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(54) **Abrasive article with improved grain retention and performance**

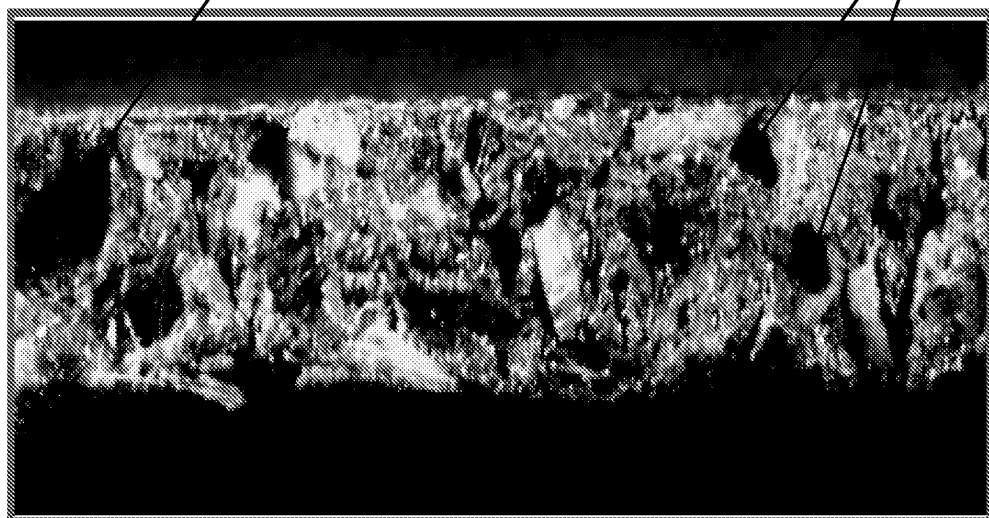
(57) An abrasive article with improved grain retention and performance and method of making are disclosed.

The abrasive article with improved grain retention results in an article with improved performance and longer article life.

**300**

**310**

**310**



**FIG. 3**

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## Description

### BACKGROUND

**[0001]** The present invention relates generally to abrasive articles and more particularly to an abrasive article with improved grain retention and performance.

**[0002]** Abrasive articles are typically used in various industries to machine workpieces by cutting, lapping, grinding, or polishing. The use of abrasive articles for machining spans a wide industrial scope from optics industries, automotive plant repair industries to metal fabrication industries. In each of these examples, manufacturing facilities use abrasives to remove bulk material to reach designed dimension, geometry, and surface characteristics of products (e.g., planarity, surface roughness).

**[0003]** Manufacturers of rough grinding abrasive articles are constantly challenged to make abrasive articles that meet higher productivity as well as high performance requirements specified by their customers. One particular reason why manufacturers are challenged to make rough grinding abrasive articles that meet higher productivity and performance requirements is that the abrasive articles are subject to not only mechanical failure due to abrasive grain fracture or attrition or bond fracture, but also to thermal failure at the interface of the abrasive grain and their surrounding organic bond (i.e.; grain pull-out). In particular, the high power associated with rough grinding abrasive articles to remove material without any coolant to remove the heat makes these articles more prone to the latter type of failure (i.e., thermal degradation at the interface of the abrasive grain and bond). This thermal degradation is even more apparent when using an abrasive grain that exhibits good resistance to mechanical fractures. Eventually, the thermal degradation weakens the rough grinding abrasive articles, impairing performance and ultimately leading to a shortened life. Thermal degradation can be especially problematic relative to ultra-thin, dry cut-off wheels, which tend to reach thermal degrading temperatures very quickly at the grain/bond interface.

### SUMMARY

**[0004]** In one embodiment, there is an ultra-thin, small diameter cutoff wheel, comprising: a plurality of abrasive grains, an organic bond material and an active filler material. The active filler material comprises an effective amount of an active endothermic filler material that provides an endothermic reaction at normal dry cutting conditions.

**[0005]** In a second embodiment, there is an ultra-thin, small diameter cutoff wheel that comprises a plurality of abrasive grains and an organic bond material comprising an active filler material providing an endothermic reaction added thereto. The amount of active endothermic filler material is in a range of about 12 to about 50 percent by

volume of the bond.

**[0006]** In a third embodiment, there is an ultra-thin, small diameter cutoff wheel that comprises a plurality of abrasive grains and an organic bond material with an active endothermic filler material added thereto to provide an endothermic reaction that improves grain retention. The plurality of abrasive grains are selected from the group consisting of seeded or unseeded sol gel alumina grains,  $Al_2O_3$ - $ZrO_2$  grains and combinations thereof. The active endothermic filler material is selected from the group consisting of sulfides, low melting point oxides and combinations thereof.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0007]** FIG. 1 is an image of an abrasive article according to one embodiment of the present invention;

**[0008]** FIG. 2 is a micrograph image of a conventional abrasive article showing a large-number of grain pull-out according to the prior art; and

**[0009]** FIG. 3 is a micrograph image of an abrasive article formed according to one embodiment of the present invention.

