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(54) Pad conditioner for conditioning a CMP pad and method of making such a pad conditioner

(57) The invention provides a pad conditioner for conditioning a CMP pad. The pad conditioner includes a substrate, a plurality of cavities on the substrate, a bonding agent filling in the cavities, and a plurality of abrasive particles securely placed and fixed in the cavities separately. The cavities are arranged in a regular manner and each cavity is sized such that it can accommodate only one abrasive particle. The cavities may be bowl-shaped or of other shapes. A method of making such a pad conditioner is also disclosed.

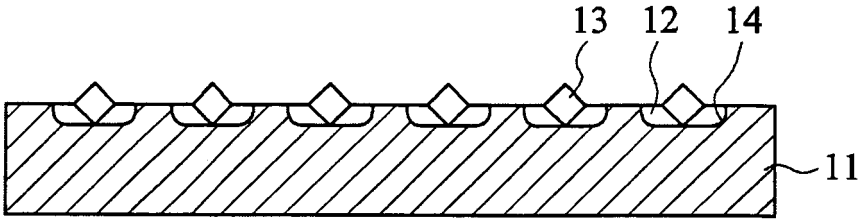

FIG. 2

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Description

BACKGROUND

a) Field of the Invention

[0001] The present invention relates to a pad conditioner for dressing or conditioning a CMP pad and a method of making such a pad conditioner, and more particularly to a pad conditioner for conditioning a CMP pad and a method of making such a pad conditioner wherein abrasive particles are evenly distributed on the pad conditioner and securely fixed on a substrate.

b) Description of the Related Art

[0002] In current semiconductor manufacturing processes, as the manufacturing technology advances, the line width and die size become smaller, and interconnections more concentrated and need to be stacked into more layers. Thus the planarization of the wafer becomes important, and Chemical Mechanical Polishing (CMP) is the key technology that provides global planarization.

[0003] In CMP, a silicon wafer is held by a rotating or moving polishing head and pressed on a rotating polishing pad, and slurry is injected onto the polishing pad. Besides the micro abrasive particles, the slurry also contains acid solution or alkaline solution that is chosen based on the material to be polished. For example, since most dielectric materials are oxides, the selected slurry is usually alkaline solution, and if the metal materials such as tungsten or copper are to be polished, the selected slurry is often acid solution. The polishing pads are commonly made from polyurethane resin and the polishing pad has a rough surface with via holes.

[0004] The top of polishing pad holds the abrasive particles, usually by a means such as fibers. It is very important to keep the top as flexible as possible to provide necessary friction for holding particles. Therefore, although the majority of debris coming from the polishing of silicon wafers, slurry particles and conditioning disk is washed away by water during the CMP process, a small amount of debris still accumulates in the via holes of the polishing pad, causing the polishing pad surface to glaze or harden, which makes the pad less able to hold the slurry particles. Thus the removal rate of polishing is decreased, which causes instability in the CMP process and fast wear-out of the polishing pad.

[0005] Hence, a pad conditioner that is capable of removing the debris on the polishing pad surface and reviving the polishing pad is needed so that the process remains stable. Moreover, the pad conditioner must also be capable of distributing the slurry uniformly on the polishing pad so that the process is more stable.

[0006] There are two most common types of conventional pad conditioners: electroplated pad conditioner and alloy-brazed pad conditioner. The abrasive particles of the electroplated pad conditioner are fixed on its substrate by way of electroplating nickel, but the bonding force of such mechanical locking method is poor and the abrasive particles tend to be dislodged easily and may scratch the wafer being polished. Furthermore, the electroplated layer must cover more than half of each abrasive particle in order to engage the abrasive particles to the substrate, therefore the protrusion level of the abrasive particles is limited, and thus the polishing pad cannot be effectively conditioned and the via holes are stuffed with the debris. Therefore, the current CMP process uses less of the electroplated pad conditioner.

[0007] On the other hand, abrasive particles of alloy-brazed pad conditioner are fixed on its substrate by way of alloy brazing, and the bonding force of such chemical locking method is better, and the abrasive particles are harder to dislodge than when the electroplated pad conditioner is used. However, there are some disadvantages, one of them being uneven distribution of particles on the substrate, which may result from the unevenness of spacing between abrasive particles or the unevenness of the level of height where the abrasive particles exist. Both of the unevenness causes the abrasive particles to apply uneven forces to the polishing pad, which in turn will cause the abrasive particles that bear bigger force to be wholly dislodged or partly chipped easily, thereby leading to scratching of the wafers. In addition, if the spacing between the distributed abrasive particles is too close, the debris would accumulate easily, and the work efficiency of the pad conditioner would be reduced. Besides, an excessive amount of accumulated debris will easily scratch the wafer once they fall off. Thus, different kinds of alloy-brazed pad conditioners have been provided to improve the aforementioned problem.

