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(54) **CHEMICAL MECHANICAL POLISHING CONDITIONER HAVING DIFFERENT HEIGHTS**

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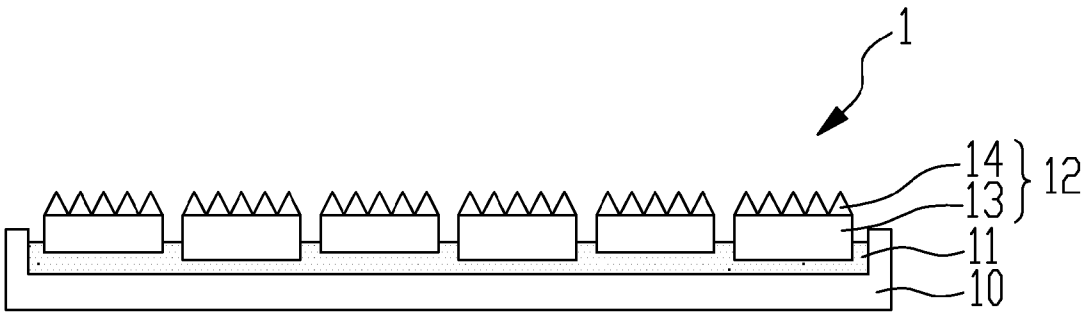
(57) **ABSTRACT**

The present invention relates to a chemical mechanical polishing conditioner having different heights, comprising: a substrate; a binding layer disposed on the substrate; and multiple abrasive units placed on the binding layer. Each abrasive unit has an abrasive unit substrate and an abrasive layer which is a diamond film formed by chemical vapor deposition and has multiple abrasive tips. The abrasive units have a first tip height and a second tip height. The first tip height is different from the second tip height. The chemical mechanical polishing conditioner can adjust the surface roughness of the pad to be polished and improve the drainage of abrasive slurry.



