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(54) **GRINDING TOOL**

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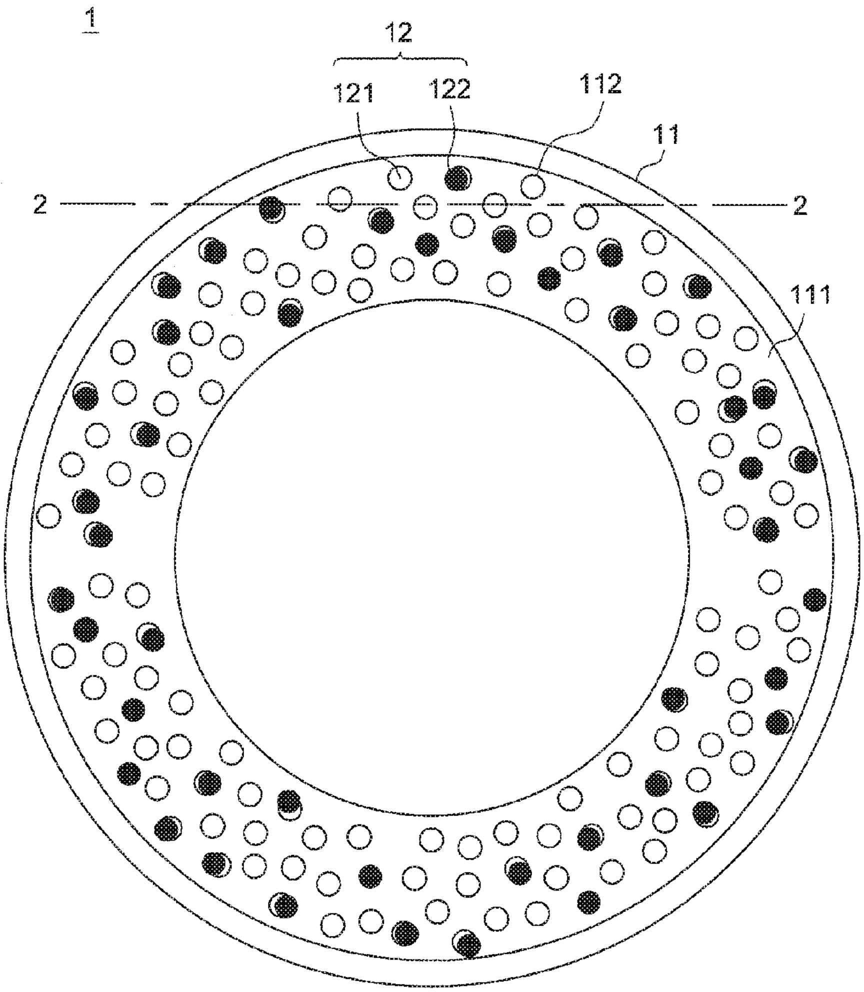
CPC ***B24B 53/017*** (2013.01); ***B24D 7/066*** (2013.01)

(57) **ABSTRACT**

A grinding tool includes a substrate having a working surface, and a plurality of abrasive particles distributed across the working surface and protruding outward from the working surface, wherein at least some of the abrasive particles are machined to form abrasive particles respectively having a pyramid shape, the pyramid shape being a right square pyramid or a right hexagonal pyramid.



