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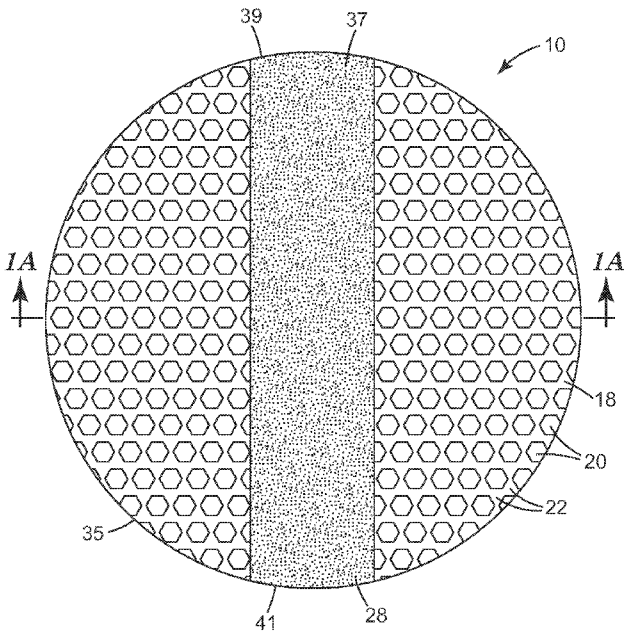

Fig. 1

(57) Abstract: An abrasive article with a backing having a first major surface and a second major surface opposed to the first major surface. A three-dimensional abrasive layer attached to the first major surface, the three-dimensional abrasive layer comprising a plurality of shaped abrasive composites spaced apart by a plurality of land areas between the shaped abrasive composites, each of the shaped abrasive composites comprising a top surface and a sidewall, and the plurality of shaped abrasive composites and the plurality of land areas both formed from abrasive particles dispersed within an organic binder. A preconditioning indicator located on the top surface of at least some of the plurality of shaped abrasive composites and a persistent indicator located on at least some of the plurality of land areas.

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ABRASIVE ARTICLE WITH PRECONDITIONING AND PERSISTENT INDICATORS

BACKGROUND

Abrasive articles are useful for a variety of grinding and finishing applications. One such application is precision lapping and polishing machines. Single-side lapping and polishing machines have a platen that is rotated relative to the workpiece. Double-side machines utilize a pair of opposing platens which rotate relative to the workpiece. Both types of machines can be used with fixed abrasives or liquid abrasive slurries. When used with fixed abrasives, such as a coated abrasive product, there can be a need to precondition or break-in the abrasive article prior to its general production use. There also can be a need to identify what type of abrasive article is mounted to the platen by its backing layer.

SUMMARY

The inventors have discovered that both of the above needs, preconditioning and identification, can be provided by indicators on the working surface of the abrasive article. During break-in, the preconditioning indicator is worn away. Once the preconditioning indicator is uniformly worn away, the preconditioning step is complete and the abrasive article can be placed into production to remove stock from the workpiece. During production, the persistent indicator on the working surface of the abrasive article allows the operator to identify the type of abrasive article mounted to the platen without needing to remove the abrasive article to see the backing where grade information is often printed on coated abrasives. Lastly, in some embodiments, the persistent indicator serves as an end point indicator signaling that the coated abrasive article has a limited life remaining after the persistent indicator is completely worn away.

Hence, in one embodiment, the invention resides in an abrasive article comprising: A backing having a first major surface and a second major surface opposed to the first major surface. A three-dimensional abrasive layer attached to the first major surface, the three- dimensional abrasive layer comprising a plurality of shaped abrasive composites spaced apart by a plurality of land areas between the shaped abrasive composites, each of the shaped abrasive composites comprising a top surface and a sidewall, and the plurality

of shaped abrasive composites and the plurality of land areas both formed from abrasive particles dispersed within an organic binder. A preconditioning indicator located on the top surface of at least some of the plurality of shaped abrasive composites and a persistent indicator located on at least some of the plurality of land areas.

DESCRIPTION OF THE DRAWINGS

It is to be understood by one of ordinary skill in the art that the present discussion is a description of exemplary embodiments only, and is not intended as limiting the broader aspects of the present invention, which broader aspects are embodied in the exemplary construction.

FIG. 1 illustrates a top view of a coated abrasive article having a preconditioning indicator.

FIG. 1A illustrates a partial cross section through the coated abrasive article taken at 1A - 1A of FIG. 1.

FIG. 2 illustrates a top view of a coated abrasive article having a persistent indicator after preconditioning.

FIG. 2A illustrates a partial cross section through the coated abrasive article taken at 2A - 2A of FIG. 2.

FIG. 3 illustrates a top view of a coated abrasive article signaling that the coated abrasive article has limited life remaining after the persistent indicator is completely worn away

FIG. 3A illustrates a partial cross section through the coated abrasive article taken at 3A - 3A of FIG. 3.

FIG. 4A illustrates printed indicia on the three-dimensional abrasive layer of the coated abrasive article prior to preconditioning.

FIG. 4B illustrates printed indicia on the three-dimensional abrasive layer of the coated abrasive article during use.

Repeated use of reference characters in the specification and drawings is intended to represent the same or analogous features or elements of the invention.

