US 20120302146A1

(19) **United States**

(12) **Patent Application Publication**

Sung

(10) **Pub. No.: US 2012/0302146 A1**

(43) **Pub. Date: Nov. 29, 2012**

(54) **CMP PAD DRESSER HAVING LEVELED TIPS AND ASSOCIATED METHODS**

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(21) Appl. No.: **13/479,148**

(22) Filed: **May 23, 2012**

Related U.S. Application Data

(60) Provisional application No. 61/489,074, filed on May 23, 2011.

Publication Classification

(51) **Int. Cl.**

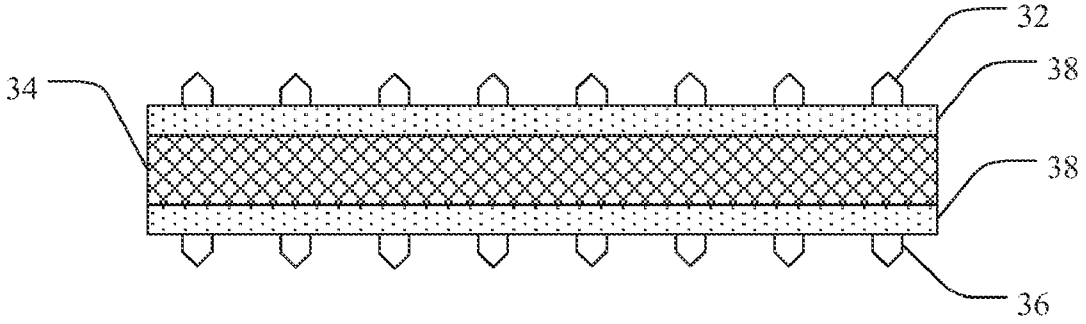
B24B 53/12 (2006.01)

B24D 3/06 (2006.01)

(52) **U.S. Cl.** **451/443**; 428/143; 51/309; 51/298

(57) **ABSTRACT**

CMP pad dressers having leveled tips and associated methods are provided. In one aspect, for example, a CMP pad dresser can include a matrix layer and a monolayer of a plurality of superabrasive particles embedded in the matrix layer, where each superabrasive particle in the monolayer protrudes from the matrix layer. The difference in the 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 20 microns, 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.