### DETAILED DESCRIPTION OF THE EMBODIMENTS

**[0010]** Referring to the drawings, FIG. 1 is an image of an abrasive article 100 according to one embodiment of the present invention. In particular, FIG. 1 shows that abrasive article 100 is an abrasive wheel product. As is known in the art, abrasive wheel products come in a variety of sizes such as for example, large diameter cutoff abrasive wheel products, medium diameter cutoff abrasive wheel products and small diameter cutoff abrasive wheel products. Generally, large diameter cutoff abrasive wheel products have a diameter that is greater than about 1000 mm, medium diameter cutoff abrasive wheel products have a diameter that is greater than about 400 mm and less than about 1000 mm, while small diameter cutoff abrasive wheel products have a diameter that is less than about 400 mm. Although the description of the abrasive mix used to form abrasive article 100 that follows is preferably suitable for small diameter cutoff abrasive wheel products and more particularly to ultra-thin, small diameter cutoff abrasive wheel products that have diameters less than about 250 mm, those skilled in the art will recognize that the abrasive mix used to form abrasive article 100 may have applicability for large diameter cutoff abrasive wheel products and medium diameter cutoff abrasive wheel products.

**[0011]** In one embodiment, abrasive article 100 is an ultra-thin, small diameter bonded abrasive article formed from an abrasive mix that comprises abrasive grains and an organic bond material with active filler materials added thereto such as active endothermic filler material(s) that provides an endothermic reaction at "normal dry cutting conditions" to reduce the temperature at the interface of grains and their surrounding organic bond. Generally,

active fillers can be used in bonded abrasives to enhance grinding performance. Active fillers also known as reactive fillers are designed to be either physically and/or chemically active. They generally provide extended, increased cutting rates and coolness of cut. Depending on various parameters, such as the size and geometry of the abrasive tool, the type of grain and bond used and the operating conditions encountered, active fillers can do one or more of the following actions:

- 1.) Decrease the friction between the abrasive grains and the workpiece being abraded;
- 2.) Prevent the abrasive grains from "capping", i.e., prevent metal particles from becoming welded to the tops of the abrasive grains.
- 3.) Decrease the interface temperature between the abrasive grains and the workpiece.
- 4.) Decrease the required grinding force.

These actions can fall into the following different mechanisms:

- 1.) Lubrication to reduce friction between the abrasive grain and the workpiece.
- 2.) Chemical corrosion of metal surface to prevent bonding of metal onto the tops of abrasive grains or swarf particles from welding to the workpiece, or by modifying the integrity of the metal surface to facilitate the formation of chips.
- 3.) Prevention of bond ablation by inhibiting the free radical process of oxidation of the bond material used to firmly hold the abrasive grain in place.
- 4.) Controlled bond erosion allows new grains to come into play and discharge old worn abrasive particles.
- 5.) Heat dissipation by highly endothermic reaction which help to dissipate heat away from the grinding interface between the abrasive grains and the workpiece.

**[0012]** As shown below, using at least one type of active endothermic filler material that provides an endothermic reaction to reduce the temperature at the interface of the abrasive grains and their surrounding organic bond at "normal dry cutting conditions" results in improved grain retention or utilization. A result of improved grain retention is that abrasive article 100 will have improved cutting performance and longer life than other ultra-thin cutoff abrasive wheel products formed from conventional abrasive mixes.

**[0013]** In this embodiment, the abrasive article 100 contains at least one type of primary abrasive grain selected from the group of abrasive families consisting of seeded or unseeded sol gel alumina and  $\text{Al}_2\text{O}_3\text{-ZrO}_2$ . A non-exhaustive list of abrasive grains from the seeded or unseeded sol gel alumina family that may be used in embodiments of this invention include SG grain and NQ grain, commercially available from Saint-Gobain Abra-

sives, Inc. of Worcester, MA, 3M321 Cubitron grain and 3M324 Cubitron grain commercially available from 3M Corporation of St. Paul, MN and combinations thereof. A non-exhaustive list of abrasive grains from the  $\text{Al}_2\text{O}_3\text{-ZrO}_2$  family that may be used in embodiments of this invention include NZ Plus grain, commercially available from Saint-Gobain Abrasives, Inc. of Worcester, MA, ZF grain and ZS grain, commercially available from Saint-Gobain Abrasives, Inc. of Worcester, MA, ZK40 grain, commercially available from Treibacher Industry, Inc. of Toronto, Ontario CA, ZR25B grain and ZR25R grain, commercially available from A1can, Inc. of Montreal, Quebec CA. In one embodiment, the amount of the primary abrasive grain comprises between about 20 to about 100 percent of the total amount of abrasive grain by volume.

