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(54) **A composite material**

Ein Verbundwerkstoff

Un matériau composite

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(73) Proprietor: **Diamond Innovations, Inc.**
Worthington, OH 43085 (US)

(72) Inventors:
- **CHEN, Zheng**
  c/o American Standard
  Piscataway, NJ 08855 (US)
- **GOETZ, Richard, John**
  Naperville, IL 60540 (US)

(74) Representative: **D'Arcy, Julia et al**
Murgitroyd & Company
Scotland House
165-169 Scotland Street
Glasgow G5 8PL (GB)

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- **PATENT ABSTRACTS OF JAPAN vol. 2000, no. 15, 6 April 2001 (2001-04-06) -& JP 2000 334663 A (MITSUBISHI MATERIALS CORP), 5 December 2000 (2000-12-05)**

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Description

FIELD OF INVENTION

[0001] The present invention relates to a composite material as defined in claim 1. An example of a composite material of the preamble of claim 1 is disclosed by JP 2000 334 663 A.

BACKGROUND

[0002] Abrasive materials and superhard materials, i.e., superabrasives such as natural and synthetic diamonds and cubic boron nitride, exhibit outstanding ability for machining both metallic and non-metallic materials. They are frequently used in saw blade and grinding tools as a cutting point to cut, grind, polish a variety of hard and abrasive materials. When abrasive or superabrasive particles reinforced metal or ceramic composites or polymer based composites are used to perform a task, such as cutting or grinding or polishing a highly abrasive workpiece, the particles in the composite take most of applied force due to their higher Young's modulus: The shear and tensile stress built along the interface between the particles and the matrix may be very significant. The superabrasive particles are often pulled out from the matrix due to weak interface bonding. Because most of abrasives/superabrasives have relatively smooth surfaces and are inert to most chemical substances, there is little mechanical or chemical bonding between the particles and the matrix.

[0003] Premature gross pull-out of only partially used abrasive particles ("grit") is a major factor in grinding wheel wear in resin, vitreous or metal bonds. Retention of diamond particles in the matrix, such as metals, ceramic, and polymer, is poor. As an example, diamond saw blades may lose up to 40% of the abrasive particles in the matrix during one cutting use.

[0004] An approach for enhancing the adhesion of abrasive and superabrasive particles to the resin, vitreous, or metal bond, may utilize bond compositions which are reactive with the abrasive particles so that during tool fabrication the bond composition adheres to the surface of the abrasive particles. For example, U.S. Patent-Nos. 5,190,796 and 5,232,469, teach methods to improve the retention of diamonds in abrasive tools by providing/coating the diamond particles with multiple layers of metals, such as molybdenum, titanium, niobium, chromium, zirconium, copper and nickel. As another example, U.S. Patent Application Serial No. 091901,159
discloses incorporating a silane coupling agent into a mixture of metal coated superabrasive particles and resin bond matrix to enhance the bond between the coating and the resin matrix.

[0005] In another approach to enhance or increase the retention of the grits in the matrix, the surface of the diamond particles is modified. For example, U.S. Patent No. 3,650,714 proposes adding ceramic whiskers during the coating of diamond with copper or nickel and also obtaining roughness by heating a mixture of sponge iron and braze coated diamond under a vacuum. As another example, U.S. Patent No. 4,435,189 discloses metal coated abrasives with a controlled, rough textured surface, for improved adherence to resinous materials. The controlled, rough textured surface is prepared by interrupting the electroless coating process to passivate diamond surface and then reactivate the passivated surface each time with a catalytic material to control the metal deposition rate for "rougher" grit.

[0006] There is a need to enhance the bond strength between coated abrasive/superabrasive particles and the matrix as well as the bond strength between the abrasive/superabrasive crystals and its metal coating. A novel and inventive approach to enhance the retention of coated abrasive particles in a matrix through the interface design has been found.

SUMMARY

[0007] The present invention relates to a composite material comprising a plurality of coated particles in a matrix as per claim 1 and a method as per claim 18. Preferred embodiments of the invention are set forth in the dependent claims.

[0008] The coated abrasives particle may have a wear-resistant coating comprising one or more materials selected from the group consisting of nickel, cobalt, iron, chromium, tungsten, molybdenum, carbides, phosphorus, titanium, zinc, palladium, borides, nitrides, oxides, intermetallics, and mixtures thereof. In an embodiment, the coated abrasive particles may have one or more additional coating layers comprised of metal, metal alloys, or other suitable coating materials. The coated abrasive particle has an outer surface topography characterized as having about 5 peaks per abrasive particle and a tortuosity T of about 1.1. One embodiment of the present invention is a composite material comprising a plurality of such coated abrasive particles in a matrix.

[0009] Also described is a method to improve particle retention in a composite matrix comprising coated abrasive particles for improved performance in areas of grinding cutting or polishing. The process comprises providing the abrasive particles with a coating comprising one or more materials selected from the group consisting of nickel, cobalt, iron, chromium, tungsten, molybdenum, carbides, phosphorus, titanium, zinc, palladium, borides, nitrides, oxides, and mixtures thereof. The coated abrasive particle may be coated with one or more coating layers. The coated abrasive particles have an outer surface topography characterized as having an average of at least 5 peaks per abrasive particle and a tortuousity T of at least 1.1. Such coated particles may be dispersed in a matrix material

[0010] Embodiments of the coated superabrasive particles may be used in machining application such as saw blades, polishing tools, grinding tools, and cutting tools, and they may also be used in coating applications. Embodiments of the coated abrasive and superabrasive particles of the present invention maybe used in applications, such as composite materials and articles in which increased bonding strength between the particles and matrix material would be beneficial.