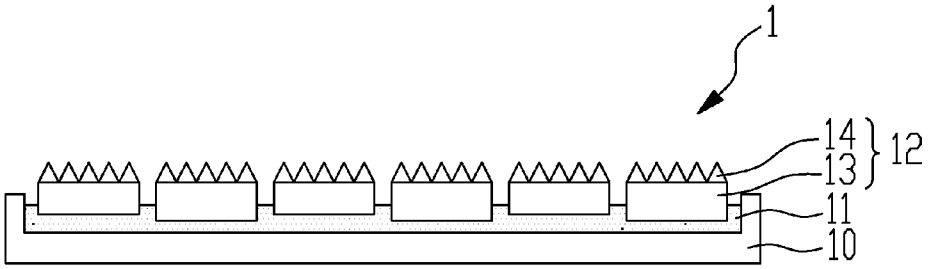


FIG.1A

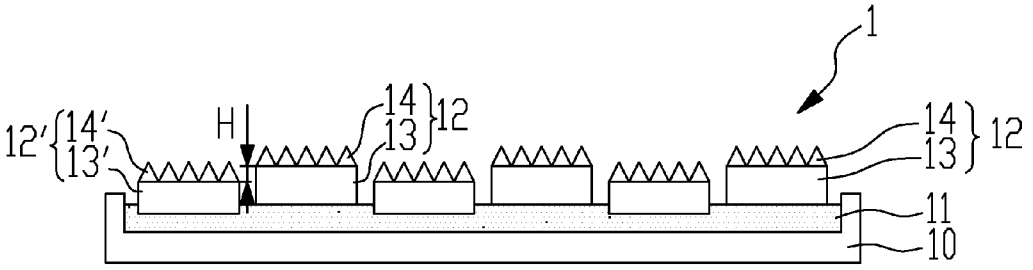


FIG.1B

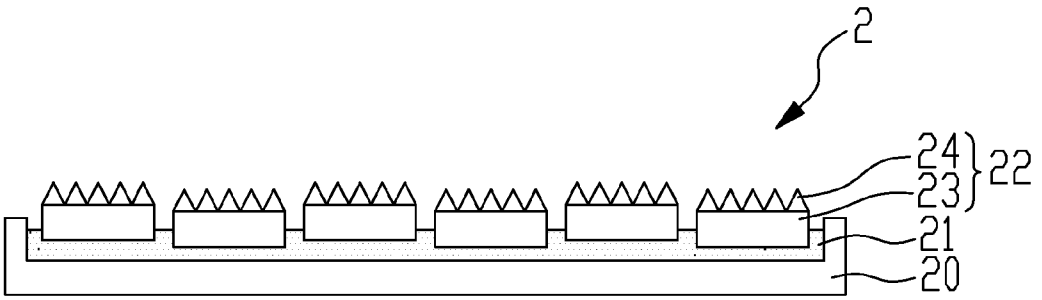


FIG.2

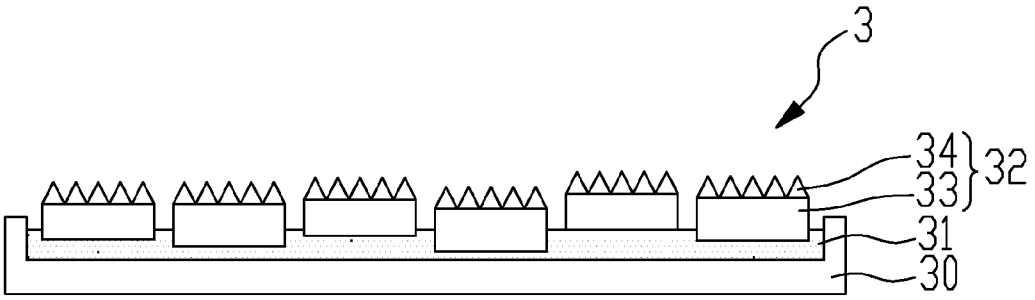


FIG.3

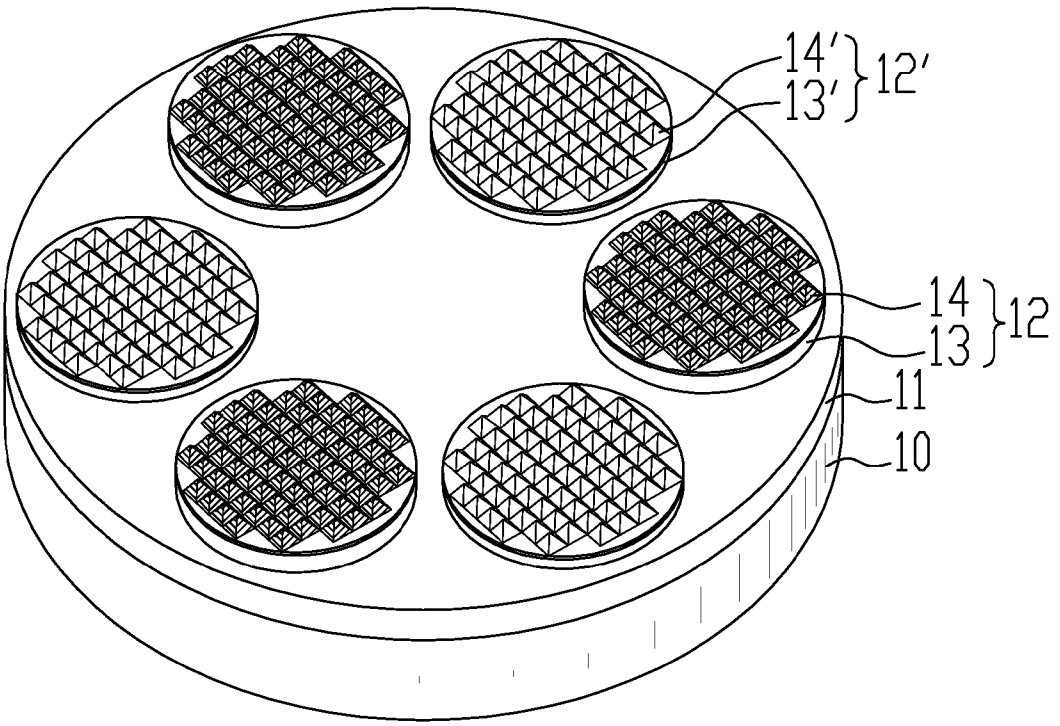


FIG.4

FIG.5A

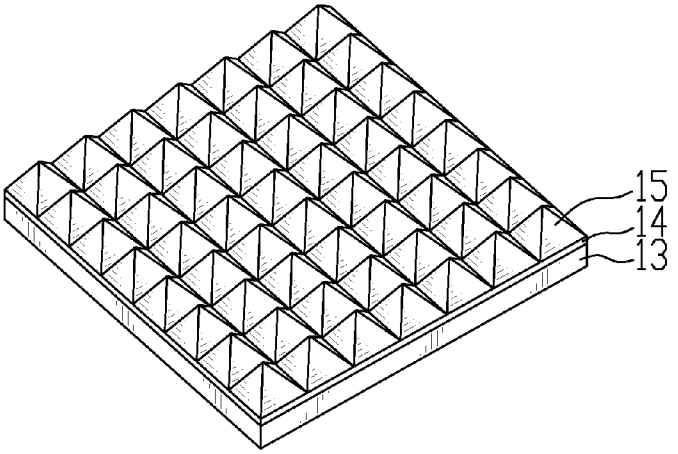


FIG.5B

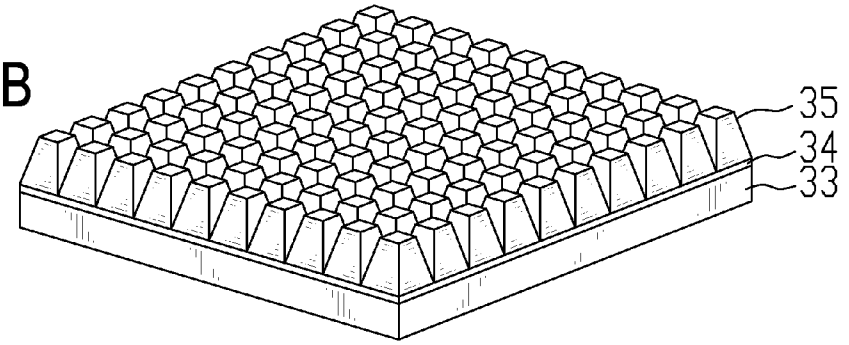
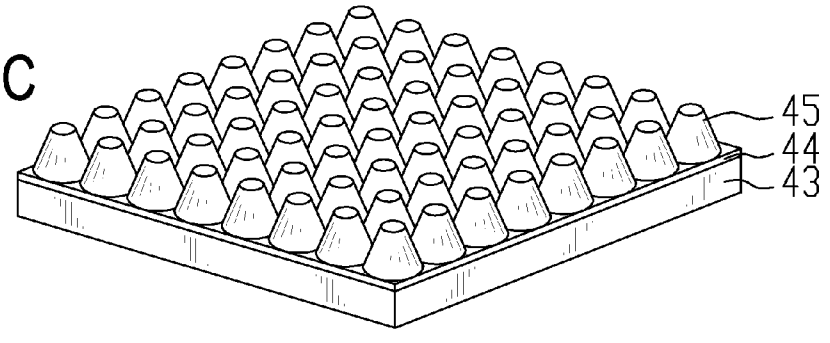


FIG.5C



CHEMICAL MECHANICAL POLISHING CONDITIONER HAVING DIFFERENT HEIGHTS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a chemical mechanical polishing conditioner having different heights, especially to a combinational chemical mechanical polishing conditioner having different heights.

[0003] 2. Description of the Prior Art(s)

[0004] Chemical Mechanical Polishing (abbreviated as CMP) is commonly used in various industries to polish the surfaces of various articles made of ceramic, silicon, glass, quartz, or metal. With the applicability of large-scaled planarization of integrated semiconductor device, CMP becomes a common planarization technique in the semiconductor process.

[0005] During the CMP process of the semiconductor, a pad is contacted with a wafer or other semiconductor elements in conjunction with suitable abrasive slurry to remove impurities or protruding structures on the surface of the wafer through both chemical reaction and mechanical force. When the pad has been used for a period of time, polishing debris produced from the CMP process will accumulate and stagnate on the surface of the pad, thereby reducing the polishing effect and efficiency. Therefore, a chemical mechanical polishing conditioner can be used to dress the surface of the pad for the desired polishing effect and efficiency.