DEFINITIONS

As used herein, forms of the words "comprise", "have", and "include" are legally equivalent and open-ended. Therefore, additional non-recited elements, functions, steps or limitations may be present in addition to the recited elements, functions, steps, or limitations.

DETAILED DESCRIPTION

The present invention pertains to coated abrasive articles 10 that have a backing 12 and a three-dimensional abrasive layer 18 typically comprising diamond, diamond agglomerates, ceria, or other abrasive particles. The abrasive particles are dispersed within a binder and bonded to a surface of the backing 12. The abrasive layer typically comprises a plurality of shaped abrasive composites 20 separated by a plurality of land areas 22 both of which are formed from a binder precursor and a plurality of abrasive particles that is cured or hardened into the three-dimensional abrasive layer 18.

The abrasive article is useful for polishing or grinding a variety of hard to abrade substrates such as ceramics, glass, single-crystal substrates, and hard metals. The abrasive article can be mounted to a platen of a lapping or a polishing machine that rotates the platen relative to the workpiece to produce the desired stock removal and finish on the workpiece. Typically, a coated abrasive product when used in a lapping or polishing machine is required to be preconditioned prior to its general production use. The preconditioning serves to precisely machine the three-dimensional abrasive layer 18 of the coated abrasive article 10 such that all areas of the three-dimensional abrasive layer are in uniform contact with the workpiece and to prepare the three-dimensional abrasive layer such that the cut rate of the three-dimensional abrasive layer is substantially uniform at all locations within the working surface of the three-dimensional abrasive layer. Thus, there is a need to know when the preconditioning sequence is complete; preferably, by viewing the three-dimensional abrasive layer 18 of the coated abrasive article 10 to determine when it is substantially uniform.

Often a manufacturing plant will need coated abrasive articles 10 in various grades having faster or slower cut rates and producing rougher or smoother finishes to obtain the desired final finish on the workpiece. Since the coated abrasive article 10 is mounted to the platen by the backing 12, the grade identification typically printed on the backing 12 is

often obscured during use of the coated abrasive article 10. Removing the coated abrasive article 10 from the platen to check the grade or identification information typically requires another preconditioning sequence to uniformly prepare the abrasive layer again for use. Thus, there is a need to identify what type of abrasive article is mounted to the platen while viewing the three-dimensional abrasive layer 18 of the coated abrasive article 10.

Referring now to FIGS. 1, 1A, 2 and 2A, one embodiment of a coated abrasive article 10 in accordance with the invention is illustrated. The coated abrasive article 10 includes a backing 12 having a first major surface 14 and a second major surface 16, which oppose each other. A three-dimensional abrasive layer 18 is attached to the first major surface 14. The three-dimensional abrasive layer 18 comprises a plurality of shaped abrasive composites 20 separated from each other by a plurality of land areas 22 between the shaped abrasive composites 20. The shaped abrasive composites 20 comprise a top surface 24 and at least one sidewall 26. Typically, the shaped abrasive composites 20 and the land areas 22 are integrally formed from the same abrasive slurry comprising a binder and a plurality of abrasive particles that is hardened or cured in a mold to form the three-dimensional abrasive layer 18. The three-dimensional abrasive layer 18 comprises an organic resin binder and abrasive particles, and any optional additives such as fillers, pigments, or coupling agents, etc.

The three dimensional abrasive layer 18 also includes a preconditioning indicator 28 (FIG. 1) and a persistent indicator 30 (FIG. 2). The preconditioning indicator 28 can comprise a first coating 32 on at least some of the top surfaces 24 of the shaped abrasive composites 20 (FIG. 1A). The persistent indicator 30 can comprise a second coating 34 on at least some of the land areas 22 between the shaped abrasive composites 20. In one embodiment, the persistent indicator 28 comprises a second coating 34 on at least some of the land areas 22 and on at least some of the sidewalls 26 of the shaped abrasive composites 20 (FIG. 2A).

When the coated abrasive article 10 is initially molded, the top surfaces 24 are often slightly rounded or uneven and not perfectly parallel to the second major surface 16 that is attached to the platen of the polishing or lapping machine. Once the coated abrasive article 10 is preconditioned as shown in FIG. 2A, the first coating 32 is completely removed from the top surfaces 24, and the top surfaces 24 are uniformly planar

(same height from the second major surface 16) and parallel to the second major surface 16. Thus, the transition from the first coating 32 appearing on at least some or a portion of the top surfaces 24 to the absence of the first coating 32 anywhere on the top surfaces 24 of the shaped abrasive composites 20 signals when the preconditioning step is complete as best seen by comparing FIG. 1 and FIG. 2. Once the first coating 32 is entirely worn away, the coated abrasive article 10 is ready for use.

It is believed that having a relatively steep sidewall 26, such that the angle α between the sidewall 26 and the top surface 24 after preconditioning is less than about 110 degrees facilitates detection of the exact moment when the first coating 32 is completely removed. A steeper sidewall 26 angle can prevent excessive preconditioning of the coated abrasive article 10, which would reduce its useful life without providing any additional benefit during the coated abrasive article's initial use. In various embodiments of the invention, the angle α can be between about 90 degrees to about 110 degrees, or between about 90 degrees to about 100 degrees.