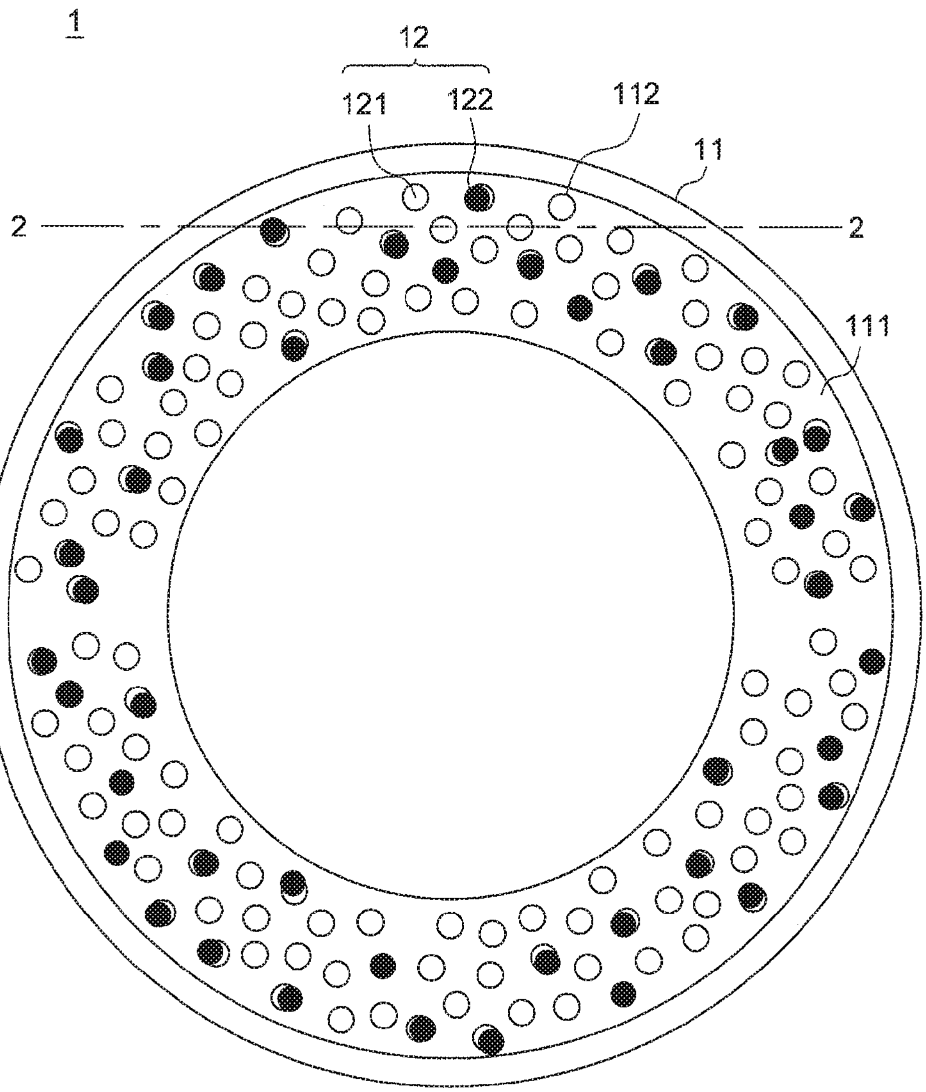


FIG. 1

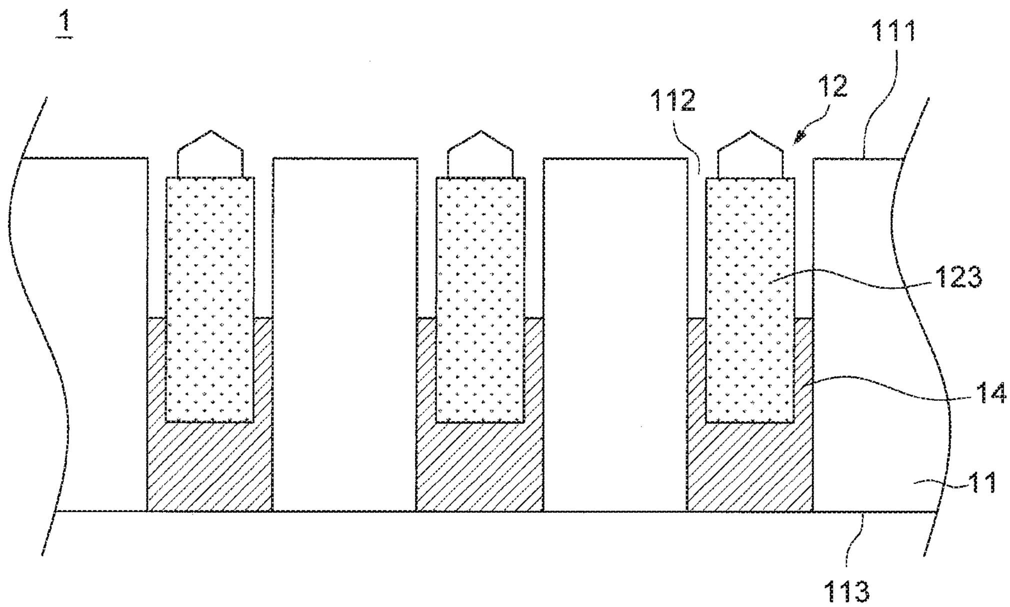


FIG. 2

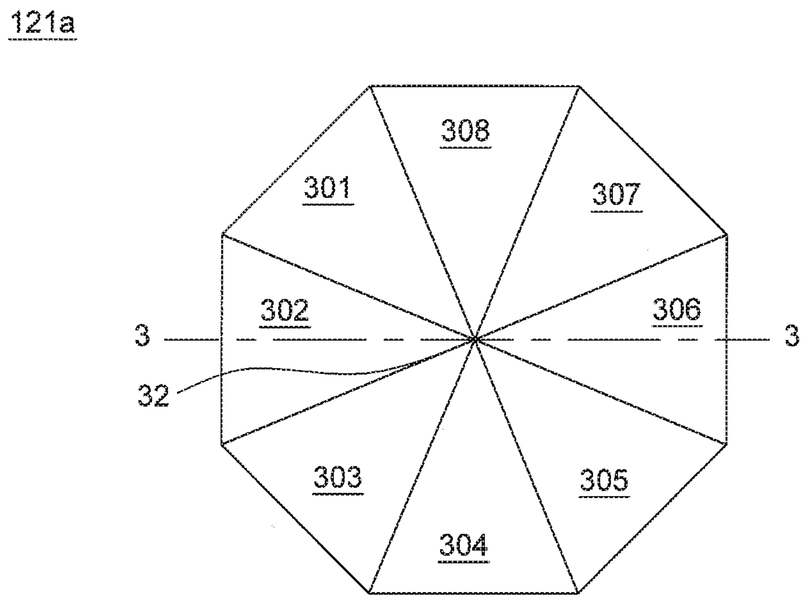


FIG. 3A

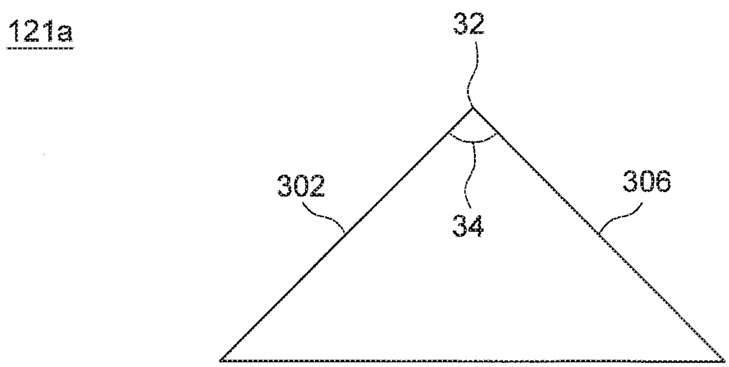


FIG. 3B

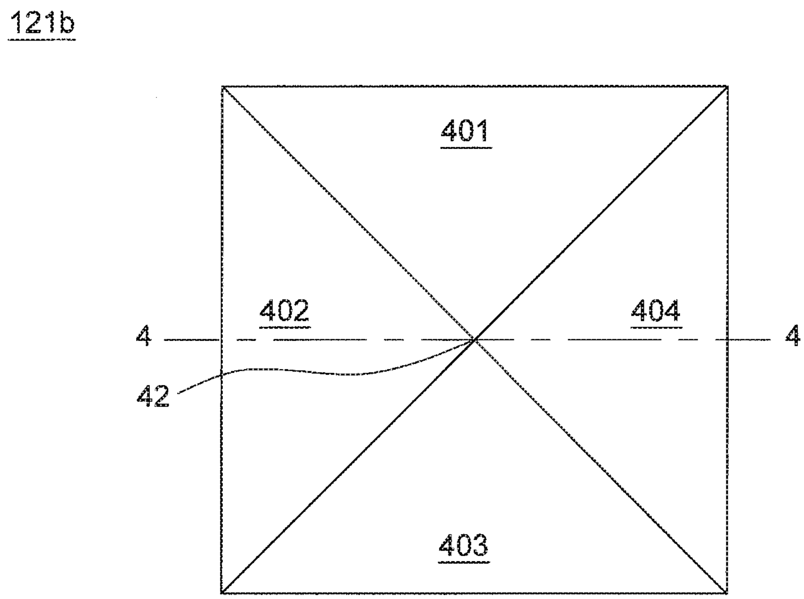