[0011] Another embodiment of the present invention relates to a method of coating superabrasasive/abrasive particles with three metallic layers. In this embodiment, the particles are coated with at least three different coatings: an outer layer, a diffusion layer, and a. chemical forming layer. A first layer applied to the particles is a chemical forming layer wherein a chemical bond between, the particles and the chemical forming layer is formed. A second layer is a diffusion layer, an intermediary layer that forms bonds between the chemical layer and the outer layer. An outer layer is applied to the diffusion layer, which then bonds the coated particles to the matrix.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] For a fuller understanding of the nature and advantages of the present invention, reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

[0013] FIG. 1 is a schematic drawing illustrating the tortuous topography of the surface of the coated particles in one embodiment of the invention.

[0014] FIG. 2 is a schematic drawing showing the coating design of the coated particles in one embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0015] Before the present compositions and methods are described, it is to be understood that this invention is not limited to the particular processes, compositions, or methodologies described, as these may vary. It is also to be understood that the terminology used in the description is for the purpose of describing the particular versions or embodiments only, and is not intended to limit the scope of the present invention which will be limited only by the appended claims.

[0016] It must also be noted that as used herein and in the appended claims, the singular forms "a", "an", and "the' include plural reference unless the context clearly dictates otherwise. Thus, for example, reference to a "particle" is a reference to one or more particles and equivalents thereof known to those skilled in the art, and so forth. Unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art. Although any methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the present invention, the preferred methods, devices, and materials are now described. Nothing herein is to be construed as an admission that the invention is not entitled to antedate such disclosure by virtue of prior invention.

[0017] Although the invention is described with reference to cutting and grinding tools, the coated particles herein described may be used in connection with a variety of composite materials and articles.

[0018] An embodiment of the present invention relates to coated abrasive particles having a tortuous topography on the outer surface of a coating layer. Applicants have surprisingly found that providing a coated particle with a tortuous surface varies the orientation of the interface relative to the global shear stress direction along the interface of the coated abrasive particles and a matrix. As a result, the mechanical interlock force resulting from the increased frictional force strengthens the interfacial bonding and resist interface movement, for increased abrasive product life, improved abrasive product performance, and increased particle retention within the matrix material.

[0019] As used herein, "abrasive" or "abrasives" refers to a conventional abrasive, a superabrasive or combination thereof. Conventional abrasives include, but are not limited to: aluminum oxide, silicon carbide, zirconia-alumina, garnet, emery, and flint. Superabrasives include, but are not limited to: natural and synthetic diamond, cubic boron nitride (CBN), and boron suboxide. Various combinations or mixtures of abrasive materials are also contemplated, such as, for example, mixtures of aluminum oxide and zirconia alumina, or mixtures of diamond and CBN. Another example of suitable abrasives are solgel derived abrasives. Examples of these are sol-gel alumina abrasive grits, which can be seeded or unseeded. As such, any of these abrasive materials are suitable in the embodiments of the present invention.

[0020] The average particle size of the abrasive grains (sometimes referred to as "grit") for use in the present invention can be determined by a variety of factors, such as the particular abrasive utilized, as well as the end use applications. In general, an average particle size for suitable superabrasives and abrasives is in a range of about between 0.5 and about 5000 micrometers. In another embodiment, abrasive particles may be in a range of between about 2 and about 200 micrometers. Other particle sizes are possible.

[0021] The abrasive grains of the present invention maybe coated with one or more layers of a metal or metal alloy coating, wherein the coating comprises one or more of Al, Ag, Au, B, C, Co, Cu, Cr, Mg, Mn, P, Pd, Pt, Mo, Ni, Si, Sn, Ti, Zn, W, Sn, Y, Zn, Zr, alloys thereof, and mixtures thereof The grains may be coated with one or several layers of metals of the same or different types, i.e., the inner layer adjacent to the abrasive particle surface being of one type of coating and the outer having the tortuous surface topography being of another material type. In several embodiments, the tortuous coating layer may be a single layer coating, such as a nickel boride (NiB), tungsten, copper or tin coating, a double layer coating, such as a tungsten/chromium (W/Cr) or a tungsten/nickel boride (W/NiB) coating, or even a triple layer coating, such as a nickel boride/tungsten/chromium (NiB/W/Cr) coating.

[0022] In one embodiment, the tortuous topography coating comprising one or more layers has a thickness of about 2 μm to 100μm. In a second embodiment, the coated particles with tortuous topography have an average coating thickness of about 4 μm to 50 μm. Other thicknesses are possible.

[0023] Coated Particles Having Tortuous Surface Topography. For good particle retention in the composites of the invention, the outer layer of a coated abrasive particle may have a strong bond with the matrix material. The strong bond may be characterized by the highly tortuous surface topography on the outer surface of the coated abrasives, allowing for a mechanical interlock bonding. The strong particle retention may also be caused by diffusion bonding between the outer layer and the matrix.

[0024] The topography of the abrasive particles may vary in appearance/structure from non-uniform to substantially uniform and from discontinuous to continuous, with the appearance being in any or combinations of various shapes including chiral, spire-like, spike-like, helical, rod-like, plate-like, acicular, spherical, ellipsoidal, disc-shaped, irregular-shaped, plate-like, needle-like, twist, rotini, and honeycomb-like. The topography of the abrasive particles allows for increased surface contacts as well as a mechanical interlock to better retain the abrasives in the composite matrix.

[0025] A coated surface may be characterized as having an interface arranged at angles, including any coating surface that has protrusions, irregularities or imperfections arranged in any spike, peak, ridge, bump, mound, or any suitable shape. A surface may also have corrugated configurations. As used herein, the term "spike" refers to any of these protrusions or imperfections on the coating surface. The spikes or corrugated configurations also help with a reduced local stress state at the interface of the abrasive surface due to the tortuous surface interface.

[0026] In one embodiment of the invention, the average number of "spikes" per circumference (i.e., $2\pi R_A$) in the coated superabrasive particles is 5 or more. In a second embodiment of the invention, the average number of spikes or corrugated peaks is 7 or more. In yet a third embodiment of the invention, the average number of spikes or peaks is 10 or more.

