities of the polishing pad. The smaller the required IC circuit dimensions, the greater the demand to the flatness of the wafer surface, also the greater the demand to the conditioner, and which can lead to previous diamond conditioner not being able to satisfy the pre-requisite of the chemical-mechanical planarization process smaller than 45 nm.

In an effort to obtain a dresser with abrasive tips that are as even as possible, it is often prudent to use diamond abrasives of high shape regularity, and the crystal surface coverage of this kind of crystals quite high, otherwise, using the crystal with low crystal surface coverage would cause an overshooting height difference. Additionally, a diamond having the highest polishing pad penetration ability, the so-called k-diamond, presents no difference when compared to other diamonds with respect to pad height. In order to meet the demand for a smaller circuit dimensions, continuing improvement of the conditioner is necessary. Using the sharper polishing tips and maintaining the flatness of the tips height (i.e. the difference of the polishing tips top height), making conditioner forming the subtler and more uniform neck on the polishing pad, and improving the removal rate to the polishing pad

Comparison between U.S. Pub. No. 2014/0120724 and U.S. Patent No. 9,724,802
(New subject matter added to the '802 Patent is shown in red)

~~s mu~~ltaneou s y, by th s, t s off c ent to remove the hard ayer and recover the asper t es on the po sh ng pad to po sh the coat ng on the wafer rap d y.

The semiconductor industry currently spends in excess of one billion U.S. dollars each year manufacturing silicon wafers that must exhibit very flat and smooth surfaces. Known techniques to manufacture smooth and even-surfaced silicon wafers are plentiful. The most common of these involves the process known as Chemical Mechanical Polishing (CMP) which includes the use of a polishing pad in combination with an abrasive slurry. Of central importance in a CMP process is the attainment of high performance even in aspects such as uniformity of polished wafer, smoothness of the IC circuitry, removal rate for productivity, longevity of consumables for CMP economics, etc.

SUMMARY OF THE INVENTION

~~The present disclosure provides efficient methods, devices, and systems of conditioning a CMP pad. In one aspect, for example, a composite conditioner can include a base plate and a plurality of polishing units secured to a surface of the base plate by an adhesive layer, where each polishing unit includes a plurality of polishing tips secured in a binding layer. Additionally, a height difference between a first highest polishing tip and a second highest polishing tip is less than or equal to about 10 μm , a height difference between the first highest polishing tip and a tenth highest polishing tip is less than or equal to about 20 μm , and a height difference between the first highest polishing tip and a 100th highest polishing tip is less than or equal to about 40 μm . Furthermore, the first highest polishing tip protrudes from the binding layer to a height of greater than or equal to about 50 μm . In some aspects, at least 1% of the plurality of polishing tips actively condition a CMP pad during a conditioning process. In other aspects, less than 40% of the surface of the base plate is covered with polishing units. The polishing units can be arranged on the plate in a variety of configurations. Non-limiting examples can include a serpentine, double rings, multiple rings, radial arrangements, spiral arrangements, and the like.~~

~~In another aspect of the present disclosure, a method of making a composite conditioner can include depositing a second mold on a first mold, where the second mold includes a plurality of holes, placing a polishing unit in each of the plurality of holes of the second mold, where each polishing unit includes a plurality of polishing tips secured in a binding layer, applying an adhesive layer over the second mold to secure the polishing units, and removing the first mold and the second mold to form a composite conditioner. Regarding the conditioner, a height difference between a first highest polishing tip and a second highest polishing tip is less than or equal to about 10 μm , a height difference between the first highest polishing tip and a tenth highest polishing tip is less than or equal to about 20 μm , and a height difference between the first highest polishing tip and a 100th highest polishing tip is less than or equal to about 40 μm and the first highest polishing tip protrudes from the binding layer to a height of greater than or equal to about 50 μm .~~

~~In yet another aspect, a process of chemical mechanical polishing (CMP) can include polishing a wafer against a rotating polishing pad and applying the conditioner as has been described against the polishing pad to remove debris and condition the pad.~~

The present disclosure provides CMP pad dressers and associated methods, including without limitation, methods directed to the manufacture and use of such dressers. In one aspect, for example, a CMP pad dresser can include a support substrate and a plurality of superabrasive particles secured to the support substrate with each superabrasive particle extending away from the support substrate to a protrusion distance. The plurality of superabrasive particles can be positioned such that the highest protruding tip of each of the plurality of superabrasive particles is along a designated profile with a tip variation of from about 5 microns to about 100 microns. In another aspect, the highest protruding tip of each of the plurality of superabrasive particles is along the designated profile with a tip variation of from about 20 microns to about 40 microns. In a further aspect, the highest protruding tip of each of the plurality of superabrasive particles is along the designated profile with a tip variation of less than about 20 microns. The designated profile can include any geometric configuration that can be useful in dressing a CMP pad, and any such configuration is considered to be within the present scope. Non-limiting examples can include a plane, a slope, a curved shape, a dome shape, and the like, including appropriate combinations thereof.

The positioning of superabrasive particles relative to the support substrate can also be described in terms of the depths that the superabrasive particles cut into a CMP pad when used to abrade the CMP pad. In one aspect, for example, the protrusions of the plurality of superabrasive particles produce cutting depths of less than about 20 microns when used to abrade a CMP pad. In another aspect, the protrusions of the plurality of superabrasive particles produce cutting depths of from about 1 micron to about 20 microns when used to abrade a CMP pad. In yet another aspect, the protrusions of the plurality of superabrasive particles produce cutting depths of from about 10 microns to about 20 microns when used to abrade a CMP pad.

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As another exemplary aspect of the present disclosure, a CMP pad dresser can include a rigid support substrate and a monolayer of a plurality of superabrasive particles coupled to the support substrate, where each superabrasive particle in the monolayer extends from the support substrate to a protrusion distance. In one aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 50 microns, and the difference in protrusion distance between the highest 1% of the protruding tips of the monolayer of superabrasive particles is within about 80 microns or less. In another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In a further aspect, the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns.

As yet another exemplary aspect of the present disclosure, a CMP pad dresser can include a rigid support substrate and a monolayer of a plurality of superabrasive particles coupled to the support substrate, where the plurality of superabrasive particles includes a plurality of working superabrasive particles, such that rotating the dresser against a CMP pad cuts asperities into the CMP pad having a cutting depth of less than or equal to about 50 microns. In another aspect, the cutting depth is from about 10 microns to about 50 microns. In yet another aspect, the plurality of working superabrasive particles includes at least 100 working superabrasive particles. In a further aspect, the plurality of working superabrasive particles includes at least 1000 working superabrasive particles. In yet another aspect, the plurality of working superabrasive particles includes from about 1000 to about 6000 working superabrasive particles. In another aspect, the plurality of working superabrasive particles includes from about 2000 to about 5000 working superabrasive particles. In a further aspect, the plurality of working superabrasive particles include at least about 1000 working superabrasive particles that protrude from the rigid support substrate to distances within about 30 microns of one another.

As another exemplary aspect of the present disclosure, a method of dressing a CMP pad can include applying a CMP pad dresser to a CMP pad, and moving at least one of the CMP pad or the CMP pad dresser with respect to one another to cut asperities into the CMP pad having a cutting depth of from about 10 microns to about 50 microns.

As a further exemplary aspect of the present disclosure, a CMP pad dresser is provided including a support substrate and a plurality of superabrasive particles secured to the support substrate and positioned to engage and dress a CMP pad, where the plurality of superabrasive particles cut to depths of less than 50 microns into a CMP pad during a dressing procedure.

There has thus been outlined, rather broadly, various features of the invention so that the detailed description thereof that follows may be better understood, and so that the present contribution to the art may be better appreciated. Other features of the present invention will become clearer from the following detailed description of the invention, taken with the accompanying claims, or may be learned by the practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A to 1G show 1 ~~a few charts~~ schematic ~~s de~~ view of ~~manufacturing a composite conditioner~~ CMP pad dresser in accordance with ~~one~~ an embodiment of the present ~~invention~~ disclosure;

FIG. 2A to 2G show 2 ~~a few charts~~ schematic ~~s de~~ view of ~~manufacturing the composite conditioner~~ CMP pad dresser in accordance with ~~one~~ an embodiment of the present ~~invention~~ disclosure;

FIG. 2H shows 3 ~~a top~~ schematic ~~s de~~ view of a CMP pad dresser in accordance with an embodiment of the present disclosure; and

FIG. 4 ~~compos~~ te 4 ~~s a~~ schematic ~~s de~~ view of a CMP pad dresser in accordance with an embodiment of the present invention;

disclosure.

FIG. 3 ~~shows a comparison chart of the tip height difference and the working granule amount of a conditioner in accordance with one embodiment of the present invention as compared to a prior art conditioner;~~

FIG. 4 ~~shows a comparison chart of the height difference (μm) and the scratch amount of the first highest point and the second highest point of a conditioner in accordance with one embodiment of the present invention as compared to a prior art conditioner;~~

FIG. 5 ~~shows a comparison chart of the scratch amount and the removal rate of a conditioner in accordance with one embodiment of the present invention as compared to a prior art conditioner;~~

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~~FIG. 6 shows a comparison chart of the n-use time and the removing rate of a cond toner n accordance with one embodiment of the present nvention as compared to a pr or art cond toner;~~

~~FIG. 7 shows a comparison chart of the po sh ng wafer amount and the remove rate of a cond toner n accordance with one embodiment of the present nvention as compared to a pr or art cond toner;~~

~~FIG. 8 shows a schematic diagram of the chem ca mechan ca p anar zat on process n accordance with one embodiment of the present nvention; and~~

~~FIG. 9 shows a schematic diagram of po sh ng granu es n accordance with one embodiment of the present nvention.~~

It w be understood that the above f gures are mere y for ustrat ve purposes n further ng an understand ng of the nvention. Further, the f gures are not drawn to sca e, thus d mens ons, part ce s zes, and other aspects may, and genera y are, exaggerated to make ustrat ons thereof ce arer. Therefore, departure can be made from the spec f c d mens ons and aspects shown n the f gures n order to produce the heat spreaders of the present nvention.

DETAILED DESCRIPTION

Before the present nvention s d sc osed and descr bed, t s to be understood that th s nvention s not m ted to the part cu ar structures, method steps, or mater a s d sc osed here n, but s extended to equ va ents thereof as wou d be recogn zed by those ord nar y sk d n the re evant arts. It shou d a so be understood that term no ogy emp oyed here n s used for the purpose of descr b ng part cu ar embod ments on y and s not ntended to be m t ng.

It must be noted that, as used n th s spec f cat on and the appended c a ms, the s ngu ar forms “a,” “an” and, “the” nc ude p ura referents un ess the context ce ar y d ctates otherw se. Thus, for examp e, reference to “a d amond part ce” nc udes one or more of such part ces and reference to “the ayers” nc udes reference to one or more of such ayers.

DEFINITIONS

In descr b ng and c a m ng the present nvention, the fo ow ng term no ogy w be used n accordance with the def n t ons set forth be ow.

As used here n, the terms “cond toner” and “dresser” can be used nterchangeab y, and refer to a too used to cond ton or dress a pad, such as a CMP pad.

~~As used here n, “dress ng segment” and “po sh ng un t” can be used nterchangeab y, and refer to a dress ng or cond ton ng e ment of a CMP pad dresser. Dress ng segments are ut zed n the present nvention to carry superabras ve part ces hav ng ove d t ps. Thus superabras ve part ces are ntroduced nto a CMP pad dresser by the ncorporat on of mu t p e dress ng segments. It shou d be noted that a var ety of techn ques of attach ng the dress ng segments to the substrates, and a var ety of techn ques of attach ng the superabras ve part ces to the dress ng segments, are d scussed here n. It s to be understood that a of these var ous attachment mechan sms can be used nterchangeab y here n: that s, f a method of attach ng a dress ng segment to a substrate s d scussed here n, the method of attachment d scussed can a so be used to attach a superabras ve part ces to a dress ng segment. For any part cu ar CMP pad dresser be ng d scussed, however, t s understood that attachment methods of the superabras ve part ces to the dress ng segments can d ffer from, or can be the same as, the method used to attach the dress ng segments to the pad cond toner substrate.~~

As used here n, “superabras ve” may be used to refer to any crysta ne, or po ycrysta ne mater a , or m xture of such mater a s ~~wh ch that~~ has a Mohr's hardness of about 8 or greater. In some aspects, the Mohr's hardness may be about 9.5 or greater. ~~Such mater a s nc ude but are not m ted to~~ In other aspects, superabras ve mater a s can be mater a s hav ng a V cker's hardness of about 4000 Kg/mm² or greater. Su tab e superabras ve mater a examp es can nc ude, w thout m tat on, d amond, po ycrysta ne d amond (PCD), cub c boron n tr de (cBN), po ycrysta ne cub c boron n tr de (PcBN), corundum and sapph re, as we as other superabras ve mater a s known to those sk d n the art. Superabras ve mater a s may be ncorporated nto the present nvention var ous too s n a var ety of forms nc ud ng part ces, gr ts, f ms, ayers, p eces, segments, etc. In some cases, the ~~Wh e~~ superabras ve mater a s of the present nvention are n the very nert and thus d ff cu t to form of po ycrysta ne chem ca bonds w th, t s known that certa n react ve e ements, such as chrom um and t tan um are capab e of chem ca y react ng w th superabras ve mater a s, such as PCD and PcBN mater a s at certa n temperatures.

~~As used here n, “organ c mater a” refers to a sem so d or so d comp ex or m x of organ c compounds. “Organ c mater a ayers” and “organ c matr x” may be used nterchangeab y, and refer to a ayers or matr x of a sem so d or so d comp ex or m x of organ c compounds, nc ud ng res ns, po ymers, gums, etc. The organ c mater a can be a po ymer or copo ymer formed from the po ymer zat on of one or more monomers. In some cases, such organ c mater a can be adhes ve.~~

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(New subject matter added to the '802 Patent is shown in red)

~~As used herein, the process of "brazing" is intended to refer to the creation of chemical bonds between the carbon atoms of the superabrasive particles/matrix and the brazing matrix. Further, "chemical bond" means a covalent bond, such as a carbide or boride bond, rather than mechanical or weaker inter-atom attractive forces. Thus, when "brazing" is used to connect a superabrasive particle to a true chemical bond is being formed. However, when "brazing" is used to connect a superabrasive particle to a metal-to-metal bonding the term is used in the more traditional sense of a metalurgical bond. Therefore, brazing of a superabrasive segment to a tool body does not necessarily require the presence of a carbide former.~~

As used herein, "particle" ~~as~~refers, when used herein, to connect with diamond superabrasive particles, and refers to a particulate form of ~~diamond superabrasive particles~~. Such particles may take a variety of shapes, including round, oblong, square, euhedral, etc., can be either single crystals or polycrystalline, and can have a number of mesh sizes. As is known in the art, "mesh" refers to the number of holes per unit area, as in the case of U.S. meshes. A mesh size referred to herein are U.S. mesh unless otherwise indicated. Further, mesh sizes are generally understood to indicate an average mesh size of a given collection of particles since each particle within a particular "mesh size" may actually vary over a small distribution of sizes, unless noted otherwise.

~~As used herein, "sharp portion" means any narrow portion to which a crystal or particle may come, including but not limited to corners, apexes, ridges, edges, obelisks, and other protrusions. In some cases, corners and/or apexes are formed at the convergence of more than two faces of the particle or crystal, or other body, disposed in intersecting planes. In other aspects, edges and/or ridges may be formed at the convergence of two or at least two faces of the particle or crystal, or other body, disposed in intersecting planes. In some aspects, "sharp portion" can include a portion that is broken, chipped, cracked, jagged, and the like. In some aspects, degrees of sharpness can be correlated with the geometric angle formed by the particle, crystal, or other body, at the location in question. In some aspects, an angle of 90 degrees or less can be considered sharp. In other aspects, an angle of 60 degrees or less can be considered sharp. In yet other aspects, an angle of 45 degrees or less, or 30 degrees or less can be considered to be sharp.~~

~~As used herein, "periphery coated," "periphery coated on" and the like, mean any particle of a dresser that is coated in an area that originates at the leading edge or outer rim of a dresser and extends inwardly towards the center for up to about 90% of the radius of the dresser. In some aspects, the area may extend inwardly from about 20% to 90% of the radius. In other aspects, the area may extend in to about 50% of the radius. In yet another aspect, the area may extend in to about 33% of the radius of a dresser (i.e. 66% away from the center).~~

As used herein, "working superabrasive particles" are superabrasive particles that ~~touch~~cut or otherwise deform a CMP pad during a dressing or conditioning procedure. These ~~touch~~act on can remove debris from the surface, it can deform the surface either aesthetically or pasthically, or it can ~~cut the surface to create a groove~~or asperity in the surface of the CMP pad. In one specific aspect, a working superabrasive particle can cut deeper than about 10 microns into a CMP pad during a dressing procedure.