Referring to FIG. 1, in one embodiment, the coated abrasive article 10 comprised a circular abrasive disc 35. The preconditioning indicator 28 and persistent indicator 30 comprised at least one stripe 37 extending from a first side 39 of the circular abrasive disc 35 to a second side 41 of the circular abrasive disc. In one embodiment of the invention, the stripes 37 can intersect with each other while passing substantially through the disc's center while being uniformly or non-uniformly radially spaced about the circumference of the disc. In another embodiment, the stripes 37 can be substantially parallel to each other and spaced uniformly or non-uniformly across the three-dimensional abrasive layer 18. In yet another embodiment, the stripes can form a grid of horizontal and vertical lines. In various embodiments of the invention, the number of stripes 37 can be between 1 to about 20, or between 1 to about 10. In some embodiments as shown in FIGS. 4A and 4B, the stripes 37 can comprise printed indicia 36 as opposed to a solid continuous line.

While it is possible for the preconditioning indicator 28 and the persistent indicator 30 to completely cover the entire three-dimensional abrasive layer 18, doing so would make it difficult to use printed indicia 36 to serve as both a preconditioning indicator 28 and as a persistent indicator 30. Utilizing stripes extending across the face of the circular abrasive disc 35, can provide for a first coating 32 at the opposing sides and near the center of the three-dimensional abrasive layer 18 in order to effectively determine

that planarization of the top surfaces 24 of the shaped abrasive composites 20 has occurred completely across the entire face of the circular abrasive disc 35 while still retaining legibility of the printed indicia 36.

Referring to FIG. 2, after preconditioning, the persistent indicator 30 remains on the land areas 22 and, optionally, on the sidewalls 26 of the shaped abrasive composites 20. The persistent indicator 30 can use a code, such as different colors, different symbols, or different patterns, which correspond to a particular product identification such as the abrasive grade or abrasive product identification. Desirably, the persistent indicator 30 comprises printed indicia that allow the user to identify at least one of the following: manufacturer name, product identification number, lot number, trademark, abrasive grit designation, additives and treatments, safety information, or combinations of the foregoing.

In one embodiment, as shown in FIGS. 4A and 4B, the preconditioning indicator 28 and the persistent indicator 30 each comprise printed indicia 36. The printed indicia 36 allows for the abrasive product to be identified prior to preconditioning as shown in FIG 4A, and also after preconditioning as shown in FIG. 4B. To better effect identification of the product, it has been determined that the relative sizes of the land areas 22, the shaped abrasive composites 20, and the printing letters should be controlled. Desirably, the spacing of the shaped abrasive composites 20 from sidewall 26 to sidewall 26 should be between about 0.5 mm to about 5.0 mm, the maximum dimension of the top surface 24 should be between about 1.0 mm to about 5.0 mm, and the height, h, of the font should be between about 20 mm to about 40 mm. Selections within these ranges help to ensure that the printed indicia are readily visible and readable after preconditioning is complete.

In one embodiment, the printed indicia 36 are also present on at least some of the sidewalls 26. It is believed that by printing the land areas 22 and the sidewalls 26, the printed indicia is readable over a much larger viewing angle. In that regard, to facilitate reading the printed indicia 36 at angles significantly greater than 0 degrees to the first major surface 14, the shape of the shaped abrasive composites 20 can comprise a hexagonal shape in cross section in one embodiment. A shaped abrasive composite having a hexagonal cross section has a sidewall 26 with six flats that provide reasonably sized printing surfaces and the flats are oriented at different positions around the abrasive composite enabling the printed indicia 36 to be readily viewed regardless of the rotational

position of the circular abrasive article attached to the platen of the lapping and polishing machine. In other embodiments, shaped abrasive composites with a sidewall having 5 to 8 flats (pentagonal to octagonal) can be used.

Referring now to FIGS. 3 and 3A, the coated abrasive article 10 is shown after the shaped abrasive composites 20 have been used up and the second coating 34 is worn completely away. In this manner, the persistent indicator 30 can function as an end point indicator foreshadowing the need to replace the coated abrasive article 10 with a new one. Once the persistent indicator 30 is no longer visible, the coated abrasive product has a limited remaining life. To protect the lapping and polishing machine from possible damage by the workpiece contacting the platen or the backing 12 after the second coating 34 is worn away, the land areas 22 should be sufficiently thick to enable operating the machine for a reasonable period of time prior to completely using up the abrasive layer. In various embodiments of the invention, the thickness, t, of the land areas 22 can be between about 25 microns to about 125 microns, or between about 10 microns to about 200 microns.

In some embodiments, the coated abrasive article 10 is used with various lubricants and grinding aids. Suitable lubricants include water-based solutions of one or more of the following: amines, mineral oil, kerosene, mineral spirits, pine oil, water-soluble emulsions of oils, polyethylenimine, ethylene glycol, propylene glycol, monoethanolamine, diethanolamine, triethanolamine, amine borate, boric acid, amine carboxylate, indoles, thioamine salt, amides, hexahydro-1,3,5-triethyltriazine, carboxylic acids, sodium 2-mercaptobenzothiazole, isopropanolamine, triethylenediamine tetraacetic acid, propylene glycol methyl ether, benzotriazole, sodium 2-pyridinethiol-1-oxide, and hexylene glycol. Lubricants may also include corrosion inhibitors, fungi inhibitors, stabilizers, surfactants, and/or emulsifiers.