[0027] These spikes may be defined by at least two dimensions: the length from the center of the particle to the outermost peak of the spike and the length from the center of the particle to the base of the spike. Each of these two lengths may be determined for all the spikes found on a coating surface. As used herein, the tortuosity (T) of a coated abrasive particle is defined as the ratio of the average length from the center of the particle to the outermost peak of the spikes (Rp) divided by the average length from the center of the particle to the base the spikes (R_A). As shown in FIG. 1, the coated abrasive particle **10** is coated with a coating **60** having a surface comprising one or more spikes **20**. The tortuosity T is defined as the average outermost peak length **50** (R_P) divided by the average base length **40** (R_A).

[0028] In one embodiment of the invention, coated abrasive particles have a T in the range of about 1.05 to about 1.70. In a preferred embodiment, the T value is in the range of about 1.10 to about 1.70. In a more preferred embodiment, the T value is greater than about 1.10. In yet a more preferred embodiment, the T value is greater than about 1.15.

[0029] Process for Making Coated Particles Having Tortuous Topography. The coated particles of the present invention can be made by conventional coating methods known in the art. Such methods include, for example, electroless plating, chemical reduction, sputtering chemical vapor deposition, physical vapor deposition, plasma assisted chemical vapor deposition, a fluidized bed process followed by a sintering process, or a combination thereof for single or multiple layers of coatings, optionally followed by a reaction heat treatment, thermal pyrosis, plating, or sol-gel process.

[0030] The coating process may be carried out under conditions such that the deposition/plating/sputtering of the metal coating layer being controlled for a modified coating surface with tortuous/corrugated properties. Although not to be bound by theory, it is believed that enhanced electroless deposition rate at high temperatures, i.e., with the deposition becoming less uniform, helps increase the tortuosity T and provide a coated surface with multiple spike configurations.

[0031] The abrasive particles may be coated with one or more coating layer by any suitable method. For example, U.S. Patent No. 3,779,873, discloses a method to electrolytically metal plate diamond particles. U.S. Patent No. 5,024,680, discloses the use of a chromium, titanium, or zirconium carbide-forming layer as part of a multi-layer coating on diamond particles. U.S. Patent No. 5,232,469, discloses multi-layer coated diamond abrasive particles having improved wear performance in abrasive tools, wherein the coating comprises a single homogenous, carbide forming metal primary layer, preferably of chromium, and at least one non-carbide forming secondary layer applied by electroless deposition, preferably comprised of nickel/phosphorus or cobalt/phosphorus.

[0032] The coated abrasive particles may be incorporated into a matrix material in any suitable method. For example, one such process is described in U.S. Patent No. 6,156,390. A method to metal plate articles by the co-deposition of fluorinated carbon and diamond material with electroless metal is provided, wherein the diamond material is in the form of synthetic diamonds. One example of an electroplated coating is a composite coating that comprises an electroless nickel layer having wear resistant particles incorporated within the layer. The particles, which may be either silicon carbide or diamond, are co-deposited as the nickel layer forms onto the base material.

[0033] In one embodiment of the invention, a highly tortuous surface topography is obtained by selecting adequate outer layer alloys based on the type of matrix into which the coated particles will be included.

[0034] Coated Particles Coated with Three Coating Layers Having Tortuous Topography. The coating is comprised of three different layers to further optimize the particle retention properties in the composites as illustrated in FIG. 2. FIG. 2 illustrates a coated particle **10** according to one embodiment of the present invention. A abrasive particle **30** is coated with a chemical forming layer **100,** a diffusion layer **90**, and an outer layer **80**. The tortuous surface topography **70** of the outer layer **80** results in increased bonding strength between the coated particles and the matrix.

[0035] The first layer is a chemical forming layer **100** that may be a carbide or nitride oxide forming layer which forms a chemical bond between the abrasive particle **30** and the chemical forming layer **100**. The process for the coating of any of the three layers illustrated in FIG. 2 may be chemical vapor deposition (CVD), physical vapor deposition (PVD), and plasma assisted chemical vapor deposition, thermal pyrosis, or sol-gel process, followed by a reaction heat treatment. The thickness of each layer illustrated in FIG. 2 may be in the range of about 0.1 μm to about 10μm.

[0036] The second layer is a diffusion layer **90** that may be a metal alloy, such Co based alloys, Ni based alloys, Cu based alloys and mixtures thereof. In one embodiment of the invention, the alloys have an operating temperature in the range of about 600-1150°C. The alloy elements may be Al, Ag, Au, B, C, Co, Cu, Cr, Mg, Mn, P, Pd, Pt, Mo, Ni, Si, Sn, Ti, Zn, W, Sn, Y, Zn, Zr and mixtures thereof. The diffusion coating **90** is an intermediate layer between the chemical forming layer **100** and outer layer **80**. In one embodiment, the diffusion layer **90** provides an intermediate bond between the chemical layer **100** and outer layer **80** by a diffusion process through thermal treatment before sintering or during sintering. The intermediate bond may form a diffusion bond, such as Cr/Cu/Ni, T/Cu/Ni, Sn/Pd/Ni, Zn/Ni, Cr/Ni, Cr/Pd/Ni, Cr/P/N, Ti/Ni, Ti/Pd/Ni, Ti/P/Ni, or other Ni or Co based alloy, or intermetalic bond such as Al_xNi_y, Ti_xCu_y, Ni_xTi_y, and Ni_xSn_y. In one embodiment, the average thickness of the diffusion layer **90** is in the range of about 0.05 μm to about 10 μm. In a second embodiment, it is between about 0.1 μm to about 5 μm. Thus the diffusion layer **90** acts to bond the particle **30** to the outer layer **80**.

[0037] The third layer is the outer layer **80**, and with the intermediate bonds, this outer layer can strongly bond the particle **30** to the matrix material In one embodiment, the outer layer is comprised of Ni, Co, Cu based alloys and mixtures thereof. That alloy elements maybe Al, Ag, Au, B, C, Co, Cu, Cr, Mg, Mn, P, Pd, Pt, Mo, Ni, Si, Sn, Ti, Zn, W, Sn, Y, Zn, and Zr based alloys.