[0008] U.S. Patent No. 6,368,198 discloses a pad dresser and a method of making such a pad dresser. As shown in FIG. 1, abrasive particles 3 are affixed to a substrate 1 via a brazing alloy sheet 2, and the reason that the abrasive particles 3 can be evenly distributed is due to a template with apertures (not shown) that was used to place the abrasive particles on the brazing alloy sheet 2 before brazing. Moreover, an anti-corrosive layer of diamond-like carbon (DLC) 5 can be added thereon by physical vapor deposition. However, the brazing alloy is molten and flows freely in the high temperature vacuum furnace. Therefore, the pre-placed abrasive particles could be displaced by the brazing liquid such that neighboring particles touch each other. The bonding force is decreased due to such clustering of abrasive particles. The dislodging of abrasive particles would still occur at times.

[0009] Therefore, a CMP pad conditioner with evenly distributed and firmly fixed abrasive particles on its substrate is urgently needed in semiconductor manufacturing technology.

BRIEF SUMMARY OF THE INVENTION

[0010] An object of the invention is to provide a pad

conditioner for evenly conditioning a CMP pad, and a method of making such a pad conditioner.

[0011] Another object of the invention is to provide a pad conditioner for conditioning a CMP pad, wherein abrasive particles are securely fixed on the substrate, and a method for making such a pad conditioner.

[0012] In this invention, abrasive particles refer to all super-hard crystals, including: natural diamond, synthetic single crystal diamond, synthetic polycrystalline diamond (PCD), cubic boron nitride (cBN), polycrystalline cubic boron nitride (PcBN), etc.

[0013] In this invention, a substrate refers to a base member made of material such as metal, alloy, or ceramic.

[0014] In this invention, cavities are for containing and holding the abrasive particles, and the cavities can be of any shape, such as hemispherical shape, bowl shape, cylindrical shape, or conical shape.

[0015] In this invention, a bonding agent is any material that is capable of affixing the abrasive particles to the substrate, including: metal, alloy, etc.

[0016] The invention provides a pad conditioner for conditioning a CMP pad, including: a substrate having a plurality of cavities thereon; a bonding agent filling the plurality of cavities; and a plurality of abrasive particles fixed in the plurality of cavities by the bonding agent. Preferably, the cavities are arranged in a regular manner and the size of each cavity is such that only one abrasive particle can be accommodated. The cavities are preferred to be bowl-shaped. The bonding agent affixes the plurality of abrasive particles to the plurality of cavities by way of brazing.

[0017] The aforementioned pad conditioner for conditioning a CMP pad further includes a lubricating layer; the lubricating layer is made of parylene, tungsten carbide/carbon film (WC/C), diamond film, or diamond-like carbon film (DLC). The lubricating layer can enhance the speed of debris removal, reduce the accumulation of debris, and shorten the conditioning time.

[0018] Moreover, the invention provides a method of making a pad conditioning for conditioning a CMP pad, including: providing a substrate; forming a plurality of cavities on the substrate; filling a bonding agent in the plurality of cavities; placing a plurality of abrasive particles in the bonding agent; and securely fixing the plurality of abrasive particles on the substrate by using the bonding agent. The cavities are regularly arranged and each cavity is sized such that preferably it can only accommodate one abrasive particle. The cavities are preferably bowl-shaped. The bonding agent bonds the plurality of abrasive particles to the plurality of cavities by way of brazing.

[0019] The aforementioned method of making such a pad conditioner further includes: forming a lubricating layer on the substrate, the bonding agent and the plurality of abrasive particles. The lubricating layer is made of parylene, WC/C, diamond film, or DLC.

[0020] Through the invention, the efficiency and uniformity of the pad conditioner are improved, and the life of the polishing pad is extended. Moreover, the invention can enhance the stability of CMP process, reduce the conditioning time, minimize the number and time of equipment maintenances, and reduce the generation of scratched wafers, thus enhancing the quality and yield of wafers.

BRIEF DESCRIPTION OF DRAWINGS

[0021] FIG. 1 illustrates a sectional view of a conventional pad conditioner.

[0022] FIG. 2 illustrates a sectional view of a pad conditioner according to a first embodiment of the invention.

[0023] FIG. 3 illustrates a sectional view of a pad conditioner according to a second embodiment of the invention.

[0024] FIG. 4 illustrates a sectional view of a pad conditioner according to a third embodiment of the invention.