When a lubricant or grinding aid is used, the first and second coatings (32, 34) should be selected such that they are not readily dissolved or removed during use by the lubricant or grinding aid. Suitable first and/or second coatings can include pigmented or dye-based colorants in oil-based, solvent-based, water-based, or UV-curable liquid carrier systems. For printing on non-porous surfaces, solvent-based or UV-curable coatings are preferred. Examples of suitable solvent-based coatings include: n-butyl lactate based

printing inks, ketone based printing inks, ester based printing inks, or acetone/toluene based paints.

In other embodiments, the preconditioning indicator 28 and/or the persistent indicator 30 can be molded into at least a portion of the three-dimensional abrasive layer 18 by using appropriately colored resins. For example, during the initial filling of the mold, a first colored abrasive slurry can be used to slightly fill the mold cavities to a first height. Then a second colored abrasive slurry can be used to fill the majority of the height of the mold cavities to a second height corresponding to approximately the bases of the shaped abrasive composites, and finally a third colored abrasive slurry could be used to fill the mold cavities to the final height corresponding to approximately the thickness, t, of the land areas. The transition from the first color to the second color would mark the point where preconditioning is completed. The transition from the second color to the third color would mark the point where the abrasive article was nearly used up and needs replacement (end point indicator). If desired, the first and the third colors could be the same. Additionally, it is possible to use selected mold cells as a pseudo "dot-matrix printer" to mold printed indicia 36 directly into the three-dimensional abrasive layer 18 by selectively differentially coloring specific shaped abrasive composites 20 in the abrasive layer to form letters, numbers, or symbols.

Suitable materials and methods to produce the coated abrasive article 10 are generally known to those of skill in the art. Suitable organic binders to mold the three-dimensional abrasive layer 18 are disclosed in U.S. patent number 7,044,835 starting at column 9, line 20 and proceeding until column 11, line 65. Suitable backing 12 materials to support the three-dimensional abrasive layer 18 are disclosed in U.S. patent number 7,044,835 starting at column 11, line 65 and proceeding until column 12, line 40. Suitable abrasive particles to mold within the three-dimensional abrasive layer 18 are disclosed in U.S. patent number 7,044,835 starting at column 12, line 41 and proceeding until column 15, line 44. Suitable additives for use with the three-dimensional abrasive layer 18 are disclosed in U.S. patent number 7,044,835 starting at column 15, line 45 and proceeding until column 18, line 18. Methods for making the coated abrasive article 10 are disclosed in U.S. patent number 7,044,835 starting at column 18, line 45 and proceeding until column 19, line 26.

EXAMPLE

High-resolution indicia markings were applied to 673LA or 673FA coated abrasive discs (available from 3M Corporation) using a PZ Pilot Plus piezoelectric impulse inkjet print head and ImageMaster software, both from Squid Ink Manufacturing, Spring Lake Park, MN. The abrasive discs were approximately 30 cm in diameter. The shaped abrasive composites 20 had a hexagonal cross section with a top surface 24 measuring 3.30 mm across the flats, having a height of 0.76 mm, and the spacing between adjacent composites was 1.40 mm. The shaped abrasive composites 20 and the land areas 22 comprised diamond abrasive particles in radiation-curable resin binders. 3M coated abrasive products were used for test examples, commercially available under the following trade names: 3M Trizact 673LA grade A10, Trizact 673FA grade A80, and Trizact 673FA grade A160.

Suitable indicia to print including text characters and solid stripe markings were selected through the ImageMaster computer interface. Disc samples were translated by hand past the piezoelectric print head using a sliding table device mounted under the print head. After printing, the disc markings were held briefly under a Squid Ink infrared lamp to speed drying of the ink. In one embodiment, PZ 4845 black ink available from Squid Ink was fed to the print head. The printed indicia comprised one or more stripes that extended from one edge of the disc to an opposing edge and/or printed letters and numbers having various heights of 1/2 inch (1.27 cm), 5/8 inch (1.59 cm), 3/4 inch (1.91 cm), 1 inch (2.54 cm), 1.125 inch (2.86 cm), or 1.25 inch (3.18 cm).

Printed discs were then tested using a Strasbaugh 6DC single-side lapping machine and an aqueous coolant solution (10% Sabrelube 9016 / water). Coolant flow was 30 ml/min. The machine table rotation was set at 100 rpm and the sample plate rotation was 100 rpm. Simulated preconditioning and use cycles were performed for 5-minute intervals using A35 268XA Trizact PSA or A45 963FA Trizact PSA discs (available from 3M Corporation) mounted on the sample plate and with a 25 or 35 lb load applied to the sample head. In some cases, disc wear was accelerated by introducing P180 AlOx abrasive grain (Treibacher Alodur BFRPL) onto the disc surface during the test cycles. Legibility of disc stripes and text markings was judged visually after each test cycle and recorded with a digital camera.

The testing indicated that the preconditioning indicator 28 comprising a first coating 32 of ink on the top surfaces 24 functioned to indicate when the top surfaces 24 were planar and parallel to the first major surface 14 once the first coating was worn away. The testing also indicated that persistent indicator 30 comprising a second coating 34 of ink on the land areas 22 and the sidewalls 26 of the shaped abrasive composites 20 remained throughout the test until the shaped abrasive composites 20 were substantially worn away. Furthermore, printed letters and numbers having a height of 3/4 inch (1.91 cm) or greater were readable throughout the duration of the test until the second coating 34 was substantially worn away after the shaped abrasive composites 20 were used up.