[0038] Composites and Articles Comprising the Coated Abrasives of the Invention. The coated abrasives having tortuous topography of the invention may be used in abrasive composites, e.g., metal/metal alloy matrix composites, ceramic/glass matrix composites, polymer based matrix composites and mixtures thereof. In one embodiment, the coated abrasive particles are used in a concentration of about 10% to about 100% by volume of the total composite volume.

[0039] In one embodiment, the coated abrasives are surrounded in a matrix of a metal, such as Ni, Cu, Fe, Co, Sn, W, Ti, alloys thereof and mixtures thereof In another embodiment, a polymer based matrix composite is suitable and the abrasives are used in a composite comprising a resin, such as phenol formaldehyde. Other resins or organic polymers may be used such as melamine or urea formaldehyde resins, epoxy resins, polyesters, polyamides, polyimides, poly(phenyl sulfide) polybenzoxazole, polycarbonate, polyepoxide, polyketone, and mixtures thereof. In another embodiment, the composite matrix comprises oxides selected from SiO_2, Al_2O_3, ZrO, MgO, and mixtures thereof.

[0040] Example Applications. The composites of the present invention may be used in any suitable application including cutting tool blanks, wire dies, drill blanks, coating applications and the like. The cutting tool blanks can be used in dressing or cutting tools, in machining and woodworking tools such as grinding wheels, saw blades, wire saws, drills, honing tools, or as a bearing element, and the like.

[0041] EXAMPLES. The examples below are merely representative of the work that contributes to the teaching of the present invention, and the present invention is not to be restricted by the examples that follow.

[0042] Coated Diamond Particles having Tortuous Topography. Diamond particles having a mesh particle size ranging from 30/40, 40/50, 50/60, 70/80, and 170/200, commercially available from Diamond Innovations, Inc. of Worthington, OH, were coated to have tortuous surface topography. Diamond particles were placed into a 75.7 liters (20-gallon) sized plating vessel with an electroless nickel plating solution. Agitation was provided by an air driven impeller. The particulate matter was uniformly dispersed throughout the plating solution.

[0043] A reducing agent component comprising sodium hypophosphite, was added to the plating solution at a rate of about 0.5 ml/sec to about 4 ml/sec. The addition caused the plating reaction to begin and plating continued for about a few hours at a process temperature of about 63°C (145°F) to about 77°C (170°F) until substantially all of the nickel was depleted from the plating solution. The coated diamond particulate was removed from the vessel and dried in an oven. In one embodiment, the tortuousity was adjusted by increasing temperature at or above about 145°F. In one embodiment, the above process was repeated multiple times to get the desired tortuosity.

[0044] Composite Bonding Examples. Composites made with the coated diamonds according to one embodiment of the present invention, having a tortuosity T of 1.1, were compared with composites comprising uncoated diamonds. Various tests revealed that the composites comprising the coated diamonds show at least 25% strength increase over the comparable composites. Additionally, fracture surface analysis indicated that the bonding between coated diamond particles of the invention and bond matrix is stronger than the bonding between uncoated diamond particles in the same bond matrix.

[0045] Saw Blade Examples. Saw blades made with diamond particles having 40/50 mesh size commercially available from Diamond Innovations, Inc. as MBS 945 were coated for a tortuosity of 1.1 and were compared with saw blades made with uncoated diamond particles commercially available from Diamond Innovations, Inc. under the trade name MBS 970. MBS 970 is sold as a higher grade diamond than MBS 945. Test results indicated that the blades comprising the coated diamond particles demonstrated at least 50% longer useful life than uncoated higher grade diamond blades. Additionally, the blades employing the coated particles of the invention exhibited better cutting capability and used less power (20% less power than uncoated MBS 970) for the same amount of cutting work than the saw blades employing uncoated abrasive particles.

[0046] The blade tests further illustrated that the saw blade comprising the coated particles have the same cutting capacity as saw blades comprising uncoated particles despite the fact that the saw blade with uncoated particles had a concentration of 18% more particles as compared to the saw with coated particles.

[0047] Grinding wheel Examples. Grinding wheels made with diamond particles having 80/100 mesh size commercially available from Diamond Innovations, Inc. under the trade name MBG 660 were coated to a tortuosity (T) of about 1.05 and of about 1.15. These Grinding wheels having tortuously coated particles were compared with a grinding wheel made with uncoated diamond particles having the same particle size (MBG 660). Test results from grinding ceramic oxides indicated 23% reduction on diamond particle pull-out with T=1.05 over uncoated diamond grinding wheel and 81% reduction on diamond particle pull-out with T=1.15 over uncoated diamond grinding wheel.

[0048] Some of the preferred embodiments have been set forth in this disclosure for the purpose of illustration only. However, the foregoing description should not be deemed to be a limitation on the scope of the invention. Accordingly, various modifications, adaptations, and alternatives may occur to one skilled in the art without departing from the claims.

Claims

1. A composite material comprising a plurality of coated abrasive particles (10) in a matrix, wherein the coated abrasive particles are coated with a coating comprising one or more materials selected from the group consisting of nickel, cobalt, iron, chromium, tungsten, molybdenum, carbides, phosphorus, titanium, zinc, palladium, borides, nitrides, oxides, intermetallics, and mixtures thereof; and
the coating outer layer surface has a tortuous topography such that the outer surface topography of the coated particle (10) comprises at least 5 spikes (20) and a tortuosity T of at least 1.1, wherein the tortuosity is the average length from a centre of the particle (30) to an outermost peak of each of the spikes (50) (Rp) divided by an average length from the centre of the particle (30) to a base of each of the spikes (40) (R_A), **characterized by** said coating comprising at least three coating layers wherein the first layer is a chemical forming layer (100), wherein the second layer is a diffusion layer (90) comprising a metal alloy which bonds to the chemical forming layer (100), and wherein the third layer is an (80) outer layer comprising a metal or metal alloy which bonds to the diffusion layer (90).

