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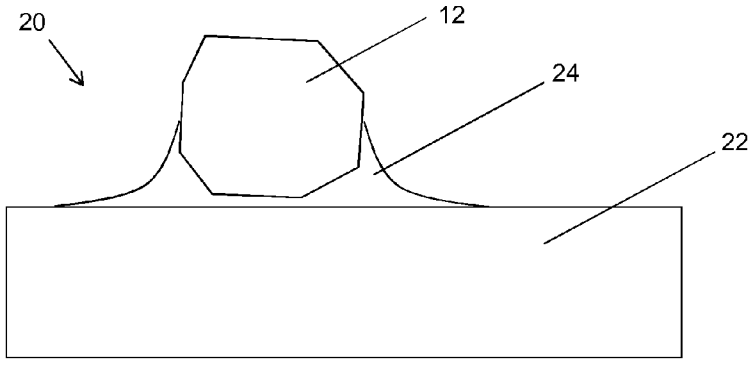


Fig. 2

(57) Abstract: A method of making a construction comprising a diamond body joined to carrier body, the method including disposing chromium adjacent a surface of diamond material comprised in the diamond body, and joining the diamond body to the carrier body by means of braze material, in an atmosphere containing oxygen.

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METHOD FOR MAKING TOOLS AND CONSTRUCTIONS FOR TOOLS

This disclosure relates generally to constructions comprising diamond, tools comprising same and methods for making same.

United States patent number 5,647,878 discloses a diamond article for brazing to a substrate. The article comprises a diamond substrate, a tungsten and titanium metal layer bonded directly to the diamond substrate through an interface and a substantially non-oxidisable protective layer comprising braze compatible material disposed on and adhered to the metal bonding layer. The interface comprises titanium carbide to provide adhesion of the metal layer to said diamond substrate.

European patent application number 2 165 002 discloses coated diamond comprising a diamond substrate, a primary carbide-containing layer of a carbide forming element, a secondary layer and an overcoat. The secondary layer comprises a high melting point metal selected from W, Mo, Cr, Ni, Ta, Au, Pt, Pd or any combination or alloy thereof and is substantially free of carbide forming metal from the primary layer. The overcoat comprises Ag, Ni, Cu, Au, Pd, Pt, Rh, Os, Ir, Re or any combination or alloy thereof. The metal of the secondary layer is different to the metal of the overcoat.

There is a need for coated diamond constructions that are capable of being brazed in air.

Viewed from one aspect, there can be provided a method of making a construction comprising a diamond body joined to carrier body, the method including disposing chromium adjacent a surface of diamond material comprised in the diamond body, and joining the diamond body to the carrier body by means of braze material, in an atmosphere containing oxygen (in some examples, the atmosphere may comprise at least about 10 atomic per cent oxygen, or the atmosphere may consist of air).

Various example variations of the method are envisaged by this disclosure, non-limiting and non-exhaustive examples of which are provided below.

In some examples, the construction may be comprised in a tool or a component for a tool.

In some example variations, the method may include depositing material comprising chromium directly onto the surface of the diamond material.

In some example variations, the method may include forming a chromium-comprising layer structure on the surface of the diamond.

In some examples, the method may include depositing material comprising or consisting of chromium directly onto the surface of the diamond material, the chromium being substantially in elemental form, and forming a layer structure comprising the chromium (which may simply be referred to as the “layer”, “chromium layer” or “chromium coat”) on the surface of the diamond body.

In some examples, the chromium layer may consist of chromium in elemental form, apart from practically unavoidable impurities or a minor amount of practically unavoidable chromium carbide adjacent the surface of the diamond material. In some examples, the material comprising chromium (as deposited onto the surface of the diamond material) and or the chromium layer may comprise at least 50 weight per cent, at least about 80 weight per cent, at least about 90 weight per cent, at least about 95 weight per cent or at least about 99 weight per cent chromium in elemental form.

In some example arrangements, a layer comprising chromium may contact a surface area of the diamond material; the layer may have a mean thickness in the range of 0.01 micron to 5 microns.

In some example variations, the braze material may comprise chromium; and or the braze material may comprise nickel.

In some example arrangements, the melting point of the braze material may be at most about 1,200 degrees Celsius.

In some example arrangements, the diamond body may be joined to the carrier body by the braze structure.

In some example variations, the method may include forming a braze-comprising structure adjacent the surface of the diamond body or on the layer comprising the chromium.

The construction may be a tool or a component for a tool, or comprised in a tool or in a component for a tool, in which the diamond body is joined to the carrier body by a braze structure. The method may include depositing a layer structure comprising chromium substantially in elemental form directly onto the surface of the diamond material, the layer having a mean thickness in the range of 0.01 micron to 5 microns; and the braze material comprising nickel and having a melting point of at most about 1,200 degrees Celsius.