Other modifications and variations to the present invention may be practiced by those of ordinary skill in the art, without departing from the spirit and scope of the present invention, which is more particularly set forth in the appended claims. It is understood that aspects of the various embodiments may be interchanged in whole or part or combined with other aspects of the various embodiments. All cited references, patents, or patent applications in the above application for letters patent are herein incorporated by reference in a consistent manner. In the event of inconsistencies or contradictions between the incorporated references and this application, the information in the preceding description shall control. The preceding description in order to enable one of ordinary skill in the art to practice the claimed invention is not to be construed as limiting the scope of the invention, which is defined by the claims and all equivalents thereto.

What is claimed is:

1. An abrasive article comprising:

a backing having a first major surface and a second major surface opposed to the first major surface;

a three-dimensional abrasive layer attached to the first major surface, the three-dimensional abrasive layer comprising a plurality of shaped abrasive composites spaced apart by a plurality of land areas between the shaped abrasive composites, each of the shaped abrasive composites comprising a top surface and a sidewall, and the plurality of shaped abrasive composites and the plurality of land areas both formed from abrasive particles dispersed within an organic binder;

a preconditioning indicator located on the top surface of at least some of the plurality of shaped abrasive composites; and

a persistent indicator located on at least some of the plurality of land areas.

2. The abrasive article of claim 1 wherein the preconditioning indicator comprises a first coating on the top surface.

3. The abrasive article of claim 2 wherein the first coating comprises ink.

4. The abrasive article of claim 3 wherein the first coating comprises printed indicia.

5. The abrasive article of claim 1 comprising a circular abrasive disc and the preconditioning indicator comprises at least one stripe extending from a first side of the circular abrasive disc to a second side of the circular abrasive disc.

6. The abrasive article of claim 5 wherein the at least one stripe comprises printed indicia.

7. The abrasive article of claim 6 wherein the printed indicia also resides on at least some of the plurality of land areas.

8. The abrasive article of claim 1 wherein the persistent indicator comprises a second coating forming printed indicia.

9. The abrasive article of claim 8 wherein the persistent indicator comprises the second coating on the sidewall of at least some of the plurality of shaped abrasive composites.

10. The abrasive article of claim 9 wherein the second coating comprises ink.

11. The abrasive article of claim 10 wherein the plurality of shaped abrasive composites comprise a cross section having a hexagonal shape.

12. The abrasive article of claim 11 wherein the printed indicia comprise a height and the height is 3/4 inch (1.91 cm) or greater.