2. The composite material of Claim 1, wherein the matrix comprises a polymer selected from the group consisting of melamine resins, urea formaldehyde resins, epoxy resins, polyesters, polyamides, polyimides, poly(phenyl sulfide) polybenzoxazole, polycarbonate, polyepoxide, polyketone, and mixtures thereof.

3. The composite material of either one of Claims 1 and 2, wherein the matrix comprises a metal selected from the group consisting of Ni, Cu, Fe, Co, Sn, W, Ti, alloy thereof, and mixtures thereof.

4. The composite material of any one of Claims 1 to 3, wherein the matrix comprises an oxide selected from the group consisting of SiO_2, Al_2O_3, ZrO, and MgO.

5. The composite material of any one of Claims 1 to 4, wherein the abrasive particles (30) are selected from the group consisting of diamond, cubic boron nitride, boron suboxide, aluminium oxide, silicon carbide, zirconia-alumina, garnet, emery, flint, and mixtures thereof.

6. The composite material of any one of Claims 1 to 5, wherein the abrasive particles (30) are coated with a metal selected from the group consisting of NiB, tungsten, copper, tin, chromium, and mixtures thereof.

7. The composite material of any one of Claims 1 to 6, wherein the abrasive particles (30) have a particle size of about 2 μm to about 200 μm.

8. The composite material of any one of Claims 1 to 7, wherein the particles (30) are coated with a layer

having a thickness of about 2 μm to about 100 μm.

9. The composite material of any one of Claims 1 to 8, wherein the coated abrasive particles (10) are present in a concentration of about 10% to about 100% by volume of the composite.

10. The composite material of any one of Claims 1 to 9, wherein the matrix comprises an alloy having an operating temperature in the range of about 600-1150°C.

11. The composite material of Claim 1, wherein one or more of the three layers are about 1 μm to about 10 μm thick.

12. The composite material of either one of Claims 1 and 11,
wherein the first layer is a chemical forming layer (100) comprising at least a material selected from the group consisting of titanium, chromium, tungsten, molybdenum, zinc, and mixtures thereof.

13. The composite of any one of Claims 1, 11 to 12, wherein the diffusion layer (90) comprises an alloy based on a metal selected from the group consisting of Al, Ag, Au, B, C, Co, Cu, Cr, Mg, Mn, P, Pd, Pt, Mo, Ni, Si, Sn, Ti, Zn, W, Sn, Y, Zn, and Zr.

14. The composite of any one of Claims 1, 11 to 13, wherein the diffusion layer (90) further bonds to the outer layer (80).

15. The composite of any one of Claims 1, 11 to 14, wherein the outer layer (80) comprises an alloy of a metal selected from the group consisting of Al, Ag, Au, B, C, Co, Cu, Cr, Mg, Mn, P, Pd, Pt, Mo, Ni, Si, Sn, Ti, Zn, W, Sn, Y, Zn, and Zr.

16. An article comprising the composite material of any one of Claims 1 to 15.

17. The article of Claim 16, wherein the article is selected from the group consisting of a tool blank, a wire die, a drill blank, a grinding wheel, a saw blade, a wire saw, a drill, a honing tool, and a bearing element.

18. A method of forming a composite of claim 1 comprising:

preparing a plurality of the coated abrasive particles (10) by using a process selected from the group consisting of CVD, thermal spray, electroplating, electroless plating overlay, and HVOF technique; and
dispersing the coated abrasive particles (10) within a matrix material, wherein the coated abrasive particles (10) are coated with a coating comprising one or more materials selected from the group consisting of nickel, cobalt, iron, chromium, tungsten, molybdenum, carbides, phosphorus, titanium, zinc, palladium, borides, nitrides, intermetallics, and mixtures thereof; said coating comprising at least three layers, wherein an intermediary layer (90) bonds an outer layer (80) and a chemical forming layer (100), and wherein the chemical forming layer (100) bonds to the abrasive particle (30).

19. The method of Claim 18, wherein the matrix material comprises a material selected from the group consisting of metal, metal alloy, ceramic, glass, polymers, and mixtures thereof.

20. The method of either one of Claims 18 or 19, wherein the abrasive particles (30) are selected from the group consisting of diamond, cubic boron nitride, boron suboxide, aluminum oxide, silicon carbide, zirconia-alumina, garnet, emery, flint, and mixtures thereof.

21. The method of any one of Claims 18 to 20, wherein the coating is deposited via electroless plating at temperatures greater than about 145°F.

22. The method of Claim 18, wherein the three layers are deposited consecutively on the particle (30) by an electroplating process.

Patentansprüche

1. Ein Verbundwerkstoff, der eine Vielzahl von beschichteten Schleifpartikeln (10) in einer Matrix beinhaltet, wobei die beschichteten Schleifpartikel mit einer Beschichtung beschichtet sind, die ein Material oder mehrere Materialien beinhaltet, die aus der Gruppe ausgewählt sind, die aus Folgendem besteht: Nickel, Cobalt, Eisen, Chrom, Wolfram, Molybdän, Carbiden, Phosphor, Titan, Zink, Palladium, Boriden, Nitriden, Oxiden, intermetallischen Verbindungen und Mischungen davon; und
die äußere Schichtoberfläche der Beschichtung eine gewundene Topographie aufweist, so dass die Topographie der äußeren Oberfläche des beschichteten Partikels (10) mindestens 5 Dorne (20) und eine Gewundenheit T von mindestens 1,1 aufweist, wobei die Gewundenheit die durchschnittliche Länge von einem Zentrum des Partikels (30) zu einer äußersten Spitze jedes der Dorne (50) (R_p), geteilt durch eine durchschnittliche Länge von dem Zentrum des Partikels (30) zu einer Basis jedes der Dorne (40) (R_A), ist, **dadurch gekennzeichnet, dass** die Beschichtung mindestens drei Beschichtungsschichten beinhaltet, wobei die erste Schicht eine eine Chemikalie bildende Schicht (100) ist, wobei

die zweite Schicht eine Diffusionsschicht (90) ist, die eine Metalllegierung beinhaltet, die an die eine Chemikalie bildende Schicht (100) bindet, und wobei die dritte Schicht eine äußere Schicht (80) ist, die ein Metall oder eine Metalllegierung beinhaltet, die an die Diffusionsschicht (90) bindet.