[0025] FIG. 5 illustrates a sectional view of a pad conditioner according to a fourth embodiment of the invention.

[0026] FIGs. 6A - 6E illustrate a method of making a pad conditioner according to a first embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0027] A pad conditioner for conditioning a CMP pad and a method of making such a pad conditioner according to a preferred embodiment of the invention will be described below with reference to the drawings, wherein the like reference numerals denote the like components. Please note that the embodiments of the invention described below are for explanatory purposes and are not limited to the description thereof unless such limitation is specified in the embodiments.

[0028] Referring to FIG. 2, a sectional view of a pad conditioner according to a first embodiment of the invention is disclosed, wherein a plurality of abrasive particles 13 are respectively fixed in a plurality of flat-bottom, bowl-shaped cavities 14 on a substrate 11 by a bonding agent 12. In this embodiment, the substrate 11 is made of stainless steel SUS 316, and the sizes of the abrasive particles are from about 100 μm to about 250 μm, preferably about 130 μm to about 200 μm. The depth of the cavities 14 is about 50μm, which can be adjusted according to the sizes of the abrasive particles and the protrusion that the abrasive particles are to be exposed. The diameters of the cavities 14 are designed to only accommodate one abrasive particle so that the abrasive particles can be evenly distributed as per the positioning of the cavities 14. The cavities 14 are of a bowl shape with flat bottom, which can structurally hold the abrasive particle 13 securely and separate each abrasive particle completely, so that the abrasive particles will not be dislodged easily.

[0029] FIG. 3 shows a sectional view of a pad conditioner according to a second embodiment of the invention. The pad conditioner of this embodiment further has

a lubricating layer 15 deposited on the pad conditioner described in the first embodiment. The lubricating layer 15 can be made of diamond, DLC, parylene, or WC/C, and is preferably made of Parylene or WC/C. Not only is the lubricating layer resistant to acids and bases such that it adapts to different process conditions, it is also capable of filling and fixing the defects on the surface of the pad conditioner to reduce the friction coefficient, so that the surface of the pad conditioner is smooth and the rate of debris removal is enhanced. Thus, during the CMP process, the dislodging of abrasive particles or chipping of partial sharp angles caused by uneven forces due to surface defects is decreased, and therefore the occurrence of scratching of wafers is minimized.

[0030] FIG. 4 shows a sectional view of a pad conditioner according to a third embodiment of the invention. The pad conditioner of this embodiment is as the pad conditioner described in the first embodiment with the plurality of cavities 14 being of a cylindrical shape instead of bowl-shaped.

[0031] FIG. 5 shows a sectional view of a pad conditioner according to a fourth embodiment of the invention. The pad conditioner of this embodiment is as the pad conditioner described in the first embodiment with the plurality of cavities 14 being cone-shaped instead of bowl-shaped.

[0032] The shape of the cavities of the invention is not limited to the shapes described in the aforementioned embodiments; cavities of other shapes also can achieve the intended effect of the invention.

[0033] FIGs. 6A - 6E illustrate a method of making the pad conditioner as described in the first embodiment. As shown in FIG. 6A, a substrate 11 is provided, and then a photo-resist layer 16 is formed on the substrate 11. A pre-defined pattern (not illustrated) is used to expose and develop the photo-resist layer 16 to get a patterned photo-resist layer 16a, as shown in FIG. 6B. Referring to FIG. 6C, a plurality of bowl-shaped cavities 14 are formed on the substrate 11 by wet-etching and the photo-resist layer 16a is removed. The cavities 14 are then filled with a bonding agent 12 as shown in FIG. 6D by printing method, and then as shown in FIG. 6E, a plurality of abrasive particles 13 are respectively placed in the bonding agent 12. By way of vacuum brazing, the abrasive particles 13 are securely and separately fixed on the substrate 11 by the bonding agent 12.

[0034] In the method of making such a pad conditioner of the invention, the way to form cavities is not limited to wet-etching; other methods such as mechanical drilling, laser drilling, galvanic process, dry-etching, and more, can be used.

[0035] While the invention has been described by way of example and in terms of the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. In other words, it is intended to include equivalent modifications and changes of the above embodiments without departing from the spirit and scope of the invention as would be apparent to those skilled in the art. Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such equivalent modifications and changes.

Claims

1. A pad conditioner for conditioning a CMP pad, comprising:

   a substrate having a plurality of cavities thereon;
   a bonding agent filling the plurality of cavities; and
   a plurality of abrasive particles fixed in the plurality of cavities by the bonding agent.