[0006] In the preparation of a chemical mechanical polishing conditioner (abbreviated as CMP conditioner), multiple abrasive particles are mounted to a binding layer to form an abrasive layer. The abrasive layer is fixed to a surface of a substrate by brazing or sintering. Said CMP conditioner is suitable for dressing the pads; however, in more sophisticated semiconductor process with line-width below 45 nanometers, the rough surface of the pad that is too coarse will cause problems such as scratch, local over-polishing, depression, or non-uniform thickness of the wafer. As the line-width of integrated semiconductor device is decreasing, the demand for the planarization of the surface of the wafer is increasing, and same for the CMP conditioner.

[0007] Taiwan Patent Application Publication No. 201249595 discloses a pad conditioner for CMP comprising a substrate having a first set of protrusions and a second set of protrusions. The first set of the protrusions has a first average height and the second set of the protrusions has a second average height. The first average height and the second average height are different. The first set of the protrusions includes multiple protrusions each having non-flat surfaces on their tops, and so does the second set of the protrusions. A polycrystalline diamond layer is disposed on the non-flat surfaces of the first and second sets of the protrusions. The protrusions can be discriminated by their heights, predetermined positions, or dimensions of substrates. This prior invention provides various ways to measure the height of the protrusions including an average height, a peak-to-valley height, or a protruding height from a back side of the pad conditioner for CMP. However, the protrusions and the substrate are integrally formed, failing to form a totally planarized surface to improve the abrasion efficiency and prolong lifetime of the CMP conditioner.

[0008] Taiwan Patent Application Publication No. I228066 discloses a pad conditioner and a dressing method which provide a uniform abrasive surface. An abrasive surface **4** is mounted on the edge of a metal support **2** of the pad conditioner **1**. Multiple abrasive particles of various grain sizes are mounted on the abrasive surface **4** to form a first abrasive particle group **5** and a second abrasive particle group **6**. An adjustment article **7** is mounted on the metal support **2** for arbitrarily adjusting the height difference **6** between the front surfaces S**1**, S**2** of the first abrasive particle group **5** and the second abrasive particle group **6**. However, when the pad conditioner is applied to a pad, the pad conditioner cannot control an abrasion depth of the pad.

[0009] Furthermore, the abrasive ability of a conventional CMP conditioner is limited by the crystal structure of the abrasive particles.

[0010] To overcome the shortcomings, the present invention provides a CMP conditioner to mitigate or obviate the aforementioned problems.

SUMMARY OF THE INVENTION

[0011] The main objective of the present invention is providing a CMP conditioner having different heights by combining small abrasive units with a large substrate to provide a surface with improved polishing uniformity and different heights of the abrasive units, which can prevent thermal deformation of the substrate and can produce different piercing depths while dressing a pad to form deep trenches and shallow trenches, which can adjust the surface roughness of the surface of the pad and improve the drainage of abrasive slurry, on the surface of the pad.

[0012] To achieve the abovementioned objective, the present invention provides a CMP conditioner having different heights. The CMP conditioner having different heights comprises a substrate, a binding layer disposed on the substrate, and multiple abrasive units placed on the binding layer. Each abrasive unit has an abrasive layer and an abrasive unit substrate. The abrasive layer is a diamond film formed on the abrasive unit substrate by chemical vapor deposition and has multiple abrasive tips. The abrasive units have a first tip height and a second tip height. The first tip height is different from the second tip height. Preferably, thicknesses of the abrasive units are equal and thickness of the binding layer is varied. Alternatively, the thicknesses of the abrasive units are different or partially different and the thickness of the binding layer is varied.

[0013] A height difference between the first tip height and the second tip height is 5 micrometers to 100 micrometers, inclusive. Preferably, the height difference between the first tip height and the second tip height is 15 micrometers to 60 micrometers, inclusive. More preferably, the abrasive units have a third tip height and a fourth tip height.

[0014] Shape of the abrasive tips can be customized by the users' needs or various polishing conditions. The abrasive tips are in the shape of, but not limited to, knife edges, cones, arcs, cylinders, pyramids, or prisms. Preferably, the abrasive tips are in the shape of pyramids. Alternatively, the abrasive tips are in the shape of prisms. Alternatively, the abrasive tips are cylindrical in shape.