As used herein, "non-working superabrasive particles" are superabrasive particles in a CMP pad dresser that do not significantly ~~touch~~cut or deform the pad sufficient to remove debris from the surface, deform the surface, ~~cut or create grooves in the surface to create a groove~~.

As used herein, "overly-aggressive superabrasive particles" are superabrasive particles in a CMP pad dresser that aggressively dress or condition a CMP pad. In one aspect, aggressive superabrasive particles are superabrasive particles that cut deeper than about 50 microns into a CMP pad during a dressing procedure. In another aspect, aggressive superabrasive particles are superabrasive particles that remove at least 1/5 of the material from the CMP pad. In yet another aspect, aggressive superabrasive particles are superabrasive particles that remove at least 1/2 of the material from the CMP pad.

~~As used herein, "indicator substrate" refers to a substrate material upon which a portion of the superabrasive particles of a CMP pad dresser can be positioned and moved to make markings indicative of working superabrasive particles.~~

~~As used herein, "marking pattern" refers to a pattern on an indicator substrate created by moving superabrasive particles thereacross. The markings can be any detectable marking known, including cuts, scratches, depressions, material deposits (e.g. pigment markers, chemical markers, fluorescent markers, radioactive markers, etc.).~~

~~As used herein, "transverse" refers to a directional orientation that is cross-wise to a reference axis. In one aspect, "transverse" can include a directional orientation that is at least at a substantial right angle to the reference axis.~~

~~As used herein, "alignment orientation direction" refers to the direction of an alignment axis of the plurality of superabrasive particles. For example, a plurality of superabrasive particles aligned in a grid format would have at least two alignment axes; an alignment axis in the column direction and an alignment axis in the row direction or oriented 90° to the column direction.~~

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As used herein, "abate" or "abating" refer to a process of removing a superabrasive particle from a CMP pad dresser or reducing the projection of a superabrasive particle thus reducing the degree of contact between the superabrasive particle and the indenter substrate.

As used herein, "superabrasive segment" refers to a too-body having multiple superabrasive particles associated therewith. In some aspect, a superabrasive segment can include superabrasive polycrystalline materials as cutting elements.

As used herein, a "too-substrate" refers a portion of a pad conditioner that supports abrasive materials, and to which abrasive materials and/or superabrasive segments that carry abrasive materials may be affixed. Substrates useful in the present invention may of a variety of shapes, thicknesses, or materials that are capable of supporting abrasive materials in a manner that is sufficient to provide a pad conditioner useful for its intended purpose. ~~Substrates may be of a solid material, a powdered material that becomes solid when processed, or a flexible material. Examples of typical substrate materials include without limitation, metals, metal alloys, ceramics, relatively hard polymers or other organic materials, glasses, and mixtures thereof. Further, the substrate may include a material that adheres attaching abrasive materials to the substrate, including, without limitation, brazing a metal alloy material, cementing a ceramic and the like.~~

As used herein, "working end" refers to an end of a part ~~which~~that is oriented towards the CMP pad and that during a dressing operation makes contact with the pad. ~~Most often~~In many cases the working end of a part ~~is~~ is be distal from a substrate to which the part ~~is~~ is attached.

As used herein, cutting "tip" refers to a portion of a cutting element or part ~~is~~ is that protrudes the greatest distance from the support substrate, e.g., that is the first portion of the cutting element that contacts a CMP pad when in use. It is to be understood that a cutting "tip" can include a planar surface, a pointed surface, or an edge; so long as the planar surface, pointed surface or edge of the cutting element is the first portion of the cutting element that contacts a CMP pad from which material is to be removed.

As used herein, "sharp portion" refers to any narrow portion to which a crystal or part ~~is~~ is may converge, including but not limited to corners, apexes, ridges, edges, obelisks, and other protrusions. In some cases, corners and/or apexes are formed at the convergence of more than two faces of the part or crystal or other body disposed in intersecting planes. In other aspects, edges and/or ridges may be formed at the convergence of two or at least two faces of the part or crystal or other body disposed in intersecting planes. In some aspects "sharp portion" can include a portion that is broken, chipped, cracked, jagged and the like. In some aspects, degrees of sharpness can be correlated with the geometric angle formed by the part, crystal, or other body, at the location in question. In some aspects, an angle of 90 degrees or less can be considered sharp. In other aspects, an angle of 60 degrees or less can be considered sharp. In yet other aspects, an angle of 45 degrees or less or 30 degrees or less can be considered to be sharp.

As used herein, cutting "edge" refers to a portion of a cutting element or part ~~is~~ is that includes some measurable width across a portion that contacts and removes material from a workpiece. As an exemplary illustration, a typical knife blade has a cutting edge that extends longitudinally along the knife blade, and the knife blade would have to be oriented transverse to a workpiece to scrape or plane material from the workpiece in order for the cutting "edge" of the knife blade to remove material from the workpiece.

As used herein, "peripherally located," "peripheral location," and the like, refer to any part or other cutting element of a dresser that is located in an area that originates at the leading edge or outer rim of a dresser and extends inwardly towards the center for up to about 90% of the radius of the dresser. In some aspects, the area may extend inwardly from about 20% to 90% of the radius. In other aspects, the area may extend in to about 50% of the radius. In yet another aspect, the area may extend in to about 33% of the radius of a dresser (i.e. 66% away from the center).

As used herein, "centrally located part," "part in a central location," and the like refer to any part or other cutting element of a too that is located in an area of the too that originates at a center point of the too and extends outwardly towards the too's edge for up to about 90% of the radius of the too. In some aspects, the area may extend outwardly from about 20% to about 90% of the radius. In other aspects, the area may extend out to about 50% of the radius. In yet another aspect, the area may extend out to about 33% of the radius of a too.

As used herein, "attitude" ~~means~~refers to the position or arrangement of a superabrasive particle in relation to a defined surface, such as a substrate to which it is attached, or a CMP pad to which it is to be applied during a work operation. For example, a superabrasive particle can have an attitude that provides a specific portion of the part or orientation toward a CMP pad.

As used herein, "leading edge" refers to the edge of a CMP pad dresser that is a front edge based on the direction that the CMP pad is moving, or the direction that the pad is moving, or both. Notably, in some aspects, the leading edge may be considered to encompass not only the area specifically at the edge of a dresser, but may also include

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portions of the dresser which extend slightly inward from the actual edge. In one aspect, the leading edge may be located along an outer edge of the CMP pad dresser. In another aspect, the CMP pad dresser may be configured with a pattern of abrasive particles that provides at least one effective leading edge on a central or inner portion of the CMP pad dresser working surface. In other words, a central or inner portion of the dresser may be configured to provide a functional effect similar to that of a leading edge on the outer edge of the dresser.

As used herein, the term "profile" and "geometric profile" can be used interchangeably, and refer to a predetermined contour above a support substrate to which a plurality of superabrasive particles or other cutting elements are intended to a given. Examples of such profiles may include, without limitation, flat or planar profiles, curved profiles, wavy profiles, convex profiles, concave profiles, multi-tiered profiles, and the like, including combinations thereof.

As used herein, "geometric configuration" refers to a shape that is capable of being described in readily understood and recognized mathematical terms. Examples of shapes qualifying as "geometric configurations" include, without limitation, cubic shapes, polyhedra (including regular polyhedra) shapes, triangular shapes (including equilateral triangles, isosceles triangles and three-dimensional triangular shapes), pyramidal shapes, spheres, rectangles, "p" shapes, wedge shapes, octagonal shapes, circles, etc.

As used herein, "dressing segment" refers to a dressing or conditioning element of a CMP pad dresser. In one aspect, dressing segments are utilized to carry superabrasive particles having embedded tips. Thus, in some cases superabrasive particles can be introduced into a CMP pad dresser by the incorporation of multiple dressing segments. It should be noted that a variety of techniques of attaching the dressing segments to the substrates, and a variety of techniques of attaching the superabrasive particles to the dressing segments, are possible, any of which are considered to be within the present scope. It is to be understood that any of these various attachment mechanisms can be used interchangeably herein: that is, a method of attaching a dressing segment to a substrate disclosed here, the method of attachment disclosed can also be used to attach superabrasive particles to a dressing segment. For any particular CMP pad dresser being disclosed, however, it is understood that attachment methods of the superabrasive particles to the dressing segments can differ from or can be the same as the method used to attach the dressing segments to the pad conditioner substrate.

As used herein, "cutting element" describes a variety of structures capable of removing (e.g., cutting) material from a CMP pad. A cutting element can be a mass having several cutting points, ridges or mesas formed thereon or thereon. It is notable that such cutting points, ridges or mesas may be from a multiplicity of protrusions or asperities included in the mass. Furthermore, a cutting element can also refer to a non-dividual part that may have only one cutting point, ridge or mesa formed thereon or thereon.

As used herein "organic material" refers to a semisolid or solid complex or mix of organic compounds. "Organic material layer" and "organic matrix" may be used interchangeably, and refer to a layer or mass of a semisolid or solid complex or mix of organic compounds including resins, polymers, gums, etc. The organic material can be a polymer or copolymer formed from the polymerization of one or more monomers. In some cases, such organic material can be adhesive.

As used herein, the process of "brazing" is intended to refer to the creation of chemical bonds between the carbon atoms of the superabrasive particles/materials and the braze material. Either "chemical bond" means a covalent bond such as a carbide or boride bond rather than mechanical or weaker inter-atom attractive forces. Thus, when "brazing" is used in connection with superabrasive particles a true chemical bond is being formed. However, when "brazing" is used in connection with metal to metal bonding the term is used in the more traditional sense of a metallurgical bond. Therefore, brazing of a superabrasive segment to a tool body does not necessarily require the presence of a carbide former.

As used herein, "mechanical bond" and "mechanical bonding" may be used interchangeably, and refer to a bond interface between two objects or layers formed primarily by frictional forces. In some cases the frictional forces between the bonded objects may be increased by expanding the contacting surface areas between the objects, and by imposing other specific geometrical and physical configurations, such as substantially surrounding one object with another.

As used herein, "sintering" refers to the joining of two or more individual parts to form a continuous solid mass. The process of sintering involves the consolidation of particles to at least partially eliminate voids between particles. Sintering may occur in either metal or carbonaceous particles, such as diamond. Sintering of metal particles occurs at various temperatures depending on the composition of the material. Sintering of diamond particles generally requires ultrahigh pressures and the presence of a carbon solvent as a diamond sintering aid. Sintering aids are often present to aid in the sintering process and a portion of such may remain in the final product.

The term "metals" refers to both metals and metalloids. Metals include those compounds typically considered metals found within the transition metals, alkali and alkali earth metals. Examples of metals are Ag, Au, Cu, Al, and Fe.

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Metals include specifically S, B, Ge, Sb, As, and Te. Materials also include alloys or mixtures that include metals. Such alloys or mixtures may further include additional additives. In the present invention, carbide formers and carbon wetting agents may be included as alloys or mixtures, but are not anticipated to be the only metal component. Examples of such carbide formers are Sc, Y, Ti, Zr, Hf, V, Nb, Cr, Mo, Mn, Ta, W, and Ta. Examples of carbon wetting agents are Co, Ni, Mn, and Cr.

As used herein, "infiltrating" refers to a situation where a material is heated to its melting point and then flows as a liquid through the interstitial voids between particles.

As used herein, the terms "substrate" and "support substrate" can be used interchangeably, and refer a portion of a pad condenser that supports superabrasive materials, and to which abrasive materials and/or superabrasive segments that carry abrasive materials may be affixed. Substrates can have a variety of shapes, thicknesses, and/or materials that are capable of supporting abrasive materials in a manner that is sufficient to provide a CMP pad dresser useful for its intended purpose. Substrates may be of a solid material, a powdered material that becomes solid when processed, or a flexible material. Examples of typical substrate materials include without limitation, metals, metal alloys, ceramics, relatively hard polymers or other organic materials, glasses, and mixtures thereof. Further, the substrate may include a material that adheres to the abrasive materials to the substrate including without limitation, brazing alloy materials, sintering aids and the like.

As used herein, the term "substantially" refers to the complete or nearly complete extent or degree of an action, characteristic, property, state, structure, item, or result. For example, an object that is "substantially" enclosed would mean that the object is either completely enclosed or nearly completely enclosed. The exact allowable degree of deviation from absolute completeness may in some cases depend on the specific context. However, generally speaking the nearness of completion will be so as to have the same overall result as if absolute and total completion were obtained.

The use of "substantially" is equally applicable when used in a negative connotation to refer to the complete or nearly complete lack of an action, characteristic, property, state, structure, item, or result. For example, a composition that is "substantially free of" particles would either completely lack particles, or so nearly completely lack particles that the effect would be the same as if completely lacking particles. In other words, a composition that is "substantially free of" an ingredient or element may still actually contain such item as long as there is no measurable effect thereof.

As used herein, the term "about" is used to provide flexibility to a numerical range endpoint by providing that a given value may be "at least above" or "at least below" the endpoint. However, it is to be understood that even when the term "about" is used in the present specification in connection with a specific numerical value, that support for the exact numerical value recited apart from the "about" term is also provided.

In this disclosure, "comprises," "comprising," "containing" and "having" and the like can have the meaning ascribed to them in U.S. Patent law and can mean "includes," "including," and the like, and are generally interpreted to be open ended terms. The terms "consisting of" or "consists of" are closed terms, and include only the components, structures, steps, or the like specifically stated in conjunction with such terms, as well as that which is in accordance with U.S. Patent law. "Consisting essentially of" or "consists essentially of" have the meaning generally ascribed to them by U.S. Patent law. In particular, such terms are generally closed terms, with the exception of a allowing inclusion of additional items, materials, components, steps, or elements, that do not materially affect the basic and novel characteristics or function of the item(s) used in connection therewith. For example, trace elements present in a composition, but not affecting the composition's nature or characteristics would be permissible present under the "consisting essentially of" language, even though not expressly recited in a list of items forming such termology. When using an open ended term, like "comprising" or "including," it is understood that direct support should be afforded as to "consisting essentially of" language as well as "consisting of" language as if stated explicitly and vice versa.

As used herein, a plurality of items, structural elements, compositions, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually defined as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on the representation in a common group without indications to the contrary.

Concentrations, amounts, and other numerical data may be expressed or presented herein in a range format. It is to be understood that such a range format is used merely for convenience and brevity and thus should be interpreted flexibly to include not only the numerical values explicitly recited as the limits of the range, but also to include the individual numerical values or sub-ranges encompassed within that range as if each numerical value and sub-range is explicitly recited. As an illustration, a numerical range of "about 1 to about 5" should be interpreted to include not only the explicitly recited values of about 1 to about 5, but also to include individual values and sub-ranges within the indicated range. Thus, included in this numerical range are individual values such as 2, 3, and 4 and sub-ranges such

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as from 1-3, from 2-4, and from 3-5, etc., as well as 1, 2, 3, 4, and 5, individually. The same principle applies to ranges reflecting on any one numerical value as a minimum or a maximum. Furthermore, such an interpretation should apply regardless of the breadth of the range or the characteristics being described.

The Invention

The present disclosure generally provides CMP pad dressers, methods associated with pad conditioning (e.g., smoothing, polishing, dressing), and the CMP polishing of a work piece. Pad conditioners according to aspects of the present disclosure can be advantageously utilized, for example, in dressing CMP pads that are used in polishing, finishing or otherwise affecting semiconductor materials. Specifically, in some aspects the present disclosure concerns CMP pad dressers having superabrasive particles with substantial yield strength. In other aspects, the present CMP pad dressers can have superabrasive particles that are aligned across a designated profile, and as such, are "yielded" with respect to that profile. Traditional CMP pad dresser manufacturing methods, even many of those describing techniques for yielding superabrasive particles prior to fixation, generally contain significant variation in the pressure across the surface of the dresser that is not accounted for by an intended planar alignment profile. Often, the superabrasive particles are affixed to the CMP pad dresser support in a manner that disrupts any yielding that has occurred. For example, fixation techniques that utilize high heat and/or pressure can cause warping of the dresser support as the dresser cools. Thus, unnecessary steps are taken to avoid such warpage, superabrasive particles are not maintained in the required state following cooling of the dresser. This can be particularly problematic with brazing techniques.

