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(54) **COATED ABRASIVE ARTICLES AND METHOD OF MAKING THE SAME**

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ARTICLES ABRASIFS ENROBÉS ET SON PROCÉDÉ DE FABRICATION

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Description

TECHNICAL FIELD

[0001] The present disclosure broadly relates to coated abrasive articles and methods of making and using the same.

BACKGROUND

[0002] Coated abrasive articles comprise abrasive particles adhered to a backing by a material comprising a first crosslinked polymeric resin (commonly known as a make layer or make coat). In most instances, a second crosslinked polymeric resin (commonly known as a size layer or size coat) is disposed upon the make layer and abrasive particles. Optionally, a third layer (known as a supersize layer or supersize) is disposed upon the size layer. If present, the supersize typically contains grinding aid and/or antiloading components.

[0003] In recent years, there has been a trend toward using shaped abrasive particles (e.g., triangular platelets), and there have been attempts to dispose the particles at various desired orientations relative to the backing. However, in many instances, the shaped abrasive particles tip substantially from their original orientation before curing of the make layer precursor resin that forms the make layer.

[0004] WO 2015/100018 A1 discloses a method of making a coated abrasive article, the method comprising sequential steps:

a) providing a production tool comprising a carrier member having a dispensing surface having precisely-shaped cavities therein;
b) depositing precisely-shaped abrasive platelets into at least some of the precisely-shaped cavities;
c) contacting the precisely-shaped abrasive platelets with a curable make layer precursor disposed on a major surface of a backing;
d) optionally separating the tool from the precisely-shaped abrasive platelets and the diluent abrasive particles; and
e) at least partially curing the curable make layer precursor to provide and at least partially cured make layer precursor.

[0005] WO 2011/068724 A2 discloses a coated abrasive article comprising: a backing having a first major surface;a make layer disposed on and secured to the backing;an abrasive layer contacting and secured to the make layer, wherein the abrasive layer comprises precisely-shaped abrasive platelets and diluent abrasive particles, wherein the precisely-shaped abrasive platelets comprise a second major surface disposed at a dihedral angle of less than or equal to 60 degrees relative to the first major surface of the backing and a size layer disposed over the make layer and the abrasive layer.

[0006] US 2003/207659 A1 is considered to be the starting point for the invention according to claim 1. It discloses a coated abrasive article comprising: a backing having a major surface; a make layer disposed on and secured to the backing; an abrasive layer contacting and secured to the make layer, wherein the abrasive layer comprises islands diluent abrasive particles, and wherein the islands are isolated one from another.

SUMMARY

[0007] It would be desirable to have methods of making coated abrasive articles wherein the abrasive particles substantially retain their initial orientation, as well as coated abrasive articles preparable by those methods. Advantageously, the present invention provides practical solutions to both problems with a coated abrasive article according to appended claim 1.

[0008] In some preferred embodiments, the coated abrasive article comprises additional features / steps as defined by the dependent claims.

[0009] As used herein:

The term "commonly aligned with a longitudinal axis" when used in reference to precisely-shaped abrasive platelets means that a longitudinal axis of each precisely-shaped abrasive particle is aligned similarly or identically relative to the longitudinal axis of the coated abrasive article (e.g., a coated abrasive belt).

The term "commonly aligned with a rotational axis" when used in reference to precisely-shaped abrasive platelets means that a longitudinal axis of each precisely-shaped abrasive particle is aligned similarly or identically relative to a rotational axis of the coated abrasive article (e.g., a coated abrasive disk).

The term "closed abrasive coat" means that abrasive layer is tightly packed, with substantially no spaces between adjacent abrasive particles of sufficient size to deposit another abrasive particle of comparable size.

The term "open abrasive coat" means not a closed abrasive coat. An open coat may be characterized by regions having few if any abrasive particles.

The term "precisely-shaped abrasive particle" means that the abrasive particle will have a shape that is essentially the shape of the portion of the cavity of a mold or production tool in which the particle precursor was dried, prior to optional calcining, and then sintering.

[0010] As used herein in reference to precisely shaped abrasive particles and cavities, the term "length" refers to the maximum dimension of an abrasive particle or cavity. "Width" refers to the maximum dimension of the abrasive particle that is perpendicular to the length. The terms "thickness" or "height" refer to the dimension of the precisely-shaped abrasive particle or cavity that is perpendicular to the length and width.

[0011] Features and advantages of the present disclosure will be further understood upon consideration of the detailed description as well as the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

FIG. 1 is a schematic process flow diagram of an exemplary process 100 not according to the present invention.
FIG. 2 is a schematic process flow diagram of an exemplary process 200 not according to the present invention.
FIG. 3 is a schematic process flow diagram of an exemplary process 300 not according to the present invention.
FIG. 4 is a schematic process flow diagram of an exemplary process 400 not according to the present invention.
FIG. 5 is a schematic process flow diagram of an exemplary process 500 not according to the present invention.
FIG. 6 is a schematic side view of an exemplary coated abrasive article 600 not according to the present invention.
FIG. 7A is a schematic side view of an exemplary coated abrasive article 700 according to the present invention.
FIG. 7B is a schematic top view of an exemplary coated abrasive article 700 according to the present invention.
FIG. 8 is a schematic top view of an exemplary coated abrasive disc 800 according to the present disclosure.
FIGS. 9A and 9B are optical micrographs of the coated abrasive article made in Example 1.
FIGS. 10A and 10B are optical micrographs of the coated abrasive article made in Comparative Example A.
FIGS. 11A and 11B are optical micrographs of the coated abrasive article made in Example 2.
FIGS. 12A and 12B are optical micrographs of the coated abrasive article made in Comparative Example B.

[0013] Repeated use of reference characters in the specification and drawings is intended to represent the same or analogous features or elements of the disclosure. It should be understood that numerous other modifications and embodiments can be devised by those skilled in the art, which fall within the scope of the invention as defined by the appended claims. The figures may not be drawn to scale

DETAILED DESCRIPTION

[0014] Referring now to FIG. 1, one exemplary method 100 of making a coated abrasive article not according to the present invention provides a production tool 110 comprising a carrier member 115 and a dispensing surface 112. Precisely-shaped cavities 120 extend from cavity openings 114 at the dispensing surface 112 and extend into carrier member 115. Such tools are widely known and used in the production of coated abrasive articles and typically have the form of a metal roll, a polymeric sheet, a polymeric roll sleeve, or a polymeric belt.

[0015] Next, precisely-shaped abrasive platelets 130 are disposed within the precisely-shaped cavities 120 thereby orienting them. Diluent abrasive particles 140 are then disposed onto the dispensing surface 112 of the production tool 110.

[0016] The abrasive-particle-laden dispensing surface 112 of the production tool 110 is then contacted with a make layer precursor 150 disposed on a backing 160. The make layer precursor 150 is sufficiently adherent that separation of the backing and make layer precursor combination from the dispensing surface 112 transfers the precisely-shaped abrasive platelets 130 and diluent abrasive particles 140 from the production tool 110 to the make layer precursor 150. Subsequent (not shown) curing of the make layer precursor, and the application and curing of a size layer precursor results in a coated abrasive article (not shown).

[0017] In a variation of method 100, exemplary method 200 (see FIG. 2) of making a coated abrasive article not according to the present invention provides a production tool 210 comprising a carrier member 205 and a dispensing surface 212. Precisely-shaped cavities 220 extend from cavity openings 214 at the dispensing surface 212 and extend into carrier member 205 at an incline.

[0018] Next, precisely-shaped abrasive platelets 230 are disposed within the precisely-shaped cavities 220 thereby orienting them, in some preferred embodiments at an incline. Diluent abrasive particles 240 are then disposed onto the dispensing surface 212 of the production tool 210 such that some of the diluent abrasive particles become lodged within the precisely-shaped cavities, accumulate on top of the dispensing surface.

[0019] The abrasive particle laden dispensing surface 212 of the production tool 210 is then contacted with a make layer precursor 250 disposed on a backing 260. The make layer precursor 250 is sufficiently adherent that optional separation of the backing and make layer precursor combination from the dispensing surface 212 transfers the precisely-shaped abrasive platelets 230 and diluent abrasive particles 240 from the production tool 210 to the make layer precursor 250. Subsequent (not shown) curing of the make layer precursor, and the application and curing of a size layer precursor results in a coated abrasive article (not shown).

[0020] Variations of cavity and particle size and shape can lead to many related process.

[0021] For example, referring now to FIG. 3, similarly to processes 100 and 200, exemplary method 300 of making a coated abrasive article not according to the present invention provides a production tool 310. Precisely-shaped cavities 320 have cavity openings 314. Precisely-shaped abrasive platelets 330 are disposed within the precisely-shaped cavities 320. Diluent abrasive particles 340 are then disposed into the cavities alongside the precisely-shaped abrasive platelets 330. After transfer to make layer precursor 350, the precisely-shaped abrasive platelets 330 and diluent abrasive particles 340 are disposed adjacent one another. Subsequent (not shown) curing of the make layer precursor, and the application and curing of a size layer precursor results in a coated abrasive article (not shown).

[0022] Referring now to FIG. 4, similarly to processes 100 and 200, exemplary method 400 of making a coated abrasive article not according to the present invention provides a production tool 410. Precisely-shaped cavities 420 have cavity openings 414. Precisely-shaped abrasive platelets 430 are disposed within the precisely-shaped cavities 420 assisting in orienting them vertically. Diluent abrasive particles 440 are then disposed into the cavities alongside the precisely-shaped abrasive platelets 430. After transfer to make layer precursor 450, the precisely-shaped abrasive platelets 430 and diluent abrasive particles 440 are disposed adjacent one another. Subsequent (not shown) curing of the make layer precursor, and the application and curing of a size layer precursor results in a coated abrasive article (not shown).

[0023] Referring now to FIG. 5, similarly to processes 100 and 200, exemplary method 500 of making a coated abrasive article not according to the present invention provides a production tool 510. Precisely-shaped cavities 520 have cavity openings 514. Precisely-shaped abrasive platelets 530 are disposed within the precisely-shaped cavities 520 assisting in orienting them vertically. Diluent abrasive particles 540 are then disposed into the cavities alongside the precisely-shaped abrasive platelets 530. After transfer to make layer precursor 550, the precisely-shaped abrasive platelets 530 and diluent abrasive particles 540 are disposed adjacent one another. Subsequent (not shown) curing of the make layer precursor, and the application and curing of a size layer precursor results in a coated abrasive article (not shown).

[0024] Useful production tools and methods of making them are well-known and practiced in the art. Typically, the openings of the precisely-shaped cavities are arranged in a rectangular or rotationally symmetrical array, although this is not a requirement. For example, the cavities may be shaped as square pyramids, square frustopyramids, cones, or frustoconical cavities.

[0025] Typically, the openings of the cavities at the dispensing surface are rectangular; however, this is not a requirement. The length, width, and depth of the cavities in the carrier member will generally be determined at least in part by the shape and size of the abrasive particles with which they are to be used. For example, if the precisely-shaped abrasive platelets are shaped as equilateral trigonal platelets, then the lengths of individual cavities are preferably 1.1 to 1.2 times the maximum length of a side of the precisely-shaped abrasive platelets, the widths of individual cavities are preferably from 1.1-2.5 times the thickness of the precisely-shaped abrasive platelets, and the respective depths of the cavities should are preferably 1.0 to 1.2 times the width of the precisely-shaped abrasive platelets if they are to be wholly contained within the cavities, less if they are not. Likewise, if it is desired to fill the cavities with precisely-shaped abrasive platelets and diluent abrasive particles, larger dimensions may be useful, and with be apparent to those skilled in the art.

[0026] Alternatively, for example, if the precisely-shaped abrasive platelets are shaped as triangular or rectangular platelets, then the lengths of individual cavities may preferably be less than that of an edge of the precisely-shaped abrasive platelets, and/or the respective depths of the cavities should be less than that of the width of the abrasive particles if the precisely-shaped abrasive platelets are to protrude from the cavities. Similarly, the width of the cavities should be selected such that a single abrasive particle fits within each one of the cavities. Similarly, the width of the cavities should be selected such that at least a single precisely-shaped abrasive particle fits within each one of the cavities. The cavity openings may be angled and offset from adjacent openings.

[0027] The carrier member can be in the form of, for example, an endless belt, a sheet, a continuous sheet or web, a coating roll, a sleeve mounted on a coating roll, or die. If the production tool is in the form of a belt, sheet, web, or sleeve, it will have a contacting surface and a non-contacting surface. If the production tool is in the form of a roll, it will have a contacting surface only.

[0028] The carrier member can be made, for example, according to the following procedure. A master tool is first provided. The master tool is typically made from, or plated with, metal, e.g., nickel. The master tool can be fabricated by any conventional technique, such as, for example, engraving, hobbing, knurling, electroforming, diamond turning, or laser machining. If a pattern is desired on the surface of the production tool, the master tool should have the inverse of the pattern for the production tool on the surface thereof. The thermoplastic material can be embossed with the master tool to form the pattern. Embossing can be conducted while the thermoplastic material is in a flowable state. After being embossed, the thermoplastic material can be cooled to bring about solidification.