[0015] Alignment directions or tip angles of the abrasive tips can be customized by the users' needs or various polishing conditions. The alignment directions of the abrasive tip are uniform, partially uniform, or different. Preferably, the abrasive tips are perpendicular to a pad to be polished. Alternatively, the abrasive tips are non-perpendicular to the pad.

[0016] The tip angles of the abrasive tips are equal, partially equal, or different. Preferably, the tip angles of the abrasive tips are 60 degrees, 90 degrees, or 120 degrees. Alternatively, the tip angles of some of the abrasive tips are 60 degrees and the tip angles of the other abrasive tips are 90 degrees.

[0017] Besides, horizontal distances between any two neighboring abrasive tips can be customized by the users' needs or various polishing conditions. The horizontal distances between any two neighboring abrasive tips are equal, partially equal, or different. Preferably, the horizontal distances between any two neighboring abrasive tips are 1.5 times, 2 times, or 3 times larger than an outer diameter of the abrasive tips. Alternatively, some of the horizontal distances between two neighboring abrasive tips are 2 times larger than the outer diameter of the abrasive tips and the other horizontal distances between two neighboring abrasive tips are 3 times larger than the outer diameter of the abrasive tips.

[0018] A thickness of the substrate and the thicknesses of the abrasive units can be customized by the users' needs or various polishing conditions. The thickness of the substrate ranges from 10 millimeters (abbreviated as mm) to 200 mm. Preferably, the thickness of the substrate ranges from 60 mm to 100 mm. More preferably, the thickness of the substrate is 80 mm. The thicknesses of the abrasive units are equal, partially equal, or different. Preferably, the thicknesses of the abrasive units range from 5 mm to 100 mm. More preferably, the thicknesses of the abrasive units range from 15 mm to 30 mm. More preferably, the thicknesses of the abrasive units are 20 mm.

[0019] Preferably, a middle layer is disposed between the abrasive layer and the abrasive unit substrate to improve the binding strength between the abrasive layer and the abrasive unit substrate. The middle layer is made of the group consisting of aluminum oxide, silicon carbide, and aluminum nitride. More preferably, the middle layer is made of silicon carbide.

[0020] The middle layer can be formed by, but not limited to, chemical vapor deposition, physical vapor deposition, soldering, or brazing.

[0021] The abrasive layer is made of monocrystalline diamond or polycrystalline diamond. Preferably, the abrasive layer is made of polycrystalline diamond, and a crystal dimension of the abrasive layer ranges from 5 nanometers to 50 micrometers, inclusive. More preferably, the crystal dimension of the abrasive layer ranges from 10 nanometers to 20 micrometers, inclusive.

[0022] The abrasive unit substrate is a conductive substrate or an insulating substrate. The conductive substrate is made of molybdenum, tungsten, or tungsten carbide. A patterned surface with multiple surface tips can be formed on the conductive substrate by electric discharge machining, and the abrasive layer are successively formed on the surface tips by chemical vapor deposition to obtain the abrasive tips. Alternatively, a patterned surface with multiple surface tips can be formed on the insulating substrate by mechanical polishing or laser processing, and the abrasive layers are successively formed on the surface tips by chemical vapor deposition to obtain the abrasive tips. Alternatively, a surface of the abrasive unit substrate is flat. The abrasive layer is deposited on the abrasive unit substrate by chemical vapor deposition and has the abrasive tips. The insulating substrate is made of a ceramic material or a monocrystalline material. Preferably, the ceramic material is silicon carbide. The monocrystalline material is silicon or aluminum oxide.

[0023] The binding layer can be customized by the users' needs or various polishing conditions. The binding layer is made of, but not limited to, a ceramic material, a brazing material, an electroplating material, a metallic material, or a polymeric material. Preferably, the binding layer is made of a brazing material. The brazing material is made of the group consisting of iron, cobalt, nickel, chromium, manganese, silicon, aluminum, and any combination thereof. Alternatively, the binding layer is made of a polymeric material. The polymeric material is epoxy resin, polyester resin, polyacrylate resin, or phenol resin.