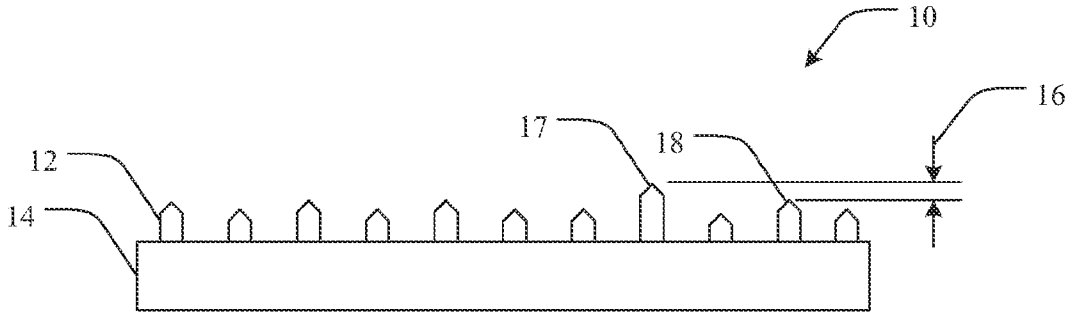


FIG. 1

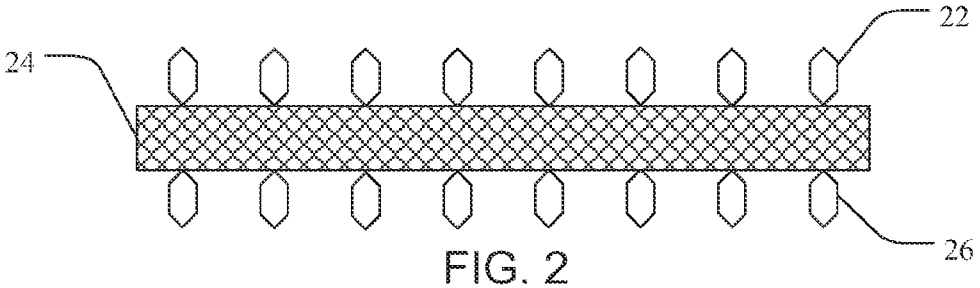


FIG. 2

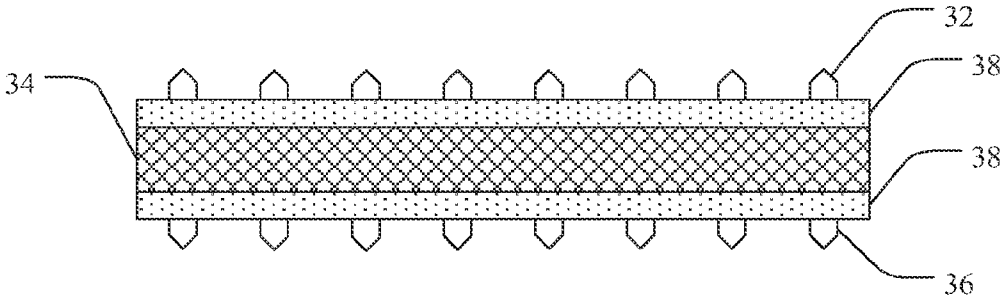


FIG. 3

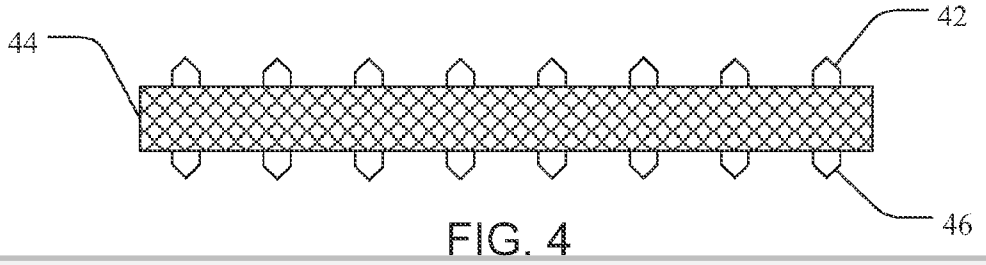


FIG. 4

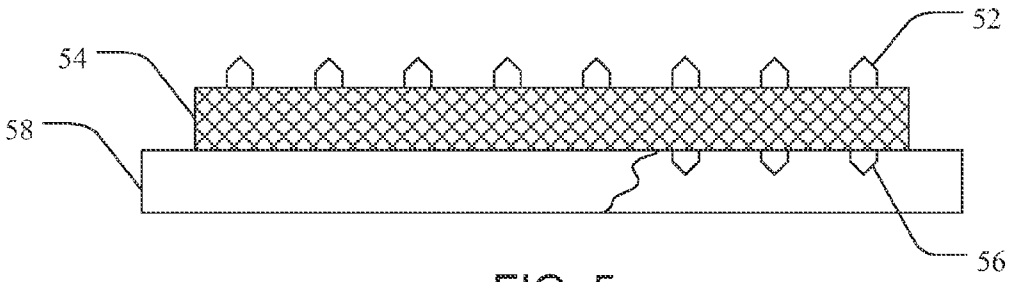


FIG. 5

CMP PAD DRESSER HAVING LEVELED TIPS AND ASSOCIATED METHODS

PRIORITY DATA

[0001] This application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/489,074, filed on May 23, 2011, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 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 all CMP processes 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

[0003] The present disclosure provides CMP pad dressers and associated methods thereof. In one aspect, for example, a CMP pad dresser can include a matrix layer and a monolayer of a plurality of superabrasive particles embedded in the matrix layer, where each superabrasive particle in the monolayer protrudes from the matrix layer. The difference in the protrusion distance between the highest protruding tip and the next highest protruding tip of the monolayer of superabrasive particles can be less than or equal to about 20 microns, 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. In one specific aspect, a rigid support is coupled to the matrix layer.

[0004] 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 10^{th} 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 100^{th} highest protruding tip protrudes from the matrix layer to a height greater than or equal to about 50 microns.

[0005] 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 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, and a rigid support is coupled to the second monolayer of superabrasive particles opposite the first monolayer.

[0006] In yet another aspect, a method of making a CMP pad dresser includes disposing a first monolayer of superabrasive particles on a metal support layer and disposing a second monolayer of superabrasive particles on the metal support layer on a side opposite 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. The method further includes bonding the first monolayer of superabrasive particles and the second monolayer of superabrasive particles to the metal support layer such that symmetrical forces due to the substantially similar distribution between the first monolayer and the second monolayer precludes substantial warping of the metal support layer. In one aspect, the method can further include coupling the second monolayer of superabrasive particles to a rigid support.

[0007] In one aspect, the bonding of at least one of the first monolayer and the second monolayer is by brazing with a braze material. In another aspect, the bonding of at least one of the first monolayer and the second monolayer is under heat and pressure. In one specific aspect, the heat and pressure bonds at least one of the first monolayer and the second monolayer directly to the metal support layer. In another specific aspect, the bonding of at least one of the first monolayer and the second monolayer further includes disposing a sintering compound on the metal support layer in contact with at least one of the first monolayer and the second monolayer and sintering the sintering compound to bond the at least one of the first monolayer and the second monolayer to the metal support layer. In one specific aspect, the method further includes infiltrating the sintering compound with a braze material during bonding.

[0008] 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 warping forces on opposing sides of a metal support layer during bonding of a plurality 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 plurality of superabrasive particles on opposing sides of the support layer such that the plurality of superabrasive particles has substantially the same distribution on either side of the support layer to substantially equalize warping forces during bonding.

[0009] In a further aspect, a CMP pad dresser is provided. Such a dresser can include a plurality of superabrasive particles arranged as a working surface, 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

less than or equal to about 20 microns, the difference in protrusion distance between the highest protruding tip and the 100^{th} 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.

[0010] 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

[0011] FIG. **1** is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention;

[0012] FIG. **2** is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention;

[0013] FIG. **3** is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention;

[0014] FIG. **4** is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention; and

[0015] FIG. **5** is a schematic side view of a CMP pad dresser in accordance with an embodiment of the present invention;

[0016] 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

[0017] 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.

[0018] 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

[0019] In describing and claiming the present invention, the following terminology will be used in accordance with the definitions set forth below.

[0020] 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.

[0021] 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 that [illegible]. The [illegible] ration 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 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.

[0022] 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.

[0023] 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.

[0024] 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.

[0025] 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.

[0026] As used herein, "sharp portion" means any narrow [illegible]

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