[0029] The carrier member may also be formed by embossing a pattern into an already formed polymer film softened by heating. In this case, the film thickness may be less than the cavity depth. This is advantageous in improving the flexibility of carriers having deep cavities.

[0030] Preferably, the carrier member comprises metal and/or organic polymer. Such organic polymers are preferably moldable, have low cost, and are reasonably durable when used in the abrasive particle deposition process of the present invention. Examples of organic polymers, which may be thermosetting and/or thermoplastic, that may be suitable for fabricating the carrier member include: polypropylene, polyethylene, vulcanized rubber, polycarbonates, polyamides, acrylonitrile-butadiene-styrene plastic (ABS), polyethylene terephthalate (PET), polybutylene terephthalate (PET), polyimides, polyetheretherketone (PEEK), polyetherketone (PEK), and polyoxymethylene plastic (POM, acetal), poly(ether sulfone), poly(methyl methacrylate), polyurethanes, polyvinyl chloride, and combinations thereof.

[0031] The carrier member can also be made of a cured thermosetting resin. A production tool made of thermosetting material can be made according to the following procedure. An uncured thermosetting resin is applied to a master tool of the type described previously. While the uncured resin is on the surface of the master tool, it can be cured or polymerized by heating such that it will set to have the inverse shape of the pattern of the surface of the master tool. Then, the cured thermosetting resin is removed from the surface of the master tool. The production tool can be made of a cured radiation curable resin, such as, for example acrylated urethane oligomers. Radiation cured production tools are made in the same manner as production tools made of thermosetting resin, with the exception that curing is conducted by means of exposure to radiation (e.g., ultraviolet radiation).

[0032] The carrier member may have any thickness as long as it has sufficient depth to accommodate the abrasive particles and sufficient flexibility and durability for use in manufacturing processes. If the carrier member comprises an endless belt, then carrier member thicknesses of from about 0.5 to about 10 millimeters are typically useful; however, this is not a requirement.

[0033] A resilient compressible layer may be secured to the non-dispensing surface of the carrier member, regardless of whether the cavities extend through to the back surface. This may facilitate web handling and/or abrasive particle removal from the cavities. For example, in embodiments wherein the resilient compressible layer comprises shaped recesses aligned in registration with the respective second opening of each one of at least a portion of the cavities abrasive particles in the cavities that extend into the shaped recesses may be mechanically urged out of the cavities by pressure applied against the resilient compressible layer. This may occur, for example, by compression at a nip roll where the abrasive particle positioning system contacts a make coat precursor on a backing during manufacture of coated abrasive articles. If present, the resilient compressible layer may have any thickness, with the specific choice of abrasive particles and equipment condition determining the selection of thickness, composition, and/or durometer. If the resilient compressible layer comprises an endless belt, then resilient compressible layer thicknesses of from about 1 to about 25 millimeters are typically useful, but this is not a requirement.

[0034] Exemplary materials suitable for the resilient compressible layers include elastic foams (e.g., polyurethane foams), rubbers, silicones, and combinations thereof.

[0035] The pattern of the contacting surface of the production tool will generally be characterized by a plurality of cavities or recesses. The opening of these cavities can have any shape, regular or irregular, such as, for example, a rectangle, semi-circle, circle, triangle, square, hexagon, or octagon.

[0036] The walls of the cavities can be vertical or tapered. The pattern formed by the cavities can be arranged according to a predetermined plan or can be random. In some embodiments, the cavities can butt up against one another. In other embodiments, the cavities can be separated from each other by distance (e.g., at least 0.1 mm, at least 0.2 mm, at least 0.3 mm, at least 0.4 mm, at least 0.5 mm, at least 1 mm, at least 2 mm, at least 3 mm, at least 4 mm, or even at least 5 mm).

[0037] Preferably, the orientation and any incline of the cavities will be chosen such that the finished coated abrasive will have the precisely-shaped abrasive platelets aligned such that the abrading performance will be substantially optimized for its intended use.

[0038] Further details concerning the manufacture of useful production tools can be found, for example, in U. S. Pat. No. 9,776,302 B2 (Keipert), U. S. Pat. Appl. Publ. No. 2016/0311084 A1 (Culler et al.), and PCT Pat. Publ. Nos. WO 2019/102331 (Hanschen et al.), WO 2019/102332 A1 (Hanschen et al.), WO 2019/102330 A1 (Hanschen et al.), WO 2019/102329 A1 (Hanschen et al.), and WO 2019/102325 A1 (Hanschen et al.).

[0039] The abrasive particles (e.g., the precisely-shaped abrasive platelets and diluent abrasive particles) have sufficient hardness and surface roughness to function as abrasive particles in abrading processes.

[0040] Abrasive particles may include organic and/or inorganic particles.

[0041] Examples of suitable inorganic abrasive particles include: fused aluminum oxide; heat-treated aluminum oxide; white fused aluminum oxide; ceramic aluminum oxide materials such as those commercially available under the trade designation 3M CERAMIC ABRASIVE GRAIN from 3M Company, St. Paul, MN; brown aluminum oxide; blue aluminum oxide; silicon carbide (including green silicon carbide); titanium diboride; boron carbide; tungsten carbide; garnet; titanium carbide; diamond; cubic boron nitride; garnet; fused alumina zirconia; iron oxide; chromia; zirconia; titania; tin oxide;

quartz; feldspar; flint; emery; sol-gel-derived abrasive particles (e.g., including both precisely-shaped and crushed forms); and combinations thereof.

[0042] Preferably, the abrasive particles (especially precisely-shaped abrasive platelets) comprise sol-gel-derived alpha-alumina particles.

[0043] Abrasive particles composed of crystallites of alpha-alumina, magnesium alumina spinel, and a rare earth hexagonal aluminate may be prepared using sol-gel precursor alpha alumina particles according to methods described in, for example, U.S. Pat. No. 5,213,591 (Celikkaya et al.) and U.S. Publ. Pat. Appln. Nos. 2009/0165394 A1 (Culler et al.) and 2009/0169816 A1 (Erickson et al.).

[0044] Alpha-alumina-based precisely-shaped abrasive particles can be made according to a well-known multistep processes. Briefly, the method comprises the steps of making either a seeded or non-seeded sol-gel alpha-alumina precursor dispersion that can be converted into alpha-alumina; filling one or more mold cavities having the desired outer shape of the precisely-shaped abrasive particle with the sol-gel, drying the sol-gel to form precursor precisely-shaped ceramic abrasive particles; removing the precursor precisely-shaped ceramic abrasive particles from the mold cavities; calcining the precursor precisely-shaped ceramic abrasive particles to form calcined, precursor precisely-shaped ceramic abrasive particles, and then sintering the calcined, precursor precisely-shaped ceramic abrasive particles to form precisely-shaped ceramic abrasive particles. Further details concerning methods of making sol-gel-derived abrasive particles can be found in, for example, U.S. Pat. Nos. 4,314,827 (Leitheiser); 5,152,917 (Pieper et al.); 5,435,816 (Spurgeon et al.); 5,672,097 (Hoopman et al.); 5,946,991 (Hoopman et al.); 5,975,987 (Hoopman et al.); and 6,129,540 (Hoopman et al.); and in U.S. Publ. Pat. Appln. No. 2009/0165394 A1 (Culler et al.). Further examples of sol-gel-derived precisely-shaped alpha-alumina (i.e., ceramic) abrasive particles can be found in U. S. Pat. Nos. 5,201,916 (Berg); 5,366,523 (Rowenhorst (Re 35,570)); 5,984,988 (Berg); 8,142,531 (Adefris et al.); 8,142,891 (Culler et al.); and 8,142,532 (Erickson et al.); and in U.S. Pat. Appl. Publ. Nos. 2012/0227333 (Adefris et al.); 2013/0040537 (Schwabel et al.); and 2013/0125477 (Adefris).

[0045] In some embodiments, the base and the top of the precisely-shaped abrasive particles are substantially parallel, resulting in prismatic or truncated pyramidal shapes, although this is not a requirement. In some embodiments, the sides of a truncated trigonal pyramid have equal dimensions and form dihedral angles with the base of about 82 degrees. However, it will be recognized that other dihedral angles (including 90 degrees) may also be used. For example, the dihedral angle between the base and each of the sides may independently range from 45 to 90 degrees, typically 70 to 90 degrees, more typically 75 to 85 degrees.

[0046] Suitable organic abrasive particles (especially as diluent abrasive articles) may be formed from a thermoplastic polymer and/or a thermosetting polymer. Organic abrasive particles can be formed from a thermoplastic material such as polycarbonate, polyetherimide, polyester, polyvinyl chloride (PVC), polymethacrylate, polymethylmethacrylate, polyethylene, polysulfone, polystyrene, acrylonitrile-butadiene-styrene block copolymer, polypropylene, acetal polymers, polyurethanes, polyamide, and combinations thereof. The organic abrasive particle may be a mixture of a thermoplastic polymer and a thermosetting polymer. Other suitable organic abrasive particles include natural products such as nut shells.

[0047] It is also contemplated that the abrasive particles could comprise abrasive agglomerates such, for example, as those described in U.S. Pat. Nos. 4,652,275 (Bloecher et al.), 4,799,939 (Bloecher et al.), 6,521,004 (Culler et al.), or 6,881,483 (McArdle et al.). It is further contemplated that the abrasive particles could comprise precisely-shaped polymeric particles which comprise an organic binder and optional abrasive particles, such as those described in US 5,714,259 (Holmes et al.). Further examples include shaped abrasive composites of abrasive particles in a binder matrix, such as those described in U.S. Pat. No. 5,152,917 (Pieper et al.). Many such abrasive particles, agglomerates, and composites are known in the art.

[0048] In some embodiments, the abrasive particles may be surface-treated with a coupling agent (e.g., an organosilane coupling agent) or other physical treatment (e.g., iron oxide or titanium oxide) to enhance adhesion of the abrasive particles to the binder. The abrasive particles may be treated before combining them with the binder, or they may be surface treated in situ by including a coupling agent to the binder.

[0049] In some embodiments, the abrasive particles have a Mohs hardness of at least 4, at least 5, at least 6, at least 7, or even at least 8.

[0050] In some preferred embodiments, the abrasive particles comprise shaped ceramic abrasive particles (e.g., shaped sol-gel-derived polycrystalline alpha alumina particles) that are generally triangularly-shaped (e.g., a triangular prism or a truncated three-sided pyramid).

[0051] The abrasive particles are typically selected to have a length in a range of from 1 micron to 4 millimeters, more typically 10 microns to about 3 millimeter, and still more typically from 150 to 2600 microns, although other lengths may also be used.

[0052] The abrasive particles are typically selected to have a width in a range of from 0.1 micron to 3500 microns, more typically 100 microns to 3000 microns, and more typically 100 microns to 2600 microns, although other lengths may also be used.

[0053] The abrasive particles are typically selected to have a thickness in a range of from 0.1 micron to 1600 microns, more typically from 1 micron to 1200 microns, although other thicknesses may be used.

[0054] In some embodiments, the abrasive particles may have an aspect ratio (length to thickness) of at least 2, 3, 4, 5, 6, or more.

[0055] Surface coatings on the abrasive particles may be used to improve the adhesion between the shaped ceramic abrasive particles and the binder in coated abrasive articles, or can be used to aid in electrostatic deposition of the shaped ceramic abrasive particles. In one embodiment, surface coatings as described in U.S. Pat. No. 5,352,254 (Celikkaya) in an amount of 0.1 to 2 percent surface coating to abrasive particle weight may be used. Such surface coatings are described in U.S. Pat. Nos. 5,213,591 (Celikkaya et al.); 5,011,508 (Wald et al.); 1,910,444 (Nicholson); 3,041,156 (Rowse et al.); 5,009,675 (Kunz et al.); 5,085,671 (Martin et al.); 4,997,461 (Markhoff-Matheny et al.); and 5,042,991 (Kunz et al.). Additionally, the surface coating may prevent the shaped abrasive particle from capping. Capping is the term to describe the phenomenon where metal particles from the workpiece being abraded become welded to the tops of the shaped ceramic abrasive particles. Surface coatings to perform the above functions are known to those of skill in the art.

[0056] The abrasive particles may be independently sized according to an abrasives industry recognized specified nominal grade. Exemplary abrasive industry recognized grading standards include those promulgated by ANSI (American National Standards Institute), FEPA (Federation of European Producers of Abrasives), and JIS (Japanese Industrial Standard). ANSI grade designations (i.e., specified nominal grades) include, for example: ANSI 4, ANSI 6, ANSI 8, ANSI 16, ANSI 24, ANSI 36, ANSI 46, ANSI 54, ANSI 60, ANSI 70, ANSI 80, ANSI 90, ANSI 100, ANSI 120, ANSI 150, ANSI 180, ANSI 220, ANSI 240, ANSI 280, ANSI 320, ANSI 360, ANSI 400, and ANSI 600. FEPA grade designations include F4, F5, F6, F7, F8, F10, F12, F14, F16, F16, F20, F22, F24, F30, F36, F40, F46, F54, F60, F70, F80, F90, F100, F120, F150, F180, F220, F230, F240, F280, F320, F360, F400, F500, F600, F800, F1000, F1200, F1500, and F2000. JIS grade designations include JIS8, JIS12, JIS16, JIS24, JIS36, JIS46, JIS54, JIS60, JIS80, JIS100, JIS150, JIS180, JIS220, JIS240, JIS280, JIS320, JIS360, JIS400, JIS600, JIS800, JIS1000, JIS1500, JIS2500, JIS4000, JIS6000, JIS8000, and JIS10,000

[0057] According to an embodiment of the present invention, the average diameter of the abrasive particles may be within a range of from 260 to 4000 microns in accordance with FEPA grades F60 to F24.