[0024] A component or a dimension of the substrate can be customized by the users' needs or various polishing conditions. The substrate is a stainless steel substrate, a die steel substrate, a metal alloy substrate, a ceramic substrate, a plastic substrate, or any combination thereof. Preferably, the substrate is a stainless steel substrate.

[0025] Preferably, the substrate is a flat substrate or a notch substrate. More preferably, the substrate is the flat substrate. Alternatively, the substrate is the notch substrate.

[0026] With the non-uniform configuration in height, the CMP conditioner having different heights of the present invention has the effect of adjusting the surface roughness of the pad and improving the drainage of abrasive slurry. In summary, the CMP conditioner having different heights has the abrasive units assembled onto the substrate prevents both the thermal deformation of the substrate and polishing non-uniformity, thus renders the pad a uniform surface after polishing.

[0027] Other objectives, advantages and novel features of the invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] FIG. **1**A is a side view of a CMP conditioner having different heights in accordance with Embodiment 1 of the present invention;

[0029] FIG. **1**B is another side view of the CMP conditioner having different heights in accordance with Embodiment 1 of the present invention;

[0030] FIG. **2** is a side view of a CMP conditioner having different heights in accordance with Embodiment 2 of the present invention;

[0031] FIG. **3** is a side view of a CMP conditioner having different heights in accordance with Embodiment 3 of the present invention;

[0032] FIG. **4** is a top view of the CMP conditioner having different heights in accordance with Embodiment 1 of the present invention;

[0033] FIG. **5**A is a top view of an abrasive unit of a CMP conditioner having different heights in accordance with Embodiment 1 of the present invention;

[0034] FIG. **5**B is a top view of an abrasive unit of a CMP conditioner having different heights in accordance with Embodiment 4 of the present invention; and

[0035] FIG. **5**C is a top view of an abrasive unit of a CMP conditioner having different heights in accordance with Embodiment 5 of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiment 1

[0036] With reference to FIG. **1**A, the present invention provides a chemical mechanical polishing conditioner having different heights **1**. The chemical mechanical polishing conditioner having different heights **1** comprises a substrate **10** made of stainless steel, a binding layer **11**, and multiple abrasive units **12**. The substrate **10** is a flat substrate and has a thickness of 80 mm. The binding layer **11** is disposed on the substrate **10**. Each abrasive unit **12** has an abrasive unit substrate **13** and an abrasive layer **14**. The abrasive unit substrate **13** is a ceramic substrate made of silicon carbide. The abrasive unit substrates **13** have two different thicknesses, 20 mm and 30 mm. A surface of the abrasive unit substrate **13** is a flat surface and the abrasive layer **14** is successively formed on the surface tips by chemical vapor deposition to obtain multiple abrasive tips. The abrasive tips are in the shape of pyramids. Specifically, with reference to FIG. **5**A, the abrasive tips are continuously arranged on the abrasive unit substrate **13** with an array pattern. The abrasive tips are in the shape of quadrangular pyramids. Alignment directions of the abrasive tips are uniform. Tip angles of the abrasive tips are equal. Besides, the abrasive units have a first tip height and a second tip height. Besides, the first tip height is different from the second tip height. With reference to FIG. **1**B, the abrasive units **12** have the first tip height and the abrasive units **12'** have the second tip height. A height difference H between the first tip height and the second tip height is 20 micrometers and the first tip height of the abrasive units **12** is relatively higher than the second tip height of the abrasive units **12'**. When the chemical mechanical polishing conditioner having different heights **1** is applied to dress a pad, the abrasive units **12'** having the second tip height can produce shallow trenches, which can adjust the surface roughness of the pad, on the surface of the pad. The abrasive units **12** having the first tip height can produce deep trenches, which can improve the drainage of abrasive slurry, on the surface of the pad. With reference to FIG. **4**, the abrasive units **12**, **12'** are on the substrate **10** and the binding layer **11**. The abrasive units **12** having the first tip height are shown in the shape of pyramids with grids and the abrasive units **12'** comprising the second tip height are shown in the shape of pyramids in white color. The abrasive units **12** are arranged alternately with the abrasive units **12'** in an annular pattern.