**[0014]** In one embodiment, at least one type of secondary abrasive grain can be blended with the primary abrasive grain to achieve either cost or performance requirements. The secondary abrasive grain may be selected from the group consisting of ceramic oxides (e.g., coated or non-coated fused  $\text{Al}_2\text{O}_3$ , monocrystal  $\text{Al}_2\text{O}_3$ ), nitrides (e.g.,  $\text{Si}_3\text{N}_4$ ,  $\text{AlN}$ ) and carbides (e.g.,  $\text{SiC}$ ). In one embodiment, the amount of the secondary abrasive grain may range from about 80 to about 0 percent of the total amount of abrasive grain by volume or balance.

**[0015]** In one embodiment, the organic bond material comprises essentially of art-recognized organic bond material, such as one or more organic resins - e.g. epoxy, polyester, phenolic, and cyanate ester resins, or other suitable thermosetting or thermoplastic resins. Specific, non-limiting examples of resins that can be used include the following: the resins sold by Dynea Oy, Finland, under the trade name Prefere and available under the catalog/product numbers 8522G, 8528G, 8680G, and 8723G; the resins sold by Hexion Specialty Chemicals, OH, under the trade name Rutaphen.RTM. and available under the catalog/product numbers 9507P, 8686SP, and SP223; and the resins sold by Durez Corporation, TX, under the following catalog/product numbers: 29344, 29346, and 29722. In a preferred embodiment, the bond material comprises a dry resin material.

**[0016]** In various embodiments, types and amounts of active endothermic fillers are chosen in order to provide an endothermic reaction at "normal dry cutting conditions." The term "normal dry cutting conditions" refers generally to those conditions encountered at the grain/bond interface of a small diameter, ultra-thin cutoff wheel during dry cutting of common materials for which the wheel is designed to cut/grind. An "effective amount" of active endothermic filler provides an endothermic reaction at normal dry cutting conditions. These conditions typically include very quick ramping to thermal degrading temperatures in excess of  $450^\circ\text{C}$ . Thermal degradation can be especially problematic relative to ultra-thin, dry cutoff wheels, which tend to transfer heat very quickly and to reach thermal degrading temperatures very quickly at the grain/bond interface. In the ultra-thin wheels of

the present application, the active endothermic fillers produce an endothermic reaction at the conditions typically encountered during dry cutting and, therefore, reduce the temperature at the grain/bond interface, resulting in much improved grain retention and longer life. In various alternative embodiments, the active endothermic fillers provide an endothermic reaction when temperature at the grain/bond interface is at least about 450°C, or at least about 500°C, or at least about 527°C, or at a temperature which provides an amount of thermal energy greater than the activation energy necessary to decompose the active endothermic filler. It is noted that when the heating rate is slow or if the grain/bond interface temperature is too low, exothermic reactions may occur; therefore, the thickness of the abrasive article can play a significant roll in obtaining the desired endothermic reaction.

**[0017]** In one embodiment, at least one type of active endothermic filler material that provides an endothermic reaction is selected from the group of filler types consisting of sulfides and low melting point oxides. A non-exhaustive list of active endothermic fillers from the sulfide types that may be used in embodiments of the present invention include pyrite, zinc sulfide, copper sulfide, and combinations thereof. A non-exhaustive list of active endothermic fillers from the low melting point oxides types that may be used in embodiments of the present invention include bismuth oxide, lead oxide, tin oxide and combinations thereof. Note that in one embodiment, it is preferable that the active fillers of the low melting point oxides have a melting point below about 1000 degrees Celsius.

**[0018]** Those skilled in the art will recognize that various other fillers may be added to the organic bond material in order to enhance the ability of abrasive article 100 to cut, lap or grind, or polish. The fillers may include active and/or inactive fillers. A non-exhaustive list of active fillers may include Cryolite, PAF,  $\text{KBF}_4$ ,  $\text{K}_2\text{SO}_4$ ,  $\text{NaCl/KCl}$ , and combinations thereof. A non-exhaustive list of inactive fillers may include  $\text{CaO}$ ,  $\text{CaCO}_3$ ,  $\text{Ca(OH)}_2$ ,  $\text{CaSiO}_3$ , Kyanite (a mixture of  $\text{Al}_2\text{O}_3\text{-SiO}_2$ ), Saran (Polyvinylidene chloride), Nephenline (Na, K)  $\text{AlSiO}_4$ , wood powder, coconut shell flour, stone dust, feldspar, kaolin, quartz, short glass fibers, asbestos fibers, balotini, surface-treated fine grain (silicon carbide, corundum etc.), pumice stone, cork powder and combinations thereof. In a preferred embodiment, an active filler material such as PAF, which is a mixture of  $\text{K}_3\text{AlF}_6$  and  $\text{KAlF}_4$ , can be added to the organic bond material in order to corrode metals and reduce the friction between the wheel and workpiece.