FIG. 4A

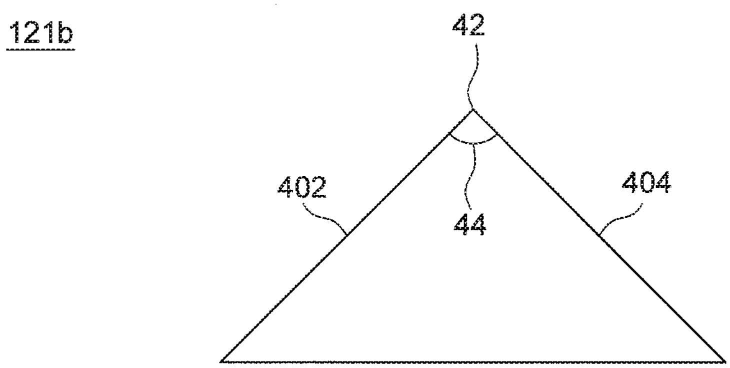


FIG. 4B

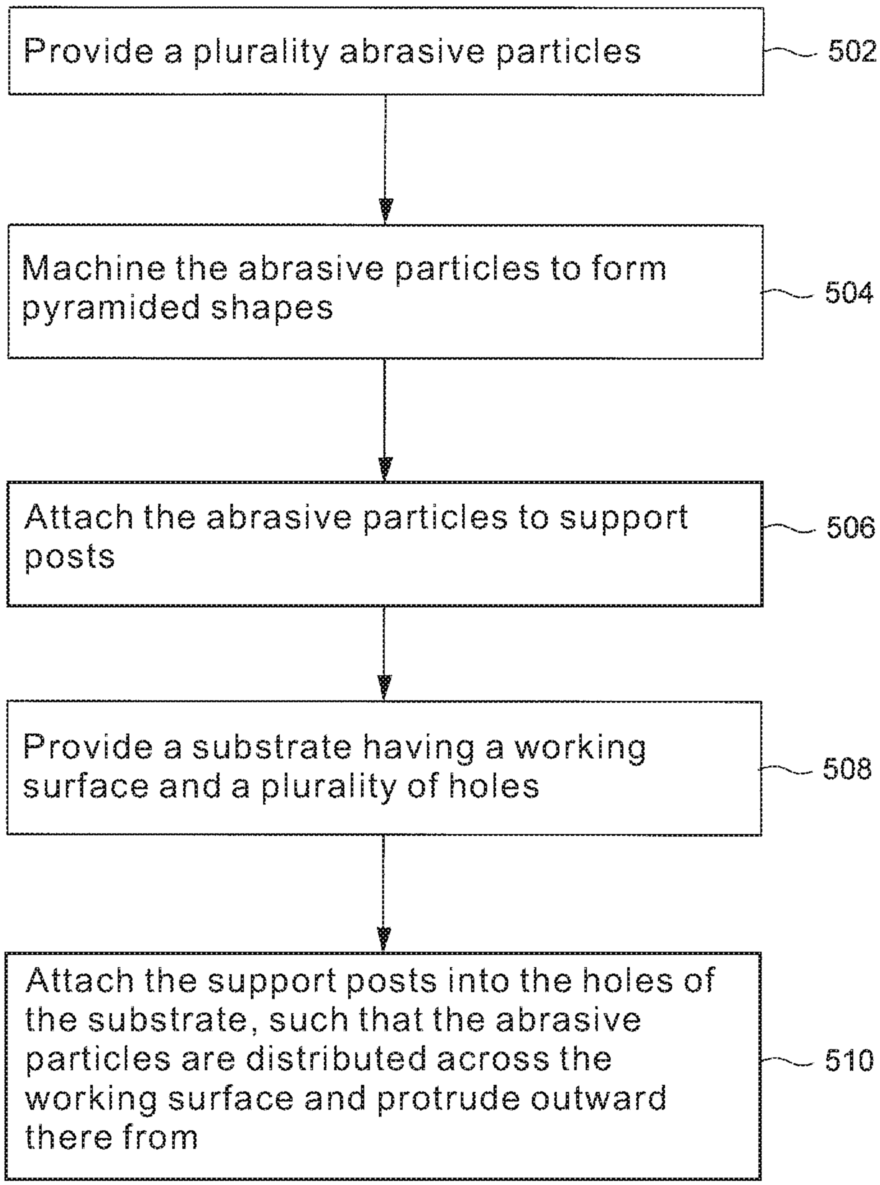

Provide a plurality abrasive particles
502
Machine the abrasive particles to form pyramided shapes
504
Attach the abrasive particles to support posts
506
Provide a substrate having a working surface and a plurality of holes
508
Attach the support posts into the holes of the substrate, such that the abrasive particles are distributed across the working surface and protrude outward there from
510