Embodiment 2

[0037] With reference to FIG. **2**, the CMP conditioner having different heights **2** in Embodiment 2 is similar with the CMP conditioner having different heights in Embodiment 1. The difference between the two embodiments is that the thicknesses of the abrasive units of the CMP conditioner having different heights in Embodiment 1 are different and the thickness of the binding layer of the CMP conditioner having different heights in Embodiment 1 is fixed. However, the thicknesses of the abrasive units of the CMP conditioner having different heights in Embodiment 2 are equal and thickness of the binding layer of the CMP conditioner having different heights in Embodiment 2 is varied. The CMP conditioner having different heights **2** of the present embodiment comprises the substrate **20** made of stainless steel, the binding layer **21**, and the abrasive units **22**. The substrate **20** is a flat substrate and has a thickness of 80 mm. The binding layer **21** is disposed on the substrate **20**. Each abrasive unit **22** has the abrasive unit substrate **23** and the abrasive layer **24**. The abrasive unit substrate **23** is a ceramic substrate made of silicon carbide. The thickness of the abrasive unit substrate **23** is 20 mm. The surface of the abrasive unit substrate **23** is flat. The abrasive layer **24** is deposited on the abrasive unit substrate **23** by chemical vapor deposition. The abrasive layer **24** has the abrasive tips. The abrasive tips are in the shape of pyramids, specifically, quadrangular pyramids (such as FIG. **5**A). The abrasive tips are continuously arranged on the abrasive unit substrate **23** with an array pattern. The alignment directions of the abrasive tips are uniform. The tip angles of the abrasive tips are equal. The thickness of the binding layer **21** is varied, which can adjust the heights of the abrasive units **22** to make the abrasive units **22** form the first tip heights and the second tip heights. The first tip height is different from the second tip height.

Embodiment 3

[0038] With reference to FIG. **3**, the CMP conditioner having different heights **3** in Embodiment 3 is similar with the CMP conditioner having different heights in Embodiment 1. The difference between the two embodiments is that thicknesses of the abrasive units of the CMP conditioner having different heights in Embodiment 1 are different and thickness of the binding layer of the CMP conditioner having different heights in Embodiment 1 is fixed. However, the thicknesses of the abrasive units of the CMP conditioner having different heights in Embodiment 3 are different and the thickness of the binding layer of the CMP conditioner having different heights in Embodiment 3 is varied. The CMP conditioner having different heights **3** of the present embodiment comprises the substrate **30** made of stainless steel, the binding layer **31**, and the abrasive units **32**. The substrate **30** is a flat substrate and has a thickness of 80 mm. The binding layer **31** is disposed on the substrate **30**. Each abrasive unit **32** has the abrasive unit substrate **33** and the abrasive layer **34**. The abrasive unit substrate **33** is a ceramic substrate made of silicon carbide. The abrasive unit substrates **33** have two different thicknesses, 20 mm and 30 mm. A surface of the abrasive unit substrate **33** is a flat surface and the abrasive layer **34** is successively formed on the surface tips by chemical vapor deposition to obtain multiple abrasive tips. The thickness of the binding layer **31** is varied, which can adjust the heights of the abrasive units **32** to make the abrasive units **32** form the first tip height, the second tip height, and the third tip height. The first tip height, the second tip height, and the third tip height are different.

Embodiment 4

[0039] The CMP conditioner having different heights in Embodiment 4 is similar to the CMP conditioner having different heights in Embodiment 1. The difference between the two embodiments is that the abrasive tips of the CMP conditioner having different heights in Embodiment 1 are in the shape of pyramids and the abrasive tips of the CMP conditioner having different heights in Embodiment 4 are in a different shape from the abrasive tips of the CMP conditioner having different heights in Embodiment 1.

[0040] With reference to FIG. **5**A, the abrasive tips **15** of the CMP conditioner having different heights in Embodiment 1 are in the shape of pyramids and the abrasive tips **15** of the

abrasive layer **14** are continuously arranged on the abrasive unit substrate **13** with an array pattern. With reference to FIG. **5**B, the abrasive tips **35** of Embodiment 4 are in the shape of prisms, specifically, quadrangle prisms. The abrasive tips **35** of the abrasive layer **34** are continuously arranged on the abrasive unit substrate **33** with an array pattern.