A CMP pad dresser can be used to dress or condition a CMP pad by removing dirt and debris (i.e., degazing the pad), as well as opening up asperities on the pad surface to capture and hold chemicals during a polishing procedure. As has been described, due to difficulties associated with superabrasive particle yielding in many traditional manufacturing processes, only a small percentage of superabrasive particles in a typical CMP pad dresser are positioned so as to penetrate or cut into a CMP pad. As this small percentage of superabrasive particles become worn, past deformation of the CMP pad becomes a greater relative to the amount of CMP of pad that is cut. Consequently, the pad becomes highly deformed and accumulated with dirt. As a result the polishing rate of the CMP pad decreases, and the scratch rate of the wafer or work piece increases.

CMP pads are typically made of a relatively soft polymer, such as, for example, polyurethane. As the CMP pad is engaged by the CMP pad dresser, the polymer material is deformed first by elastic strain and then by plastic strain. Eventually, the strain energy in the deformed material exceeds the bond energy density (i.e., the hardness of the pad) and the polymer material ruptures. Thus, the function of superabrasive particles in the CMP pad dresser is to dress the CMP pad material by breaking polymer bonds through this deformation process. It should be noted that sharp superabrasive particles can penetrate the CMP pad material without causing excessive deformation. As such, the sharpness of a superabrasive particle can be defined as being inverse to the deformed volume prior to rupture. In other words, the smaller the volume of deformation prior to cutting, the sharper the cutting tip. This deformation information can be used to determine the sharpness of superabrasive particles in the CMP pad dresser.

Additionally, a superabrasive particle having a tip with smaller tip radius, such as would be the case with a broken corner, can cut more cleanly through the CMP pad with less deformation as compared to a superabrasive particle having a larger tip radius. Consequently, an irregularly shaped superabrasive particle can be sharper than a euhedral superabrasive corner having an obtuse angle relative to the CMP pad. This also applies to the difference between a superabrasive particle corner as compared with a superabrasive particle face.

It is thus noted that sharp superabrasive particles can cut CMP pad material with less deformation and material strain. Conversely, a dull superabrasive particle may deform but not cut the CMP pad material because the strain energy does not exceed the bond energy density of the polymer material. As the tips of such particles are worn, the contact area between the polymer material and the particles increase. This increase in contact area results in an increase in the deformation volume of the pad. Due to the increased strain energy required for the polymer material to rupture with such an increased deformation volume, the number of superabrasive particles cutting the polymer material will decrease in relation to the degree of dulling during a CMP process.

CMP pad dressing can also be affected by the proportion of superabrasive particles in the CMP pad dresser that are working and the proportion that are over-aggressively cutting. As an example, a typical CMP pad dresser can have greater than 10,000 superabrasive particles. Of these 10,000 particles, in some cases there may only be a few working superabrasive particles that are actually able to cut the CMP pad. Additionally, out of these few working superabrasive particles, there may be a smaller proportion of over-aggressive superabrasive particles that cut over 50% of the entire pad that is consumed during conditioning, and in some cases can remove more than 25% of the total pad material. This uneven workload distribution can cause erratic CMP performance, and can result in overconsumption of the CMP pad, chipping of the over-aggressive superabrasive particles that can scratch the wafer, unpredictable wafer removal rates, uneven wafer surface planarization, shortened CMP pad dresser life, compact on

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of the CMP pad with debris, and the like. Such effects can greatly lower the yield of wafers or work pieces processed under these conditions. A more effective normalization of workload distribution across the surface of the CMP pad dresser can lead to a more uniformly deglazed pad and more uniform pad asperities.

The present CMP pad dressers include a layer of superabrasive particles having substantially evenly distributed across the working surface of the finished CMP pad dresser. A variety of techniques can be utilized to manufacture evenly, and any such techniques considered to be within the present scope. A few non-limiting examples of such techniques are described below. It is intended that the term "evenly" with respect to superabrasive particles can refer to superabrasive particles that are evenly distributed with respect to a planar profile, as well as to superabrasive particles that are arranged along a designated profile that is non-planar. In the latter case, "evenly" would thus describe the arrangement of the superabrasive particles along the designated profile. So in the case of a profile having a dome-shape, evenly distributed superabrasive particles would be particles that were in a uniformity with the profile.

Furthermore, superabrasive topography can additionally be described in terms of height distribution, or in some cases protrusion distance from the support substrate that is represented by a height distribution across the periphery of superabrasive particles. An even height distribution of superabrasive particles may function to more effectively preserve the integrity of the CMP pad dresser as compared to CMP pad dressers lacking such an even height distribution. Similarly, a periphery of superabrasive particles can be described as extending away from a support substrate to a predetermined height, represented by a protrusion distance from the substrate, where the predetermined heights of the particles along a designated profile. Thus, the actual distribution of protrusion distances across the periphery of superabrasive particles in a finished dresser can be compared against the designated profile to determine the variance, or degree of "evenly" achieved.

In one aspect, for example, a CMP pad dresser is provided including a support substrate and a periphery of superabrasive particles secured to the support substrate, with each superabrasive particle extending away from the support substrate to a protrusion distance, where the highest protruding top of each of the periphery of superabrasive particles is along a designated profile. While it is intended that the tops of the superabrasive particles are along a designated profile, some even of deviation may occur. These deviations may be a result of the design or manufacturing process of the tool. Given the wide variety of sizes of superabrasive particles that may potentially be utilized in a given tool, such deviations may be highly dependent on a particular application. As so, when referring to the designated profile, it should be noted that the term "top" is intended to include the highest protruding point of a superabrasive particle, whether that point be an apex, an edge, or a face.

As such, in one aspect the periphery of superabrasive particles are arranged such that the tops vary from the designated profile by from about 1 micron to about 150 microns. In another aspect, the periphery of superabrasive particles are arranged such that the tops vary from the designated profile by from about 5 microns to about 100 microns. In yet another aspect, the periphery of superabrasive particles are arranged such that the tops vary from the designated profile by from about 10 microns to about 75 microns. In a further aspect, the periphery of superabrasive particles are arranged such that the tops vary from the designated profile by from about 10 microns to about 50 microns. In another aspect, the periphery of superabrasive particles are arranged such that the tops vary from the designated profile by from about 10 microns to about 150 microns. In yet another aspect, the periphery of superabrasive particles are arranged such that the tops vary from the designated profile by from about 20 microns to about 100 microns. In a further aspect, the periphery of superabrasive particles are arranged such that the tops vary from the designated profile by from about 20 microns to about 50 microns. In another aspect, the periphery of superabrasive particles are arranged such that the tops vary from the designated profile by from about 20 microns to about 40 microns. Additionally, in one aspect, the periphery of superabrasive particles are arranged such that the tops vary from the designated profile by less than about 20 microns. In another aspect the periphery of superabrasive particles are arranged such that the tops vary from the designated profile by less than about 10 microns. In yet another aspect, the periphery of superabrasive particles are arranged such that the tops vary from the designated profile by less than about 5 microns. In yet another aspect, the periphery of superabrasive particles are arranged such that the tops vary from the designated profile by less than about 1 micron. In a further aspect, a majority of the periphery of superabrasive particles are arranged such that the tops vary from the designated profile to less than about 10% of the average size of the superabrasive particles.

In another aspect, each of the periphery of superabrasive particles can be defined by a protrusion distance from an exposed surface of a bonding material from which they protrude to a predetermined height. Though the predetermined height may vary between tool applications, in one aspect the predetermined height may be greater than about 20 microns. In another aspect the variation from the predetermined height may be from about 1 micron to about 20 microns. In yet another aspect the variation from the predetermined height may be from about 5 microns to about 20 microns. In a further aspect the variation from the predetermined height may be from about 10 microns to about 20 microns. Superabrasive particles may also be arranged with respect to arrangement or distribution, attitude, size, etc. Furthermore, the distribution of protrusion of the periphery of superabrasive particles is reflected in the depth that the particles cut into a CMP pad.

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aspect, the p u r a t y of work ng superabras ve part c es nc udes from about 1000 to about 6000 work ng superabras ve part c es. In a further aspect, the p u r a t y of work ng superabras ve part c es nc udes from about 2000 to about 5000 work ng superabras ve part c es. In yet another aspect, the p u r a t y of work ng superabras ve part c es nc ude at east about 1000 work ng superabras ve part c es that protrude from the r g d support substrate to d stances w th n about 30 m crons of one another.

It s noted that, n some cases, the number of work ng superabras ve part c es can be determ ned by observ ng edge or t p wear after use n a dress ng operat on. As such, n one aspect a CMP pad dresser can have greater than about 300 superabras ve part c es w th worn t ps or edges fo ow ng a CMP pad dress ng procedure. In another aspect, a CMP pad dresser can have greater than about 500 superabras ve part c es w th worn t ps or edges fo ow ng a CMP pad dress ng procedure. In a further aspect, a CMP pad dresser can have greater than about 1000 superabras ve part c es w th worn t ps or edges fo ow ng a CMP pad dress ng procedure.

In one examp e, superabras ve part c e t ps can be descr bed n terms of the d stance that each superabras ve part c e protrudes from the b nd ng mater a , or matr x ayer. The d fference n protrus on d stance between the h ghest protrud ng t p and the next h ghest protrud ng t p of the mono ayer of superabras ve part c es s descr bed as the protrus on d fference. In one aspect, the protrus on d fference can be ess than or equa to about 50 m crons. In another aspect, the protrus on d fference can be ess than or equa to about 20 m crons. In a further aspect, the protrus on d fference can be ess than or equa to about 10 m crons. It s noted that the term "protrus on d fference" can a so be used to descr be the d fference n protrus on d stance between any two or more superabras ve part c es.

In another aspect, and n add t on to the protrus on d fference between the h ghest two protrud ng t ps, the d fference n protrus on d stance between the h ghest 10 protrud ng t ps of the mono ayer of superabras ve part c es are w th n about 30 m crons or ess. In yet another aspect, the d fference n protrus on d stance between the h ghest 10 protrud ng t ps of the mono ayer of superabras ve part c es are w th n about 20 m crons or ess.

Add t on a y, n some aspects the d fference n protrus on d stance between the h ghest 1% of the protrud ng t ps of the frst mono ayer of superabras ve part c es can be w th n about 80 m crons or ess. In other words, for the 1% of the p u r a t y of superabras ve part c es that have the h ghest protrud ng t ps, the var ance n protrus on d stance for that 1% s ess than or equa to about 80 m crons. For examp e, the two h ghest protrud ng superabras ve part c e t ps protrude to w th n about 10 m crons or ess of each other, and n add t on, the h ghest protrud ng 1% of superabras ve part c e t ps protrude to w th n about 80 m crons or ess of each other. In yet another aspect, the d fference n protrus on d stance between the h ghest 1% of the protrud ng t ps of the mono ayer of superabras ve part c es are w th n about 60 m crons or ess. In yet another aspect, the d fference n protrus on d stance between the h ghest 1% of the protrud ng t ps of the mono ayer of superabras ve part c es are w th n about 40 m crons or ess.

It s noted that the rec ted protrus on d stances can nc ude a d str but on across the ent re mono ayer surface or a d screte area or segment of the mono ayer. For examp e, the h ghest 1% of protrud ng t ps can be ocated around the per phery of the mono ayer. In one aspect, for examp e, substant a y a of the asper t es are cut n the CMP pad by superabras ve part c es ocated at a per phera ocat on of the dresser. In another aspect, the per phera ocat on extends from an outer edge of the dresser nward y toward a center po nt of the dresser for up to about 90% of the dresser rad us. In yet another aspect, the per phera ocat on extends from an outer edge of the dresser nward y toward a center po nt of the dresser for up to about 50% of the dresser rad us. In a further aspect, the per phera ocat on extends from an outer edge of the dresser nward y toward a center po nt of the dresser for up to about 33% of the dresser rad us. Add t on a y, n some aspects, substant a y a of the superabras ve part c es are ocated at a per phera ocat on of the dresser. In other aspects, substant a y a of the superabras ve part c es are arranged n un form predeterm ned pattern at a per phera ocat on of the dresser.

In another examp e, d screte reg ons of eve ed superabras ve part c e t ps can be ocated w th n a arger area of superabras ve part c es hav ng a ower protrus on d stance than the eve ed port on. It s a so contemp ated that the mono ayer can nc ude mu t p e reg ons or segments of superabras ve part c es that are eve ed as descr bed, w th n a arger area of superabras ve part c es hav ng a ower protrus on d stance.

Thus, the re at ve eve ng of the mono ayer of superabras ve part c es can great y affect the morpho ggy and d str but on of asper t es cut nto the CMP pad by the dresser. For examp e, n one aspect, the mono ayer s eve ed such that rotat ng the dresser aga nst the CMP cuts asper t es hav ng a max mum cutt ng depth of about 80 m crons. In another aspect, the mono ayer s eve ed such that rotat ng the dresser aga nst the CMP cuts asper t es hav ng a max mum cutt ng depth of about 60 m crons. In yet another aspect, the mono ayer s eve ed such that rotat ng the dresser aga nst the CMP cuts asper t es hav ng a max mum cutt ng depth of about 40 m crons. By form ng po nt ed asper t es, the contact pressure between the work p ece and the CMP pad s ncreased, thus mprov ng the po sh ng character st cs of the pad. As these po nt ed reg ons beg n to f atten, the contact pressure beg ns to decrease, and s urry ocated therebetween s ess effect ve y pressed aga nst the work p ece. In some aspects t can be benef c a for the contact area between the pad and the wafer to be ess than or equa to about 1% of the tota wafer surface area

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fac ng the pad. In other aspects, t can be benef c a for the contact area between the pad and the wafer to be ess than or equa to about 0.1% of the tota wafer surface area fac ng the pad. Th s sma contact area s due to the wafer be ng perched on the contact po nts of the asper t es. Dur ng the po sh ng process, the sharp t ps of the asper t es become worn, thus ncreas ng the contact area and decreas ng the contact pressure to a po nt whereby the s ury abras ves do not effect ve y abrade the wafer. At th s po nt the remova rate of mater a from the wafer drops, and the pad needs to be redressed to sharpen the asper t es.

Add tona y, the oad p ced on the CMP pad by the dresser can affect the morpho gy of the spacers, such as, n some cases, the asper ty depth. The oad can be ad ust ed for a g ven dresser to ad ust penetrat on depth. In one aspect, for examp e, the oad can be from about 0.1 Kg to about 60 Kg. In other aspects, the oad can be from about 2 Kg to about 20 Kg. In further aspects, the oad may be from about 6 Kg to about 12 Kg. In some aspects the oad may be Kg/m². For examp e, n one aspect an 11.5 Kg oad can a ow a mater a remova rate from the wafer of about 200 m crons per hour for Cu ayers. In a re ated examp e, an 11.5 Kg oad can a ow a mater a remova rate from the wafer of about 100 m crons per hour for ox des. In many cases, a ower oad can be used n order to m n m ze the superabras ve part ce damage (e.g., ess than or equa to about 2 Kg).

Furthermore, eve ng of the t ps of the superabras ve part ces n the mono ayer a ows d ffer ng amounts of superabras ve part ces to actua y cut asper t es nto the pad. In one aspect, for examp e, the t ps are eve ed such that at east 100 t ps of the p ura ty of superabras ve part ces cut asper t es nto the CMP pad as the dresser s rotated. In another aspect, the t ps are eve ed such that at east 50 t ps of the p ura ty of superabras ve part ces cut asper t es nto the CMP pad as the dresser s rotated. In a further aspect, the t ps are eve ed such that at east 25 t ps of the p ura ty of superabras ve part ces cut asper t es nto the CMP pad as the dresser s rotated.