2. Verbundwerkstoff gemäß Anspruch 1, wobei die Matrix ein Polymer beinhaltet, das aus der Gruppe ausgewählt ist, die aus Folgendem besteht: Melaminharzen, Harnstoff-Formaldehydharzen, Epoxidharzen, Polyestern, Polyamiden, Polyimiden, Poly(phenylsulfid)polybenzoxazol, Polycarbonat, Polyepoxid, Polyketon und Mischungen davon.

3. Verbundwerkstoff gemäß einem der Ansprüche 1 und 2, wobei die Matrix ein Metall beinhaltet, das aus der Gruppe ausgewählt ist, die aus Folgendem besteht: Ni, Cu, Fe, Co, Sn, W, Ti, Legierung davon und Mischungen davon.

4. Verbundwerkstoff gemäß einem der Ansprüche 1 bis 3, wobei die Matrix ein Oxid beinhaltet, das aus der Gruppe ausgewählt ist, die aus Folgendem besteht: SiO_2, Al_2O_3, ZrO und MgO.

5. Verbundwerkstoff gemäß einem der Ansprüche 1 bis 4, wobei die Schleifpartikel (30) aus der Gruppe ausgewählt sind, die aus Folgendem besteht: Diamant, kubischem Bornitrid, Borsuboxid, Aluminiumoxid, Siliciumcarbid, Zirkonoxid-Aluminiumoxid, Granat, Schmirgel, Feuerstein und Mischungen davon.

6. Verbundwerkstoff gemäß einem der Ansprüche 1 bis 5, wobei die Schleifpartikel (30) mit einem Metall beschichtet sind, das aus der Gruppe ausgewählt ist, die aus Folgendem besteht: NiB, Wolfram, Kupfer, Zinn, Chrom und Mischungen davon.

7. Verbundwerkstoff gemäß einem der Ansprüche 1 bis 6, wobei die Schleifpartikel (30) eine Partikelgröße von etwa 2 μm bis etwa 200 μm aufweisen.

8. Verbundwerkstoff gemäß einem der Ansprüche 1 bis 7, wobei die Partikel (30) mit einer Schicht beschichtet sind, die eine Dicke von etwa 2 μm bis etwa 100 μm aufweist.

9. Verbundwerkstoff gemäß einem der Ansprüche 1 bis 8, wobei die beschichteten Schleifpartikel (10) in einer Konzentration von etwa 10 Vol.-% bis etwa 100 Vol.-% des Verbunds vorliegen.

10. Verbundwerkstoff gemäß einem der Ansprüche 1 bis 9, wobei die Matrix eine Legierung beinhaltet, die eine Betriebstemperatur in dem Bereich von etwa 600-1150 °C aufweist.

11. Verbundwerkstoff gemäß Anspruch 1, wobei eine oder mehrere der drei Schichten etwa 1 μm bis etwa 10 μm dick sind.

12. Verbundwerkstoff gemäß einem der Ansprüche 1 und 11, wobei die erste Schicht eine eine Chemikalie bildende Schicht (100) ist, die mindestens ein Material beinhaltet, das aus der Gruppe ausgewählt ist, die aus Folgendem besteht: Titan, Chrom, Wolfram, Molybdän, Zink und Mischungen davon.

13. Verbundwerkstoff gemäß einem der Ansprüche 1, 11 bis 12, wobei die Diffusionsschicht (90) eine Legierung beinhaltet, die auf einem Metall basiert, das aus der Gruppe ausgewählt ist, die aus Folgendem besteht: Al, Ag, Au, B, C, Co, Cu, Cr, Mg, Mn, P, Pd, Pt, Mo, Ni, Si, Sn, Ti, Zn, W, Sn, Y, Zn und Zr.

14. Verbund gemäß einem der Ansprüche 1, 11 bis 13, wobei die Diffusionsschicht (90) ferner an die äußere Schicht (80) bindet.

15. Verbund gemäß einem der Ansprüche 1, 11 bis 14, wobei die äußere Schicht (80) eine Legierung eines Metalls beinhaltet, das aus der Gruppe ausgewählt ist, die aus Folgendem besteht: Al, Ag, Au, B, C, Co, Cu, Cr, Mg, Mn, P, Pd, Pt, Mo, Ni, Si, Sn, Ti, Zn, W, Sn, Y, Zn und Zr.

16. Ein Gegenstand, der den Verbundwerkstoff gemäß einem der Ansprüche 1 bis 15 beinhaltet.

17. Gegenstand gemäß Anspruch 16, wobei der Gegenstand aus der Gruppe ausgewählt ist, die aus Folgendem besteht: einem Werkzeugrohteil, einem Ziehstein, einem Bohrerrohteil, einer Schleifscheibe, einem Sägeblatt, einer Drahtsäge, einem Bohrer, einem Honwerkzeug und einem Lagerelement.

18. Ein Verfahren zum Bilden eines Verbunds gemäß Anspruch 1, das Folgendes beinhaltet:

Vorbereiten einer Vielzahl von beschichteten Schleifpartikeln (10) durch Verwenden eines Vorgangs, der aus der Gruppe ausgewählt ist, die aus Folgendem besteht:

CVD, thermischem Spritzen, Elektroplattierung, Überzug durch stromlose Plattierung und HVOF-Technik; und

Dispergieren der beschichteten Schleifpartikel (10) innerhalb eines Matrixmaterials, wobei die beschichteten Schleifpartikel (10) mit einer Beschichtung beschichtet sind, die ein Material oder mehrere Materialien beinhaltet, die aus der Gruppe ausgewählt sind, die aus Folgendem besteht: Nickel, Cobalt, Eisen, Chrom, Wolfram, Molybdän, Carbiden, Phosphor, Titan, Zink, Palladium, Boriden, Nitriden, intermetallischen Verbindungen und Mischungen davon; wobei die Beschichtung mindestens drei Schichten beinhaltet, wobei eine Zwischenschicht (90) eine äußere Schicht (80) und eine eine Chemikalie bildende Schicht (100) bindet und wobei die eine Chemikalie bildende Schicht (100) an das Schleifpartikel (30) bindet.