[0058] Alternatively, the abrasive particles can be graded to a nominal screened grade using U.S.A. Standard Test Sieves conforming to ASTM E11-17 "Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves". ASTM E11-17 prescribes the requirements for the design and construction of testing sieves using a medium of woven wire cloth mounted in a frame for the classification of materials according to a designated particle size. A typical designation may be represented as -18+20 meaning that the abrasive particles pass through a test sieve meeting ASTM E11-17 specifications for the number 18 sieve and are retained on a test sieve meeting ASTM E11-17 specifications for the number 20 sieve. In one embodiment, the abrasive particles have a particle size such that most of the particles pass through an 18 mesh test sieve and can be retained on a 20, 25, 30, 35, 40, 45, or 50 mesh test sieve. In various embodiments, the abrasive particles can have a nominal screened grade of: -18+20, -20/+25, -25+30, -30+35, -35+40, 5 -40+45, -45+50, -50+60, -60+70, -70/+80, -80+100, -100+120, -120+140, -140+170, -170+200, -200+230, -230+270, -270+325, -325+400, -400+450, -450+500, or -500+635. Alternatively, a custom mesh size can be used such as -90+100.

[0059] The precisely-shaped abrasive particles may be deposited into cavities by any suitable method including, for example, dropping and/or wiping, preferably with vibration of the production tool or an air assist. Typically, an excess of precisely-shaped abrasive particles is deposited onto the dispensing surface by an abrasive particle feeder such that there are more precisely-shaped abrasive particles present per unit length of the production tool cavities present. Supplying an excess of precisely-shaped abrasive particles helps to ensure substantially all cavities within the production tool are eventually filled with a precisely-shaped abrasive particle. Since the bearing area and spacing of the precisely-shaped abrasive particles is often designed into the production tooling for the specific grinding application it is desirable to not have too many unfilled cavities. The abrasive particle feeder is typically the same width as the production tool (especially if the production tool comprises a roll, roll sleeve, or endless belt, and supplies precisely-shaped abrasive particles across the entire width of the production tool. The abrasive particle feeder can be, for example, a vibratory feeder, a hopper, a chute, a silo, a drop coater, or a screw feeder.

[0060] Optionally, a filling assist member is provided after the abrasive particle feeder to move the precisely-shaped abrasive particles around on the surface of the production tool and to help orientate or slide the precisely-shaped abrasive particles into the cavities. The filling assist member can be, for example, a doctor blade, a felt wiper, a brush having a plurality of bristles, a vibration system, a blower or air knife, a vacuum box, or combinations thereof. The filling assist member moves, translates, sucks, or agitates the precisely-shaped abrasive particles on the dispensing surface to place more precisely-shaped abrasive particles into the cavities. Without the filling assist member, generally at least some of precisely-shaped abrasive particles dropped onto the dispensing surface will fall directly into a cavity and no further movement is required but others may need some additional movement to be directed into a cavity.

[0061] Optionally, the filling assist member can be oscillated laterally in the cross machine direction or otherwise have a relative motion such as circular or oval to the surface of the production tool using a suitable drive to assist in completely filling each cavity in the production tool with an abrasive particle. Typically if a brush is used as the filling assist member, the bristles may cover a section of the dispensing surface from 2-4 inches (5.0 - 10.2 cm) in length in the machine direction preferably across all or most all of the width of the dispensing surface, and lightly rest on or just above the dispensing surface, and be of a moderate flexibility. A vacuum box, if used as the filling assist member, is often used in conjunction with a production tool having cavities extending completely through the production tooling; however, even a production tool having a solid back surface can be an advantage since it will flatten and draw the production tooling more planar for improved filling of the cavities.

[0062] If the production tool is an endless belt, the belt can have a positive incline to advance to a higher elevation as it moves past the abrasive particle feeder. If the production tool is a roll, the abrasive particle feeder can be positioned such that it applies the abrasive particles to the roll before top dead center of the roll's outer circumference such as between 270 degrees to 350 degrees on the face of the roll with top dead center being 0 degrees as one progresses clockwise about the roll with the roll turning in a clockwise in operation.

[0063] Optionally, an abrasive particle removal member can be provided to assist in removing the excess precisely-shaped abrasive particles from the surface of the production tooling once most or all of the cavities have been filled by an abrasive particle. The abrasive particle removal member can be, for example, a source of air to blow the excess precisely-shaped abrasive particles off the dispensing surface of the production tooling such as an air wand, air shower, air knife, a coanda effect nozzle, or a blower. A contacting device can be used as the abrasive particle removal member such as a brush, a scraper, a wiper, or a doctor blade. A vibrator, such as an ultrasonic horn, can be used as the abrasive particle removal member.

[0064] Alternatively, a vacuum source such as vacuum box or vacuum roll located along a portion of the first web path after an abrasive particle feeder with a production tool having cavities extending completely through the production tool can be used to hold the precisely-shaped abrasive particles in the cavities. In this span or section of the first web path, the dispensing surface of the production tool can be inverted or have a large incline or decline approaching or exceeding 90 degrees to remove the excess precisely-shaped abrasive particles using the force of gravity to slide or drop them from the dispensing surface while retaining the precisely-shaped abrasive particles disposed in the cavities by vacuum until the dispensing surface is returned to an orientation to keep the precisely-shaped abrasive particles in the cavities due to the force of gravity or they are released from the cavities onto the resin coated backing.

[0065] In embodiments, where the abrasive particle is fully contained within the cavity of the production tooling, the abrasive particle removal member can slide the excess precisely-shaped abrasive particles across the dispensing surface of the production tooling and off of the production tool without disturbing the precisely-shaped abrasive particles contained within the cavities. The removed excess precisely-shaped abrasive particles can be collected and returned to the abrasive particle feeder for reuse. The excess precisely-shaped abrasive particles can alternatively be moved in a direction opposite to the direction of travel of the production tool past or towards the abrasive particle feeder where they may fill unoccupied cavities.

[0066] Further details concerning deposition of precisely-shaped abrasive particles into the cavities of the production tool can be found, for example, in U. S. Pat. Appl. Publ. No. 2016-0311081 A1 (Culler et al.).

[0067] The diluent abrasive particles may be applied by any suitable means that does not dislodge the precisely-shaped abrasive particles from the cavities; however, it is permissible that diluent abrasive particles may also become lodged in the cavities along with the precisely-shaped abrasive particles. The diluent abrasive particles may be applied using an abrasive feeder. The abrasive particle feeder can be, for example, a vibratory feeder, a hopper, a chute, a silo, a drop coater, or a screw feeder. One preferred deposition method is drop coating. An abrasive particle removal member (e.g., as discussed above) can be used to assist in removing excess diluent abrasive particles from the surface of the production tooling.

[0068] Generally, the diluent abrasive particles have minimum average dimensions (e.g. average particle diameter) that are smaller than the longest dimensions of the precisely-shaped abrasive platelets. For example, the ratio of the average particle diameter of the diluent abrasive particles o the average longest dimension of the precisely-shaped abrasive platelets may be less than 1/2, less than 1/3, less than 1/4, less than 1/5, less than 1/6, or even less than1/8, however, this is not a requirement.

[0069] If desired, grinding aid particles may be deposited with the diluent abrasive particles using a simultaneous or sequential procedure. Useful grinding aids include cryolite, fluoroborates (e.g., potassium tetrafluoroborate), metal salts of fatty acids (e.g., zinc stearate or calcium stearate), salts of phosphate esters (e.g., potassium behenyl phosphate), phosphate esters, urea-formaldehyde resins, mineral oils, crosslinked silanes, crosslinked silicones, and/or fluorochemicals.

[0070] Once the diluent abrasive particles have been deposited (as an open coat, closed coat, or patterned coat) on the dispensing surface of the production tool, it is brought into contact with a make layer precursor disposed on a backing. Once in contact, the abrasive particles adhere to the make layer precursor and remain attached to it after the backing and make layer precursor are optionally separated from the production tool.

[0071] Referring now to FIG. 2, wherein an inclined orientation of the precisely-shaped abrasive platelets is shown, after transfer, at least a majority (e.g., at least 50 percent, at least 60 percent, at least 70 percent, at least 80 percent, or even at least 90 percent) of the precisely-shaped abrasive platelets overhang a respective plurality of the diluent abrasive particles.

[0072] Various methods can be employed to transfer the abrasive particles from cavities of the production tool to the make layer precursor. In no particular order, the various methods include, for example: gravity assist where the production tool and dispensing surface is inverted so that the abrasive particles fall out of the cavities under the force of gravity onto the make layer precursor; pushing assist wherein each cavity in the production tooling has two open ends such that the abrasive particle can reside in the cavity with a portion of the abrasive particle extending past the back surface of the production tooling; vibration assist where the abrasive particle transfer roll or production tooling is vibrated by a suitable source such as an ultrasonic device to shake the abrasive particles out of the cavities and onto the resin coated backing; and pressure assist where each cavity in the production tooling has two open ends or the back surface or the entire production tool is suitably porous and the abrasive particle transfer roll has a plurality of apertures and an internal pressurized source of air. The various above listed embodiments are not limited to individual usage and they can be mixed and matched as necessary to more efficiently transfer the abrasive particles from the cavities to the make layer precursor.

[0073] The make layer precursor is then at least partially cured (at least an amount sufficient to secure the abrasive particles for further handling) to form a make layer. Thereafter, the make layer and abrasive particles are overcoated with a size layer precursor, which is then at least partially cured (at least an amount sufficient to secure the abrasive particles for intended abrading processes). Optionally, other processing steps known to those of skill in the art of making coated abrasive articles.

[0074] As will be apparent to those of skill in the art, the make layer precursor, optional size layer precursor, and optional supersize layer can be coated using conventional techniques such as, for example, gravure coating, curtain coating, knife coating, spray coatings, roll-coating, reverse roll gravure coating, or bar coating.

[0075] Exemplary backings include those known in the art for making coated abrasive articles, including conventional sealed coated abrasive backings and porous non-sealed backings. Typically, the backing has two opposed major surfaces, although this is not a requirement. The thickness of the backing generally ranges from about 0.02 to about 5 millimeters, desirably from about 0.05 to about 2.5 millimeters, and more desirably from about 0.1 to about 0.4 millimeter, although thicknesses outside of these ranges may also be useful.

[0076] The backing may be flexible or rigid. Desirably the backing is flexible. Exemplary backings include polymeric film (including primed films) such as polyolefin film (e.g., polypropylene including biaxially oriented polypropylene, polyester film, polyamide film, cellulose ester film), metal foil, mesh, foam (e.g., natural sponge material or polyurethane foam), cloth (e.g., cloth made from fibers or yarns comprising polyester, nylon, silk, cotton, and/or rayon), paper, vulcanized paper, vulcanized fiber, nonwoven materials, combinations thereof, and treated versions thereof. Cloth backings may be woven, knitted, or stitch bonded, for example. The backing may also be a laminate of two materials (e.g., paper/film, cloth/paper, film/cloth).

[0077] The backing may be treated to include a presize (i.e., a barrier coat overlying the major surface of the backing onto which the abrasive layer is applied), a backsize (i.e., a barrier coat overlying the major surface of the backing opposite the major surface on which the abrasive layer is applied), a saturant (i.e., a barrier coat that is coated on all exposed surfaces of the backing), or a combination thereof. Useful presize, backsize, and saturant compositions include glue, phenolic resins, lattices, epoxy resins, urea-formaldehyde, urethane, melamine-formaldehyde, neoprene rubber, butyl acrylate, styrol, starch, and combinations thereof. Other optional layers known in the art may also be used (e.g., a tie layer; see, e.g., U. S. Pat. No. 5,700,302 (Stoetzel et al.)).

[0078] Backing treatments may contain additional additives such as, for example, a filler and/or an antistatic material (for example, carbon black particles, vanadium pentoxide particles). The addition of an antistatic material can reduce the tendency of the coated abrasive article to accumulate static electricity when sanding wood or wood-like materials. Additional details regarding antistatic backings and backing treatments can be found in, for example, U. S. Pat. Nos. 5,108,463 (Buchanan et al.); 5,137,542 (Buchanan et al.); 5,328,716 (Buchanan); and 5,560,753 (Buchanan et al.).

[0079] Typically, at least one major surface of the backing is smooth (for example, to serve as the first major surface). The second major surface of the backing may comprise a slip resistant or frictional coating. Examples of such coatings include an inorganic particulate (e.g., calcium carbonate or quartz) dispersed in an adhesive.

[0080] The backing may contain various additive(s). Examples of suitable additives include colorants, processing aids, reinforcing fibers, heat stabilizers, UV stabilizers, and antioxidants. Examples of useful fillers include clays, calcium carbonate, glass beads, talc, clays, mica, wood flour; and carbon black.