Add tona y, var ous methods can be ut zed to measure superabras ve part ce t p he ght to determ ne the d fference n protrus on d stance between t ps. As such, any method for mak ng such a determ nat on s cons dered to be w th n the present scope. It shou d be noted that for the purposes of the present d sc osure, the term "protrus on" refers to the he ght of a part ce re at ve to some reference po nt. Techn ques for such measurements can ncude d rect measurements of the t p he ghts re at ve to a reference po nt such as, for examp e, the h ghest part ce t p, a surface of a r g d support, the bottom surface of the matr x, etc. Measurements of part ce he ght from the surface of the matr x mater a can be prob emat c, however, due to the rregu ar nature of such mater a s due to w ck ng around the superabras ve part ces. In those cases whereby the matr x mater a s un form, such a surface may be used to determ ne part ce he ght. Add tona y, a re at ve protrus on or he ght d fference between two part ces wou d be the d fference n the he ghts between these part ces measured from a common reference po nt. Furthermore, n some cases the superabras ve part ces may e a ong a s ope, curvature, or some other arrangement that s not para e to the under y ng support, such as, for examp e, a meta support ayer. In these cases, the protrus on he ght wou d be norma zed aga nst the s ope, curvature, or other arrangement so that the re at ve protrus on he ght d fference between part ces can be measured n the absence of the s ope, curvature, etc. It shou d be noted that superabras ve part ce t p he ght eve ng can, n some cases, be ndependent from the pos t on ng or pattern ng of the superabras ve part ces across the surface of the dresser.

One examp e of a d rect measurement techn que can ncude an opt ca scann ng process to eva uate superabras ve part ce t p pos t ons. In one such process, an opt ca scanner can scan the surface of the CMP pad dresser to determ ne the he ght of the superabras ve part ce t ps re at ve to a f xed po nt. For examp e, the scanner can scan downward n space toward the dresser unt the h ghest t p s ocated. The h ghest t p can then be set to the reference po nt, and the scanner can cont nue scann ng n a d rect on toward the dresser measur ng the d stance from the reference po nt to each superabras ve part ce t p across the surface of the dresser. Accord ng y, the d fference n protrus on d stance between a of the superabras ve part ces across the dresser can be d rect y measured.

Furthermore, measurement techn ques can a so ncude nd rect measurements, such as, for examp e, app y ng the d amond mono ayer to a deformab e substrate that deforms re at ve to the protrus on d stance of the part ce t ps. The d amond mono ayer can be pressed nto the deformab e substrate and/or moved across the deformab e substrate to form a scratch pattern there n. T p he ght can thus be extrapo ated from such nd rect measurements.

Numerous conf gurat ons for des gnated prof es are poss b e depend ng on the part cu ar use of the abrad ng too , and a such des gnated prof es are cons dered to be w th n the present scope. In one aspect, for examp e, the des gnated prof e can be a p ane. In p anar prof es, the h ghest protrud ng po nts of the superabras ve part ces are ntended to be substant a y eve n the trad tona sense. It s mportant to po nt out that, though t s preferred that these po nts a gn w th the des gnated prof e, there may be some he ght dev at on between superabras ve part ces that occur due to m tat ons nherent n the manufactur ng process.

In add t on to p anar prof es, n another aspect of the present nvent on the des gnated prof e has a s ope. Too s hav ng s op ng surfaces may funct on to more even y spread the fr ct ona forces mp ng ng thereon across the superabras ve part ces, part cu ar y for rotat ng too s such as d sk sanders and CMP pad dressers. The greater

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downward force applied by higher central portions of the tool may offset the higher rotational velocity at the periphery, thus reducing the mechanical stress experienced by superabrasive particles in that location. As such, the scribe may be continuous from a central point of the tool to a peripheral point, or the scribe may be discontinuous, and thus be present on only a portion of the tool. Similarly, a given tool may have a single scribe or multiple scribes. In certain aspects, the tool may scribe in a direction from a central point to a peripheral point, or it may scribe from a peripheral point to a central point. Various scribes are contemplated that may provide a benefit to a scribed organochemical layer tool. It is not intended that the claims of the present invention be limited as to specific scribes, as a variety of scribes in numerous different tools are possible. In one aspect, however, a CMP pad dresser may benefit from an average scribe of 1/1000 from the center to the periphery.

Furthermore, in certain aspects the designed profile may have a curved shape. One specific example of a curved shape is a dome shape CMP pad dresser. Such curved profiles function in a similar manner to the scribed surfaces. CMP pad dressers may include such curved profiles in order to more effectively distribute the frictional forces between a set of the superabrasive particles, thus reducing failures of individual particles and prolonging the life of the dresser. Also, CMP pad dressers can have designed profiles that combine any of a plane, a scribe, a curved shape, a dome shape, and the like, into a variety of complex profiles.

In another aspect of the present disclosure, a CMP pad dresser can include a support substrate, such as a rigid support substrate, and a monolayer of a plurality of superabrasive particles coupled to the support substrate, where each superabrasive particle in the monolayer extends away from the support substrate to a protrusion distance, and where the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the monolayer of superabrasive particles is less than or equal to about 50 microns. Additionally, the difference in protrusion distance between the highest 1% of the protruding tips of the monolayer of superabrasive particles are within about 80 microns or less. In another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns. In a further aspect, the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns. In yet another aspect, the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns.

In another aspect of the present disclosure, a CMP pad dresser is provided including a support substrate and a plurality of superabrasive particles secured to the support substrate and positioned to engage and dress a CMP pad, where the plurality of superabrasive particles cut to depths of less than 50 microns into a CMP pad during a dressing procedure.

In a further aspect, a method of dressing a CMP pad is provided. Such a method can include applying a CMP pad dresser to a CMP pad, and moving at least one of the CMP pad or the CMP pad dresser with respect to one another to cut asperities into the CMP pad having a cutting depth of from about 10 microns to about 50 microns. As one non-limiting example, an exemplary CMP pad can include a support substrate and a monolayer of a plurality of superabrasive particles coupled to the support substrate, where the plurality of superabrasive particles includes a plurality of working superabrasive particles.

In one exemplary aspect, as is shown in FIG. 1, a CMP pad dresser 100 includes a monolayer of a plurality of superabrasive particles 102 coupled to a support substrate 104 with, for example, a bonding material 105. Each superabrasive particle in the monolayer protrudes to a protrusion distance from the support substrate. The difference in protrusion distance 106 between the highest protruding tip 108 and the next highest protruding tip 110 of the monolayer of superabrasive particles is described as the protrusion difference. In one aspect, the protrusion difference can be less than or equal to about 50 microns. In another aspect, the protrusion difference can be less than or equal to about 20 microns. In a further aspect, the protrusion difference can be less than or equal to about 10 microns. It is noted that the term "protrusion difference" can also be used to describe the difference in protrusion distance between any two or more superabrasive particles.

A variety of materials are contemplated for use as superabrasive particles. Any superabrasive known that can be utilized in a CMP pad dresser should be considered to be within the present scope. Non-limiting examples of such materials include diamond materials, nitride materials, ceramics, and the like. In one aspect, the superabrasive particles include diamond materials. Such diamond materials can include natural or synthetic diamond, single crystals, polycrystalline, and the like. In another aspect, the superabrasive particles include cubic boron nitride materials.

It is intended that the scope of the present disclosure include superabrasive particles of a conceivable size that would be useful in dressing a CMP pad. Aspects of the present disclosure, however, specifically allow the retention of superabrasive particles in a CMP pad dresser of sizes that have not previously been feasible for use in metal tooling made using traditional techniques with particles exposed and arranged in a pattern. In one aspect, superabrasive

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part c es may range n s ze from about 30 m crons to about 250 m crons. In another aspect, superabras ve part c es may range n s ze from about 100 m crons to about 200 m crons. In yet another aspect, superabras ve part c es can range from 100 m crons to 150 m crons. Add t ona y, various d amond part c es s zes can be used, ncud ng mesh s zes such as 10/20, 30/40, 80/90, 90/100, 100/120, 120/140, 140/170, 170/200, 200/230, 230/270, 270/325, and 325/400.

Add t ona y, the p ura ty the superabras ve part c es can be or ented so as to affect dress ng performance of a CMP pad. Or ent ng the superabras ve part c es n a spec f c att tude n re at on to the CMP pad to be dressed creates d fferent asper t es n the pad surface, thus a ter ng the performance of the CMP pad. D fferent asper t es reta n s urry n d fferent manners and thus po sh a workp ece d fferent y accord ng to asper ty depth, w dth, dens ty, etc. The superabras ve part c es of a CMP pad dresser can be or ented accord ng to the des red po sh ng character st cs of the CMP pad. For examp e, f the superabras ve part c es predom nant y have an apex or ented towards the CMP pad, the asper t es of the pad w be narrow and deep. The advantages of narrow and deep asper t es are that the pad can better reta n the po sh ng s urry, and thus the po sh ng rate of the wafer ncreases. However, the ncreased po sh ng rate may a so ncrease the wear rate of the superabras ve part c es. As such, wear rate may vary depend ng on the att tude of the superabras ve part c es, and therefore, the or entat on of each superabras ve part c e may be cons dered when des gn ng a dev ce w th des red performance character st cs. Genera y speak ng, superabras ve part c e att tudes that prov de h gh er dress ng rates (.e. deeper penetrat on nto a pad) a so wear part c es out at a h gh er rate.

In contrast, f the superabras ve part c es are or ented w th a face towards the pad, the resu t ng asper t es may po sh at a ower rate. The face of the part c e s genera y thought to be more durab e, but does not typ ca y cut deep and narrow asper t es n the pad, but rather asper t es that are sha ow and broad. Therefore the face port on of a part c e w dress a CMP pad at a reduced rate compared to the apex port on of a part c e, but the superabras ve part c e w wear at a much ower rate.

The edge port ons of a superabras ve part c e have dress ng and wear character st cs that are between those of the face and apex port ons. It has been thought that f the edge port on s ut zed to dress a CMP pad, the asper t es are not as deep or narrow as those dressed w th an apex port on, but may prov de asper t es hav ng des rab e ntermed ate character st cs. Further, the edge port on of the part c e does not wear at such a h gh rate as that of an apex.

In one aspect, the p ura ty of superabras ve part c es are substant a y a conf gured n an att tude hav ng e ther an apex port on or an edge port on or ented toward a pad to be dressed. In another aspect, the p ura ty of superabras ve part c es are substant a y a conf gured n an att tude hav ng e ther an edge port on or a face port on or ented toward a pad to be dressed. In yet another aspect, the p ura ty of superabras ve part c es can be conf gured n an att tude hav ng a sharp port on or ented towards a pad to be dressed. In a further aspect, the p ura ty of superabras ve part c es can be conf gured n an att tude hav ng an apex port on or ented towards a pad to be dressed.

A CMP pad dresser hav ng a substant a y eve ed t p arrangements can have a ow scratch rate because superabras ve part c es are ess ke y to pu out of the matr x ayer due to the r more un form protrus on d str but on compared to trad tona dressers. Add t ona y, the more un form protrus on d str but ons of such a dressers a ows the cond t on ng of CMP pads n such a manner as to fac tate good po sh ng rates wh e at the same t me extend ng the effect ve work ng fe of the dresser. These benef ts can be affected by, for examp e, un form asper ty spac ng and s ze d str but on n the CMP pad.

CMP pad dressers hav ng substant a y eve ed or eve ed superabras ve part c e t ps can be made us ng various manufactur ng techn ques, and any such techn que s cons dered to be w th n the present scope. The fo ow ng descr pt on prov des a few non- m t ng descr pt ons of such exemp ary processes.

In one aspect, for examp e, a CMP pad dresser can be made us ng a braz ng process, and as such wou d genera y ncude a support substrate and a p ura ty of superabras ve part c es coup ed to the support substrate by a meta or meta a oy braze mater a . As has been descr bed, trad tona braz ng techn ques create warpage n the dresser as the braze mater a coo s. As such, superabras ve part c e t ps that were eve ed pr or to braz ng are substant a y m sa gned n the manufactured dresser. Therefore, steps to m n m ze or e m nate the warpage must be taken when us ng a braze process n order to ma nta n t p eve ng. Var ous techn ques to m n m ze or e m nate warpage are contemp ated, and any such techn que s cons dered to be w th n the present scope.

As one genera examp e, a CMP pad dresser can be made n at east a two stage process, where the fr st stage s performed n a manner that m n m zes perturbat ons of the eve ed t ps n a process that wou d norma y s gn f cant y move the superabras ve t ps out of a eve ed arrangement, such as, for examp e, by braz ng. The second stage of the process can further enhance the eve ng of superabras ve part c e t ps across the CMP pad dresser. Other exam es may ncude ut z ng ower temperature a oys, us ng s ow temperature ramp ng n heat ng and/or coo ng of the

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support substrate, using additional mechanical support to form the support substrate from moving when warpage occurs, and the like.

Warpage can also be minimized or eliminated through the structural design of the dresser. For example, in one aspect a CMP pad dresser can include a first mono layer of superabrasive particles disposed on one side of a meta support layer and a second mono layer of superabrasive particles disposed on the meta support layer on an opposite side from the first mono layer. The superabrasive particles of the second mono layer are positioned to have substantially the same distribution as the superabrasive particles of the first mono layer. A rigid support is coupled to the second mono layer of superabrasive particles opposite the first mono layer to provide support to the dresser.

As shown in FIG. 2, for example, a first mono layer of superabrasive particles 202 is arranged on a surface of a support substrate 204. A second mono layer of superabrasive particles 206 is arranged on the support substrate 204 on a side that is opposite to the first mono layer. As discussed further below, in some cases the first and second mono layers of superabrasive particles can be arranged such that corresponding superabrasive particles across the support layer are in substantial alignment, as shown in FIG. 2. In other cases, the superabrasive particles of the first and second mono layers can be arranged in a substantially similar distribution, but may or may not be substantially aligned with one another across the support substrate.

The distribution of a mono layer of superabrasive particles on each side of the support substrate thus moderates the thermal shrinkage from the brazing temperature that would otherwise buckle a distribution of superabrasive particles arranged on just one side. By applying a mono layer to each side of the support substrate, warping forces such as thermal movement and pressure can be equalized or substantially equalized from both sides. As such, the warpage of the support substrate can be minimized. In other words, the forces responsible for warping are applied substantially equally to each side of the support substrate and can thus at least partly cancel one another out, thus minimizing warpage that can otherwise occur. In some aspects, the superabrasive particles making up the mono layers on each side of the support substrate can have matching configurations, patterns, or orientations to one another. In this way there can be a substantially matching spatial arrangement of superabrasive particles on each side of the support substrate. In another aspect, the configurations, patterns, or orientations can be different or varied from one another, or may be partly matching. In yet another aspect, the patterned placement of the superabrasive particles on one side of the support substrate can be substantially aligned with the pattern of superabrasive particles on the other side of the support substrate so that particle locations match one another. In some aspects, there can be a direct correspondence between the spatial positioning of superabrasive particles on one side of the support substrate and the spatial positioning of superabrasive particles on the other side of the meta support substrate. In another aspect, the patterns of superabrasive particles may match or substantially match one another, but may be offset on opposite sides of the support substrate so that particle locations do not match one another.

Accordingly, minimizing the warpage of the support substrate can maintain a greater degree of evenness of superabrasive particles in the finished tool. When heat and/or pressure are used to make a superabrasive tool, warpage of the support substrate can cause great variations in the height evenness, even for those particles that were even prior to heating and/or applying pressure. In one aspect, distributing the warpage forces equally or substantially equally on both sides of a support substrate through the arrangement of the superabrasive particles can effectively cancel forces on opposite sides and thus greatly reduce the degree of warpage occurring in the support substrate, thus also minimizing the relative height movement of the superabrasive particles relative to one another. In other aspects, CMP pad dressers can be made using processes that do not utilized high pressure and/or high temperature.

The support substrate can be any material capable of supporting the diamond mono layer during tool formation. Such materials can include, without limitation, metal materials, metal alloy materials, brazed alloy materials, ceramic materials, composites, and the like.

In one aspect, the superabrasive particles can be arranged into a predetermined pattern. Such a pattern can be a uniformly distributed pattern or a non-uniformly distributed pattern. Additionally, a variety of techniques are contemplated to facilitate the arrangement of superabrasive particles into a predetermined pattern. Predetermined is understood to mean a non-random pattern that has been determined prior to arranging the superabrasive particles. In one aspect, a predetermined pattern can also apply to a predetermined spacing between particles. Non-limiting examples of such techniques include arrangement by a template, arrangement using spots of adhesives, arrangement on a first substrate followed by a pattern specific transfer from the first substrate to the support substrate, and the like, including combinations thereof. The superabrasive particles from either of the mono layers can be temporarily held in position in the predetermined pattern using a variety of techniques, including, without limitation, adhesives, damped locations on the meta support matrix, a supporting compound such as, for example, a wax, and the like, including combinations thereof. In one specific aspect, the superabrasive particles can be temporarily coupled to the support substrate using an adhesive that then volatilizes away and is eliminated during construction of the dresser.