**[0019]** In certain embodiments, the formulation of the abrasive mix used to form abrasive article 100 may be as follows. In one embodiment, the abrasive grains present in this mix may range from about 35 to about 55 percent by volume of the total mix (i.e., excluding porosity). In another embodiment, the abrasive grains present in this mix may range from about 40 to about 54 percent by volume of the total mix (i.e., excluding porosity). In

one embodiment, the organic bond material (e.g., resin) in this mix may range from about 25 to about 45 percent by volume of the total mix. In another embodiment, the organic bond material (e.g., resin) in this mix may range from about 30 to about 40 percent by volume of the total mix. In one embodiment, the active endothermic filler material in this mix may be in an amount that ranges from about 5 to about 30 percent by volume (amount in the total mix). In another embodiment, the active endothermic filler material in this mix may be in an amount that ranges from about 5 to about 24 percent by volume (amount in the total mix). In other embodiments, the active endothermic filler material in this mix may be in an amount that ranges from about 12 to about 50 percent by volume (amount in the total bond). While in other embodiments, the active endothermic filler material in this mix may be in an amount that ranges from about 12 to about 35 percent by volume (amount in the total bond). The balance will be other fillers that include active or inactive fillers. In one embodiment, the volume ratio of the active filler material providing endothermic reaction to the organic bond material is in the range of about 0.136 to about 1 (e.g., resin). In another embodiment, the volume ratio of the active filler material providing endothermic reaction to the organic bond material is in the range of about 0.136 to about 0.67 (e.g., resin).

**[0020]** As mentioned above, in one embodiment, abrasive article 100 is an ultra-thin, small diameter cutoff abrasive wheel product. In certain embodiments, abrasive article 100 has a diameter that ranges from about 75 mm to about 250 mm and, a thickness of less than about 2.5 mm. In other embodiments, the thickness of the wheel is between about 0.8 mm and about 2.2 mm. In various embodiments, the wheel can have an aspect ratio that ranges from about 40 to about 160. These dimensions make ultra-thin, small diameter abrasive article 100 well suited for dry cutting applications. The dimensions and composition of the wheel can be chosen in accordance with the present teachings to provide significant performance improvement.

**[0021]** As shown below herein, the abrasive article formed from the above-described formulation does not suffer from large amounts of grain pull-out like conventional abrasive articles. Abrasive articles formed from conventional formulations are adversely affected by large amounts of grain pull-out because the bond between the abrasive grains and bond material in these mixes is unable to withstand the thermal degradation that arises from the heat input associated with the cutting action of the abrasive article. It has been determined herein that the temperature at the interfaces of the grains and their surrounding organic bond at the surface level of the abrasive article is at the highest and can range from about 600 degrees Celsius to about 1000 degrees Celsius when utilizing certain embodiments. The organic bond material can act as an insulation layer due to its low thermal conductivity (i.e., less than  $2 \text{ W/(m-K)}$ ) and thus the heat input from the cutting action does not substantially

penetrate the depth of the abrasive article where other layers of abrasives reside. Therefore, the temperature at the interfaces of the grains and their surrounding organic bond at these lower levels, which can be from 250 degrees Celsius to 350 degrees Celsius, is substantially less than the temperatures at the interfaces of the top surface. Because the temperature at the interfaces of the grains and their surrounding organic bond at the surface level is very high, the bond becomes weaker (a typical thermal decomposition temperature of an organic bond material such as a resin is 500 degrees Celsius) and eventually the grains at this level pull-out and fall from the surface instead of being steadily worn out through the typical attrition process. The abrasive article formed from the above-described formulation suffers from less amounts of grain pull out because it is less adversely affected by thermal degradation at the interfaces of the grains and their surrounding bond material due to the endothermic reaction occurring to reduce the interfacial temperature.

**[0022]** Compared to the prior art, the abrasive article according to embodiments of the present invention are not adversely affected by thermal degradation at the interface of the grains and their surrounding organic bond material because the dimensioning of the wheel and the formulation of the specific types of abrasive grains and active endothermic fillers that provide endothermic reaction to reduce its interfacial temperature. In particular, it has been found herein that the use of the active fillers in the formulations noted above act to provide thermal decomposition of the active fillers that result in a cooling effect that lowers the temperature at the interface of the abrasive grains and the bond, thus counteracting the propensity for rampant thermal degradation to occur. In addition to the use of these active fillers that provide an endothermic reaction in the above-noted formulations, it has been found that the selection and formulation of the above-identified abrasive grains result in an abrasive product with significantly less grain pull-out than the conventional abrasive articles. FIG. 2 is a micrograph image 200 of a conventional abrasive article showing a large-number of grain pull-out holes 210. Note that for ease of illustration only a few grain pull-out holes 210 are highlighted. A closer look at image 200 shows that this abrasive article formed according to the prior art has a very large number of grain pull-out holes 210. An abrasive article with this many grain pull-out holes will not perform well and consequently have a shorter life-span. In comparison to the conventional abrasive article shown in FIG. 2, FIG. 3 shows a micrograph image 300 of an abrasive article formed according to embodiments of the present invention having significantly less grain pull-out holes. Although not all the grain pull-out holes are highlighted in FIG. 3, it is clear that there are significantly less grain pull-out holes in this figure than in FIG. 2.