FIG. 5

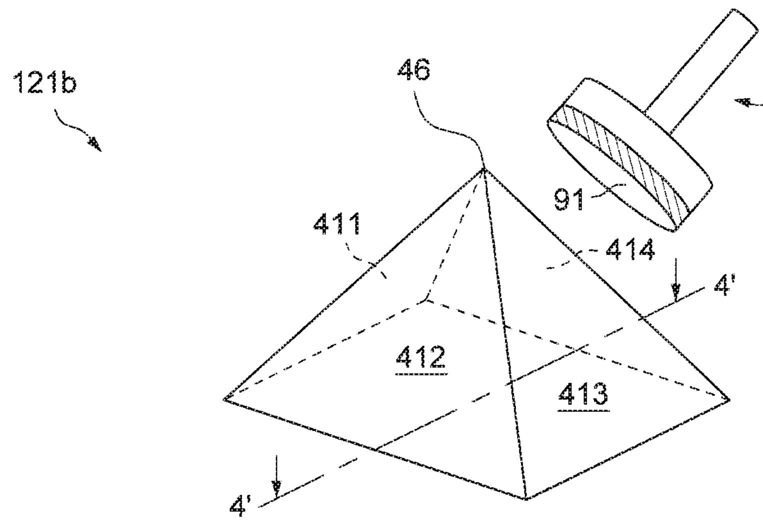


FIG. 6A

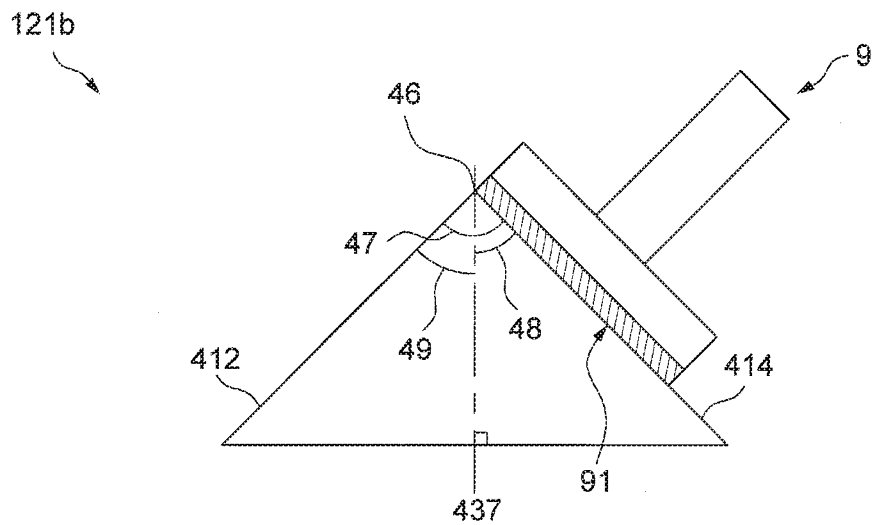


FIG. 6B

GRINDING TOOL

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority to Taiwan Patent Application No. 104112575 filed on Apr. 20, 2015, the disclosure of which is incorporated herein by reference.

BACKGROUND

[0002] 1. Field of the Invention

[0003] The present invention relates to grinding tools used in chemical mechanical polishing techniques.

[0004] 2. Description of the Related Art

[0005] Grinding and/or polishing techniques are generally applied to create a desirable surface roughness or planarity on a rigid part, such as metal, ceramic or glass parts, or semiconductor wafers. To this purpose, the grinding and/or polishing techniques use tools having abrasive elements that can wear the hard surface.

[0006] A well known polishing technique is the chemical mechanical polishing (CMP) technique employed in semiconductor fabrication processes. CMP uses corrosive chemical slurry in conjunction with a polishing pad to remove undesired residues and planarize a wafer surface, which can be made of ceramic, silicon, glass, sapphire or metal. CMP can be typically conducted multiple times to planarize wafers. For example, the fabrication process of semiconductor wafers having 28 nm-wide features may require up to 30 CMP steps. After the polishing pad is used over a period of time, the grinding action of the polishing pad may diminish. Accordingly, an additional grinding tool (also called "conditioner") may be typically used to coarsen the surface of the polishing pad for maintaining an optimal grinding efficiency of the polishing pad.