19. Verfahren gemäß Anspruch 18, wobei das Matrixmaterial ein Material beinhaltet, das aus der Gruppe ausgewählt ist, die aus Folgendem besteht: Metall, Metalllegierung, keramischem Material, Glas, Polymeren und Mischungen davon.

20. Verfahren gemäß einem der Ansprüche 18 oder 19, wobei die Schleifpartikel (30) aus der Gruppe ausgewählt sind, die aus Folgendem besteht: Diamant, kubischem Bornitrid, Borsuboxid, Aluminiumoxid, Siliciumcarbid, Zirkonoxid-Aluminiumoxid, Granat, Schmirgel, Feuerstein und Mischungen davon.

21. Verfahren gemäß einem der Ansprüche 18 bis 20, wobei die Beschichtung bei Temperaturen von mehr als 145 °F mittels stromloser Plattierung abgelagert wird.

22. Verfahren gemäß Anspruch 18, wobei die drei Schichten durch einen Elektroplattierungsvorgang konsekutiv auf dem Partikel (30) abgelagert werden.

Revendications

1. Un matériau composite comprenant une pluralité de particules abrasives revêtues (10) dans une matrice, dans lequel les particules abrasives revêtues sont revêtues d'un revêtement comprenant un ou plusieurs matériaux sélectionnés dans le groupe consistant en nickel, cobalt, fer, chrome, tungstène, molybdène, carbures, phosphore, titane, zinc, palladium, borures, nitrures, oxydes, intermétalliques, et des mélanges de ceux-ci ; et
la surface de couche externe de revêtement a une topographie tortueuse de telle sorte que la topographie de surface externe de la particule revêtue (10) comprenne au moins 5 pointes (20) et une tortuosité T d'au moins 1,1, dans lequel la tortuosité est la longueur moyenne d'un centre de la particule (30) à un pic le plus à l'extérieur de chacune des pointes (50) (R_p) divisée par une longueur moyenne du centre de la particule (30) à une base de chacune des pointes (40) (R_A), **caractérisé en ce que** ledit revêtement comprend au moins trois couches de revêtement dans lequel la première couche est une couche de formation chimique (100), dans lequel la deuxième couche est une couche de diffusion (90) comprenant un alliage métallique qui se lie à la couche de formation chimique (100), et dans lequel la troisième couche est une couche externe (80) comprenant un métal ou un alliage métallique qui se lie à la couche de diffusion (90).

2. Le matériau composite de la revendication 1, dans lequel la matrice comprend un polymère sélectionné dans le groupe consistant en résines de mélamine, résines urée-formaldéhyde, résines époxydes, polyesters, polyamides, polyimides, poly(sulfure de phénylène) polybenzoxazole, polycarbonate, polyépoxyde, polycétone, et des mélanges de ceux-ci.

3. Le matériau composite de l'une ou l'autre des revendications 1 et 2, dans lequel la matrice comprend un métal sélectionné dans le groupe consistant en Ni, Cu, Fe, Co, Sn, W, Ti, alliage de ceux-ci, et des mélanges de ceux-ci.

4. Le matériau composite d'une quelconque des revendications 1 à 3, dans lequel la matrice comprend un oxyde sélectionné dans le groupe consistant en SiO_2, Al_2O_3, ZrO, et MgO.

5. Le matériau composite d'une quelconque des revendications 1 à 4, dans lequel les particules abrasives (30) sont sélectionnées dans le groupe consistant en diamant, nitrure de bore cubique, sous-oxyde de bore, oxyde d'aluminium, carbure de silicium, zircone-alumine, grenat, émeri, silex, et des mélanges de ceux-ci.

6. Le matériau composite d'une quelconque des revendications 1 à 5, dans lequel les particules abrasives (30) sont revêtues d'un métal sélectionné dans le groupe consistant en NiB, tungstène, cuivre, étain, chrome, et des mélanges de ceux-ci.

7. Le matériau composite d'une quelconque des revendications 1 à 6, dans lequel les particules abrasives (30) ont une taille de particule allant d'environ 2 μm à environ 200 μm.

8. Le matériau composite d'une quelconque des revendications 1 à 7, dans lequel les particules (30) sont revêtues d'une couche ayant une épaisseur allant d'environ 2 μm à environ 100 μm.

9. Le matériau composite d'une quelconque des revendications 1 à 8, dans lequel les particules abrasives revêtues (10) sont présentes dans une concentration allant d'environ 10 % à environ 100 % en volume du composite.

10. Le matériau composite d'une quelconque des revendications 1 à 9, dans lequel la matrice comprend un alliage ayant une température de fonctionnement dans la gamme comprise entre environ 600 et 1 150 °C.

11. Le matériau composite de la revendication 1, dans lequel une ou plusieurs couches parmi les trois couches ont une épaisseur allant d'environ 1 μm à environ 10 μm.

12. Le matériau composite de l'une ou l'autre des revendications 1 et 11, dans lequel la première couche est une couche de formation chimique (100) comprenant au moins un matériau sélectionné dans le groupe consistant en titane, chrome, tungstène, molybdène, zinc, et des mélanges de ceux-ci.

13. Le matériau composite d'une quelconque des revendications 1, 11 à 12, dans lequel la couche de diffusion (90) comprend un alliage basé sur un métal sélectionné dans le groupe consistant en Al, Ag, Au, B, C, Co, Cu, Cr, Mg, Mn, P, Pd, Pt, Mo, Ni, Si, Sn, Ti, Zn, W, Sn, Y, Zn, et Zr.