Using braze material having a relatively low melting point is likely to have the aspect of reducing the risk of degrading the diamond material as a result of having to heat the braze material to above its melting point, since diamond is thermodynamically metastable at ambient or lower pressure.

In some example variations, the method may include forming a pellet comprising the diamond body and the braze material.

In some example arrangements, the braze material may contain at least about 5 weight per cent or at least 10 weight per cent chromium. In one example, the braze material may comprise chromium in the range of about 2 to about 12 weight per cent (for example, about 7 weight per cent), boron in the range of about 1 weight per cent to about 5 weight per cent (for example, about 3 weight per cent), silicon in the range of about 2 weight per cent to about 7 weight per cent (for example, about 4.5 weight per cent), iron in the range of about 1 weight per cent to about 5 weight per cent (for example, about 3 weight per cent) and rest of the material consisting of nickel.

In some example approaches, a layer rich in chromium may not be applied onto the diamond body prior to combining the braze material with the diamond body, since the chromium comprised in the braze material may sufficiently enhance the wetting of the

surface of the diamond body by the braze material when the latter is melted during the brazing process. For example, braze material comprising nickel, chromium, boron and silicon may be applied directly to the surface of the diamond body.

In some examples, the composition of the braze material may be selected to include chromium and nickel, the relative amounts of the constituent materials being selected substantially to minimise the melting point of the braze material. Using braze material having a relatively low melting point is likely to have the aspect of reduced the risk of degrading the diamond material as a result of having to heat the braze material to above its melting point, since diamond is thermodynamically metastable at ambient or lower pressure.

In some example variations, the method may include depositing chromium into a surface of the diamond body by means of a method that substantially avoids the formation of chromium carbide at the surface of the diamond body.

In some examples, the method may include depositing chromium onto a surface of the diamond body by means of physical vapour deposition.

In some example variations, the method may include depositing chromium onto a surface of the diamond body by means of physical vapour deposition (PVD) or chemical vapour deposition (CVD). In some examples, the chromium may be deposited substantially in elemental, metallic form; and in some examples, a minor amount of the chromium may react with carbon at a surface of diamond material comprised in the diamond body. In some example variations, the method may include depositing a layer of chromium onto the surface of the diamond body using a process in which substantially none of the chromium, or only a minor amount of the chromium, reacts with carbon at the surface of diamond material comprised in the diamond body.

In various example arrangements, the chromium may be in elemental or metallic form, the chromium may be comprised in an alloy material, comprised in braze material or comprised in a chemical compound.

In some example variations, the method may include depositing chromium-comprising material directly onto non-diamond material comprised in the diamond body, such that chromium material contacts the diamond material.

In some example variations, the diamond body may comprise or consist of a diamond grain.

In some example variations, the method may include combining a plurality of diamond grains with a paste comprising the braze material.

In some example variations, the method may include combining a plurality of diamond grains, chromium-coated or non-coated, with a braze material and binder material to form a diamond-containing paste, and extruding the paste to form a brazable body.

In various example arrangements, the diamond body may comprise directly inter-bonded diamond grains; and or the diamond body may comprise a plurality of diamond grains dispersed in a matrix.

In some example variations, the diamond body may comprise a diamond grain. In some example variations, the diamond body may comprise directly inter-bonded diamond grains; and or the diamond body may comprise a plurality of diamond grains dispersed in a matrix. In some examples, the method may include combining a plurality of diamond grains with a paste comprising the braze material. In some example variations, the method may include combining a plurality of diamond grains with braze material and forming a strip, a paste, granules, rod or a powder thereof.

In some examples, the diamond body may comprise synthetic diamond material manufactured by means of an ultra-high pressure and high temperature (HPHT) apparatus, by means of chemical vapour deposition (CVD), by explosion or by shock wave methods. In some example arrangements, the diamond body may comprise polycrystalline diamond (PCD) material, silicon carbide bonded diamond (SCD), thermally stable diamond material, material, a single diamond grain, a cluster of diamond grains or a CVD diamond wafer. In some examples, the diamond body may comprise thermally stable polycrystalline diamond (PCD) material, which may be

sintered at ultra-high pressure and temperature, and which may comprise voids between a plurality of directly inter-grown diamond grains, and or which may comprise silicon carbide.