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In one aspect, the predetermined pattern can be a uniformly distributed grid. In another aspect, the predetermined pattern can be an annular configuration having a central region devoid of superabrasive particles. In one specific aspect, the annular configuration can include an annular ring. In another specific aspect, the annular configuration can include a portion of an annular ring. In yet another aspect, an annular configuration can include one or more concentric annular rings nested inside one another. In other aspects, the monolayer distribution can be discretized along regions, spiral regions, and the like.

In another aspect, as shown in FIG. 3, a first monolayer of superabrasive particles 302 is arranged on a surface of a support substrate 304. A second monolayer of superabrasive particles 306 is arranged on the support substrate 304 on a side that is opposite to the first monolayer. A bonding material 308 secures the first monolayer and the second monolayer to the support substrate 304. The bonding material can be any material capable of securing the first and second monolayer to the support substrate. In some aspect, the bonding material can be the same for securing the first monolayer and the second monolayer, while in other aspects the bonding material can be different for securing the first monolayer and the second monolayer.

It is noted that the various descriptions of materials, attachment techniques, and the like, can be generally applicable to any CMP pad dresser design to which such materials, techniques, and the like are applicable. For example, a material that can be used to secure a superabrasive particle to a substrate can be used in both dual monolayer and single monolayer dresser designs.

Accordingly, the bonding material can be any material capable of securing superabrasive particles thereon. Non-limiting examples of bonding materials include metal brazes, metal brazing alloys, organic matrix materials, sintered materials, ectoplated materials, and the like, including combinations thereof.

In one aspect, for example, the superabrasive particles can be brazed to the support substrate, and thus the bonding material can be a metal braze or metal brazing alloy. Metal brazing techniques are known in the art. A green braze material can be applied to the support substrate on or around the superabrasive particles. The metal braze can be applied in any known configuration, including braze sheets, powders, pastes, sprays, and the like, including combinations thereof. Once applied to the support substrate, the braze can be heated and melted to coat at least a portion of the support substrate and to bond the superabrasive particles. The heating temperature can vary depending on the braze material used, but in one aspect can be from about 700° C. to about 1200° C.

In one non-limiting example, the superabrasive particles can be bonded to the support substrate by brazing with a nickel-based alloy containing chromium. In another example, the brazing can include pressing the superabrasive particles with a flat ceramic material that cannot be bonded to the braze in order to even the superabrasive particle tops. Various brazing alloys are contemplated, including non-limiting examples such as BN₂, BN₇, and the like.

Additionally, in one aspect superabrasive particles can be coupled to the support substrate by an electrodeposition process, and thus the bonding material can be an electrodeposited metal material. As an example of a suitable method for positioning and retaining abrasive material prior to and during the electrodeposition process, a mold can be used that includes an insulating material that can effectively prevent the accumulation of electrodeposited material on the molding surface. Superabrasive particles can be held on the molding surface of the molding electrodeposition. As such, the accumulation of electrodeposited material can be prevented from occurring on the particle tops and the working surface of the pad conditioner substrate. Such techniques are described in [U.S. patent application Ser. No. 11/292,938](#), filed Dec. 2, 2005, which is hereby incorporated herein by reference.

In another aspect, the superabrasive particles can be bonded to the support substrate by sintering, and thus the bonding material can include a sintering material. For example, the bonding of the superabrasive particles to the support substrate can include dissolving a sintering compound on the support substrate in contact with the particles of superabrasive particles, and sintering the sintering compound to bond the superabrasive particles to the support substrate. Suitable sintering methods will be readily appreciated by one of ordinary skill in the art having possession of this disclosure. Basically, a sintering compound is applied around the superabrasive particles and in contact with the support substrate. The sintering compound can be any known sintering material that can be used to secure superabrasive particles to a substrate. Non-limiting examples of such materials can include metal and metal alloy powders, ceramic powders, and the like. One specific non-limiting example of a sintering compound is cobalt powder.

Once the sintering compound has been applied around the superabrasive particles and to the support substrate, heat and in some cases pressure can be applied to cause sintering to occur. In some aspects, a braze or brazing alloy can be infiltrated into the sintering compound during bonding to further strengthen the bonding material matrix.

In yet another aspect, sintering can be used to sinter the purity of superabrasive particles into a CMP pad dresser, where the support substrate is the sintering material. In this case, the above recited procedure can be repeated without the use of a support substrate.

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In another aspect, heat and pressure can be applied to bond the purity of superabrasive particles directly into the support substrate. Thus, upon the application of heat and pressure, the support substrate can be softened or partially melted. The superabrasive particles are then pressed into the support substrate. A planar even surface can be used to apply pressure to the mono layer of superabrasive particles to thus maintain the even nature of the superabrasive particles as the superabrasive particles are pressed into the support substrate. Pressure can be maintained upon the support substrate and superabrasive particles until cooled, thus minimizing warping.

In yet another aspect, as shown in FIG. 4, a dual mono layer CMP pad dresser can include a first mono layer of superabrasive particles 402 and a second mono layer of superabrasive particles 406 coupled to a support substrate 404. The superabrasive particles can be coupled to the support substrate directly or via a bonding material. The second mono layer of superabrasive particles 406 is coupled to a second support substrate 408. A portion of the second support substrate is shown removed in FIG. 4 to expose the second mono layer. The second support substrate 408 can facilitate handling and use of the CMP pad dresser. By bonding the superabrasive particles of the second mono layer to the second support substrate, the first mono layer of superabrasive particles remains exposed for CMP pad conditioning operations.

The second support substrate can be made from any material compatible with the abrading or dressing process. Such materials can include polymeric materials, metal materials, ceramic materials, glasses, composites, and the like. In one aspect, the second support substrate can be a polymeric material and the second mono layer of superabrasive particles can be embedded therein using heat, pressure, adhesives, etc. In some aspects, the second support substrate can be a non-polymeric material such as a metal layer. In such cases, the superabrasive particles can be bonded to the second support substrate by adhesives attachment, soldering, brazing, eutectic alloying, and the like. For brazing techniques, care can be taken to minimize or eliminate warpage in the substrate during the heating and cooling process. In another aspect, one or more magnetic elements can be placed into the second support substrate to attract and hold the CMP pad dresser in place, thus forming a temporary attachment. An optional locking mechanism can be utilized to further immobilize the CMP pad dresser to the second support substrate during use. In some aspects the second support substrate can include surface features to hold the dresser in place during rotational movement against a CMP pad. The second support substrate can have approximately the same diameter as the meta support layer, a larger diameter than the meta support layer, or, in some cases, a smaller diameter than the meta support layer.

In another aspect, a CMP pad dresser can be comprised of a purity of dressing segments having a purity of evened superabrasive particles, where the purity of dressing segments are held in place by a rigid support or support substrate. Such a design allows a purity of smaller dressing segments to be manufactured having precise evened tips. Smaller diameter support layers in these dressing segments can be made by processes involving heat and/or pressure with less warpage due to the smaller size. For example, a 4 inch diameter metal disc can exhibit greater warping due to brazing as compared to a 0.5 inch diameter metal disc. Thus thermal distortion and particle float problems are decreased. A purity of such dressing segments can then be coupled to a larger diameter support substrate by processes that do not introduce significant warpage, such as bonding in an organic material. Such dressing segments can have one or more layer(s) of superabrasive particles coupled to a support layer. In one aspect, a segment can have a single layer of superabrasive particles coupled to a support layer. In another aspect, a segment can have a layer of superabrasive particles coupled to each side of a support layer, as has been described herein. Thus, this process allows the manufacture of CMP pad dressers that can have precise tip protrusions. Additionally, in one aspect, each dressing segment can have at least three superabrasive particles that protrude to the greatest extent. If the three highest protruding superabrasive particles on every dressing segment are evened across the entire support substrate, a CMP pad dresser is made having very precise tip evenness across the entire surface. If, for example, ten dressing segments are used to make the CMP pad dresser, then the highest protruding thirty superabrasive particles in the too will have effectively the same protrusion distance and be substantially evened. Various additional details regarding dressing segments are detailed in U.S. patent application Ser. No. 13/034,213, filed Feb. One objective according to some aspects of the present invention is to provide a composite conditioner, which suitably shapes the shape of polishing tips while maintaining the distribution of tip height to avoid the over aggressive cutting of highly exposed abrasives (e.g. k or diamond) so as to improve the rate of work on polishing tips on the polishing pad during conditioning, and to increase the removal rate from the wafer and the durability of the conditioner.

In one embodiment, for example, a composite conditioner can include a base plate and a purity of polishing units secured to a surface of the base plate by an adhesive layer, where each polishing unit includes a purity of polishing tips secured in a bonding layer. The height difference between the first highest polishing tip and the second highest polishing tip is less than or equal to about 10 μm , the height difference between the first highest polishing tip and the tenth highest polishing tip is less than or equal to about 20 μm , and the height difference between the first highest polishing tip and the 100th highest polishing tip is less than or equal to about 40 μm . Furthermore, the first highest polishing tip protrudes from the bonding layer to a height of greater than or equal to about 50 μm .

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Due to the fact the chem-ca-mechan-ca-p-anar-zat-on (CMP) s-d-rected-to p-anar-po-sh-ng, the contact d-str-but-on between the h-gh-po-nt-of the wafer and the po-sh-ng-pad-eads-to conf-irm the qua-ty (.e.-y-e-d-rate) and the eff-e-ency (.e.-product-on-capac-ty) of the CMP. If the d-str-but-on-of the h-gh-po-nt-of the asper-t-es-n the CMP-pad-s-uneven, the abras-on-rate-of the wafer-n-d-fferent parts-of the po-sh-ng-pad-wou-d-be d-fferent and the wafer surface may become uneven. Furthermore, t-s-poss-b-e that some areas wou-d-be over-po-sh-ed-to resu-t-n-d-sh-ng-or-ayer-eros-on; or-n-some cases can resu-t-n-under-po-sh-ed-reg-ions produc-ng-res-dua-s. If w-th-n-wafer non-un-form-ty (WIWNU) s-h-gh, the effect of the chem-ca-mechan-ca-p-anar-zat-on wou-d-be not des-red. Accord-ng-y, the present d-sc-osure prov-des-an-enhanced cond-t-oner based-on-extens-ve data from test-ng-and-exper-ment, and-espec-a-y-adjusts the he-ght-of the work-ng-po-sh-ng-t-ps-by-a-th-ckness-adjustab-e-adhes-ve-ayer-to-compensate-for-the-d-fference-of-po-sh-ng-un-ts-th-ckness-and-ach-e-ve-aforesa-d-he-ght-d-str-but-on-of the h-gh-est-t-p-to-avo-d-produc-ng-k-er-d-amond-and-improve the rat-o-of the effect-ve-work-ng-po-sh-ng-t-ps-on the po-sh-ng-un-ts.

W-th-regard-to the present-nvent-on-aforesa-d-compos-te-cond-t-oner the mater-a-of the th-ckness-adjustab-e-adhes-ve-ayer cou-d-be any-su-tab-e-organ-c-adhes-ve. Each po-sh-ng-un-t further compr-ses-a-un-t-substrate, and-a-b-nd-ng-ayer-s-pos-t-oned-between the surface-of the un-t-substrate-and the po-sh-ng-t-ps. Th-s-b-nd-ng-ayer-can-be-a-so-der, a-braze, an-organ-c-po-lymer, a-p-at-ng-ayer, a-s-ntered-ayer, a-res-n-ayer, or the-ke. The po-sh-ng-t-ps-refer-to-t-ps, a-p-ura-ty-of-wh-ch-are-ocated-on each po-sh-ng-un-t, can-ach-e-ve the po-sh-ng-effect, and the t-ps-are-exposed-at the b-nd-ng-ayer, that-s, the he-ght-of the po-sh-ng-t-ps-means the he-ght-of the po-sh-ng-t-ps-protrude-over the b-nd-ng-ayer-surface.

W-th-regard-to h-gh-prec-s-on-measurement-for the he-ght-of the po-sh-ng-t-ps, var-ous-techn-ques-are-contem-pated. In-one-aspect, for-examp-e, measurement-can-be-accomp-shed-by-an-opt-ca-detect-on-system-such-as-the-surface-detector-manufactured-by-Germany-FRT (Fr-es-Research-&Techno-gy-GmbH). The-surface-detector-detects the he-ght-of-tota-po-sh-ng-t-ps (ex.-more-than-10000)-of the cond-t-oner, that-s, detects the he-ght-of the po-sh-ng-t-ps-protrus-on-over the b-nd-ng-ayer-surface. Us-ng the-east-square-method-w-th the he-ght-data, a-theor-zed-p-ane-may-be-ca-cu-ated-across the tops-of the po-sh-ng-t-ps. The-frst-h-gh-est-t-p-s the he-ght-of the po-sh-ng-t-p-that-protrudes-over the-theor-zed-p-ane-to the-greatest-extent, the-second-h-gh-est-t-p-s the he-ght-of the po-sh-ng-t-p-that-protrudes-over the-theor-zed-p-ane-to the-second-most-extent, and-so-on.

The-pos-t-on-of the wafer-to-be-po-sh-ed-most-y-depends-on the d-str-but-on-of the po-sh-ng-pad-top, and the d-str-but-on-depends-on the he-ght-of the po-sh-ng-t-ps-of the cond-t-oner. The-cond-t-oner-can-be-d-sk-shaped (as-adapted-for App-ed-Mater-a-s)-or-r-ng-shaped (as-adapted-for-Ebara). The-d-iameter-of the d-sk-can-be-about 100-mm-n-genera-, and the-d-iameter-of the r-ng-can-be-greater-than-250-mm. Genera-y, there-are-tens-of-thousands-po-sh-ng-t-ps (e.g.-d-amond-part-c-es)-d-str-but-ed-on the cond-t-oner, for-examp-e: the po-sh-ng-t-ps-of-80/90-mesh, 100/120-mesh-and-120/140-mesh, but the-d-fference-n-s-ze-m-ght-be-greater-than-30%-even-n the-same-mesh. Add-t-on-a-y, there-can-a-so-be-a-d-fference-n-s-ze-n-s-m-ar-po-sh-ng-t-ps-when-or-ented-d-fferent-d-rect-ions; for-examp-e, the-d-stance-between the t-ps-s-30%-greater-than-that-between-part-c-e-p-anes, and-f the-shape-of the po-sh-ng-t-ps-s-not-regu-ar, the-d-fference-wou-d-be-greater.

Therefore, the-present-nvent-on-regu-ates the po-sh-ng-part-c-es-such-that the he-ght-d-fference-between the-frst-h-gh-est-po-sh-ng-t-p-and the-second-h-gh-est-po-sh-ng-t-p-s-ess-than-or-equa-to-about 10-µm, the he-ght-d-fference-between the-frst-h-gh-est-po-sh-ng-t-p-and the-tenth-h-gh-est-po-sh-ng-t-p-s-ess-than-or-equa-to-about 20-µm, and the he-ght-d-fference-between the-frst-h-gh-est-po-sh-ng-t-p-and the-100th-h-gh-est-po-sh-ng-t-p-s-ess-than-or-equa-to-about 40-µm, and the-frst-h-gh-est-po-sh-ng-t-p-protrudes-from the b-nd-ng-ayer-to-a he-ght-of-greater-than-or-equa-to-about 50-µm-to-ensure-that there-are-suff-c-ent-work-ng-t-ps-n the-cond-t-oner-to-ach-e-ve-effect-ve-po-sh-ng-of the-IG-wafer-surface-rap-d-y-and-un-form-y. Add-t-on-a-y, t-shou-d-be-noted-that the-frst-h-gh-est-t-p-and the-second-h-gh-est-t-p-m-ght-be-ocated-n-d-fferent-po-sh-ng-un-ts-or-at the-same-po-sh-ng-un-t, s-m-ar-w-th the-other-po-sh-ng-t-ps; n-another-words, the-t-p-d-str-but-on-s-not-centra-ized-at-s-ng-e-po-sh-ng-un-t.