14. Le composite d'une quelconque des revendications 1, 11 à 13, dans lequel la couche de diffusion (90) se lie en outre à la couche externe (80).

15. Le composite d'une quelconque des revendications 1, 11 à 14, dans lequel la couche externe (80) comprend un alliage d'un métal sélectionné dans le groupe consistant en Al, Ag, Au, B, C, Co, Cu, Cr, Mg, Mn, P, Pd, Pt, Mo, Ni, Si, Sn, Ti, Zn, W, Sn, Y, Zn, et Zr.

16. Un article comprenant le matériau composite d'une quelconque des revendications 1 à 15.

17. L'article de la revendication 16, l'article étant sélectionné dans le groupe consistant en un barreau, une filière, un foret taraudeur, une meule, une lame de sciage, une scie hélicoïdale, un foret, un outil d'affûtage, et un élément de palier.

18. Une méthode pour former un composite de la revendication 1 comprenant :

préparer une pluralité des particules abrasives revêtues (10) en utilisant un procédé sélectionné dans le groupe consistant en DCPV, pulvérisation thermique, dépôt électrolytique, recouvrement par dépôt autocatalytique, et technique HVOF (High Velocity Oxygen Fuel) ;
et
disperser les particules abrasives revêtues (10) au sein d'un matériau de matrice, les particules abrasives revêtues (10) étant revêtues d'un revêtement comprenant un ou plusieurs matériaux sélectionnés dans le groupe consistant en nickel, cobalt, fer, chrome, tungstène, molybdène, carbures, phosphore, titane, zinc, palladium, borures, nitrures, intermétalliques, et des mélanges de ceux-ci ; ledit revêtement comprenant au moins trois couches, une couche intermédiaire (90) liant une couche externe (80) et une couche de formation chimique (100), et la couche de formation chimique (100) se liant à la particule abrasive (30).

19. La méthode de la revendication 18, dans laquelle le matériau de matrice comprend un matériau sélectionné dans le groupe consistant en métal, alliage métallique, céramique, verre, polymères, et des mélanges de ceux-ci.

20. La méthode de l'une ou l'autre des revendications 18 et 19, dans laquelle les particules abrasives (30) sont sélectionnées dans le groupe consistant en diamant, nitrure de bore cubique, sous-oxyde de bore, oxyde d'aluminium, carbure de silicium, zircone-alumine, grenat, émeri, silex, et des mélanges de ceux-ci.

21. La méthode d'une quelconque des revendications 18 à 20, dans laquelle le revêtement est déposé par le biais d'un dépôt autocatalytique à des températures supérieures à environ 145 °F.

22. La méthode de la revendication 18, dans laquelle les trois couches sont déposées consécutivement sur la particule (30) par un procédé d'électroplacage.

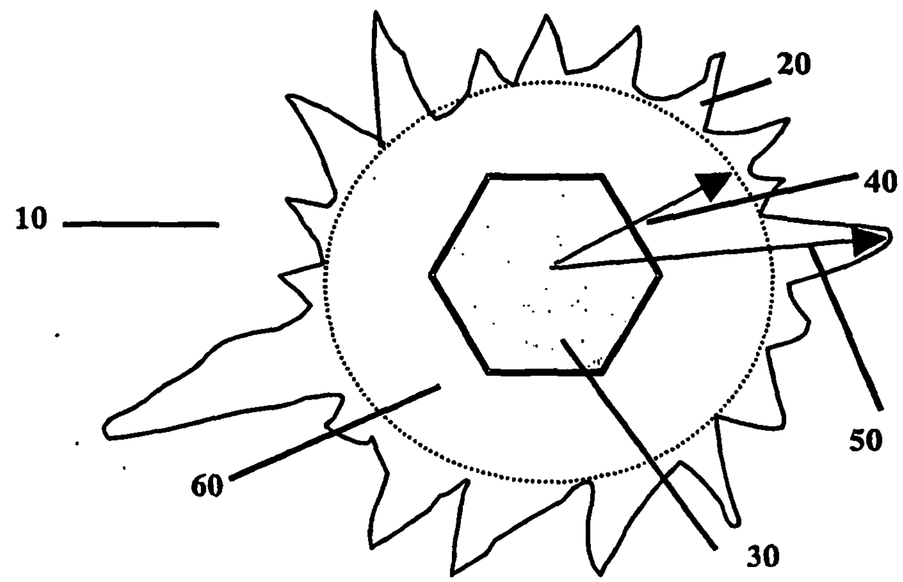

FIGURE 1

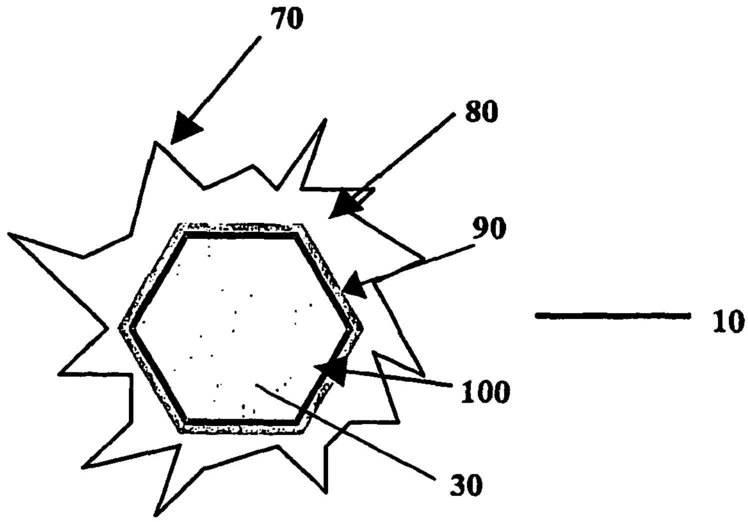

FIGURE 2

REFERENCES CITED IN THE DESCRIPTION

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