**[0023]** Because the abrasive article in FIG. 3 has significantly less grain pull-out holes, this article as shown herein performs cutting operations better and lasts longer

than conventional abrasive articles. One measurement of performance of an abrasive article is the Absolute G-Ratio. The G-Ratio as measured herein is attained by mounting the abrasive article on a portable machine for a dry cutting application that may have a maximum operation speed of about 80 m/s. A workpiece material with typical dimensions (e.g., 600 mm (length) x 100 (width) x 6 (thickness) mm) may be clamped by a vise. The number of pieces of cuts from the workpiece material is then counted and the number of cuts is recorded into a computer system along with the diameter of the abrasive article. An experienced operator then manually conducts testing by using the grinder to perform cutting operations on the workpiece material. A data acquisition system connected with the grinder monitors the power and current of the grinder, and cutting time during the testing. The testing lasts until the abrasive article is fully consumed. Then the diameter of the tested article is measured and recorded. The weight of the remaining workpiece material is weighed and recorded as well. The computer system using a commercially available software application determines material removal rate (MRR) and wheel wear rate (WWR). The application calculates the Absolute G-Ratio by dividing MRR by WWR. The higher the number for the Absolute G-Ratio is an indication that the performance of the abrasive article is better.

**[0024]** The relative G-Ratio, which is the ratio of the Absolute G-Ratio of abrasive article B divided by Absolute G-Ratio of abrasive article A (reference), is used herein to compare the performance of the abrasive articles. Hence, the Relative G-Ratio of abrasive article A is 1. The higher the number of the Relative G-Ratio is an indication that better performance improvement has been obtained. Using this approach, it has been determined that the abrasive article formed herein using the above-noted formulations has Relative G-Ratios that are greater than 1.00. Examples below show that it is possible to obtain Relative G-Ratio values that range from about 1.4 to about 2.4.

#### Examples

**[0025]** The following provides particular examples of abrasive articles formed according to embodiments described herein.

#### Example 1:

**[0026]** In this example, an abrasive article is formed with the above noted formulation. About 44 lbs of  $\text{Al}_2\text{O}_3\text{-ZrO}_2$  abrasive grains blended with about 25 lbs of monocrystal  $\text{Al}_2\text{O}_3$  abrasive grains was added into a mixing container. At least one processing liquid may be introduced to the grains. A non-exhaustive list of processing liquids that may be used in this embodiment includes liquid resins, water, oil, resin modifiers, and various solvents such as Furfural and Tridecyl Alcohol. Herein, about 5 lbs of liquid resin was added into the abrasive

grains. About 11 lbs of powder resin, about 6 lbs of PAF and about 9 lbs of pyrite were prepared in a separate mixing container. The mixture of the abrasive grains with the liquid resin was poured into that separate container to mix with the powder resin, PAF, and pyrite mixture. Then the abrasive article was formed in the same method as a conventional abrasive article, such as, for example, the forming methods described in U.S. Patent Number 6,866,691 B1 - which is incorporated by reference in its entirety. The dimension of the abrasive article was 125 mm in diameter with 1 mm thickness. The performance of the abrasive article with the above formulation was tested and its Relative G-Ratio (compared with a conventional abrasive article at the same dimension) was 2.2. The performance improvement was due to the fact that the thermal decomposition of the pyrite reduced the temperature at the interface of the abrasive grains and their surrounding organic bond resulting in improved grain retention and longer life. Although this disclosure is not to be limited by proffered theories, it is contemplated that when the temperature is higher than 527 degree Celsius, decomposition of pyrite will be the dominant process due to the high activation energy.

#### Example 2:

**[0027]** In this example, an abrasive article was formed with the above noted formulation. About 68 lbs of seeded or unseeded sol gel alumina  $\text{Al}_2\text{O}_3$  abrasive grain was added into a mixing container. At least one processing liquid was introduced to the grains. A non-exhaustive list of processing liquids that may be used includes liquid resins, water, oil, resin modifiers, and various solvents such as Furfural and Tridecyl Alcohol. Herein, about 5 lbs of liquid resin was added into the abrasive grains. About 11 lbs of powder resin, about 6 lbs of PAF and about 10 lbs of pyrite were prepared in a separate mixing container. The mixture of the abrasive grains with the liquid resin was poured into the separate container to mix with the powder resin, PAF, and pyrite mixture. Then the abrasive article was formed and tested in the same methods as a conventional abrasive article which has been mentioned above. The dimension of the abrasive article in this example was 125 mm in diameter with 1 mm thickness. Its Relative G-Ratio was 1.6. The resulted performance improvement is due to the fact that the thermal decomposition of the pyrite reduces the temperature at the interface of the abrasive grains and their surrounding organic bond resulting in improved grain retention and longer.

**[0028]** The following provides a comparative example of an abrasive article not formed according to embodiments described herein.