[0081] The backing may be a fibrous reinforced thermoplastic such as described, for example, as described, for example, in U. S. Pat. No. 5,417,726 (Stout et al.), or an endless spliceless belt, for example, as described, for example, in U. S. Pat. No. 5,573,619 (Benedict et al.). Likewise, the backing may be a polymeric substrate having hooking stems projecting therefrom such as that described, for example, in U. S. Pat. No. 5,505,747 (Chesley et al.). Similarly, the backing may be a loop fabric such as that described, for example, in U. S. Pat. No. 5,565,011 (Follett et al.)

[0082] The make layer precursor and the size layer precursor include respective curable binder precursor compositions, which may be the same or different.

[0083] Examples of curable binder precursor compositions for use in the make and/or size layer precursors include phenolic resins, urea-formaldehyde resins, acrylate resins, urethane resins, epoxy resins, aminoplast resins, and combinations thereof. The curable binder precursor compositions can also include various additives including, for example, plasticizers, fillers, fibers, lubricants, surfactants, wetting agents, dyes, pigments, antifoaming agents, dyes, coupling agents, plasticizers, and suspending agents, for example.

[0084] Depending on any curable binder precursor composition selected, an appropriate curative may be added to facilitate curing. Such curatives will be readily apparent to those of skill in the art, and may be thermally activated, photochemically activated, or both, for example.

[0085] Optionally a supersize layer may be applied to at least a portion of the size layer. If present, the supersize typically includes grinding aids and/or anti-loading materials. The optional supersize layer may serve to prevent or reduce the accumulation of swarf (the material abraded from a workpiece) between abrasive particles, which can dramatically reduce the cutting ability of the coated abrasive belt. Useful supersize layers typically include a grinding aid such as cryolite, tetrafluoroborates, (e.g., potassium tetrafluoroborate), metal salts of fatty acids (e.g., zinc stearate or calcium stearate), salts of phosphate esters (e.g., potassium behenyl phosphate), phosphate esters, urea-formaldehyde resins, mineral oils, crosslinked silanes, crosslinked silicones, and/or fluorochemicals. Useful supersize materials are further described, for example, in U. S. Pat. No. 5,556,437 (Lee et al.). Typically, the amount of grinding aid incorporated into coated abrasive products is about 50 to about 400 gsm, more typically about 80 to about 300 gsm. The supersize may contain a binder such as for example, those used to prepare the size or make layer, but it need not have any binder.

[0086] Further details concerning coated abrasive belts comprising an abrasive layer secured to a backing, wherein the abrasive layer comprises abrasive particles and make, size, and optional supersize layers are well known, and may be found, for example, in U. S. Pat. Nos. 4,734,104 (Broberg); 4,737,163 (Larkey); 5,203,884 (Buchanan et al.); 5,152,917 (Pieper et al.); 5,378,251 (Culler et al.); 5,417,726 (Stout et al.); 5,436,063 (Follett et al.); 5,496,386 (Broberg et al.); 5,609,706 (Benedict et al.); 5,520,711 (Helmin); 5,954,844 (Law et al.); 5,961,674 (Gagliardi et al.); 4,751,138 (Bange et al.); 5,766,277 (DeVoe et al.); 6,077,601 (DeVoe et al.); 6,228,133 (Thurber et al.); and No. 5,975,988 (Christianson).

[0087] Coated abrasive belts according to the present invention are useful for abrading a workpiece. Preferred workpieces include metal (e.g., aluminum, nickel alloys, stainless steel, mild steel), composites, plastics, and wood.

[0088] As will be apparent to those of skill in the art, the make layer precursor, optional size layer precursor, and optional supersize layer can be coated using conventional techniques such as, for example, gravure coating, curtain coating, knife coating, spray coatings, roll-coating, reverse roll gravure coating, or bar coating.

[0089] Referring now to FIG. 6, in one exemplary embodiment, coated abrasive article 600 comprises backing 610 having a major surface 612. Make layer 630 is disposed on and secured to the backing 610. Abrasive layer 620 contacts and is secured to make layer 630. Abrasive layer 620 comprises precisely-shaped abrasive platelets 632 and diluent abrasive particles 624. Precisely-shaped abrasive platelets 622 are disposed at a dihedral angle β of less than or equal to 60 degrees relative to major surface 612 of backing 610. At least a majority (e.g., at least 50 percent, at least 60 percent, at least 70 percent, at least 80 percent, or even at least 90 percent) of the precisely-shaped abrasive platelets 632 each overhangs a respective plurality of diluent abrasive particles 624. Size layer 670 is disposed over make layer 630 and abrasive layer 620.

[0090] Referring now to FIG. 7, in another exemplary embodiment, coated abrasive article 700 comprises coated abrasive article 700 comprises backing 710 having a major surface 712. Make layer 730 is disposed on and secured to backing 710. Abrasive layer 720 contacts and is secured to make layer 730. Abrasive layer 720 comprises islands 725. Each island 725 comprises at least one precisely-shaped abrasive platelet 722 and diluent abrasive particles 724. Islands 725 are isolated one from another. Size layer 770 is disposed over make layer 730 and abrasive layer 720. Precisely-shaped abrasive platelets 722 are commonly aligned with respect to a longitudinal axis 790 of coated abrasive article 700.

[0091] In the case of a coated abrasive article 800 (e.g., a coated abrasive disc shown in FIG. 8) that is used with rotational motion the precisely-shaped abrasive platelets 822 are commonly aligned with respect to a rotational axis (875, perpendicular to the page) of coated abrasive article 800.

[0092] Coated abrasive articles according to the present invention are useful for abrading a workpiece. One such method includes frictionally contacting at least a portion of the abrasive layer of a coated abrasive article with at least a portion of a surface of the workpiece, and moving at least one of the coated abrasive article or the workpiece relative to the other to abrade at least a portion of the surface.

[0093] Examples of workpiece materials include metal, metal alloys, exotic metal alloys, ceramics, glass, wood, wood-like materials, composites, painted surfaces, plastics, reinforced plastics, stone, and/or combinations thereof. The workpiece may be flat or have a shape or contour associated with it. Exemplary workpieces include metal components, plastic components, particleboard, camshafts, crankshafts, furniture, and turbine blades.

[0094] Coated abrasive articles according to the present invention may be used by hand and/or used in combination with a machine. At least one or both of the coated abrasive article and the workpiece is generally moved relative to the other when abrading.

[0095] Abrading may be conducted under wet or dry conditions. Exemplary liquids for wet abrading include water, water containing conventional rust inhibiting compounds, lubricant, oil, soap, and cutting fluid. The liquid may also contain defoamers, degreasers, and/or the like.

EXAMPLES

[0096] Unless otherwise noted, all parts, percentages, ratios, etc. in the Examples and the rest of the specification are by weight.

[0097] Unless stated otherwise, all other reagents were obtained, or are available from fine chemical vendors such as Sigma-Aldrich Company, St. Louis, Missouri, or may be synthesized by known methods.

[0098] Unit Abbreviations used in the Examples: °C = degrees Centigrade; cm = centimeter; g = gram; g/m^2 = grams per square meter; rpm = revolutions per minute; mm = millimeter; wt. % = weight percent.

[0099] Materials used in the Examples are described in Table 1, below:

TABLE 1

ABBREVIATION	DESCRIPTION
SAP	Precision shaped abrasive particles. Examples of SAP were described in U. S. Pat. No. 8,142,531 (Adefris et al), and U. S. Pat. Appl. No. 2015/0267097 A1 (Rosenflanz et al). The shaped abrasive particles were prepared by molding the ceramic precursor pre-Mix in equilateral triangle-shaped polypropylene mold cavities. After drying and firing, the resulting shaped abrasive particles were about 0.18 mm (side length) × 0.04 mm thick, with a draft angle approximately 98 degrees.
Crushed abrasive grains	Crushed abrasive grains are commercially available abrasive minerals. The crushed abrasive grains may be formed of any one of or a combination of abrasive grains, including silica, alumina (fused or sintered), zirconia, zirconialalumina oxides (AZ), silicon carbide (SiC), garnet, diamond, cubic boron nitride, silicon nitride, ceria, titanium dioxide, titanium diboride, boron carbide, tin oxide, tungsten carbide, titanium carbide, iron oxide, chromia, flint, emery. The term "crushed" as applied to a particle refers to a particle that is formed through a mechanical fracturing process, and specifically excludes particles that are evidently formed into shaped particles by a molding operation and then fractured. Unless stated otherwise, the crushed abrasive grains were supplied by BARTON International, Glens Falls, New York.
Fiber disc backing	Pre-cut vulcanized fibre disc blanks with a diameter of 17.8 cm, a center hole of 2.2 cm and thickness of 0.83 mm were obtained as DYNOS VULCANIZED FIBRE from DYNOS GMBH, Troisdorf, Germany.
PR1	Phenol-formaldehyde resin having a phenol to formaldehyde molar ratio of 1:1.5-2.1, and catalyzed with 2.5 percent by weight potassium hydroxide.
CACO	Calcium Carbonate commercially available as HUBERCARB Q325 from Hubercarb Engineered Materials, Atlanta Georgia.
CRY	Cryolite, obtained as CRYOLITE RTN-C from Freebee A/S, Ullerslev, Denmark.
IO	Red iron oxide pigment, obtained as KROMA RO-3097 from Elementis Specialties, Inc., East Saint Louis, Illinois.
Make Resin 1	A phenolic curable make resin prepared by mixing 49.2 parts by weight of PR1; 40.6 parts by weight of CACO; and 10.2 parts by weight of deionized water.
Size Resin 1	A phenolic curable size resin prepared by mixing 40.6 parts by weight of PR1; 69.9 parts by weight of CRY; 2.5 parts by weight IO; and 25 parts by weight deionized water.

EXAMPLE 1

Coated abrasive articles with 90 degree SAP orientation

[0100] A production tool having vertically-oriented triangular openings generally configured as described in U. S. Pat. Appln. Publ. No. 2016/0311081 A1 (Culler et al.) (length = 1.875 mm, width = 0.785 mm, depth = 1.62 mm, bottom width

= 0.328 mm) arranged in a rectangular array (length-wise pitch = 1.978 mm, width-wise pitch = 0.886 mm with all long dimensions in the same direction) was used to place abrasive particles.

[0101] In the first step, the majority of the cavities of the production tool were filled with P36 grade SAP. Excess SAP were carefully removed with a 3-inch (240-cm^2)Wooster Spiffy Brush. About 9.2 g of SAP particles were loaded onto a 37-square inch (0,024 square meter) area tool surface.

[0102] In the second step, fill the gaps between SAP and the walls of cavities with P80 grade crushed garnet grains. Excess crushed garnet grains were carefully removed with a 3 inch (0,076 meter) Wooster Spiffy Brush About 4.4 g of crushed garnet grains particles were loaded onto the 37 square inches area tool surface.

Make layer precursor

[0103] A fiber disc backing was coated by brush with Make Resin 1 to a weight of 3.0-3.1 grams.

Transfer abrasive mineral to make layer precursor

[0104] Then, the fiber disc backing with the make layer precursor was flipped over and contacted with the abrasive particle laden surface of the production tool. The assembly was clamped together with binder clips, and then flipped over to facilitate abrasive particle transfer by gravity onto the make layer precursor. Vibration of the production tool further promotes abrasive particle transfer. The production tool was separated from the make layer precursor and abrasive particles such that both the SAP and crushed abrasive particles have been transferred onto the make resin layer. The coated disc was given a make layer precursor pre-cure at 90 °C for 1 hour followed by 103 °C for 3 hours.

Size coating

[0105] Precured discs were then coated by brush with curable Size Resin 1. Excess size resin was removed with a dry brush until the flooded glossy appearance was reduced to a matte appearance. The size-coated discs were weighed to establish the size resin weight. The amount of size resin added was 11.5-13.0 g size resin coating (i.e., size layer precursor) was used. The discs were cured for 90 minutes at 90 °C, followed by 16 hours at 103 °C. The cured discs were orthogonally flexed over a 1.5-inch (3.8-cm) diameter roller. The surface of the resulting coated abrasive article was characterized with an optical microscope. Results are shown in FIGS. 9A and 9B.

COMPARATIVE EXAMPLE A

Coated abrasive articles with 90 degree SAP orientation

[0106] The procedure of Example 1 was repeated, except that the SAP loaded on the production tool was transferred onto make layer precursor first, and then the P80 grade crushed garnet grains were directly coated to fiber disc substrate through drop coating (abrasive particles fell onto the make layer precursor by gravity). Results are shown in FIGS. 10A and 10B.

EXAMPLE 2

Coated abrasive articles with 60 degree SAP orientation

[0107] The procedure of Example 1 was repeated, except that: (1) a production tool having 60°-oriented triangular openings (length=1.875 mm, width = 1.1775 mm, depth = 1.62 mm, bottom width = 0.328 mm) arranged in a rectangular array (length-wise pitch = 1.978 mm, width-wise pitch = 1.229 mm with all long dimensions in the same direction) was used; and (2) 8.3 g of SAP followed by 6.8 g of P80 grade crushed garnet grains were loaded onto the production tool. Results are shown in FIGS. 11A and 11B.