In some examples, the diamond body may comprise CVD diamond material in the form of a wafer, which may have a surface with an area of at least about one square millimetre, or in the form of a disc having a diameter of at least about 1 millimetre, or a diameter of at most about 200 millimetres; or the diamond body may comprise thermally stable PCD material in the form a block having a volume of at least about one square millimetre or in the form of a disc having a diameter of at least about 1 millimetre, or a diameter of at most about 110 millimetres.

In some example arrangements, the diamond body comprise or consist of a diamond grain; the diamond grain may have a grain size of at least about 10 microns and at most about 4,000 microns.

In various example arrangements, the carrier body may be a bead for a wire saw, a segment for a saw blade, a grinding wheel, or a drill body.

In various example arrangements, the carrier body may be a bead for a wire saw, a wire for a wire saw, a segment for a saw blade, a grinding wheel, a router body or a drill body.

In some example variations, the method may include heating the structure to a sufficiently high temperature for the chromium to react with carbon comprised in the diamond material to form a compound comprising chromium and carbon.

There can be provided a construction comprising a diamond body connected to a braze structure, according to this disclosure, in which chromium is disposed adjacent diamond material comprised in the diamond body and the braze structure comprises braze material.

In some example arrangements, the construction may comprise a chromium-coat structure in the form of a layer adjacent a surface of diamond material comprised in the diamond body, in which the chromium-coat layer has a mean thickness of at least

about 0.01 micron to about 5 microns. In some example arrangements, chromium-coat layer may have a mean thickness of at least about 0.01 micron, at least about 0.1 micron or at least about 1 micron. In some example arrangements, the structure chromium-coat layer may have a thickness of at most about 1 millimetres, at most about 1 millimetre, at most about 0.1 millimetre or at most about 0.01 millimetre. In some example arrangements, the construction may comprise a diamond grain having grain size in the range of about 10 microns to about 60 microns.

In some example arrangements, the braze structure may contain chromium and the concentration of the chromium in the braze structure may be higher in a region of the braze structure proximate the diamond body than it is in a region of the braze structure relatively more remote from the diamond body.

In some example arrangements, a chromium-comprising layer may contact the surface of the diamond material and a braze-comprising layer may contact the chromium-comprising layer.

In some example arrangements, the braze material comprises chromium, or the braze material may be substantially free of chromium. In some examples, the braze material may comprise nickel.

In some example arrangements, a layer comprising braze material may contact the surface of the diamond material, the braze material comprising chromium.

In some example arrangements, the braze structure may be substantially free of silver; and or the construction may be substantially free of tungsten between the surface of the diamond material and the braze structure.

In some example arrangements, the construction may be substantially free of chromium carbide disposed directly adjacent the surface of the diamond material.

In some example arrangements, the construction may comprise a plurality of diamond grains.

In some example arrangements, the diamond body may comprise directly inter-bonded diamond grains.

In some example arrangements, the construction may comprise a plurality of diamond grains dispersed in a matrix comprising braze material; and or the construction may comprise a plurality of diamond grains dispersed in a paste comprising the braze material.

In some example arrangements, the diamond body may be encapsulated within pellet structure comprising braze material and including chromium.

In some example arrangements, the diamond body may consist of a diamond grain.

In some example arrangements, the construction may comprise a diamond grain having a grain size of at least 10 microns and at most 4,000 microns.

In some example arrangements, the construction may comprise a bead for a wire saw, a segment for a saw blade, a grinding wheel or a cutter component for a drill.

In some example arrangements, the diamond body may comprise at least one diamond grain or may consist essentially of a single diamond grain. The diamond body may comprise a single diamond grain and the structure may comprise a coating on the diamond grain, the coating comprising braze material. The construction may comprise a plurality of diamond bodies dispersed in the structure. The diamond grain or grains may be at least about 0.1 micron and or at most about 10 millimetres in gran size (as measured across the greatest dimension of the grain). For example, the diamond grain or grains may have grain size in the range of about 0.1 micron to about 60 microns, and may be suitable for use in polishing or lapping tools; or the diamond grain or grains may in the range of about 40 microns to 200 microns, and may be suitable for use in grinding tools; or the diamond grain or grains may be in the range from about 180 microns to 2 millimetres, and may be suitable for use in saw blades and drill bits, particularly but not exclusively for earth boring bits; or the diamond grain or grains may be in the range of about 1 millimetre to 10 millimetres.

In various example arrangements, the construction may comprise a diamond grain coated entirely or partially with a chromium-coat layer a layer, in which the layer may have mean thickness in the range of about 0.01 micron to about 1 micron, or in the range of about 0.01 micron to about 0.2 micron. In some examples, the thickness of the chromium-coat layer may depend on the grain size of the diamond grain, and relatively smaller diamond grains may have relatively thinner layers.