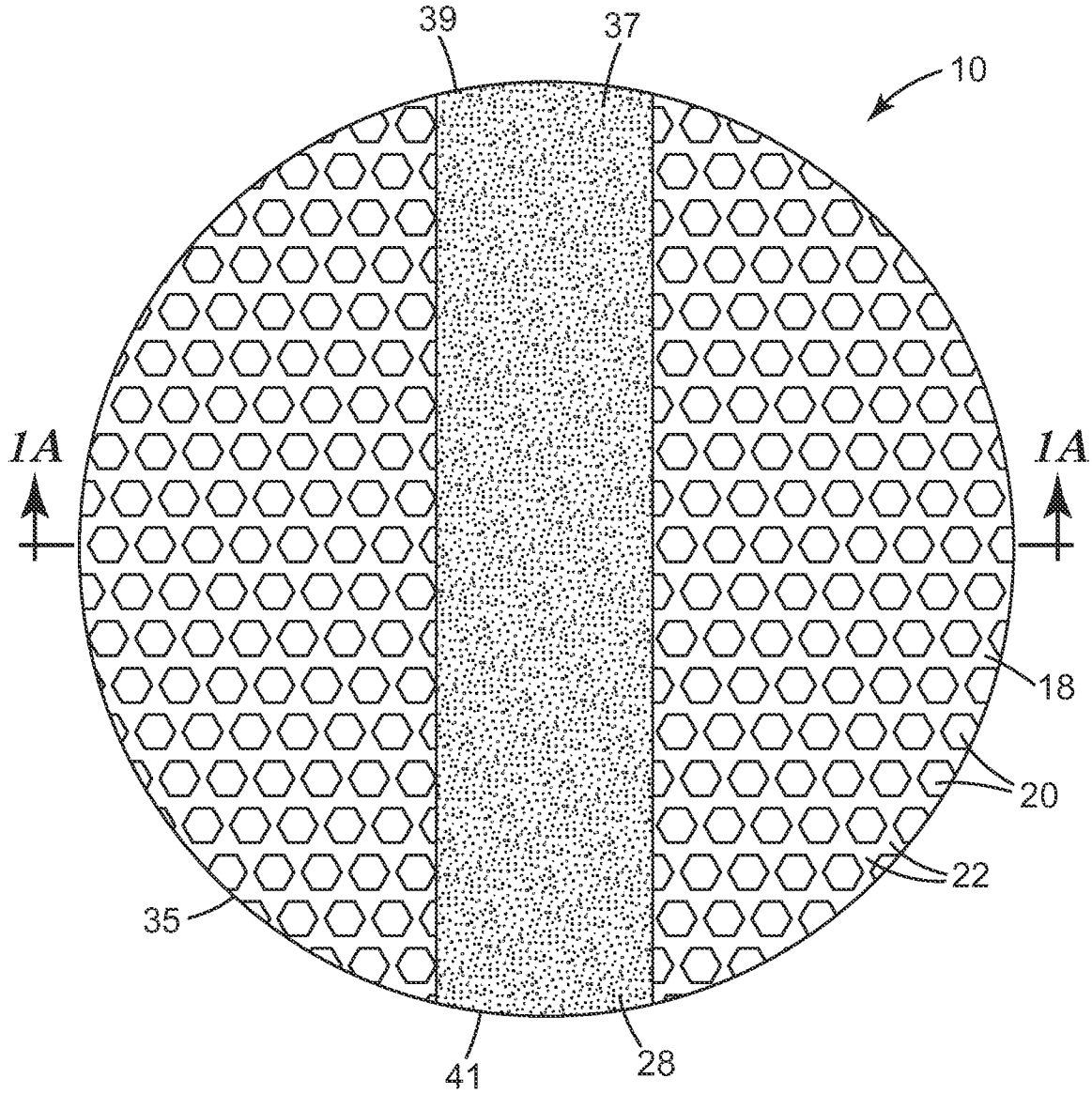

Fig. 1

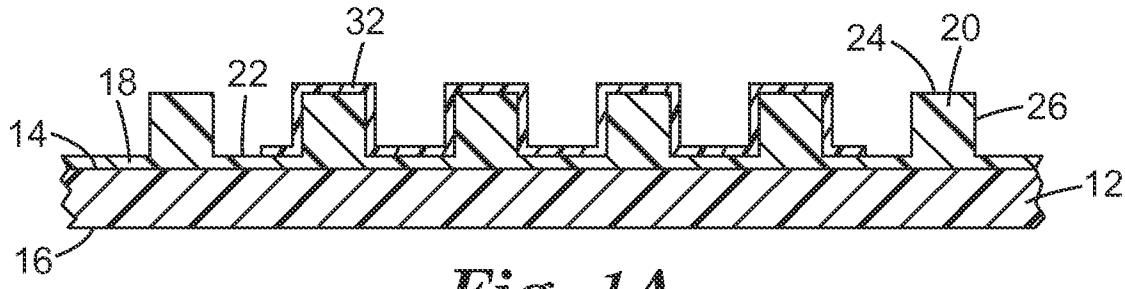

Fig. 1A

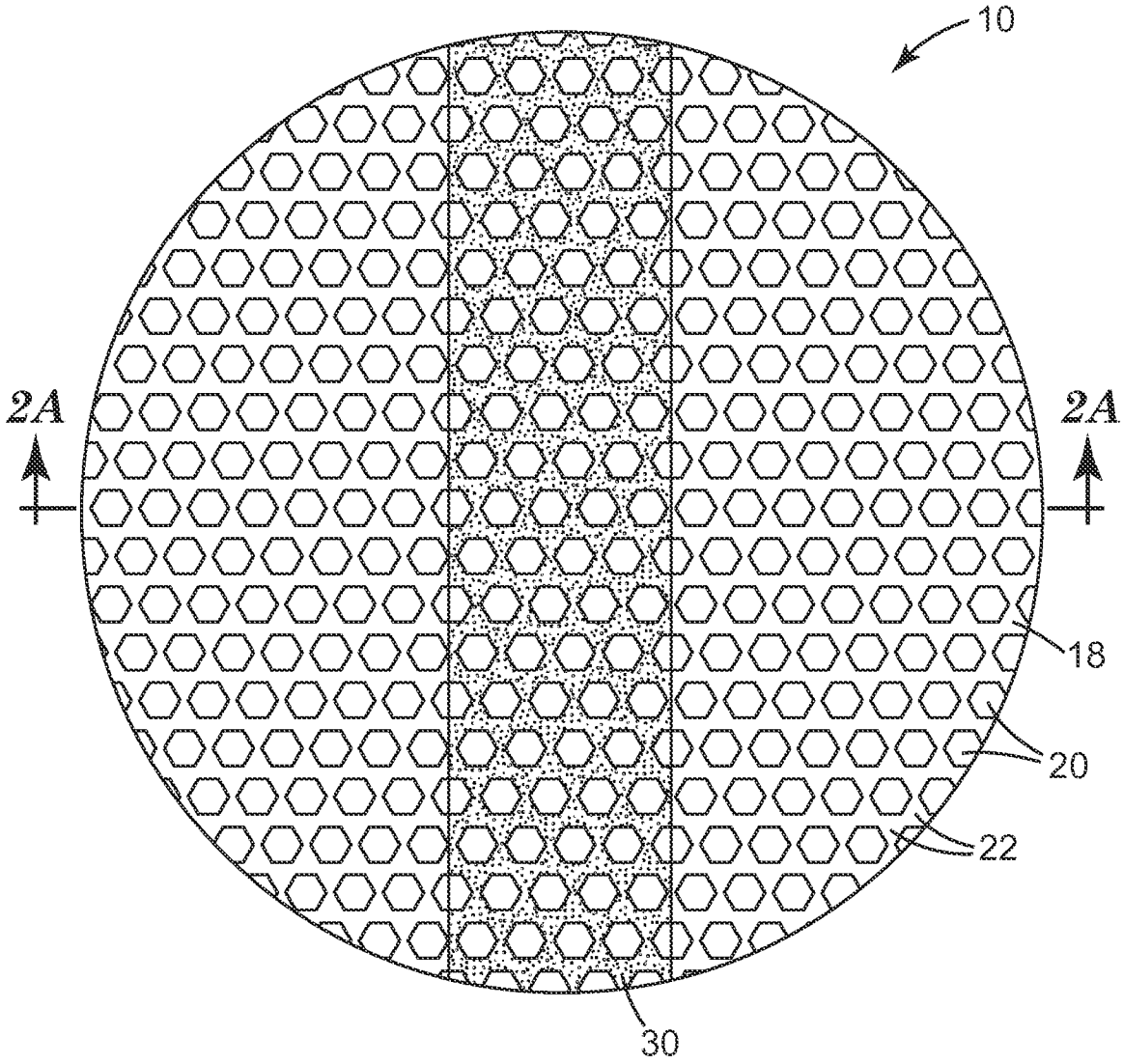