W-th-respect-to the-aforesa-d-compos-te-cond-t-oner, the-part-c-es-of the po-sh-ng-t-ps-can-be-any-superabras-ve-mater-a-, ne-ud-ng, w-thout-m-tat-on, art-f-c-a-or-natura-d-amond, po-y-crysta-ne-d-amond (PCD), cub-c-boron-n-tr-de (CBN), po-y-crysta-cub-c-boron-n-tr-de (PCBN), or-a-comb-nat-on-thereof. In-some-aspects, part-c-e-s-ze-can-be-n the-range-from-about 100-µm-to-about 500-µm. The-aforesa-d-d-amond-can-be-depos-t-on-d-amond, po-y-crysta-ne-d-amond-or the-comb-nat-on-thereof. Add-t-on-a-y, there-s-no-restr-ct-on-to the-mater-a-of the-base-p-ate, for-examp-e, res-n, meta-, a-oy, past-c, rubber, ceram-es, g-ass-or the-comb-nat-on-thereof (examp-es-ne-cude the-adm-x-ture-between-res-n-and-a-oy).

Add-t-on-a-y, n-some-cases-d-amond-s-formed-by-transform-ng-graph-te-w-th-ron-n-cke-a-oy-at-h-gh-pressure (ex.-5-GPa), thus-eav-ng-ron-n-cke-ne-c-us-on-n-s-de. The-a-oy-can-transform the-d-amond-back-to the-graph-te-or-carbon-at-h-gh-temperature, and the-vo-lume-w-ncrease-substant-a-y-to-often-sp-t the-d-amond. Thus, d-amond-secured-to the-d-amond-d-sk-by-braz-ng-can-be-prob-emat-c-n these-cases-where-h-gh-temperature-of the-braze-can-cause the-d-amond-to-sp-t. In the-CMP-process, such-fractured-d-amond-t-ps-may-crumb-e-a-ong the-m-cro-fracture-surface, re-eas-ng-d-amond-ch-ps-that-can-scratch the-wafer. In-some-aspects, an-e-ctromagnet-c-separator-can-be-used-to

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~~separate diamond particles having excessive meta-enclosures. In some aspects, it can be beneficial to choose a low melting point solder for attaching the diamond particles to the polishing units.~~

~~In the present invention, when choosing the solder as the material of the bonding layer, the solder layer could comprise greater than about 1 weight percentage of at least one of Cr, B, P, T and alloys thereof, and greater than about 50 weight percentage of at least one of N, Cu and alloys thereof. The Cr, B, P, T, etc. can be used for activating the solder layer. Specifically, the solder can be s-N-Cr-B, N-Cr-P, or Cu-Sn-T alloy, where the melting points between about 800° C. and about 1000° C.~~

~~Additionally, each polishing unit can further selectively include a meta-cover layer which covers on the surface of the bonding layer, and the material of the meta-cover layer can be at least one of N, Cr, Pd, Co, Pt, Au, Ti, Cu, W and alloys thereof to further adhere the polishing tips on the unit substrate of the polishing unit. Furthermore, each polishing unit further selectively comprises a protective layer which is thin inert material and covers on the surface of the meta-cover layer, and the material of the protective layer is metal such as Pd, Pt, or non metal such as carbon, silicon nitride, aluminum nitride, alumina, zirconia, diamond-like carbon (DLC), organic film (as Teflon) or a combination thereof to avoid the solder be eroded by the polishing slurry (ex. pH=3 tungsten process slurry).~~

~~Generally, the height of the diamond tips will determine the power pressed into the polishing pad but the sharpness will affect the depth of the diamond penetration into the polishing pad. In general, when the diamond gets sharper, the polishing pad deformation of elasticity and plasticity will be smaller, and the depth of cut is greater. Because the diamond abrasive formed on the conditioner surface is different in shape and direction, the top hundred height diamond could contact the polishing pad. If the diamond is regular in shape and symmetry, the angle will be obtuse and may be difficult to penetrate the polishing pad, and the diamond will push onto the polishing pad surface and form protruding plastic deformation from two sides; on the other hand, if the diamond has a sharp surface, which is not regular in shape, it may penetrate the polishing pad, cut the polishing pad surface and remove the waste simultaneously.~~

~~Therefore, with regard to the aforesaid composite conditioner of the present invention, the crystal surface coverage of more than 50% of the top 100 height polishing tips are less than 80%, and the preferred is less than 50%.~~

~~In some aspects, the highest 100 diamond tips may dress or condition less than 50% of a CMP pad. In other words, the 100 highest diamond tips perform less than 50% of the overall dressing workload. In some aspects, the workload is less than 80% of the overall dressing workload. In additional aspects, the 10 highest tips may dress or condition less than 50% of the CMP pad. Again, in this respect, the 10 highest diamond tips perform less than 50% of the overall dressing workload. In some aspects, the workload is less than 80%. Conversely described, the diamond particles in the dresser outside of the highest 100 or 10 may perform more than 50% of the overall dressing workload. In some aspects, the overall workload may be more than 80%.~~

~~As the crystal surface coverage of the polishing tips becomes lower than those polishing tips have more crack surface (sharp surface) and the polishing tips of the polishing unit working surface comprises corners and ridges, have more ridges with the angle less than 45° (means the angle of the two crystal surface which form the ridge), or have more angle less than 90°, therefore have higher removal rate for the polishing pad.~~

~~Referring now to FIG. 9, the schematic diagram to polish abrasive, where n A₁, E and S respectively points to corner, ridge and surface, where n S₁ is the crystal surface, A₁ is the angle of the crystal surface, S₂ is the crack surface and A₂ is the angle of at least one crack surface. From this, A₁ and A₂ are two different angles, A₁ is greater than 90° (obtuse angle) and A₂ is less than 90° (acute angle), means that when using A₂ as polishing tips, the removal efficiency is greater than A₁.~~

~~The polishing tips can be arranged in a pattern on the unit substrate or the polishing tips form a plurality of clusters and the clusters are arranged in a pattern on the unit substrate, where each the cluster is composed of two to six polishing tips.~~

~~Additionally, the polishing units can be arranged on the base plate as single rings, double rings, multiple rings, radial or spiral shape and could be disk shape, blade shape or polygon. If the polishing units are disk shape, the diameter is in the range of 5 mm to 30 mm. The diameter in the range of 14 mm to 18 mm is preferred. The base plate also could be disk shape and the diameter is in the range of 80 mm to 120 mm. It also could secure the polishing unit on the ring substrate, which is 250 mm to 270 mm in diameter, for actual use. Additionally, if the polishing unit with a disk shape is positioned at an inner surface, the polishing unit on the inner surface can be obstructed by the outer polishing units when conditioning the polishing pad, so that the inner polishing unit may not function well. Therefore, the polishing units can be arranged at the outer edge of the disk shape base plate surface, it could create a fringe effect on a outer edge during the CMP process, such that it will increase the working amount of the polishing units, and the CMP process is adapted to apply for the nanometer process of 18 inch wafer or 22 nm wafer.~~

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In the aforesaid composite cond toner of the present invention, the spacing between the polishing units is not less than 0.1 mm, a spacing of greater than 0.5 mm is preferred, so it could be sure that in the CMP process, the surry could favorably elongate the spacing between the polishing units and would not remain inside due to defect as the scratch to the wafer. Besides, the thickness of the bonding layer of the polishing unit's bottom is in the range less than 0.6 mm so that it could fully adjust the polishing tips of each polishing unit to the same plane to increase the amount of the diamonds off center.

Formerly, the height difference of the tips is too big so that the amount of the tips utilized by traditional cond toner (comprising the tips preeng into polishing pad) is less than 1% of the tips total amount and the diamond coverage area of traditional cond toner is over 40%; on the other hand, in the aforesaid composite cond toner of the present invention, the amount of the polishing tips used for cond toning a polishing pad is more than 1% of the total polishing tips; besides, the area of the polishing units covering the base plate is less than 40% of the total area of the base plate surface to achieve the best remove rate.

It is another objective of the present invention to provide a manufacture method of a composite cond toner, wherein using the polishing unit with sharp polishing tips, through the inverse method, setting the top several tips of each polishing unit as standard plane, adjusting the thickness of the bonding material under each polishing unit to secure on the substrate so that the top several tips of the polishing units would not protrude to form the destructive "kerf or diamond". Using coplanar to make the highest point of each polishing unit achieve common height could also improve the rate of working polishing tips, further to improve the remove rate and durability of the cond toner.

As such, another embodiment of the present invention provides a manufacture method of a composite cond toner, including the following steps: installing a second mold on a first mold, wherein the second mold comprises a plurality of holes; installing a polishing unit in each the hole of the second mold, wherein each the polishing unit comprises a plurality of polishing tips and a bonding layer securing the polishing tips; forming a thickness adjustable adhesive layer to secure the polishing units on a base plate; and removing the first mold and the second mold to form a composite cond toner, wherein the height difference between a first and a second highest tip, between the first and a tenth highest tip, and between the first and a 100th highest tip protruding from a predetermined plane is respectively less than 10 μ m, 20 μ m, and 40 μ m, and the height of the first highest tip protruding the bonding layer is greater than 50 μ m.

Generally, diamond cond toner is made by additive manufacturing method, that is, arranging in flat the diamond abrasive (ke matrix distribution) on the plane substrate (as stainless steel No. 316). Obtaining a diamond cond toner or too with diamond particles having a height difference of the diamond top of single cond toner surface of about 50 μ m or less is difficult using known methods of securing the diamond abrasive such as electroplating with nickel or by brazing with an alloy, which suffers from curdling and grapping due to surface tensions when the braze is quitted. The former diamond surface is usually upward and the latter tips or the ridge usually protrude, and the diamonds with surface upward pierce into the polishing pad with difficulty and the diamond with tips or the ridge cut the polishing pad more easily. In contrast, the present invention can utilize electroplating first to form polishing units, combines organic flexible material and compensates a plurality of polishing units to arrange the polishing units at the base plate, it not only has the advantage of brazing but also could avoid the disadvantage thereof. Therefore, when the diamond cond toner is cond toning the polishing pad, the protrusion diamond top could contact and pierce into the polishing pad without having the polishing tips protruding too much, so piercing into the polishing pad too deep may increase the height difference between the asperities and therefore preventing the outstanding asperities from dipping too much surry, and ultimately leading to the nano particle of the surry to penetrate excessively into the wafer surface to produce over polishing, and even scratching the wafer.

With the aforesaid manufacture method of a composite cond toner of the present invention, the thickness adjustable adhesive layer could be formed after using another plate to even the top tips of the polishing units, or after forming the thickness adjustable adhesive layer before the thickness adjustable adhesive layer so called using the base plate to even the top tips of the polishing units.

The thickness adjustable adhesive layer could be composed by the organic adhesive, for example: a paste material, a rubber material, a hot melt adhesive or the combination thereof; besides, the holes of the second mold are arranged at the second mold outer. Specifically, the holes of the second mold are arranged at the outer ring of the second mold as 12 holes. Additionally, with the composite cond toner, the polishing units also could be arranged at inner or outer ring, and the smaller the polishing units are, the more the amount of the working granules when polishing, but the cost of manufacturing will be higher, so manufacturing the cond toner with appropriate amount of polishing units could balance the effect and cost.

With the aforesaid manufacture method of a composite cond toner of the present invention, before the second mold set on the first mold, further comprising: forming a temporary adhesive layer on the first mold surface and setting the second mold on the temporary adhesive layer to fold the temporary adhesive layer between the second mold and the

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~~first~~ mod, and after remov ng the second mod, further compr s ng: remov ng the temporary adhes ve ayer. With a preferred embod ment of the present nvent on, the temporary adhes ve ayer s a doub e s ded tape.

In another preferred embod ment of the present nvent on, a s de of the po sh ng un ts has the po sh ng t ps, and the th ckness adjustab e adhes ve ayer s set on the oppos te s de, and the po sh ng un ts set at the ho es contact the frst mod through the po sh ng t ps. Bes des, after remov ng the frst mod and the second mod, further compr s ng: form ng a mo d sea ng g ue ayer to secure the po sh ng un ts. From the above, t s poss b e to make the po sh ng un ts arranged order y on the same pane by add ng pressure at the s de hav ng the po sh ng t ps of the po sh ng un ts.

With the aforesad manufacture method of a compos te cond t oner of the present nvent on, further se ect ve y compr s ng: after remov ng the frst mod, mov ng the second mod. That s, the cond t oner mght compr se the second mod.

It s another object of the present nvent on to prov de a chem ca mecha ca p ana zat on (CMP) process, where n sharp po sh ng t ps may be used wh e the p anar ty of the work ng surface s ma ntaned and the rat o of the effect ve work ng po sh ng t ps on the po sh ng un ts s mproved, and the remov ng rate and durab ty are ncreased.

To ach eve aforesad object, another embod ment of the present nvent on prov des a process of chem ca mecha ca p ana zat on, ncud ng the fo ow ng steps: prov d ng a po sh ng pad; nsta ng a wafer on the surface of the po sh ng pad to po sh the po sh ng pad with each other; and us ng a cond t oner, wh ch s nsta ed on the surface of the po sh ng pad and remov ng the scrap of the po shed wafer, where n the cond t oner s the aforesad compos te cond t oner of the present nvent on.

The Moore's aw states that the amount of the trans stor n the same s ze n the same wafer w doub e every 18 months because of the mprovement of the process techno gy and mproved speed of the wafer execut ng comput ng. In accordance with the cont nu ng mprovement suggested by the Moore's aw, the crt ca d mens on of ntegrated c rcu t (IC) gradua y exceeds the mt of 32 nm, however, the bott eneck that s occur ng now s that the t s current state of art of the chem ca mecha ca process s d ff cu t to surpass, so the process cou d not enter a stage for f ner crt ca d mens on. In other hand, because we ut ze the mproved cond t oner n the chem ca mecha ca p ana zat on process of the present nvent on, we cou d use the d ameter of the wafer n 200 mm, 300 mm or 450 mm n the chem ca mecha ca p ana zat on process of the present nvent on, and the wafer surface hav ng the IC crt ca d mens on s sma er than or equa to 45 nm, 28 nm, or 22 nm. Therefore, f the related techno gy ut zes the techno gy of the present nvent on, for exampe app y ng the chem ca mecha ca p ana zat on process of the present nvent on for manufactur ng og c dev ce, DRAM, fash memory or hard dr ve, the speed of the each aforesad dev ce execut ng comput ng w mprove as postu ated by the Moore's aw.

Genera y speak ng, because d amond s zes d ffer n great var ety, shape and d rect on, and the random d stance of the h gh po nt, the p ough of the po sh ng pad and the cut manner are mu t far ous and wh ch eads to uneven he ght of the cond t oned po sh ng pad and then eads to d ff cu t contro ng the h gh po nt pos t on of the wafer contact ng, the area and the pressure of each contact po nt, and resu t the h gh var ab ty to the po sh ng rate and the un form ty. When the wafer var es great y (8 nch to 12 nch even to 18 nch n the future), the var ab ty to the po sh ng rate and the un form ty w become h gher, and the qua ty and the eff cency of the chem ca mecha ca p ana zat on process w become ower. Not on y that, when the crt ca d mens on becomes more and more narrow (45 nm to 32 nm even to 22 nm n the future), the h gh po nt of the po sh ng pad gets broken more eas y. When the e ectr c rcu t becomes narrow, the d e ectr c mater as therebetween have to be ho ower to avo d eakage, but the ho ow d e ectr c ayer s weak, so the contact pressure of the chem ca mecha ca p ana zat on process has to weaken, but owered contact pressure w cause the speed of po sh ng wafer become ower and the poor product v ty.

Current y, the d amond cond t oner usua y adopts the method of add ng d amond on the pane to manufacture, for the reason that the top he ght s d ff cu t to contro . Bes des, under the h gh temperature manufactur ng (as braz ng), the substrates w d stort to make the top he ght more rregu ar, and s gn f cant y decrease the work ng granu e amount, and even ead to tens of thousands of d amond on the cond t oner, but there are on y severa hundred of work ng granu e. Because the d amond cond t oner adopts add t on (fatten ng by the top wh ch has d amond abras ve presses thereon) to manufacture, the s ze, shape and d rect on of the d amond are d ff cu t to contro , and the d amond amount, pos t on and p erc ng depth are a so d ff cu t to contro , cause the pred ctab ty of the chem ca mecha ca p ana zat on process effect to great y reduce. A though t str ct y contro s the fatness, d amond shape, etc. of the cond t oner substrate n ndustry, but the mprov ng effect s not enough.