2. The pad conditioner for conditioning a CMP pad as described in claim 1, wherein the plurality of cavities are arranged in a regular manner.

3. The pad conditioner for conditioning a CMP pad as described in claim 2, wherein the size of each of the plurality of cavities is such that one cavity can only accommodate one abrasive particle.

4. The pad conditioner for conditioning a CMP pad as described in claim 3, wherein the plurality of cavities are bowl-shaped with a flat bottom, cone-shaped, or of a cylindrical shape.

5. The pad conditioner for conditioning a CMP pad as described in claim 4, wherein the plurality of abrasive particles are fixed in the plurality of cavities with the bonding agent by way of brazing.

6. The pad conditioner for conditioning a CMP pad as described in claim 1, further comprising:

   a lubricating layer.

7. The pad conditioner for conditioning a CMP pad as described in claim 6, wherein the lubricating layer is made of parylene.

8. The pad conditioner for conditioning a CMP pad as described in claim 6, wherein the lubricating layer is made of tungsten carbide/carbon film (WC/C).

9. A method of making a pad conditioner for conditioning a CMP pad, the method comprising:

   providing a substrate;
   forming a plurality of cavities on the substrate;
   filling the plurality of cavities with a bonding agent;
   placing a plurality of abrasive particles on the bonding agent in the cavities; and

securely and separately fixing the plurality of abrasive particles on the substrate by using the bonding agent.

10. The method of making such pad conditioner as described in claim 9, wherein the plurality of cavities are arranged in a regular manner.

11. The method of making such pad conditioner as described in claim 9, wherein the size of each of the plurality of cavities is such that one cavity can only accommodate one abrasive particle.

12. The method of making such pad conditioner as described in claim 9, wherein the plurality of cavities are bowl-shaped with a flat bottom, cone-shaped, or of a cylindrical shape.

13. The method of making such pad conditioner as described in claim 9, wherein the plurality of abrasive particles are fixed in the plurality of cavities with the bonding agent by way of brazing.

14. The method of making such pad conditioner as described in claim 9, further comprising:

forming a lubricating layer on the substrate, the bonding agent, and the plurality of abrasive particles.

15. The method of making such pad conditioner as described in claim 14, wherein the lubricating layer is made of parylene.

16. The method of making such pad conditioner as described in claim 14, wherein the lubricating layer is made of tungsten carbide/carbon film (WC/C).

17. The method of making such pad conditioner as described in claim 9, wherein the plurality of cavities can be formed by wet-etching, laser drilling, mechanical drilling or galvanic process.

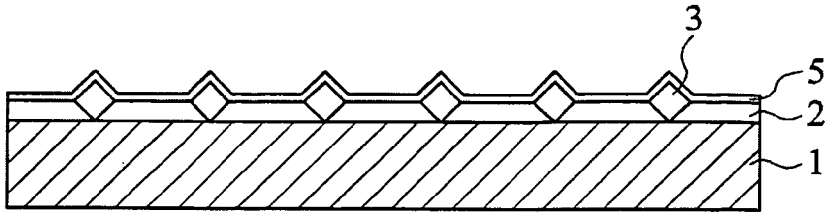

FIG. 1 (PRIOR ART)