COMPARATIVE EXAMPLE B

Coated abrasive articles with 60 degree SAP vertical orientation

[0108] The procedure of Example 2 was repeated, except that the SAP loaded on the production tool was transferred onto the make layer precursor first, and then 8.2 g P80 grade crushed garnet grains were directly coated to the make layer precursor through drop coating. Results are shown in FIGS. 12A and 12B.

Claims

1. A coated abrasive article (700) comprising:

   a backing (710) having a major surface (712);
   a make layer (730) disposed on and secured to the backing;
   an abrasive layer (720) contacting and secured to the make layer, wherein the abrasive layer comprises islands (725), each island comprising at least one precisely-shaped abrasive platelet (722) and diluent abrasive particles (724), and wherein the islands are isolated one from another; and
   a size layer (770) disposed over the make layer and the abrasive layer.

2. The coated abrasive article (700) of claim 1, wherein the diluent abrasive particles (724) are predominantly disposed beneath respective overhangs of at least a majority of the precisely-shaped abrasive platelets (722).

3. The coated abrasive article (700) of claim 1, wherein the islands (725) are separated from each other by at least twice the minimum distance between closest precisely-shaped abrasive platelets (722) of adjacent islands.

4. The coated abrasive article (700) of claim 1, wherein the precisely-shaped abrasive platelets (722) are positioned substantially according to a predetermined pattern.

5. The coated abrasive article (700) of claim 1, wherein the precisely-shaped abrasive platelets (722) are commonly aligned with respect to a longitudinal axis (790) of the coated abrasive article.

6. The coated abrasive article (800) of claim 1, wherein the precisely-shaped abrasive platelets (822) are commonly aligned with respect to a rotational axis (875) of the coated abrasive article.

Patentansprüche

1. Ein beschichteter Schleifgegenstand (700), aufweisend:

   einen Träger (710), der eine erste Hauptoberfläche (712) hat;
   eine Grundschicht (730), die an dem Träger angeordnet und an diesem befestigt ist;
   eine Schleifschicht (720), die die Grundschicht berührt und an dieser befestigt ist, wobei die Schleifschicht Inseln (725) aufweist, jede Insel aufweisend mindestens ein genau geformtes Schleifplättchen (722) und Verdünnungsmittelschleifteilchen (724) und wobei die Inseln voneinander isoliert sind; und
   eine Deckschicht (770), die über der Grundschicht und der Schleifschicht angeordnet ist.

2. Der beschichtete Schleifgegenstand (700) nach Anspruch 1, wobei die Verdünnungsmittelschleifteilchen (724) überwiegend unterhalb jeweiliger Überhänge von mindestens einer Mehrheit der genau geformten Schleifplättchen (722) angeordnet sind.

3. Der beschichtete Schleifgegenstand (700) nach Anspruch 1, wobei die Inseln (725) um mindestens ein Zweifaches des minimalen Abstands zwischen nächstgelegenen genau geformten Schleifplättchen (722) angrenzender Inseln voneinander getrennt sind.

4. Der beschichtete Schleifgegenstand (700) nach Anspruch 1, wobei die genau geformten Schleifplättchen (722) im Wesentlichen gemäß einem zuvor bestimmten Muster positioniert sind.

5. Der beschichtete Schleifgegenstand (700) nach Anspruch 1, wobei die genau geformten Schleifplättchen (722) im Allgemeinen hinsichtlich einer Längsachse (790) des beschichteten Schleifgegenstands ausgerichtet sind.

6. Der beschichtete Schleifgegenstand (800) nach Anspruch 1, wobei die genau geformten Schleifplättchen (822) im Allgemeinen hinsichtlich einer Drehachse (875) des beschichteten Schleifgegenstands ausgerichtet sind.

Revendications

1. Article abrasif revêtu (700) comprenant :

   un support (710) ayant une première surface principale (712) ;
   une couche de fabrication (730) disposée sur et fixée au support ;
   une couche abrasive (720) en contact avec et fixée à la couche de fabrication, dans lequel la couche abrasive comprend des îlots (725), chaque îlot comprenant au moins une plaquette abrasive profilée avec précision (722) et des particules abrasives diluantes (724), et dans lequel les îlots sont isolés les uns des autres ; et
   une couche d'encollage (770) disposée sur la couche de fabrication et la couche abrasive.

2. Article abrasif revêtu (700) selon la revendication 1, dans lequel les particules abrasives diluantes (724) sont principalement disposées sous des surplombs respectifs d'au moins une majorité des plaquettes abrasives profilées avec précision (722).

3. Article abrasif revêtu (700) selon la revendication 1, dans lequel les îlots (725) sont séparés les uns des autres d'au moins deux fois la distance minimale entre des plaquettes abrasives profilées avec précision (722) les plus proches d'îlots adjacents.

4. Article abrasif revêtu (700) selon la revendication 1, dans lequel les plaquettes abrasives profilées avec précision (722) sont positionnées sensiblement selon un motif prédéterminé.

5. Article abrasif revêtu (700) selon la revendication 1, dans lequel les plaquettes abrasives profilées avec précision (722) sont couramment alignées par rapport à un axe longitudinal (790) de l'article abrasif revêtu.

6. Article abrasif revêtu (800) selon la revendication 1, dans lequel les plaquettes abrasives profilées avec précision (822) sont couramment alignées par rapport à un axe de rotation (875) de l'article abrasif revêtu.

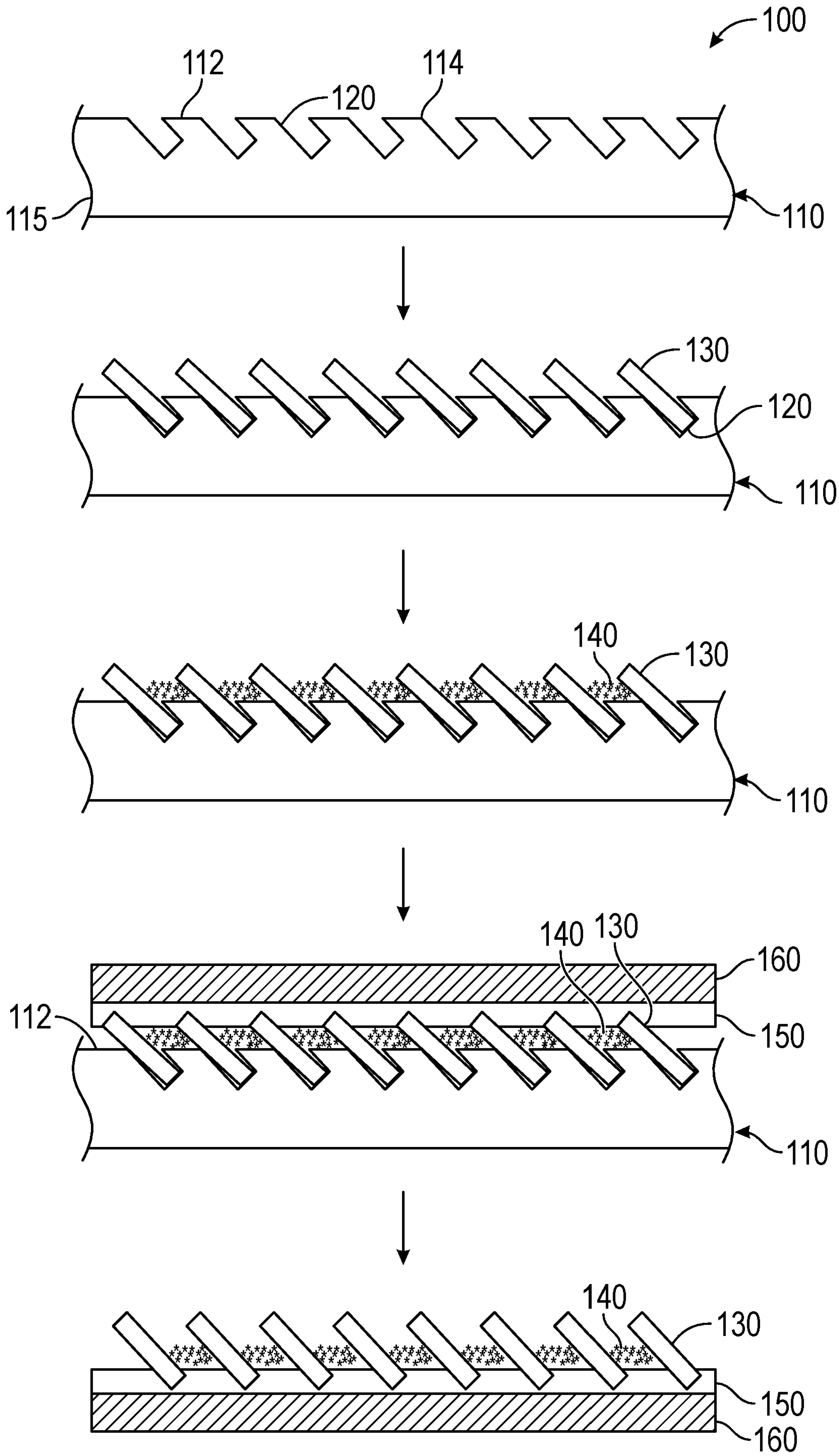

100
112
120
114
115
110
130
120
110
140
130
110
140
130
160
112
150
110
140
130
150
160

FIG. 1

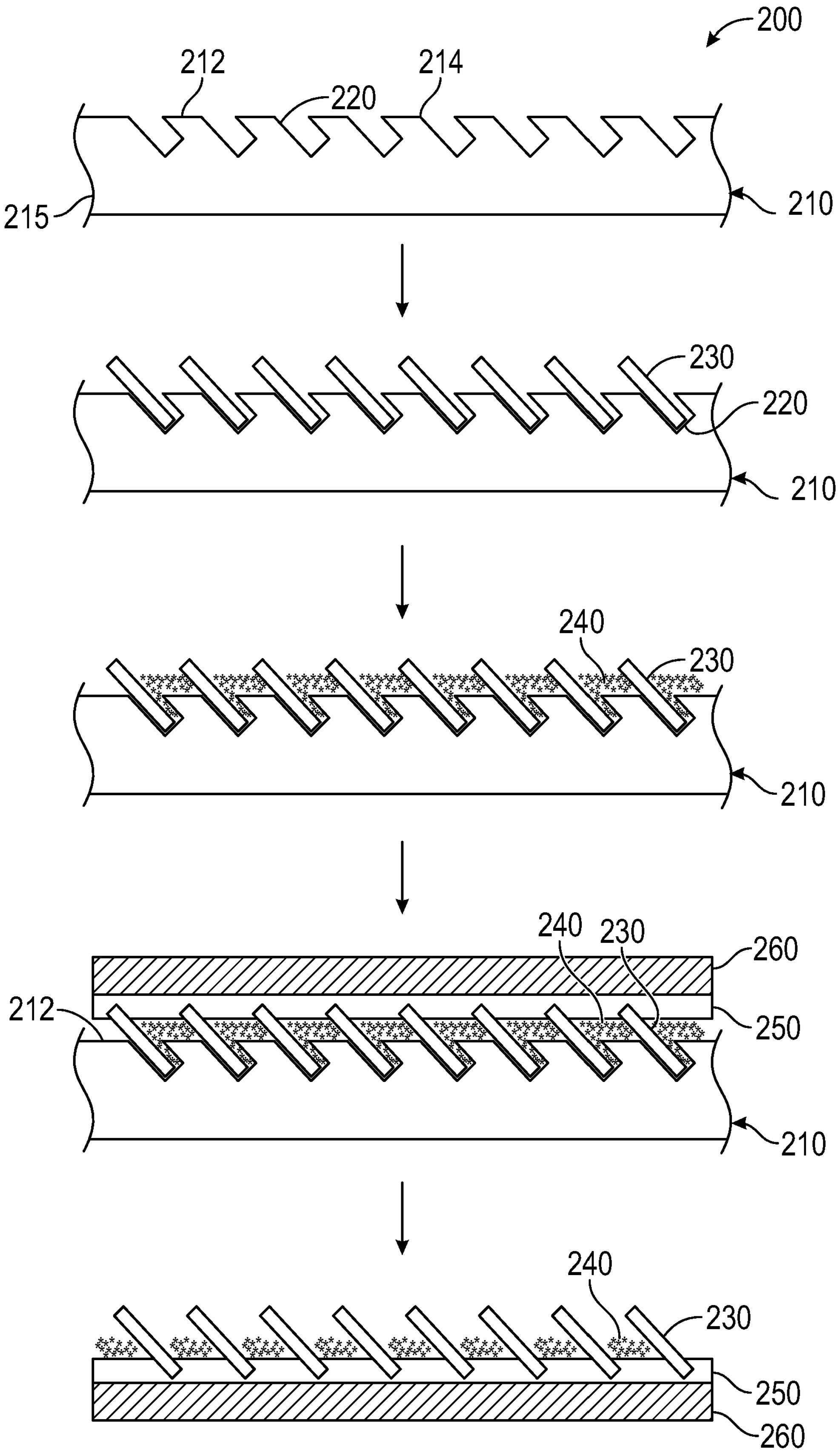

200
212
214
220
215
210
230
220
210
240
230
210
240
230
260
212
250
210
240
230
250
260