#### Comparative Example 1:

**[0029]** In this example, an abrasive article was formed with the above noted abrasive grains, but with different

active fillers. In particular, about 44 lbs of  $\text{Al}_2\text{O}_3\text{-ZrO}_2$  abrasive grain blended with about 25 lbs of monocrystal  $\text{Al}_2\text{O}_3$  abrasive grain was added into a mixing container. Herein, about 5 lbs of liquid resin was added into the abrasive grains. The only difference between the formulation in this example and the formulation above in Example 1 was that only one type of active filler, PAF, is in the bond formulation. That is, pyrite was not in this formulation. In particular, about 11 lbs of powder resin, about 13 lbs of PAF were prepared in a separate mixing container. The mixture of the abrasive grains with the liquid resin was poured into that separate container to mix with powder resin and PAF mixture. Then the abrasive article is formed and tested in the same method as described in Example 1. The dimension of the abrasive article in this example was 125 mm in diameter with 1 mm thickness. The resulting Relative G-Ratio (compared with a conventional abrasive article at the same dimension) was 1.1. The life of the abrasive article or grain retention did not improve in the same scale as in Example 1 because the endothermic reaction did not occur during the cutting operation.

**[0030]** While the disclosure has been particularly shown and described in conjunction with preferred embodiments thereof, it will be appreciated that variations and modifications will occur to those skilled in the art. Therefore, it is to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the disclosure.

#### Claims

1. An ultra-thin, small diameter cutoff wheel, comprising: a plurality of abrasive grains, an organic bond material and an active filler material, wherein the active filler material comprises an effective amount of an active endothermic filler material that provides an endothermic reaction at normal dry cutting conditions.
2. The cutoff wheel according to claim 1, wherein the plurality of abrasive grains are selected from the group consisting of seeded or unseeded sol gel alumina grains and  $\text{Al}_2\text{O}_3\text{-ZrO}_2$  grains and combinations thereof.
3. The cutoff wheel according to any one of the preceding claims, wherein the plurality of abrasive grains is present in a range of about 35 to about 55 percent by volume/total mix.
4. The cutoff wheel according to any one of the preceding claims, wherein the plurality of abrasive grains comprise a primary abrasive grain and a secondary abrasive grain, the primary abrasive grain being selected from the group consisting of seeded or unseeded sol gel alumina grains,  $\text{Al}_2\text{O}_3\text{-ZrO}_2$  grains

and combinations thereof and the primary grain comprises between about 20 to about 100 percent of the total amount of abrasive grain by volume.

5. The cutoff wheel according to any one of the preceding claims, wherein the organic bond material comprises a dry resin material. 5
6. The cutoff wheel according to any one of the preceding claims, wherein the organic bond material is present in a range of about 25 to about 45 percent by volume/total mix. 10
7. The cutoff wheel according to any one of the preceding claims, wherein the active endothermic filler material is selected from the group of filler types consisting of sulfides and low melting point oxides. 15
8. The cutoff wheel according to claim 8, wherein the active endothermic filler material is selected from the group consisting of pyrite, zinc sulfide, copper sulfide, lead oxide, tin oxide, bismuth oxide and combinations thereof. 20
9. The cutoff wheel according to any one of the preceding claims, wherein the active filler material comprises at least one of Cryolite, PAF,  $\text{KBF}_4$ ,  $\text{K}_2\text{SO}_4$ ,  $\text{NaCl/KCl}$  and combinations thereof. 25
10. The cutoff wheel according to any one of the preceding claims, wherein the active endothermic filler material is present in a range of about 25 to about 100 percent by volume of the total amount of active filler material. 30
11. The cutoff wheel according to any one of the preceding claims, wherein the active endothermic filler material is present in a range of about 12 to about 50 percent by volume in the bond material. 35
12. The cutoff wheel according to any one of claims 1-10, wherein the volume ratio of active endothermic filler material to the organic bond material is in the range of about 0.136 to about 1. 40
13. The cutoff wheel according to any one of the preceding claims, wherein the cutoff wheel comprises a thickness less than about 2.5 mm. 45
14. The cutoff wheel according to any one of the preceding claims, wherein the cutoff wheel comprises an aspect ratio that ranges from about 40 to about 160. 50
15. The cutoff wheel according to any one of the preceding claims, wherein the active endothermic filler material comprises an oxide having a melting point below 1000 degrees Celsius. 55

16. The cutoff wheel according to any one of claims 1-14, wherein the active endothermic filler material comprises pyrite.