[0007] Conventionally, a cutting rate of the grinding tool may be improved by increasing a distribution density of the abrasive elements provided thereon. This requires increasing the quantity of abrasive elements on the grinding tool, which makes the grinding tool more expensive to manufacture.

[0008] Therefore, there is a need for a grinding tool that can have an improved cutting rate, and can be fabricated in a cost-effective manner.

SUMMARY

[0009] The present application describes a grinding tool and methods of fabricating the grinding tool that can address at least the aforementioned problems. In one embodiment, the grinding tool includes a substrate having a working surface, and a plurality of abrasive particles distributed across the working surface and protruding outward from the working surface, wherein at least some of the abrasive particles are machined to form abrasive particles respectively having a pyramid shape, the pyramid shape being a right square pyramid or a right hexagonal pyramid.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a planar view illustrating an embodiment of a grinding tool;

[0011] FIG. **2** is a schematic cross-sectional view taken along section plane **2** of FIG. **1** illustrating support posts affixed in holes provided in the grinding tool;

[0012] FIG. **3**A is a top view illustrating an abrasive particle having the shape of a right hexagonal pyramid;

[0013] FIG. **3**B is a cross-sectional view of the right hexagonal pyramid of FIG. **3**A taken along section plane **3**;

[0014] FIG. **4**A is a top view illustrating an abrasive particle having the shape of a right square pyramid;

[0015] FIG. **4**B is a cross-sectional view of the right square pyramid of FIG. **4**A taken along section plane **4**;

[0016] FIG. **5** is a flowchart illustrating exemplary method steps of fabricating abrasive particles used in the grinding tool;

[0017] FIG. **6**A is a schematic view illustrating one abrasive particle machined to form a right square pyramid; and

[0018] FIG. **6**B is a schematic cross-sectional view of the abrasive particle of FIG. **6**A taken along section plane **4'**.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0019] FIG. **1** is a schematic planar view illustrating an embodiment of a grinding tool **1**, and FIG. **2** is a schematic cross-sectional view taken along section plane **2** of FIG. **1** illustrating support posts **123** affixed in holes **112** of the grinding tool **1**. In one example of implementation, the grinding tool **1** can be used as a conditioner for a polishing pad in chemical mechanical polishing (CMP) processes. Referring to FIGS. **1** and **2**, the grinding tool **1** can include a substrate **11** and a plurality of abrasive particles **12**. The substrate **11** can have a working surface **111** and a bottom surface **113** on two opposite sides, and a plurality of holes **112** respectively opening on the working surface **111** and the bottom surface **113**. The abrasive particles **12** can be respectively affixed to a plurality of support posts **123**, and the support posts **123** can be respectively attached in the holes **112** of the substrate **11** via bonding layers **14**. The bonding layers **14** can be exposed outward on the bottom surface **113** of the substrate **11**, and the abrasive particles **12** can project outward from the working surface **111** of the substrate **11**. The working surface **111** of the substrate **11** thus can be used for uniformly grinding a desirable article. Examples of suitable materials for the substrate **11** can be stainless steel, polymer or ceramic.

[0020] Exemplary techniques for attaching the abrasive particles **12** to the support posts **123** can include brazing, sintering, electroplating and the like. The support posts **123** can have cylindrical shapes, parallelepiped shapes, or any other suitable shapes. Examples of suitable materials for the support posts **123** can include metallic materials.

[0021] The abrasive particles **12** can be made of any suitable materials having high hardness. Examples of suitable materials can include diamond, cubic boron nitride, aluminum oxide, and silicon carbide. The size of the abrasive particles **12** can exemplary be 20 to 30 US mesh, i.e., a mesh screen used to filter the abrasive particles can have 20 to 30 openings per square inch.

[0022] Referring again to FIG. **1**, the abrasive particles **12** of the grinding tool **1** can include a plurality of first abrasive particles **121** and a plurality of second abrasive particles **122**. The first abrasive particles **121** have specifically machined surfaces, and the second abrasive particles **122** have no machined surfaces. In FIG. **1**, the first abrasive particles **121** are shown as hollow circles, and the second abrasive particles **122** are shown as solid circles. The first abrasive particles **121** can be distributed over the entire working surface **111**, and the second abrasive particles **122** can be dispersed among the first abrasive particles **111**.