FIG. 2

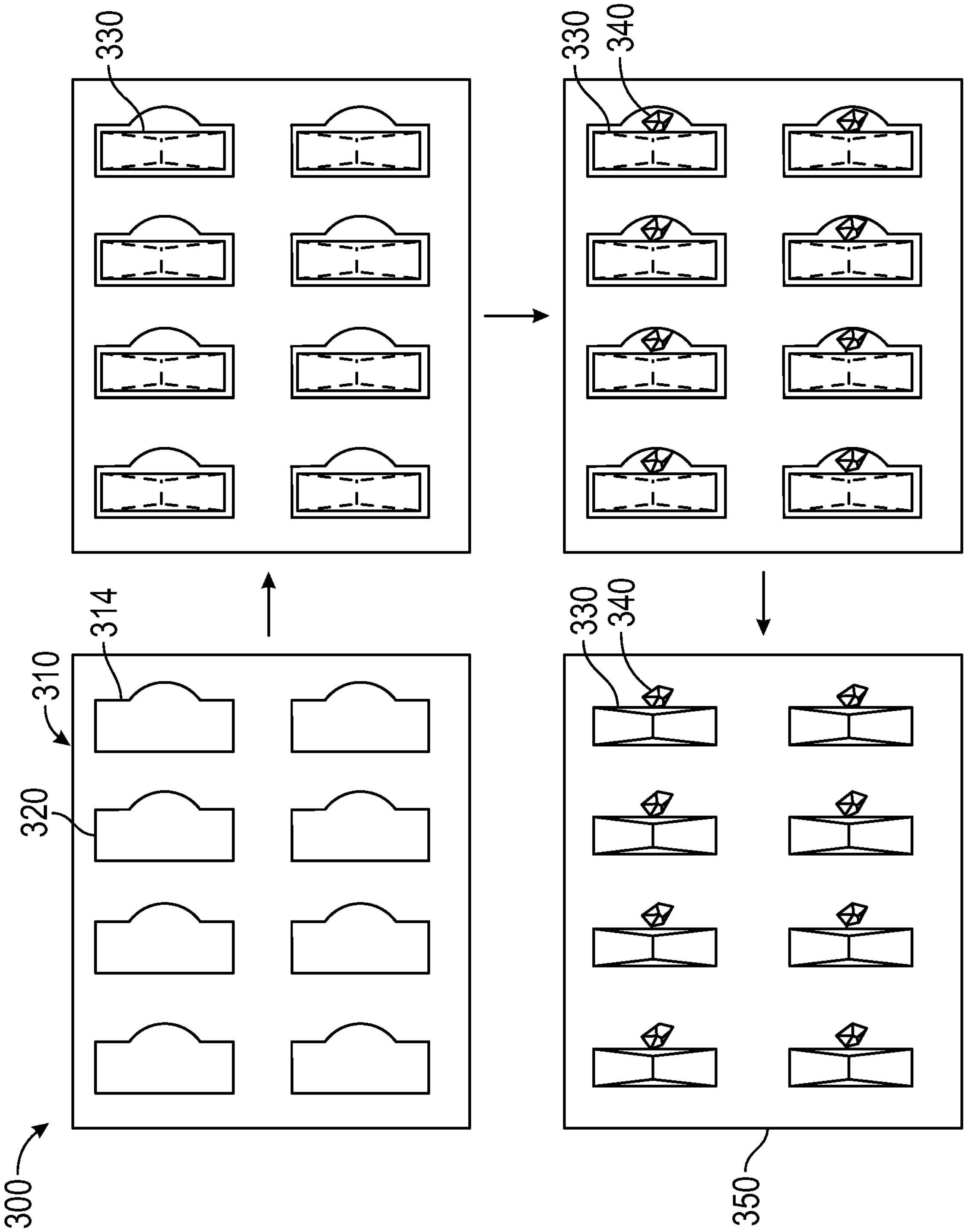


FIG. 3

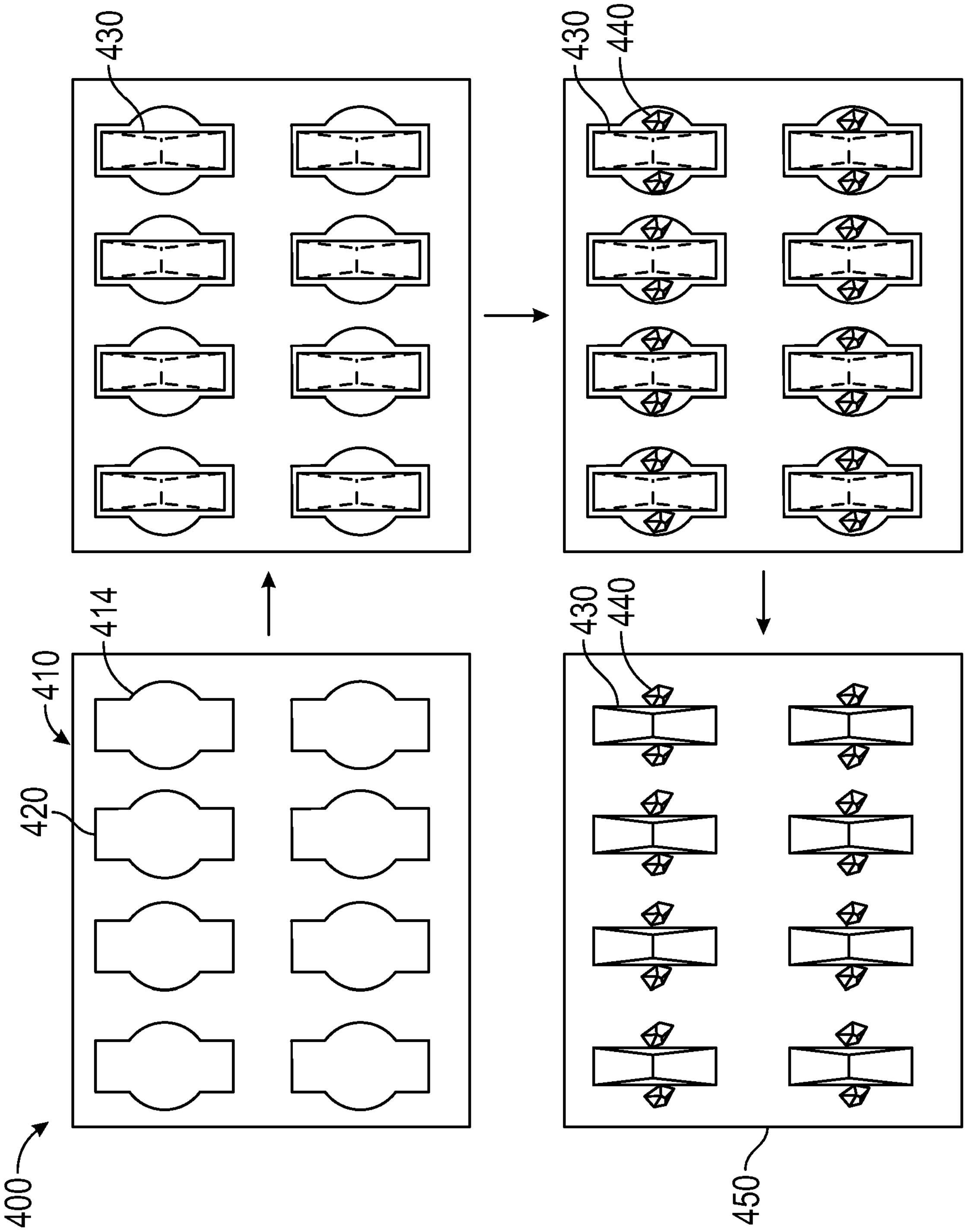


FIG. 4

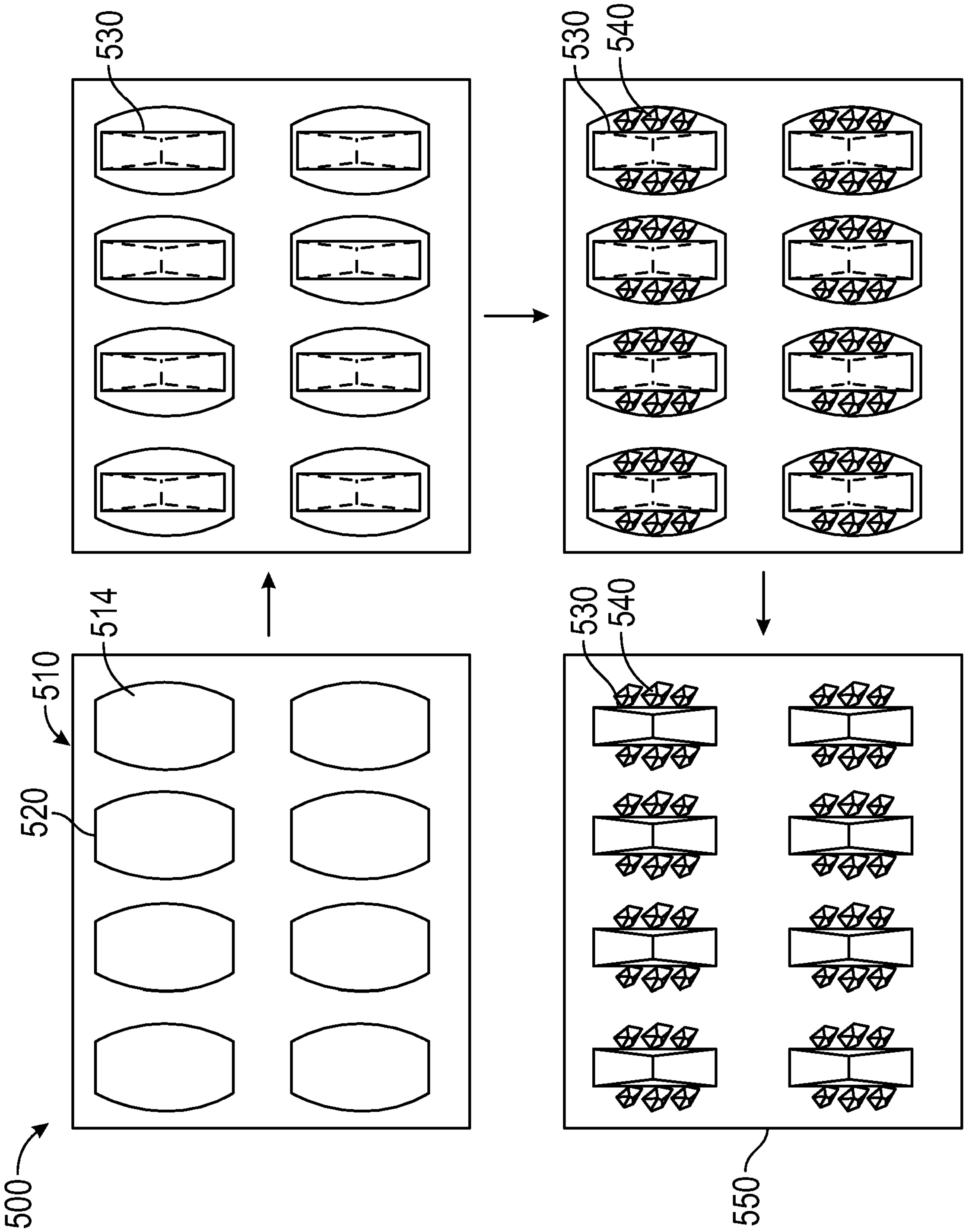


FIG. 5

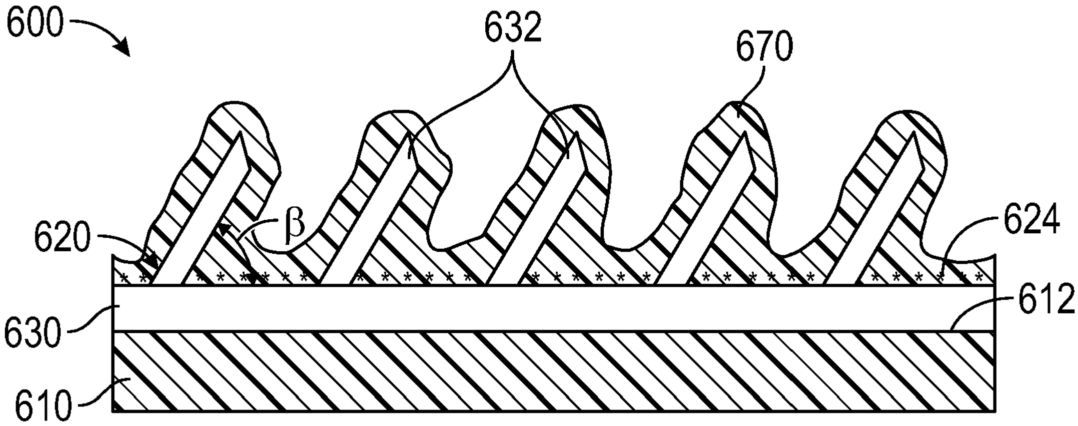

600
632
670
620
β
624
630
612
610

FIG. 6