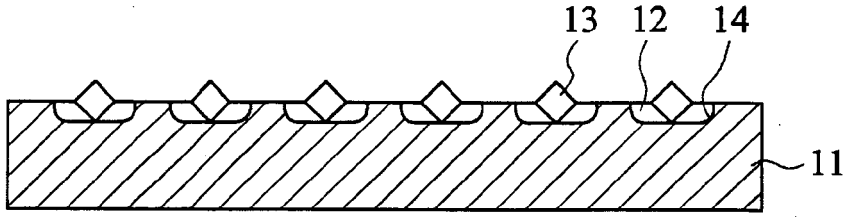

FIG. 2

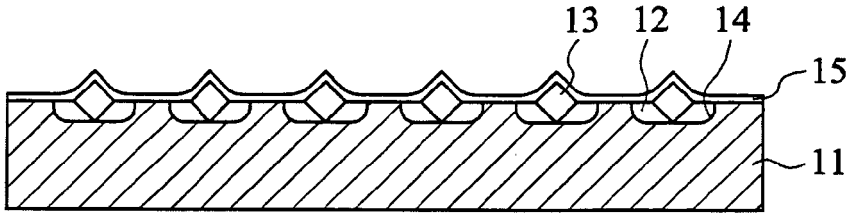

FIG. 3

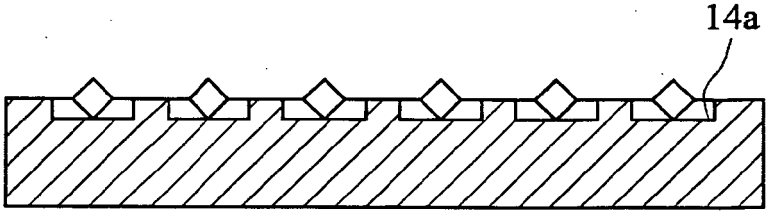

FIG. 4

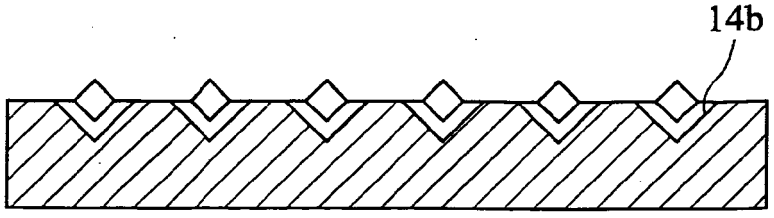

FIG. 5

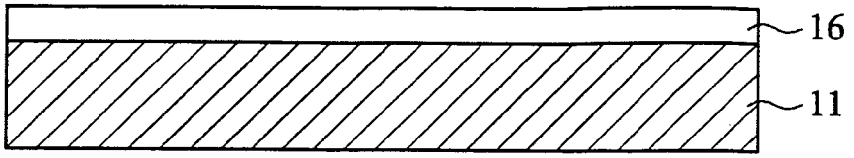

FIG. 6A

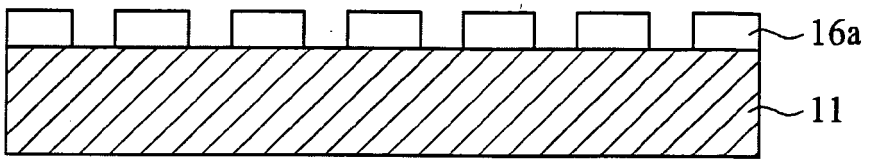

FIG. 6B

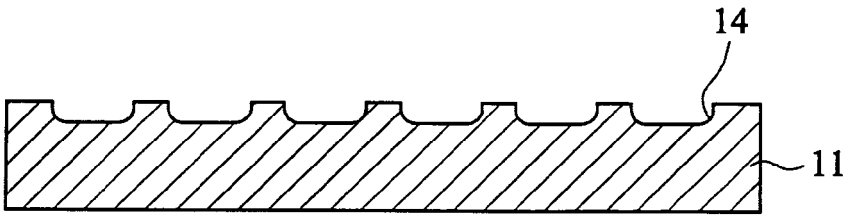

FIG. 6C

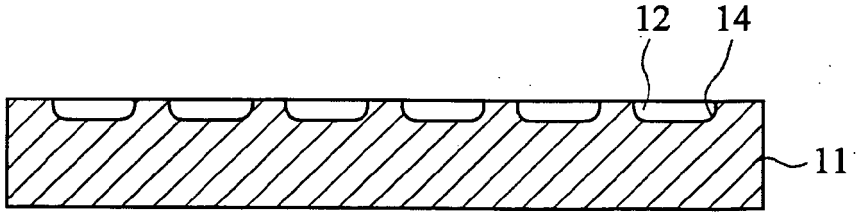

FIG. 6D

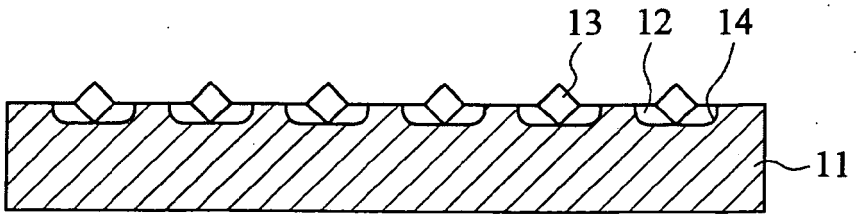

FIG. 6E

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 02 3680

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	DE 91 07 089 U1 (ZAHNRADPRAEZISION HORST REINEKE & CO. GMBH, 5980 WERDOHL, DE) 22 August 1991 (1991-08-22) * figure 10 * -----	1	
A	US 2002/197947 A1 (SAGAWA MASAYUKI) 26 December 2002 (2002-12-26) * the whole document * -----		

TECHNICAL FIELDS SEARCHED (IPC)
B24B B24D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 December 2005	Gelder, K

CATEGORY OF CITED DOCUMENTS

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15-12-2005

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