[0023] The first abrasive particles **121** can be machined with an abrasive tool to obtain a desired shape. In one embodiment, the first abrasive particles **121** can be machined to have a pyramid shape with a sharp tip. More specifically, the pyramid shape of the first abrasive particles **121** can have a hexagonal base and an apex directly above a center of the base (called "right hexagonal pyramid"), or a square base and an apex directly above a center of the base (called "right square pyramid").

[0024] FIG. **3**A is a top view illustrating an abrasive particle having the shape of a right hexagonal pyramid **121***a*, and FIG. **3**B is a cross-sectional view of the right hexagonal pyramid **121***a* taken along section plane **3** shown in FIG. **3**A. As shown in FIGS. **3**A and **3**B, the abrasive particle having the shape of a right hexagonal pyramid **121***a* can have 8 side faces **301**-**308** and an apex **32**. Any pair of opposite side faces (e.g., the side faces **302** and **306** shown in FIG. **3**B) intersecting at the apex **32** can define a tip angle **34** between about 80 and about 100 degrees. When the abrasive particle having the shape of the right hexagonal pyramid **121***a* is used for grinding a desired article (e.g., a polishing pad), the sharp apex **32** can cut relatively deeper into the article, providing a higher cutting rate. In one embodiment, the tip angle **34** of the right hexagonal pyramid **121***a* is preferably about 90 degrees.

[0025] FIG. **4**A is a top view illustrating an abrasive particle having the shape of a right square pyramid **121***b*, and FIG. **4**B is a cross-sectional view of the right square pyramid **121***b* taken along section plane **4** shown in FIG. **4**A. As shown in FIGS. **4**A and **4**B, the right square pyramid **121***b* of the abrasive particle can have 4 side faces **401**-**404** and an apex **42**. Any pair of opposite side faces (e.g., the side faces **402** and **404** shown in FIG. **4**B) intersecting at the apex **42** can define a tip angle **44** between about 70 and about 90 degrees. When the abrasive particle having the shape of the right square pyramid **121***b* is used for grinding a desired article (e.g., conditioning a polishing pad), the sharp apex **42** can cut relatively deeper into the article, providing a higher cutting rate. In one embodiment, the tip angle **44** of the right square pyramid **121***b* is preferably about 80 degrees.

[0026] In practice, it is observed that an abrasive particle having the shape of a right square pyramid may exhibit different grinding characteristics from an abrasive particle having the shape of a right hexagonal pyramid. For example, suppose that both types of abrasive particles (i.e., right hexagonal pyramid and right square pyramid) have a same tip angle and are used to condition a polishing pad. Compared to the abrasive particle having a right hexagonal pyramid shape, the abrasive particle having a right square pyramid shape can have a smaller contact surface with the polishing pad and form a narrower and deeper cutting groove. This may tend to show improved grinding action of abrasive particles having a right square pyramid shape compared to abrasive particles having a right hexagonal pyramid shape.

[0027] Generally, the higher cutting rate, the better grinding action. Through experiments, it is observed that that the cutting rate of abrasive particles with specifically machined surfaces (i.e., having right square pyramid or right hexagonal pyramid shapes) can be higher than conventional abrasive particles without specifically machined surfaces. Unlike conventional grinding tools having no abrasive particles with specifically machined surfaces (i.e., having only second abrasive particles **122** shown in FIG. **1**), the grinding tool **1** described herein can have an improved cutting rate by incorporating first abrasive particles **121** having specifically machined surfaces and second abrasive particles **122** having no machined surfaces. As a result, a surface of a polishing pad subjected to conditioning treatment can be coarser when treated with the grinding tool **1** described herein (i.e., having abrasive particles with right square and/or right hexagonal pyramid shapes) than when treated with a conventional grinding tool having no abrasive particles with specifically machined surfaces.

[0028] FIG. **5** is a flowchart illustrating exemplary method steps of fabricating abrasive particles used in the grinding tool **1** described herein. In initial step **502**, a plurality of abrasive particles are provided. The abrasive particles can be made of high hardness materials such as diamond, cubic boron nitride, aluminum oxide, and silicon carbide. The size of the abrasive particles can exemplary be 20 to 30 US mesh.

[0029] In next step **504**, an abrasive tool is then used to machine at least some of the abrasive particles to form abrasive particles **121** having a pyramid shape with a sharp tip. The pyramid shape of the abrasive particles **121** can be a right square pyramid or a right hexagonal pyramid.