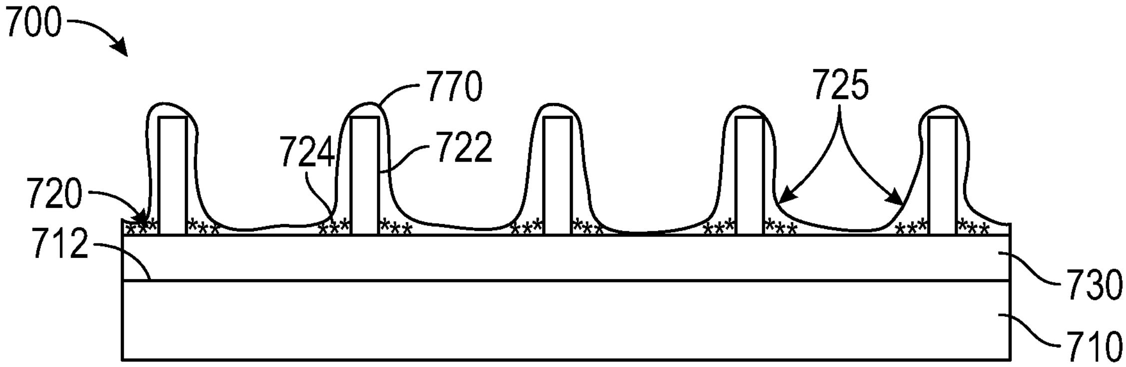

700
770
725
724
722
720
712
730
710

FIG. 7A

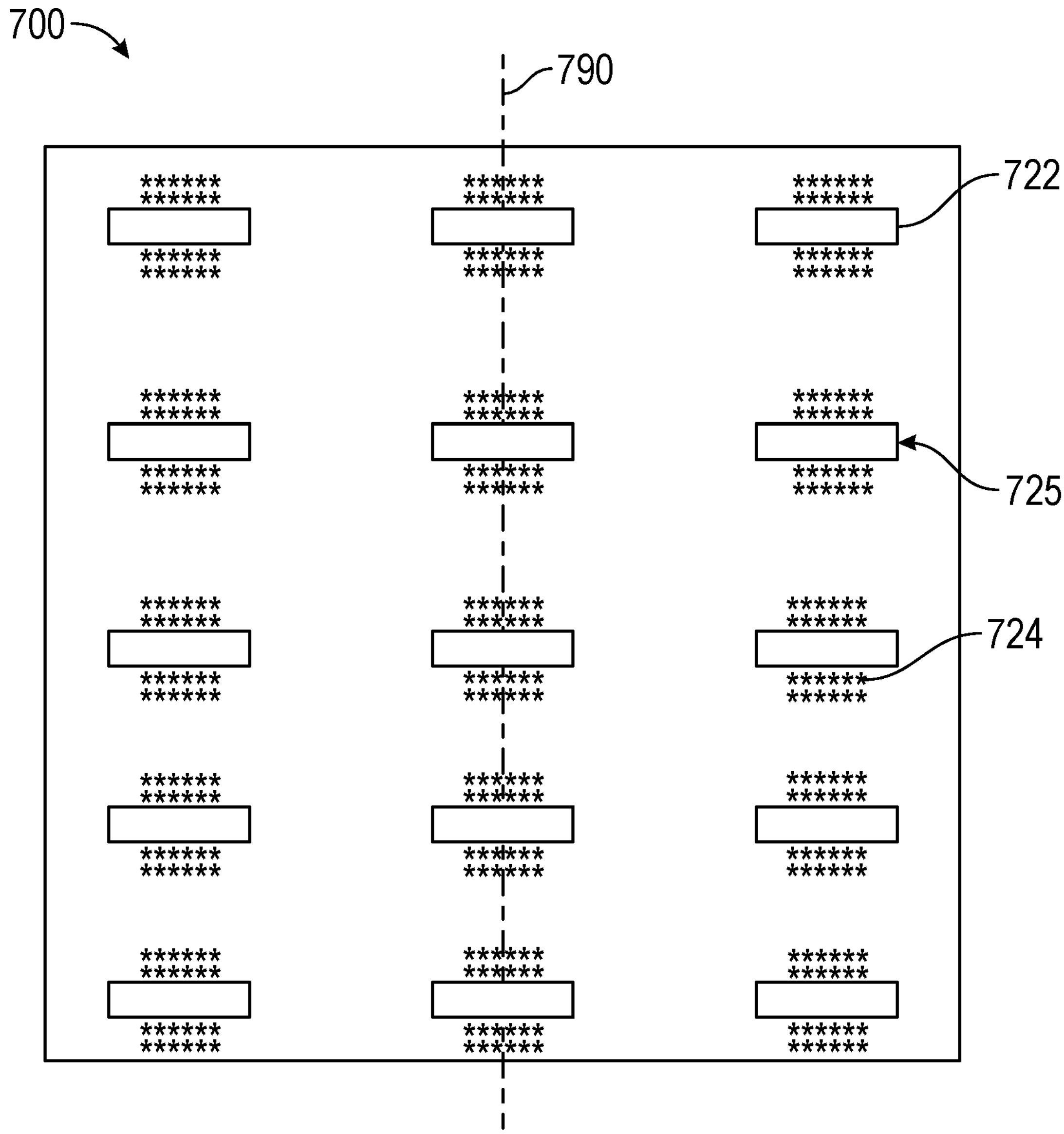


FIG. 7B

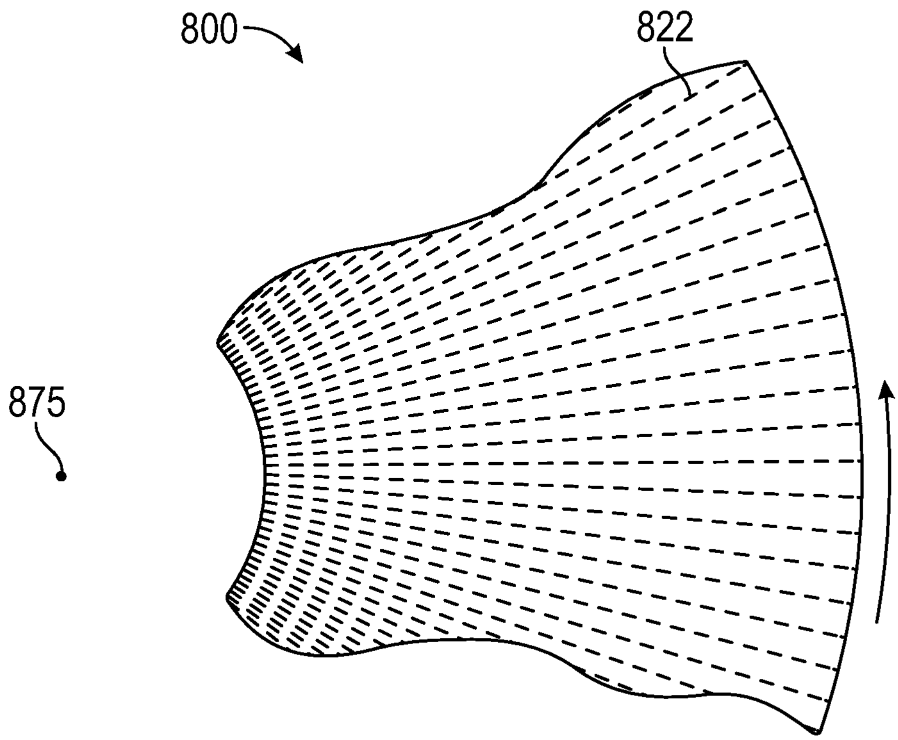
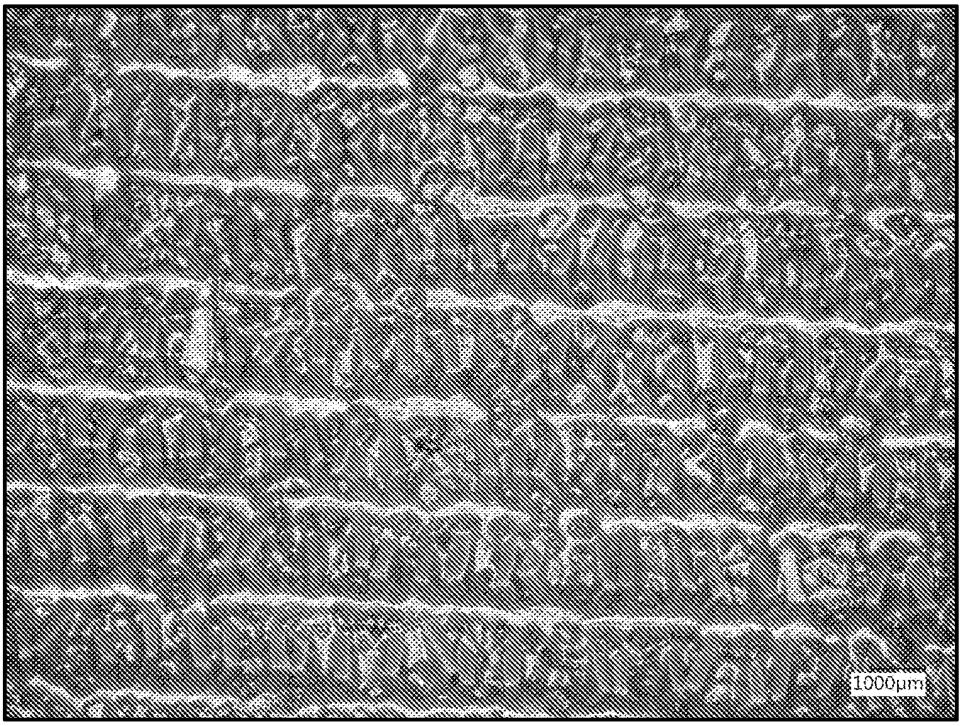
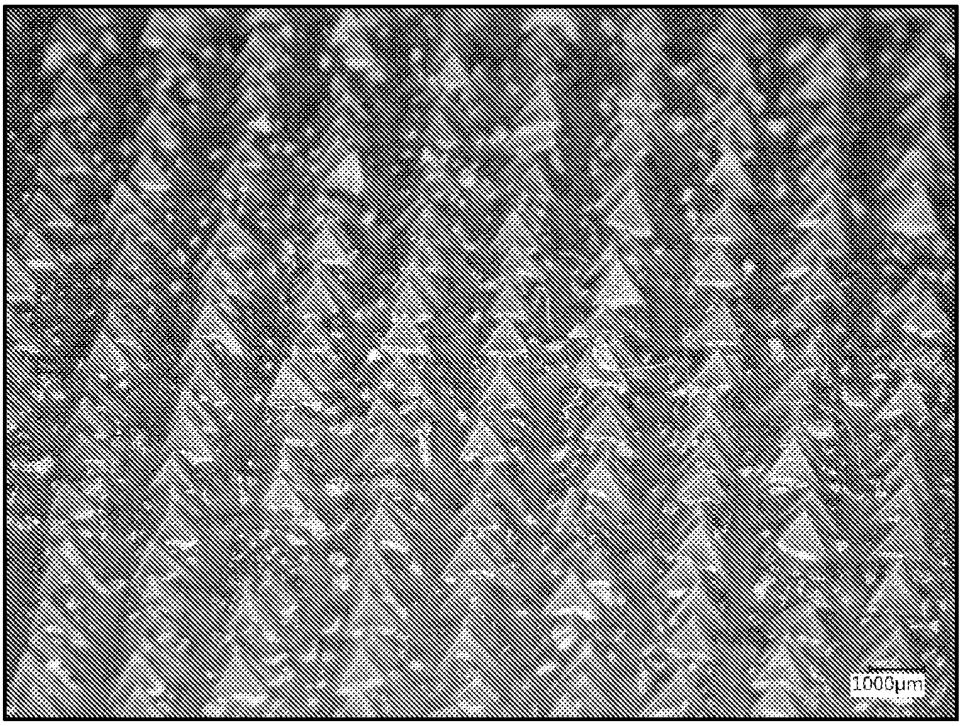