Embodiment 5

[0041] The CMP conditioner having different heights in Embodiment 5 is similar to the CMP conditioner having different heights in Embodiment 1. The difference between the two embodiments is that the abrasive tips of the CMP conditioner having different heights in Embodiment 1 are in the shape of pyramids and the abrasive tips of the CMP conditioner having different heights in Embodiment 5 are in a different shape from the abrasive tips of the CMP conditioner having different heights in Embodiment 1.

[0042] With reference to FIG. **5**A, the abrasive tips **15** of the CMP conditioner having different heights in Embodiment 1 are in the shape of pyramids and the abrasive tips **15** of the abrasive layer **14** are continuously arranged on the abrasive unit substrate **13** with an array pattern. With reference to FIG. **5**C, the abrasive tips **45** of Embodiment 5 are cylindrical in shape. The abrasive tips **45** of the abrasive layer **44** are continuously arranged on the abrasive unit substrate **43** with an array pattern.

[0043] Even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and features of the invention, the disclosure is illustrative only. Changes may be made in the details, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. A chemical mechanical polishing conditioner having different heights comprising:

a substrate;

a binding layer disposed on the substrate;

multiple abrasive units placed on the binding layer, each abrasive unit having an abrasive layer and an abrasive unit substrate, the abrasive layer being a diamond film formed on the abrasive unit substrate by chemical vapor deposition and having multiple abrasive tips;

wherein the abrasive units have a first tip height and a second tip height, and the first tip height is different from the second tip height.

2. The chemical mechanical polishing conditioner having different heights as claimed in claim **1**, wherein a height difference between the first tip height and the second tip height is 5 micrometers to 100 micrometers, inclusive.

3. The chemical mechanical polishing conditioner having different heights as claimed in claim **2**, wherein the height difference between the first tip height and the second tip height is 15 micrometers to 60 micrometers, inclusive.

4. The chemical mechanical polishing conditioner having different heights as claimed in claim **1**, wherein the abrasive units have a third tip height and a fourth tip height.

5. The chemical mechanical polishing conditioner having different heights as claimed in claim **1**, wherein the abrasive tips are in the shape of knife edges, cones, arcs, cylinders, pyramids, or prisms.

6. The chemical mechanical polishing conditioner having different heights as claimed in claim **1**, wherein alignment directions of the abrasive tips are uniform, partially uniform, or different.

7. The chemical mechanical polishing conditioner having different heights as claimed in claim **1**, wherein tip angles of the abrasive tips are equal, partially equal, or different.

8. The chemical mechanical polishing conditioner having different heights as claimed in claim **1**, wherein horizontal distances between any two neighboring abrasive tips are equal, partially equal, or different.

9. The chemical mechanical polishing conditioner having different heights as claimed in claim **1**, wherein thicknesses of the abrasive units are equal, partially equal, or different.

10. The chemical mechanical polishing conditioner having different heights as claimed in claim **1**, wherein a middle layer is disposed between the abrasive layer and the abrasive unit substrate.

11. The chemical mechanical polishing conditioner having different heights as claimed in claim **10**, wherein the middle layer is made of the group consisting of aluminum oxide, silicon carbide, and aluminum nitride.

12. The chemical mechanical polishing conditioner having different heights as claimed in claim **1**, wherein the abrasive unit substrate is a conductive substrate or an insulating substrate.

13. The chemical mechanical polishing conditioner having different heights as claimed in claim **1**, wherein the binding layer is made of a ceramic material, a brazing material, an electroplating material, a metallic material, or a polymeric material.

14. The chemical mechanical polishing conditioner having different heights as claimed in claim **13**, wherein the polymeric material is epoxy resin, polyester resin, polyacrylate resin, or phenol resin.

15. The chemical mechanical polishing conditioner having different heights as claimed in claim **13**, wherein the brazing material is made of the group consisting of iron, cobalt, nickel, chromium, manganese, silicon, aluminum, and any combination thereof.

16. The chemical mechanical polishing conditioner having different heights as claimed in claim **1**, wherein the substrate is a stainless steel substrate, a die steel substrate, a metal alloy substrate, a ceramic substrate, a plastic substrate, or any combination thereof.

17. The chemical mechanical polishing conditioner having different heights as claimed in claim **1**, wherein the substrate is a flat substrate or a notch substrate.

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