In v ew that the top of the d amond s not easy to be regu ar, the present nvent on adopts a method of reversed compos te, and manufactures the d amond po sh ng un ts frst, and nverts the d amond po sh ng un ts on a pane to make each of the po sh ng t ps regu ar. At th s t me, set a th ckness adjustab e adhes ve ayer at the contrary s de of the po sh ng t ps, and f na y rrr gate the mo d sea ng g ue ayer n (as res n) to secure a po sh ng un ts. As the aforesad manufactur ng method cou d avo d the "k er d amond" that s common on the d amond d sh, that s, the

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~~stand up protrusion diamond. If the "k or diamond" is too sharp, it may penetrate the polishing pad too deep and put to fracture, and then form the "k or asperities" on the polishing pad surface to cause the wafer scratch.~~

~~The following explains the implemented method of the present invention by specific concrete embodiment, and a skilled person in this art could easily understand other advantage and effect of the present invention through the content disclosed by the specification. The present invention also could be implemented and applied by other different concrete embodiment, and the details of the present invention also could be based on different view and apply for various decorations and changing without deviating the spirit of the present invention.~~

~~The drawings in the embodiment of the present invention are simplified schematic diagram. But the drawings only illustrate the components about the present invention, and the illustrated components are not the example when actually implemented. The components amount, shape and ratio are selective design when actually implemented, and the components layout patterns might be more complicated.~~

~~References FIG. 1A to 1G, are the flow charts of manufacturing the composite condenser.~~

~~First of all, as shown in FIG. 1A, it provides a first mold10, and first mold10 has an opening101. Then, as FIG. 1B illustrates, it forms a temporary adhesive layer11 on opening101 surface of first mold10, and then sets a second mold12 on temporary adhesive layer11 surface to make second mold12 position on opening101 of first mold10, so temporary adhesive layer11 is between second mold12 and first mold10, where second mold12 has a purity of holes121. In this preparation, temporary adhesive layer11 is a double-sided tape.~~

~~As shown in FIGS. 1C and 1G, it sets a polishing unit20 in each hole121 of second mold12, where each polishing unit20 comprises a purity of polishing granules22 (each polishing granules22 at least has a polishing tip221), a unit substrate21 and a binding layer213 set between unit substrate21 surface and polishing tips221. Polishing units20 are made by general brazing, which simply explains as follows: spot weld the solder sheet (BN₂) at unit substrate21 with 20 mm in diameter, 4 mm in thickness, and then arrange the polishing granules (as diamond granules) on the solder sheet which is coated with viscose through the template, and then put those into the vacuum furnace exhaust to about 5 torr to 10 torr, and heating to not more than 1020° C. with 12 min at (during this the viscose is volatilized), and the solder melts to quench and welds the diamond granules.~~

~~Because the diamond is organically positioned on a fixed solder material, when the solder melting to form as the quench, the carbide elements (Cr) there will diffuse to the diamond surface. So the solder will push sink the diamonds with capillary power and combine the diamond surface to form a gradient. The diamonds will stick the solder sheet surface with plane organically, but now the rotation in the quench will make the sharp corners up.~~

~~Then, as shown in FIGS. 1D and 1E, flatten polishing units20 by a base plate24, and form a thickness adjustable adhesive layer23 to secure polishing units20. Then, as shown in FIG. 1F, remove first mold10, temporary adhesive layer11 and second mold12 to form a composite condenser2.~~

~~Composite condenser2 comprises: a base plate24; a purity of polishing units20 placed on a surface of base plate24, and each polishing unit20 including a purity of polishing tips221 and a thickness adjustable adhesive layer23 which used to secure polishing units20 on the surface of base plate24, where, with polishing tips221, the height difference between a first and a second highest tip, between the first and a tenth highest tip, and between the first and a one hundredth highest tip protruding from a predetermined plane is respectively less than 10 μm, 20 μm, and 40 μm, and the height of the first highest tip protruding the binding layer213 is greater than 50 μm.~~

~~Referring now to FIG. 1G, it is an enlarged schematic of the polishing units of the present invention. Each polishing unit20 comprises a purity of polishing granules22 (each polishing granules22 at least has a polishing tip221), a unit substrate21, a binding layer213 set between unit substrate21 surface and polishing tips221, a meta-cover layer212 covering on binding layer213 surface and a protective layer211 covering on meta-cover layer212 surface.~~

~~Binding layer213 could be a solder layer, a plating layer, a sintering layer or a resin layer. If it is a solder layer, the solder layer comprises greater than 1 weight percentage selected at least one from the group consisting of: Cr, B, P, Ti and the alloy thereof, and greater than 50 weight percentage selected at least one from the group consisting of: Ni, Cu and the alloy thereof.~~

~~Meta-cover layer212 could be formed by plating, the material of the meta-cover layer is selected at least one from the group consisting of: N, Cr, Pd, Co, Pt, Au, Ti, Cu, W and the alloy thereof; the material of the protective layer211 is Pd, Pt, silicon carbide, aluminum nitride, aluminum, zirconia, diamond-like carbon (DLC) or the combination thereof.~~

~~Reference to FIG. 2A to 2G, these are the flow chart of manufacturing the composite condenser.~~

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First of all, as shown in FIG. 2A, it provides a second mold 12, and second mold 12 has holes 121, and these holes are arranged at the outer of second mold 12. Then, as shown in FIG. 2B, it sets second mold 12 on a first mold 12 surface.

As shown in FIG. 2C, set a polishing unit 20 on each hole 121 of second mold 12, where the working surface (the surface having polishing tips) of second mold 12 faces to first mold 12 surface. In this preparation, polishing unit 20 is similar to said preparation 1. Then, as shown in FIG. 2D, it goes on the contrary side of the polishing tips of each polishing unit 20 to form a thickness adjustable adhesive layer 23. Then, as shown in FIG. 2E, with a base plate 24 presses on thickness adjustable adhesive layer 23, where a base plate 24 has a notch to make base plate 24 be an inverted U shaped, and the inverted U shaped base plate 24 presses thickness adjustable adhesive layer 23 by the notch.

As shown in FIG. 2F, it removes first mold 10. Then, as shown in FIG. 2G, it inverts the structure of FIG. 2F, that removing second mold 12, forming a molding guide layer 25, strengthening polishing unit 20 and securing base plate 24 forms a composite condenser.

Although the polishing unit is made by the brazing method of the kernel diamond, but with the aforesaid method of the present invention, it could combine and use different polishing units having similar height kernel diamond, and flatten the polishing tips, so the height of the kernel diamond is close to that of the diamond tips on other polishing units.

Referring now to FIG. 3, it illustrates the composite condenser manufactured by aforesaid preparation 2 (embodiment 1, where the crystal cover ratio of the chosen diamond granules is 60% to 80%, that is PDA 878 manufactured by Element Six), the composite condenser manufactured by conventional ceramic sintering (comparison 1) and the composite condenser manufactured by the brazing (comparison 2), the comparison diagram of the tips height and working granules amount of the three condensers. As shown in FIG. 3, when polishing, the present invention condenser in embodiment 1 has 60 to 70 working granules at the height difference about 10 μm ; in contrast, comparison 1 and comparison 2 need more tips height difference to provide more working granules amount, even the condenser in comparison 1, it needs the height difference of the polishing granules more than 40 μm to provide more than 100 working granules amount. From this, the actual working polishing granules amount for the same height difference, the present invention condenser is far more than the prior art condenser.

Reference to FIG. 4 and FIG. 5, it illustrates the composite condenser manufactured by aforesaid preparation 2 (embodiment 1, where the crystal cover ratio of the chosen diamond granules is 60% to 80%, that is PDA 878 manufactured by Element Six; embodiment 2, where the crystal cover ratio of the chosen diamond granules is 40% to 60%, that is PDA 657 manufactured by Element Six), and the composite condenser manufactured by the brazing (comparison 2), the comparison diagram of the height difference of the first high point and the second high point to the scratch amount, and the scratch amount to the removing rate of the three condensers.

As shown in FIG. 4, with the present invention condenser in embodiment 1 and embodiment 2, when the height difference of the first high point and the second high point is about 0 mm, the polishing scratch amount is between 100 to 150 scratches, that means the quality of the condenser in embodiment 1 and embodiment 2 are fine, and the quality stability is nice when polishing; in contrast, with the condenser in comparison 2, the high point difference of the polishing granules is scattered mixed, and the polishing scratch amount is less than between 50 to 150 scratches, that means the quality of the condenser in comparison 2 is scattered mixed, and the quality stability is bad when polishing. On the other hand, as shown in FIG. 5, the polishing removing rate of the present invention condenser in embodiment 2 is about 250 μm to 300 μm per hour, and the scratch amount is about 100 to 150 scratches, the polishing removing rate of the present invention condenser in embodiment 1 is about 150 μm to 200 μm per hour, and the scratch amount is about 125 to 150 scratches, that means the present invention condenser in embodiment 1 and embodiment 2 are high stability and is easy for quality control; in contrast, the polishing removing rate of the condenser in comparison 2 is about 125 μm to 225 μm per hour, and the scratch amount is about 50 to 75 scratches, that means the condenser in comparison 2 has low scratch amount and is unstable in quality.

Referring next to FIG. 6, it illustrates the composite condenser manufactured by aforesaid preparation 2 (embodiment 1 and embodiment 2), the composite condenser manufactured by the brazing (comparison 2) and the composite condenser manufactured by the patting (comparison 3), the comparison diagram of the using time to the removing rate of the four condensers. As shown in FIG. 6, when polishing, the removing rate of the present invention condenser in embodiment 1 and embodiment 2 decrease slowly with the longer using time, that means the present invention condenser has the fastest condensing rate and the longest durability cause of controlling the noise phenomenon; in contrast, the removing rate of the condenser in comparison 2 is unstable and then lead the problem in quality control, and the removing rate of the condenser in comparison 3 is bad, it cannot saving the polishing process time and cost.

Reference to FIG. 7 illustrates the composite condenser manufactured by aforesaid preparation 2 (embodiment 2), the composite condenser manufactured by the brazing (comparison 2), the comparison diagram of the polishing wafer

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amount to the removing rate of the two cond toners. As shown in FIG. 7, in contrast to the comparison 2, the present invention cond toner in embodiment 2 could use in the chemical-mechanical planarization process to achieve polishing more wafer amount.

Referring to FIG. 8, it is a schematic diagram of the chemical-mechanical planarization (CMP) process. As shown in FIG. 8, generally, set a wafer 4 on a polishing pad 6 surface, and provide the polishing slurry by pipe 8 to polish polishing pad 6 with each other, and set a cond toner 2 at another margin portion of polishing pad 6 surface to remove the scrap after the wafer polished, where in, the cond toner here in could use the cond toner manufactured by aforesaid preparation of the present invention.

From of a, recently, with conventional who produce brazing diamond cond toner, the highest polishing tip is usually higher than the second highest one in more than 20 μm , and the top 10 highest polishing granules protrusion on y under 10 mm; in contrast, with the aforesaid method of the present invention, manufactured the composite cond toner by invert uniform head method to make the difference of the highest polishing tip to the second highest one less than 10 μm , therefore, it could improve the ratio of the effective working polishing tips on the polishing units, removing rate and durability.

24, 2011, which is hereby incorporated herein by reference.

Various organic materials are contemplated for use as a support substrate, and/or to secure a second monolayer of superabrasive particles and/or the dressing segments to the support substrate. Examples of suitable organic matrix materials include, without limitation, amorphous resins, acrylic resins, alkyd resins, polyester resins, polyamide resins, polyurethane resins, phenolic resins, phenolic/ate resins, epoxy resins, isocyanate resins, isocyanurate resins, polysiloxane resins, reactive vinyl resins, polyethylene resins, polypropylene resins, polystyrene resins, phenoxy resins, perylene resins, polysulfone resins, acrylonitrile-butadiene-styrene resins, acrylic resins, polycarbonate resins, polyimide resins, and mixtures thereof. In one specific aspect, the organic material can be an epoxy resin. In another aspect, the organic material can be a polyimide resin. In yet another aspect, the organic material can be a polyurethane resin.

Additionally, so-called "reverse casting" methods can be used to accurately orient and attach the dressing segments to the support substrate. Such methods can include initiating securing the placement of dressing segments to a substrate using a "mask" material. The portions of the dressing segments protruding from the mask material can then be attached to the rigid support using the methods discussed herein, after which (or during which), the mask material can be removed.

When an organic material is used, methods of curing the organic material can be a variety of processes known to one skilled in the art that cause a phase transition in the organic material from at least a pliable state to at least a rigid state. Curing can occur, without limitation, by exposing the organic material to energy in the form of heat, electromagnetic radiation, such as ultraviolet, infrared, and microwave radiation, particle bombardment, such as an electron beam, organocatalysts, inorganocatalysts, or any other curing method known to one skilled in the art.

In one aspect of the present invention, the organic material can be a thermoplastic material. Thermoplastic material can be reversibly hardened and softened by cooling and heating respectively. In another aspect, the organic material layer may be a thermosetting material. Thermosetting materials cannot be reversibly hardened and softened as with the thermoplastic materials. In other words, once curing has occurred, the process can be essentially irreversible, if desired.

As a more detailed list of what is described above, organic materials that may be useful in embodiments of the present invention include, but are not limited to: amorphous resins including alkyated urea-formaldehyde resins, melamine-formaldehyde resins, and alkyated benzoguanamine-formaldehyde resins; acrylic resins including vinyl acrylates, acrylic epoxies, acrylic urethanes, acrylic polyesters, acrylic acrylates, acrylic polyethers, vinyl ethers, acrylic oxides, acrylic siloxanes, and associated methacrylates; alkyd resins such as urethane alkyd resins; polyester resins; polyamide resins; reactive urethane resins; polyurethane resins; phenolic resins such as resole and novolac resins; phenolic/ate resins; epoxy resins such as bisphenol epoxy resins; isocyanate resins; isocyanurate resins; polysiloxane resins including a polyoxysilane resins; reactive vinyl resins; resins marketed under the Bake-TETM trade name, including polyethylene resins, polypropylene resins, epoxy resins, phenolic resins, polystyrene resins, phenoxy resins, perylene resins, polysulfone resins, ethylene copolymer resins, acrylonitrile-butadiene-styrene (ABS) resins, acrylic resins, and vinyl resins; acrylic resins; polycarbonate resins; and mixtures and combinations thereof. In one aspect of the present invention, the organic material may be an epoxy resin. In another aspect, the organic material may be a polyimide resin. In yet another aspect, the organic material may be a polyurethane resin.

Numerous additives may be included in the organic material to facilitate its use. For example, additional crosslinking agents and fillers may be used to improve the cured characteristics of the organic material layer. Additionally,

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so vents may be utilized to alter the characteristics of the organic material in the uncured state. Also, a reinforcing material may be disposed within at least a portion of the solidified organic material layer. Such reinforcing material may function to increase the strength of the organic material layer, and thus further improve the retention of the individual abrasive segments. In one aspect, the reinforcing material may include ceramics, metals, or combinations thereof. Examples of ceramics include alumina, aluminum carbide, silica, silicon carbide, zirconia, zirconium carbide, and mixtures thereof.

Additionally, in one aspect a coupling agent or an organometallic compound may be coated onto the surface of a superabrasive material to facilitate the retention of the superabrasive particles in the organic material via chemical bonding. A wide variety of organic and organometallic compounds is known to those of ordinary skill in the art and may be used. Organometallic coupling agents can form chemical bonds between the superabrasive materials and the organic material, thus increasing the retention of the superabrasive materials therein. In this way, the organometallic coupling agent can serve as a bridge to form bonds between the organic material and the surface of the superabrasive material. In one aspect of the present invention, the organometallic coupling agent can be a titanate, zirconate, silane, or mixture thereof. The amount of organometallic coupling agent used can depend upon the coupling agent and on the surface area of the superabrasive material. Often times, 0.05% to 10% by weight of the organic material layer can be sufficient.