Fig. 2

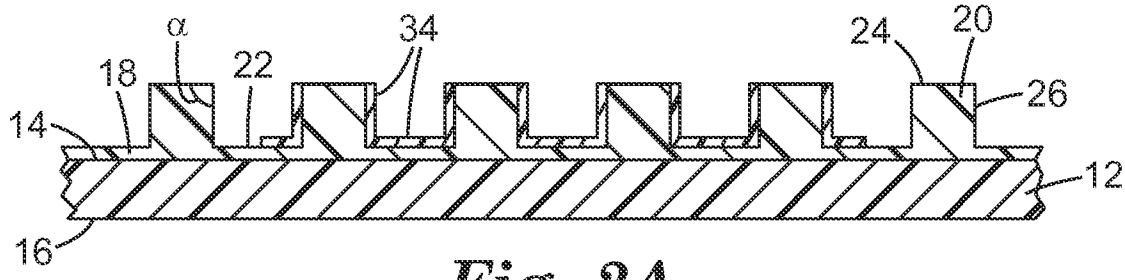

Fig. 2A

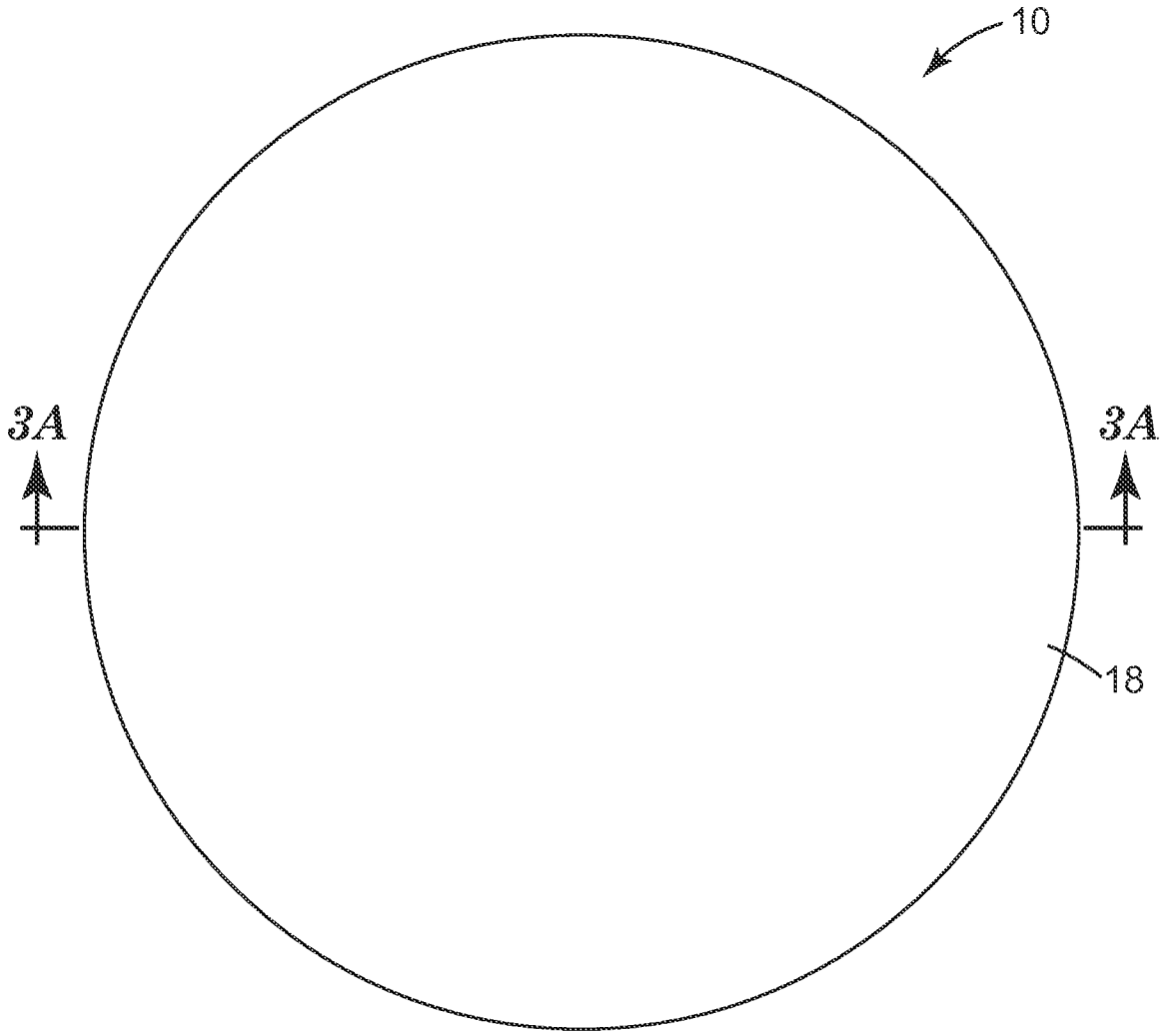

Fig. 3