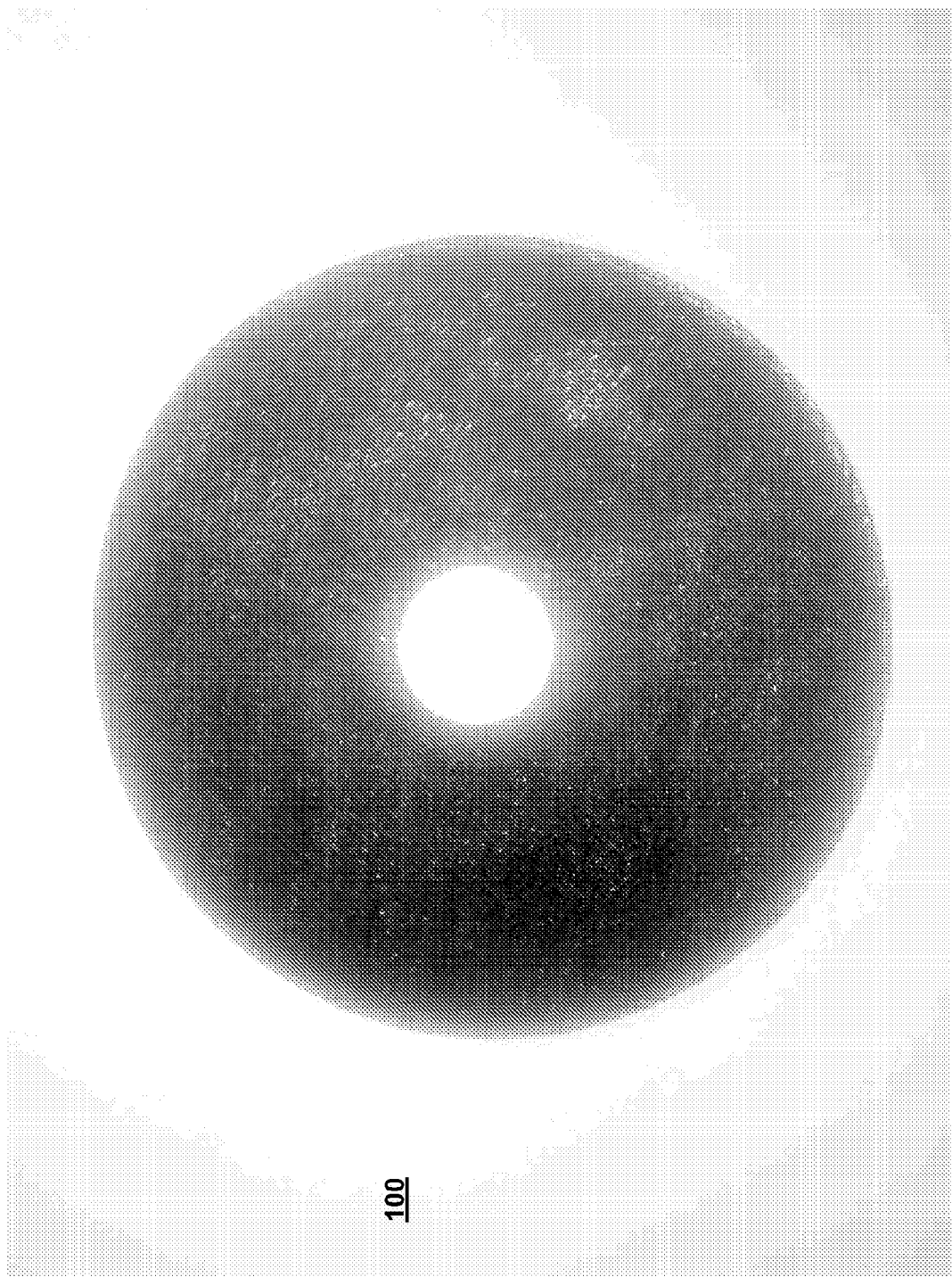


FIG. 1



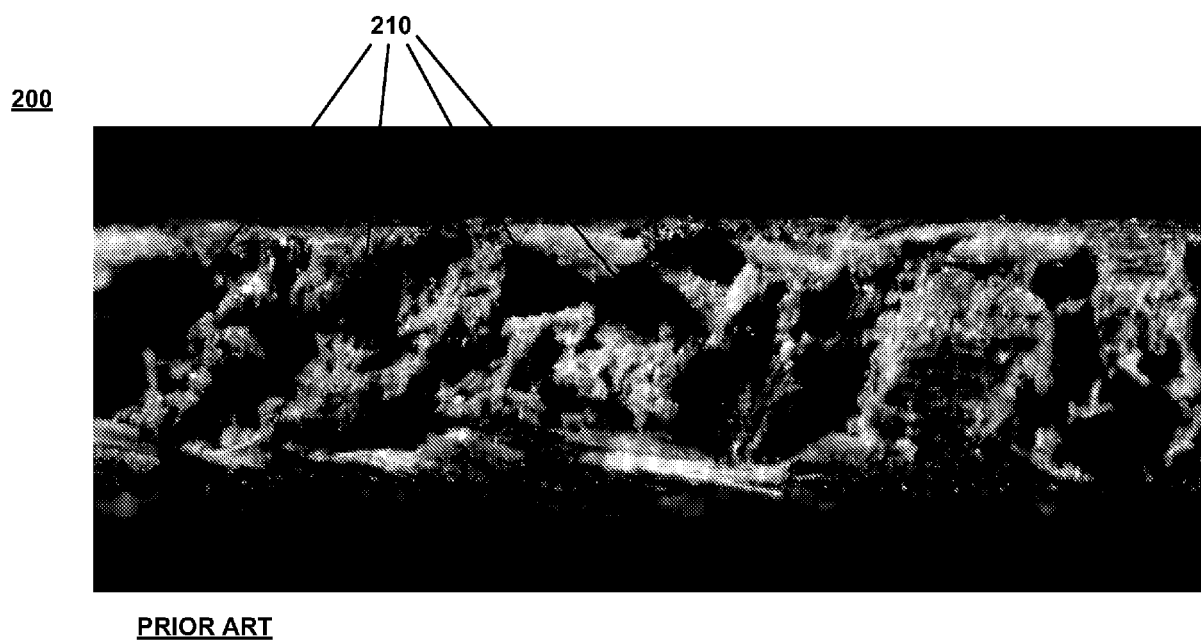


FIG. 2

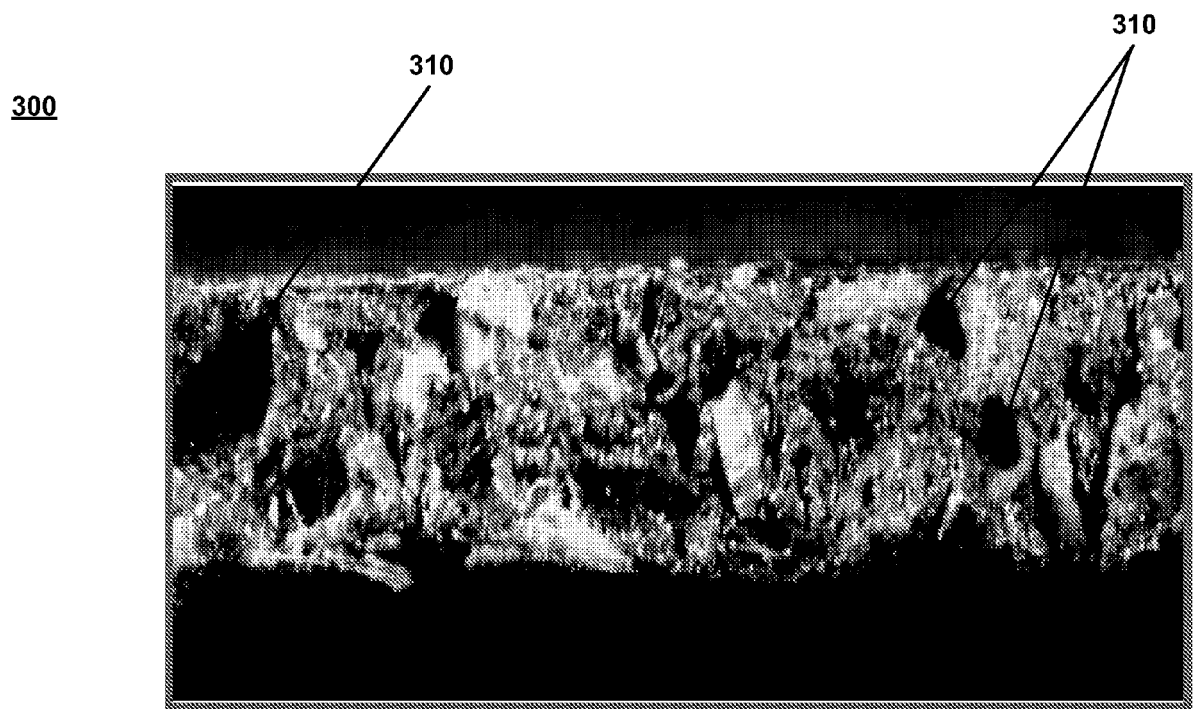


FIG. 3



## EUROPEAN SEARCH REPORT

Application Number  
EP 10 15 0370

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 078 896 A2 (NORTON CO [US]) 18 May 1983 (1983-05-18) * page 4, line 14 - page 7, line 30 * -----	1-12, 14-16	INV. B24D3/34 B24D5/12
X	US 5 061 295 A (HICKORY GORDON E [US] ET AL) 29 October 1991 (1991-10-29) * the whole document * -----	1-5, 7-12, 14-16	
X	DE 10 2004 035088 A1 (CHEMETALL GES MBH WIEN [AT]) 16 February 2006 (2006-02-16) * paragraphs [0007], [0044], [0061] * -----	1,5-12, 14,16	
X	US 5 313 742 A (CORCORAN JR ROBERT F [US] ET AL) 24 May 1994 (1994-05-24) * the whole document * -----	1-4,6-9, 13-16	
			TECHNICAL FIELDS SEARCHED (IPC)
			B24D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 26 February 2010	Examiner Zeckau, Jochen
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... &amp; : member of the same patent family, corresponding document</p>			

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