[0030] FIG. **6**A is a schematic view illustrating one abrasive particle **121***b* machined to form a right square pyramid, and FIG. **6**B is a schematic cross-sectional view of the abrasive particle **121***b* taken along section plane **4'** as shown in FIG. **6**A. Referring to FIGS. **6**A and **6**B, an abrasive particle can be machined with the abrasive tool **9** to form the abrasive particle **121***b* having four side faces **411**-**414** and an apex **46**. In order to form the side face **414** of the abrasive particle **121***b*, the abrasive tool **9** can be exemplary inclined to form an angle **48** between a grinding surface **91** of the abrasive tool **9** and a reference line **437** defined as an axis that is perpendicular to a horizontal plane and passes through the apex **46**. For forming the side face **412** of the abrasive particle **121***b* opposite to the side face **414**, the abrasive tool **9** can be inclined in a symmetrical manner to form an angle **49** between the grinding surface **91** of the abrasive tool **9** and the reference line **437**, the angle **48** and **49** being substantially equal. A tip angle **47** defined by the two side faces **412** and **414** intersecting at the apex **46** can be between about 70 degrees and about 90 degrees, and the angles **48** and **49** can respectively range from about 35 degrees to about 45 degrees. In one embodiment, the tip angle **47** of the abrasive particle **121***b* can be equal to about 80 degrees. The other two side faces **411** and **413** of the abrasive particle **121***b* can be formed in a similar way.

[0031] It will be appreciated that abrasive particles can also be machined with the abrasive tool **9** to form a right hexagonal pyramid having 8 side faces and an apex.

[0032] Next referring to FIGS. **2** and **5**, the abrasive particles **12** in step **506** can be respectively attached to the support posts **123**. Exemplary techniques for attaching the abrasive particles **12** to the support posts **123** can include brazing, sintering, and electroplating.

[0033] Referring to FIGS. **1**, **2** and **5**, a substrate **11** is provided in step **508**, the substrate **11** having a working surface **111** and a plurality of holes **112**.

[0034] In next step **510**, the support posts **123** can be respectively attached in the holes **112** of the substrate **11** with the abrasive particles **12** distributed across the working surface **111**. In one embodiment, the support posts **123** can be respectively attached in the holes **112** of the substrate **11** via bonding layers **14**. A grinding tool can be thereby fabricated with the abrasive particles **12** protruding outward on the side of the working surface **111**.

[0035] Realizations of the grinding tool and its manufacture process have been described in the context of particular embodiments. These embodiments are meant to be illustrative and not limiting. Many variations, modifications, additions, and improvements are possible. These and other variations, modifications, additions, and improvements may fall within the scope of the inventions as defined in the claims that follow.

What is claimed is:

1. A grinding tool comprising:

a substrate having a working surface; and

a plurality of abrasive particles distributed across the working surface and protruding outward from the working surface, wherein at least some of the abrasive particles are machined to form abrasive particles respectively having a pyramid shape, the pyramid shape being a right square pyramid or a right hexagonal pyramid.

2. The grinding tool according to claim **1**, wherein the pyramid shape is a right hexagonal pyramid having 8 side faces and an apex, any two opposite ones of the side faces intersecting at the apex defining an angle between about 80 degrees and about 100 degrees.

3. The grinding tool according to claim **2**, wherein the angle is equal to about 90 degrees.

4. The grinding tool according to claim **1**, wherein the pyramid shape is a right square pyramid having 4 side faces and an apex, any two opposite ones of the side faces intersecting at the apex defining an angle between about 70 degrees and about 90 degrees.

5. The grinding tool according to claim **4**, wherein the angle is equal to about 80 degrees.

6. The grinding tool according to claim **1**, wherein the abrasive particles are respectively attached to a plurality of support posts, the substrate includes a plurality of holes, and the support posts are respectively attached in the holes so that the abrasive particles protrude outward from the working surface.

7. The grinding tool according to claim **6**, wherein the abrasive particles are respectively attached to the support posts by brazing, sintering, or electroplating.

8. The grinding tool according to claim **1**, wherein the abrasive particles are made of a high-hardness material including diamond, cubic boron nitride, aluminum oxide or silicon carbide.

9. The grinding tool according to claim **1**, wherein the substrate is made of stainless steel, plastics or ceramic.

* * * * *