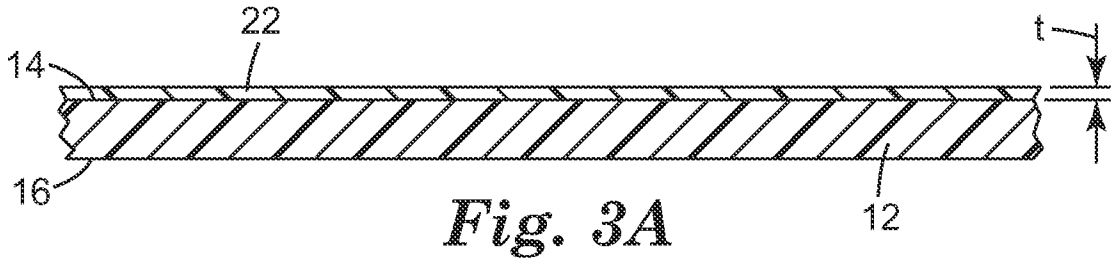

Fig. 3A

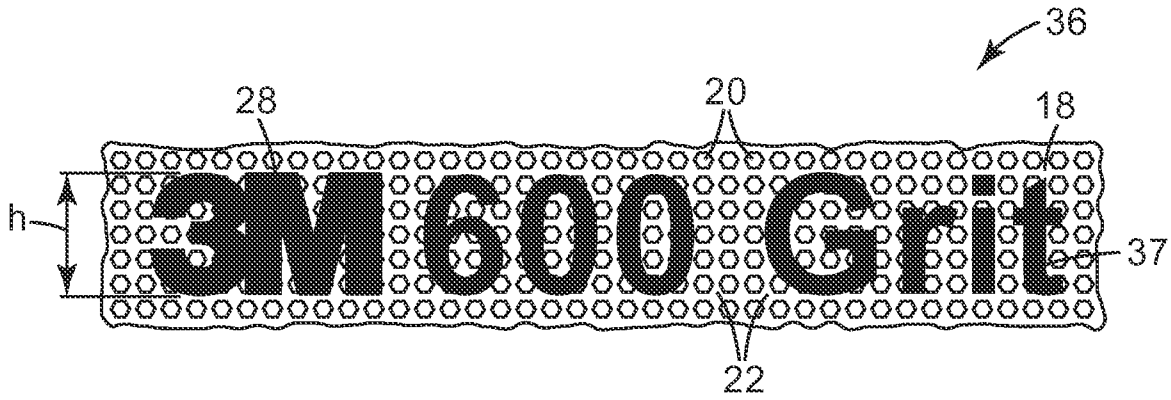

Fig. 4A

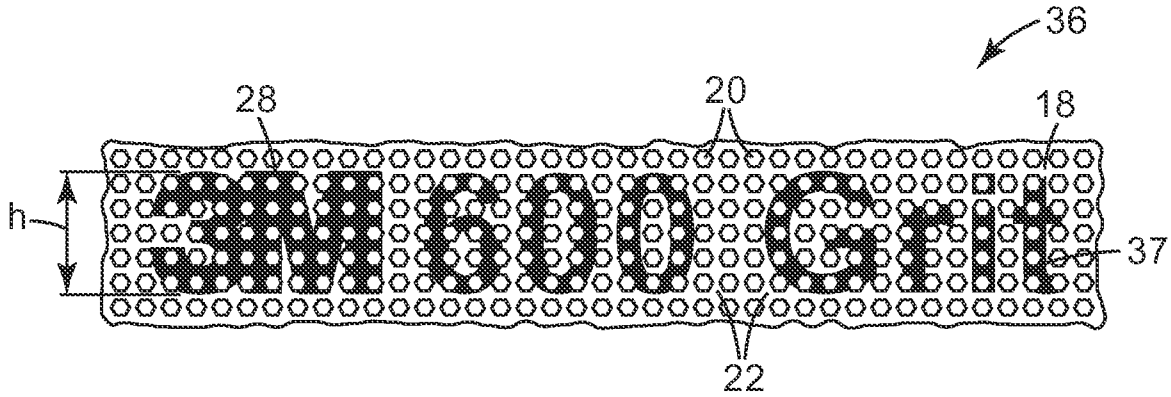

Fig. 4B