FIG. 8



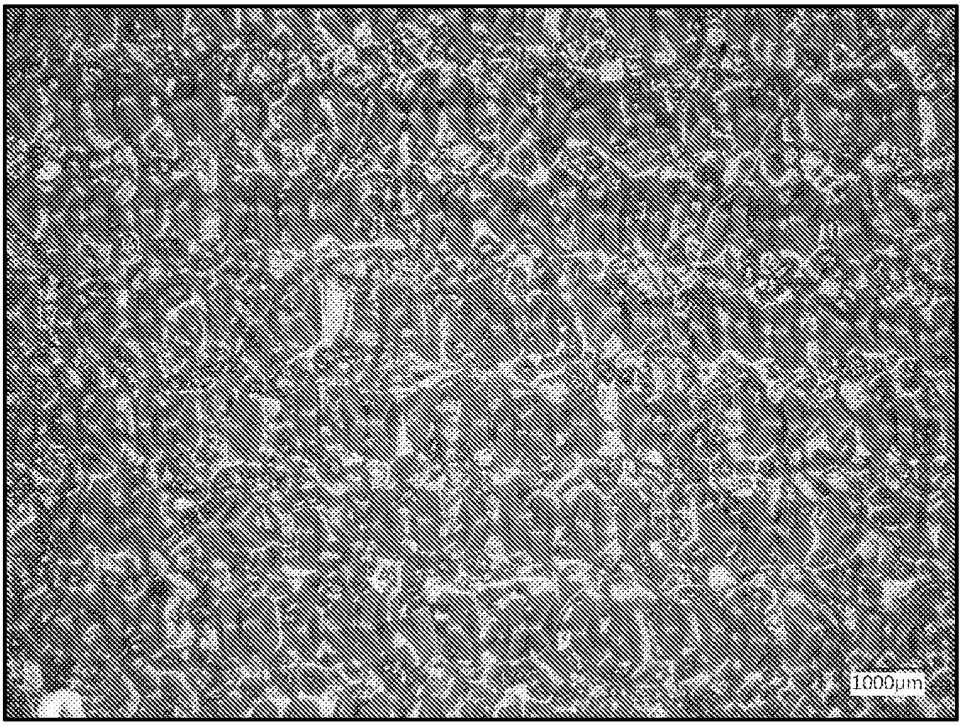
1000μm

FIG. 9A



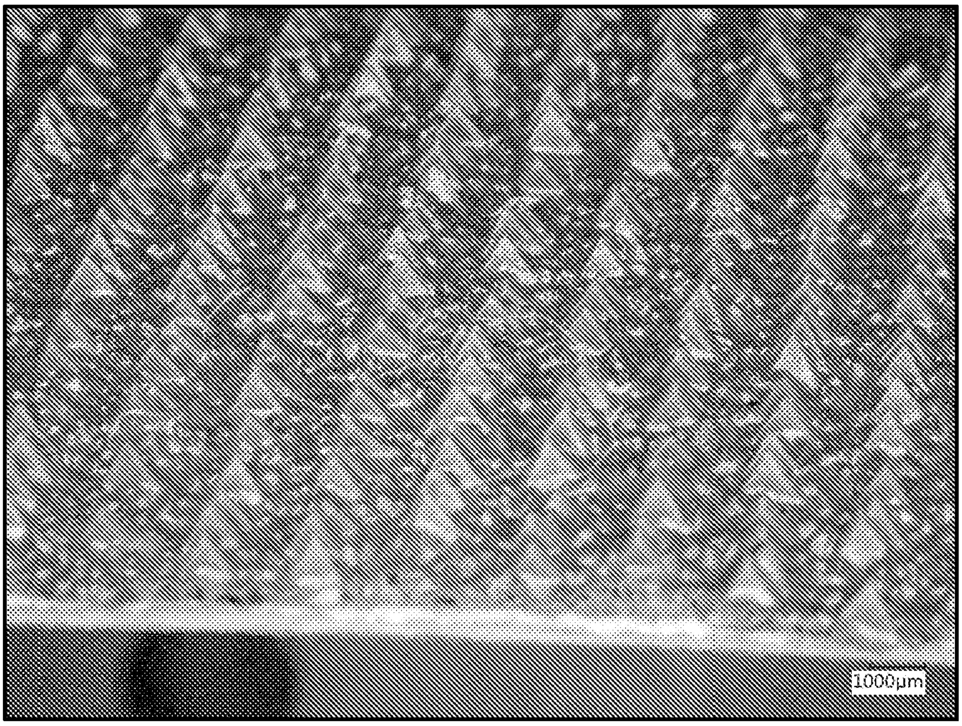
1000μm

FIG. 9B



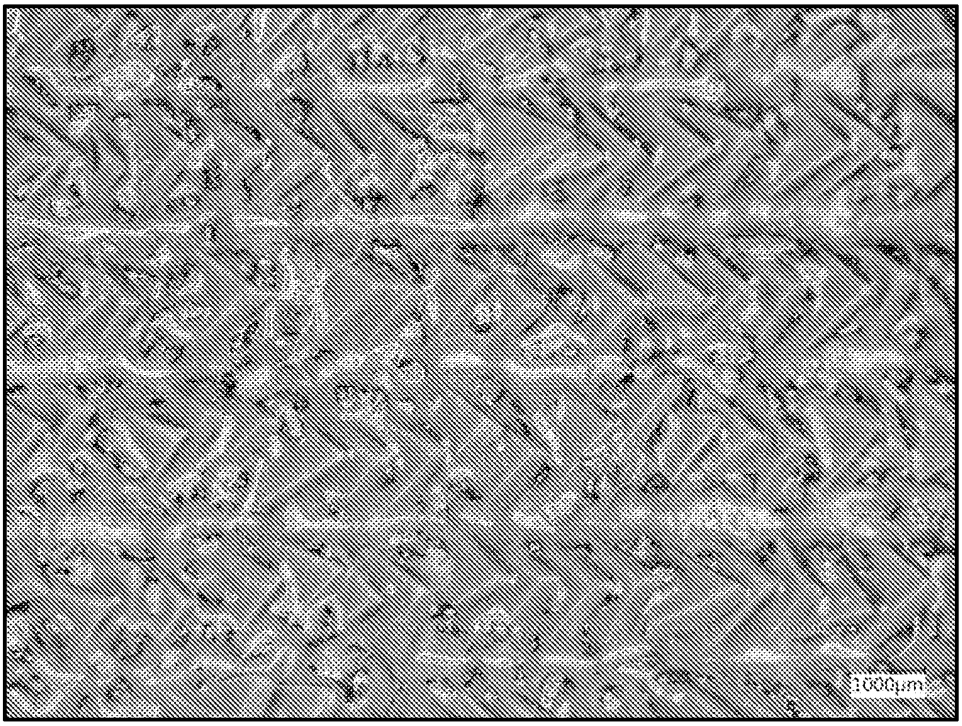
1000μm

FIG. 10A



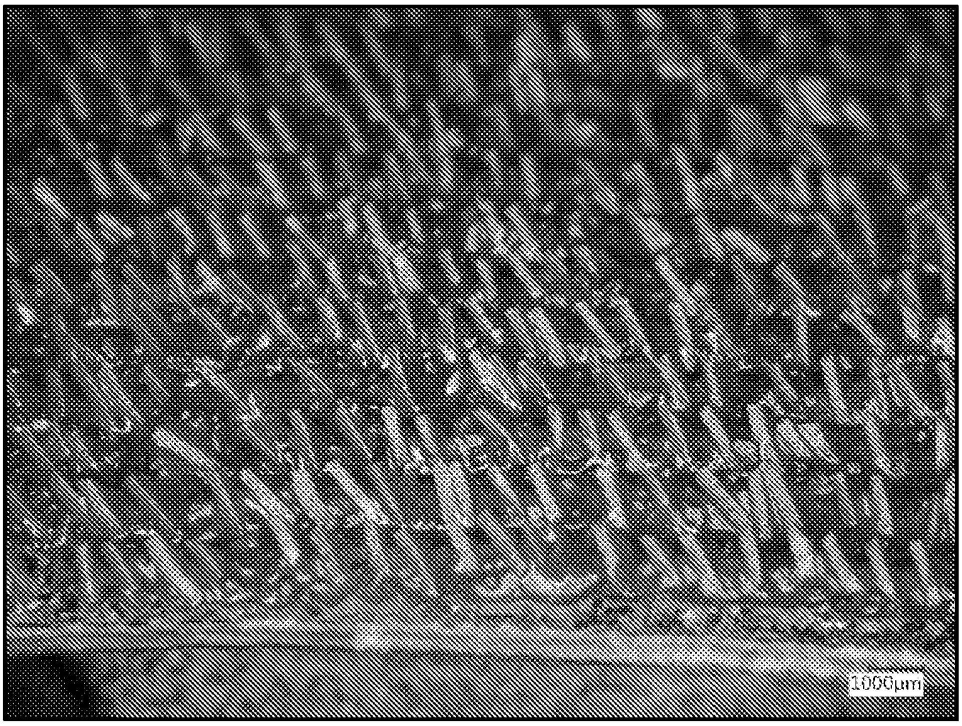
1000μm

FIG. 10B



1000μm

FIG. 11A



1000μm

FIG. 11B

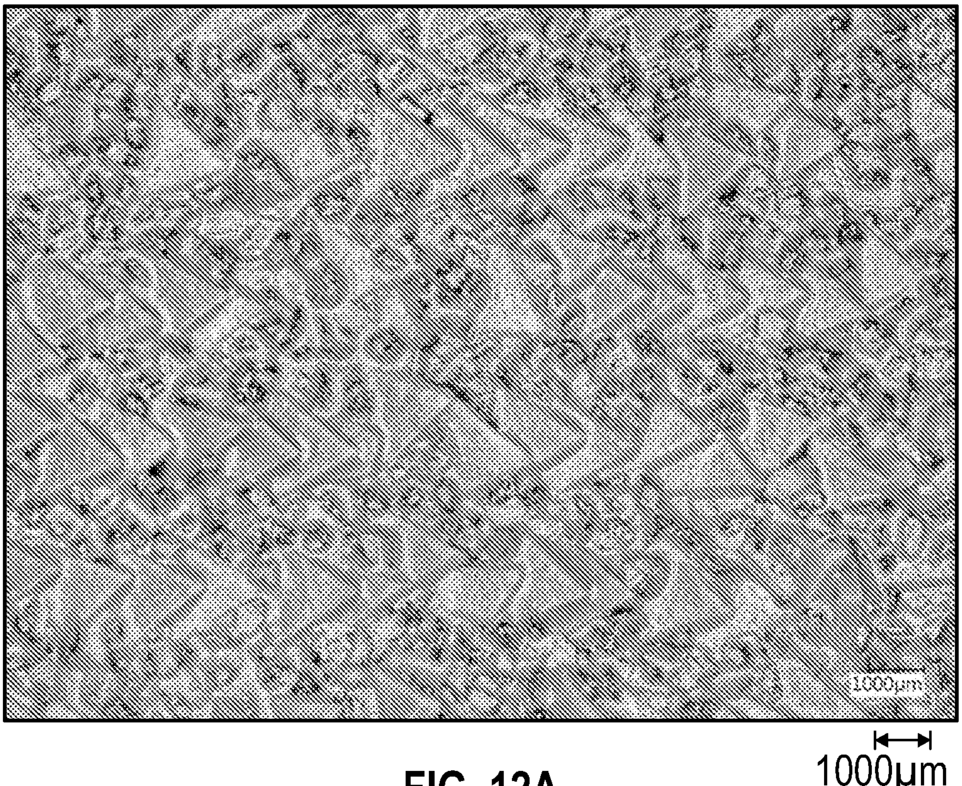


FIG. 12A

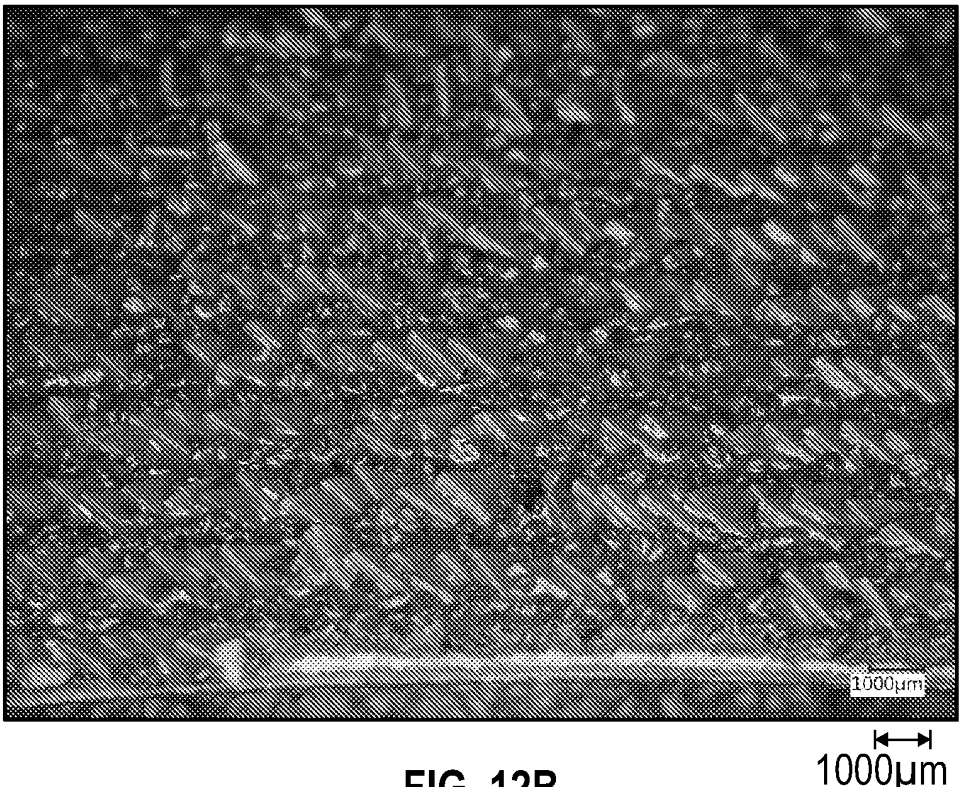


FIG. 12B

REFERENCES CITED IN THE DESCRIPTION

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