Specific non-limiting examples of substances for use in the present invention include: 3-glycidyloxypropyltrimethoxysilane (available from Dow Corning as Z-6040); γ-methacryloxypropyltrimethoxysilane (available from Union Carbide Chemicals Company as A-174); β-(3,4-epoxycyclohexyl)ethyltrimethoxysilane, γ-aminopropyltriethoxysilane, N-(β-aminooethyl)-γ-aminopropylmethyldimethoxysilane (available from Union Carbide, Shin-etsu Kagaku Kogyo K.K., etc.). Specific non-limiting examples of titanate coupling agents include: isopropyltriisostearoyltitanate, dicumylphenylateoxyacetate titanate, 4-aminobenzenesulfonate dodecylbenzenesulfonate titanate, tetraoctylbis(ditridecylphosphite) titanate, isopropyltri(N-ethylammonio-ethylammonio) titanate (available from Kenrich Petrochemicals, Inc.), neokyoxy titanates such as LICA-01, LICA-09, LICA-28, LICA-44 and LICA-97 (also available from Kenrich), and the like. Specific non-limiting examples of aluminum coupling agents include acetoxysilane, aluminum diisopropylate (available from Aromoto K.K.), and the like. Specific non-limiting examples of zirconate coupling agents include: neokyoxy zirconates, LZ-01, LZ-09, LZ-12, LZ-38, LZ-44, LZ-97 (available from Kenrich Petrochemicals, Inc.), and the like. Other known organometallic coupling agents, e.g., thioate based compounds, can be used in the present invention and are considered within the scope of the present invention.

In other aspects of the present disclosure, superabrasive particles can be leveled by reducing the protrusions of particles that are outside of the desired tolerance range. Once such particles are identified, various techniques can be utilized to reduce such protrusions. In one aspect, for example, mechanical abrasion of the dresser can reduce the protruding particles. In another aspect, a vibratory motion can be used to individually break such particles. In yet another aspect, a laser such as a Nd:YAG laser can be used to disrupt such particles.

In yet a further aspect of the present disclosure, a CMP pad dresser can include a plurality of superabrasive particles arranged as a working surface, where the difference in protrusion distance between the highest protruding tip and the second highest protruding tip of the first mono layer of superabrasive particles is less than or equal to about 20 microns, and where the difference in protrusion distance between the highest 1% of the protruding tips of the first mono layer of superabrasive particles, excluding the highest protruding tip, are within about 80 microns.

In another aspect, a CMP pad dresser can include a plurality of superabrasive particles arranged as a working surface, where the difference in protrusion distance between the highest protruding tip and the second highest protruding tip is less than or equal to about 10 microns, the difference in protrusion distance between the highest protruding tip and the 10th highest protruding tip is less than or equal to about 20 microns, the difference in protrusion distance between the highest protruding tip and the 100th highest protruding tip is less than or equal to about 40 microns, and the highest protruding tip has a protrusion distance of greater than or equal to about 50 microns.

It is noted that, while the above disclosure refers primarily to CMP pad dressers, other processing and/or abrading tools are considered to be within the present scope. As such, the techniques and teaching disclosed herein can additionally be applied to such tools.

Additionally, it is noted that traditional CMP processing techniques, including pad dressing, has limited the critical dimensions of integrated circuits. The presently disclosed CMP dressing devices and techniques can, however, allow processing of wafers having integrated circuit critical dimensions of less than or equal to 45 nm, 32 nm, 28 nm, 22 nm, or less.

Of course, it is to be understood that the above-described arrangements are only illustrative of the application of the principles of the present invention. Numerous modifications and alternative arrangements may be devised by those skilled in the art without departing from the spirit and scope of the present invention and the appended claims are intended to cover such modifications and arrangements. Thus, while the present invention has been described above

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with particularity and detail in connection with what is presently deemed to be the most practical and preferred embodiments of the invention, it will be apparent to those of ordinary skill in the art that numerous modifications, including, but not limited to, variations in size, materials, shape, form, function and manner of operation, assembly and use may be made without departing from the principles and concepts set forth herein.

Claims:

What is claimed is:

1. ~~A composite condenser comprising: a base plate; and a plurality of polishing units secured to a surface of the base plate by an adhesive layer, each polishing unit including a plurality of polishing tips secured in a binding layer, wherein a height difference between a first highest polishing tip and a second highest polishing tip is less than or equal to about 10 μm , a height difference between the first highest polishing tip and a tenth highest polishing tip is less than or equal to about 20 μm , and a height difference between the first highest polishing tip and a 100th highest polishing tip is less than or equal to about 40 μm , and the first highest polishing tip protrudes from the binding layer to a height of greater than or equal to about 50 μm .~~
2. ~~The composite condenser of claim 1, wherein at least 1% of the plurality of polishing tips actively condense on a CMP pad during a conditioning process.~~
3. ~~The composite condenser of claim 1, wherein less than 40% of the surface of the base plate is covered with polishing units.~~
4. ~~The composite condenser of claim 1, wherein the polishing units are arranged on the base plate in an arrangement selected from the group consisting of a singering, doubling, muttering, radial arrangements, and spiral arrangements.~~
5. ~~The composite condenser of claim 1, wherein at least one thousand polishing tips of the plurality of polishing tips condense on a polishing pad during a conditioning process.~~
6. ~~The composite condenser of claim 1, wherein the plurality of polishing tips include diamond, cubic boron nitride, or a combination thereof.~~
7. ~~The composite condenser of claim 6, wherein the plurality of polishing tips include diamond, and the diamond is deposited diamond, polycrystalline diamond, or a combination thereof.~~
8. ~~The composite condenser of claim 1, wherein the crystal surface coverage of more than 50% of the top 100 highest polishing tips are less than 80%.~~
9. ~~The composite condenser of claim 8, wherein the crystal surface coverage of more than 50% of the top 100 highest polishing tips are less than 50%.~~
10. ~~The composite condenser of claim 1, wherein each polishing unit further includes a polishing unit substrate upon which the plurality of polishing tips are secured with the binding layer.~~
11. ~~The composite condenser of claim 1, wherein the binding layer is selected from the group consisting of a solder layer, a plating layer, a sintering layer, and a resin layer.~~
12. ~~The composite condenser of claim 11, wherein each polishing unit further comprises a meta-cover layer that covers the binding layer, wherein the meta-cover layer includes at least one material selected from the group consisting of N, Cr, Pd, Co, Pt, Au, Ti, Cu, W, and alloys thereof.~~
13. ~~The composite condenser of claim 12, wherein each polishing unit further comprises a protective layer covering the meta-cover layer, wherein the protective layer includes a material selected from the group consisting of Pd, Pt, silicon carbide, aluminum nitride, alumina, zirconia, diamond-like carbon (DLC), and combinations thereof.~~
14. ~~The composite condenser of claim 11, wherein binding layer is a solder layer comprising 1 wt % or more of a first material selected from the group consisting of Cr, B, P, Ti, or an alloy thereof, or 50 wt % or more of a second material selected from the group consisting of N, Cu, or an alloy thereof, or 1 wt % or more of the first material and 50 wt % or more of the second material.~~

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~~15. The composite cond toner of c a m 1, where n the po-sh ng un ts are d se-shaped, rad a-shaped, or po-ygon-shaped.~~

~~16. The composite cond toner of c a m 15, where n the po-sh ng un ts are d se-shaped hav ng a d ameter of from about 5 mm to about 30 mm.~~

~~17. The composite cond toner of c a m 1, where n the base pate s d se-shaped hav ng a d ameter of from about 80 mm to about 120 mm.~~

~~18. The composite cond toner of c a m 1, where n the po-sh ng t ps have a part c e s ze of from about 100 μ m to about 500 μ m.~~

~~19. The composite cond toner of c a m 1, where n the adhes-ve ayer s an organ c adhes-ve.~~

~~20. The composite cond toner of c a m 1, where n the po-sh ng t ps are arranged n a predeterm ned pattern on the po-sh ng un t substrate.~~

~~21. The composite cond toner of c a m 1, where n the po-sh ng un ts are spaced no c oser than about 0.1 mm.~~

~~22. The composite cond toner of c a m 21, where n the po-sh ng un ts are spaced at east 0.5 mm apart.~~

~~23. The composite cond toner of c a m 1, where n the adhes-ve ayer between the base pate and the po-sh ng un ts has a th ckness of ess than or equa to about 0.6 mm.~~

~~24. A method of mak ng a composite cond toner, compr s ng: d spos ng a second mo d on a frst mo d, where n the second mo d ncudes a p ura ty of ho es; pac ng a po-sh ng un t n each of the p ura ty of ho es of the second mo d; each po-sh ng un t ncud ng a p ura ty of po-sh ng t ps secured n a b nd ng ayer; app y ng an adhes-ve ayer over the second mo d to secure the po-sh ng un ts; and remov ng the frst mo d and the second mo d to form a composite cond toner where n a he ght d fference between a frst h ghest po-sh ng t p and a second h ghest po-sh ng t p s ess than or equa to about 10 μ m, a he ght d fference between the frst h ghest po-sh ng t p and a tenth h ghest po-sh ng t p s ess than or equa to about 20 μ m, and a he ght d fference between the frst h ghest po-sh ng t p and a 100th h ghest po-sh ng t p s ess than or equa to about 40 μ m and the frst h ghest po-sh ng t p protrudes from the b nd ng ayer to a he ght of greater than or equa to about 50 μ m.~~

~~25. The method of c a m 24, where n pac ng the po-sh ng un t n the p ura ty of ho es of the second mo d further compr ses or ent ng the po-sh ng un ts such that the po-sh ng t ps face the frst mo d.~~

~~26. The method of c a m 25, where n the po-sh ng t ps contact the frst mo d such that the po-sh ng un t are eve ed across the frst mo d.~~

~~27. The method of c a m 26, where n the ho es of the second mo d are arranged around an outer per phery of the second mo d.~~

~~28. A process of chem ca meehan ca p anar zat on (CMP), ncud ng the fo ow ng steps: po-sh ng a wafer aga nst a rotat ng po-sh ng pad; and app y ng the cond toner of c a m 1 aga nst the po-sh ng pad to remove debr s and cond t on the pad.~~

~~29. The process of c a m 28, where n the d ameter of the wafer s 200 mm, 300 mm, or 450 mm.~~

~~30. The process of c a m 28, where n a surface of the wafer has an IC crt ca d mens on of ess than or equa to 45 nm.~~

~~31. The process of c a m 30, where n a surface of the wafer has an IC crt ca d mens on of ess than or equa to 28 nm.~~

~~32. The process of c a m 28, where n the surface of the wafer has an IC crt ca d mens on of ess than or equa to 22 nm~~A CMP pad dresser, compr s ng: a rg d support substrate; and a mono ayer of a p ura ty of superabras ve part c es coup ed to the support substrate, where n each superabras ve part c e n the mono ayer extends away from the support substrate to a protrus on d stance, where n a t p of each of the p ura ty of superabras ve part c es a gns a ong a des gnated prof e w th a t p var at on of from about 5 m crons to about 100 m crons, and where n the d fference n protrus on d stance between the h ghest protrud ng t p and the second h ghest protrud ng t p of the

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mono ayer of superabras ve part c es s ess than or equa to about 50 m crons, and the d fference n protrus on d stance between the h ghest 1% of the protrud ng t ps of the mono ayer of superabras ve part c es are w th n about 80 m crons or ess.

2. The dresser of c a m 1, where n the d fference n protrus on d stance between the h ghest protrud ng t p and the second h ghest protrud ng t p s ess than or equa to about 10 m crons.

3. The dresser of c a m 1, where n the d fference n protrus on d stance between the h ghest protrud ng t p and the second h ghest protrud ng t p s ess than about 10 m crons.

4. The dresser of c a m 1, where n the d fference n protrus on d stance between the h ghest protrud ng t p and the 10th h ghest protrud ng t p s ess than or equa to about 20 m crons.

5. The dresser of c a m 1, where n the d fference n protrus on d stance between the h ghest protrud ng t p and the 100th h ghest protrud ng t p s ess than or equa to about 40 m crons.

6. The dresser of c a m 1, where n the p ura ty of superabras ve part c es nc udes a p ura ty of work ng superabras ve part c es, such that rotat ng the dresser aga nst a CMP pad cuts asper t es nto the CMP pad hav ng a cutt ng depth of ess than or equa to about 50 m crons.

7. The dresser of c a m 6, where n the cutt ng depth s from about 10 m crons to about 50 m crons.

8. The dresser of c a m 6, where n the p ura ty of work ng superabras ve part c es nc udes at east 100 work ng superabras ve part c es.

9. The dresser of c a m 6, where n the p ura ty of work ng superabras ve part c es nc udes at east 1000 work ng superabras ve part c es.

10. The dresser of c a m 6, where n the p ura ty of work ng superabras ve part c es nc udes from about 1000 to about 6000 work ng superabras ve part c es.

11. The dresser of c a m 6, where n the p ura ty of work ng superabras ve part c es nc udes from about 2000 to about 5000 work ng superabras ve part c es.

12. The dresser of c a m 6, where n the p ura ty of work ng superabras ve part c es nc ude at east about 1000 work ng superabras ve part c es that protrude from the r g d support substrate to d stances w th n about 30 m crons of one another.

13. The dresser of c a m 1, where n the h ghest protrud ng t p of each of the p ura ty of superabras ve part c es a gn a ong the des gnated prof e w th a t p var at on of from about 10 m crons to about 50 m crons.

14. The dresser of c a m 1, where n the h ghest protrud ng t p of each of the p ura ty of superabras ve part c es a gn a ong the des gnated prof e w th a t p var at on of from about 20 m crons to about 40 m crons.

15. The dresser of c a m 1, where n the h ghest protrud ng t p of each of the p ura ty of superabras ve part c es a gn a ong the des gnated prof e w th a t p var at on of ess than about 20 m crons.

16. The dresser of c a m 1, where n the protrus ons of the p ura ty of superabras ve part c es produce cutt ng depths of ess than about 20 m crons when used to abrade a CMP pad.

17. The dresser of c a m 1, where n the protrus ons of the p ura ty of superabras ve part c es produce cutt ng depths of from about 1 m cron to about 20 m crons when used to abrade a CMP pad.

18. The dresser of c a m 1, where n the protrus ons of the p ura ty of superabras ve part c es produce cutt ng depths of from about 10 m crons to about 20 m crons when used to abrade a CMP pad.

19. The dresser of c a m 1, where n the des gnated prof e nc udes a conf gurat on se ected from the group cons st ng of a p ane, a s ope, a curved shape, a dome shape, and comb nat ons thereof.

20. The dresser of c a m 1, where n the p ura ty of superabras ve part c es s arranged across the support substrate n a predeterm ned pattern.

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21. The dresser of claim 20, wherein the predetermined pattern includes an even distribution of the plurality of superabrasive particles spaced at a distance of from about 100 microns to about 800 microns.

EXHIBIT 9



California Secretary of State Electronic Filing

FILED
Secretary of State
State of California

Corporation - Statement of Information

Entity Name: KINIK CORPORATION

Entity (File) Number: C2028612

File Date: 11/14/2019

Entity Type: Corporation

Jurisdiction: CALIFORNIA

Document ID: GA79524

Detailed Filing Information

1. Entity Name: KINIK CORPORATION
2. Business Addresses:
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 - b. Mailing Address: 3156 E. LA PALMA AVE., UNIT G
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 - c. Street Address of Principal Executive Office: 3156 E. LA PALMA AVE., UNIT G
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3. Officers:
 - a. Chief Executive Officer: YEN Y TANG
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 - b. Secretary: YEN Y TANG
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California Secretary of State Electronic Filing

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4. Director:

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Number of Vacancies on the Board of
Directors:

0

5. Agent for Service of Process:

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6. Type of Business:

WHOLESALE & RETAIL MACHINERY
P

By signing this document, I certify that the information is true and correct and that I am authorized by California law to sign.

Electronic Signature: YEN Y TANG

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Document ID: GA79524

EXHIBIT 10

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

CHIEN-MIN SUNG	)	
	)	
Plaintiff,	)	
	)	
v.	)	C.A. No. 14-1027-RGA
	)	
KINIK COMPANY,	)	
	)	
Defendant.	)	

**NOTICE OF WITHDRAWAL OF DEFENDANT’S MOTION TO DISMISS
AND STIPULATION TO EXTEND DEADLINE TO ANSWER COMPLAINT**

IT IS HEREBY STIPULATED AND AGREED, subject to the approval and Order of the Court, that Defendant Kinik Company (“Kinik”) hereby withdraws its Motion to Dismiss (D.I. 23) and will not be filing a reply brief in support thereof;

IT IS FURTHER STIPULATED AND AGREED, subject to the approval and Order of the Court, that the deadline for Kinik to answer the Complaint in this action shall be extended through and to include October 30, 2015.

DEVLIN LAW FIRM LLC

ASHBY & GEDDES

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/s/ Andrew C. Mayo

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Attorney for Plaintiff

Attorneys for Defendant

SO ORDERED this _____ day of _____, 2015.

United States District Court Judge