In some examples, the diamond grains may be encapsulated with a mixed or multi-layered encapsulation, in which the encapsulation material includes additive material. For example, the encapsulation structure may contain grains of hard material such as tungsten, tungsten carbide and silicon carbide.; and or the encapsulation structure may contain soft materials, such as molybdenum sulphide, copper and or silver which may enhance lubrication of a construction. In some examples, the encapsulation structure may include flux material, which may be present as blended with braze material and or as a distinct layer. In some examples, the encapsulation material may comprise multiple layers of compatible braze materials, for example different braze materials having different melting points.

There can be provided a tool or a component for a tool, comprising or consisting of a construction according to this disclosure.

In various examples, the tool or component for a tool may comprise a saw tool such as a saw blade, a diamond wire bead for a diamond wire saw, a diamond wire, saw segment, band saw, hacksaw or frame saw; a drill such as a core drill, a twist drill, an impregnated (impreg) bit, or roller cone bit; a wear part such as a calibration roller, a wire drawing die, coverage of steel rollers (for example, as may be used in the paper and textile industry); a grinding tool such as including a grinding wheel, a grinding tip, an internal grinder; a dresser tool such a rotary dresser, a dresser log for single or multiple log dressers, a profile dresser; a router such as a straight or profiled router; a polishing tool or material used for polishing, such as a polishing cup or material for concrete polishing; a single point turning tool; a gauge component; hard facing material or structure; a sintered segment containing natural or synthetic diamond; a bushing or shim; a cutting disc; a dental burr or an edge profiler.

Non-limiting example arrangements of constructions will be described below with reference to the accompanying drawings, of which

Fig. 1 shows a schematic cross section view of an example diamond pellet construction;

Fig. 2 shows a schematic cross section view of a part of an example tool body construction;

Fig. 3 shows a schematic side view of a part of a diamond wire for a wire saw; and

Fig. 4 shows a schematic cross section view of a volume of diamond-containing braze paste.

With reference to Fig. 1, an example pellet construction 10 may consist of a synthetic diamond grain 12 at least partly coated with a layer 14 consisting of chromium in elemental, metallic form; and a relatively much thicker braze-comprising layer 16. The layer consisting of chromium 14 may have a mean thickness in the range of about 0.1 micron to about 1 micron and the braze-comprising layer 16 may have a mean thickness in the range of about 5 microns to about 50 microns. The diamond grain 12 may have a grain size in the range of about 20 microns to about 200 microns.

In another example, the diamond grain 12 may have a mean size in the range of about 100 microns to about 1,000 microns, the chromium layer 14 may have a mean thickness in the range of about 0.5 micron to about 1.5 microns and the braze-comprising layer 16 may have a thickness in the range of about 50 microns to about 500 microns.

In another example, the diamond grain 12 may have a mean size in the range of about 5 microns to about 50 microns, the chromium layer 14 may have a mean thickness in the range of about 0.01 micron to about 0.1 micron and the braze-comprising layer 16 may have a thickness in the range of about 20 microns to about 100 microns.

The construction described above may be attached to a carrier body by contacting the construction to the carrier body, heating it to above the melting point of the braze material and allowing it to cool, thus providing a further construction comprising the

diamond body joined to the carrier body by means of a structure comprising the braze material.

Example methods for coating example diamond bodies will now be described.

A plurality of diamond grains may each be provided with respective chromium-coat structures by means of physical vapour deposition (PVD). A plurality of diamond grains each is provided and deposited in a physical vapour deposition (PVD) barrel apparatus. The barrel apparatus will be provided with a source of chromium and a means of ionising the argon gas to provide an argon ion plasma and accelerating the resulting argon ions onto the chromium source operative to sputter chromium ions, atoms or complexes from the source. The apparatus will be arranged such that the sputtered chromium can become deposited on the diamond grains when the barrel is rotated to agitate the diamond grains. Argon gas is leaked into the barrel after the latter has been evacuated and the ionisation and chromium scattering and deposition mechanism activated. The duration of the process will depend on the desired thickness of the layer comprising the chromium.

In examples where the diamond grains are relatively small, for example less than about 100 microns, the surfaces of the grains may be metallised using a palladium chloride solution prior to coating with chromium, which may be achieved by means of electrodeposition in a plating bath using a rotating barrel. Alternatively, an electroless method may be used, in which the diamond grains may be contained in a barrel submerged in a chromium containing solution. A reducing solution may be added in order to liberate chromium, resulting in the deposition of the chromium on the surfaces of the diamond grains in the rotating barrel.

Diamond grains, which may be chromium-coated or non-coated, may be encapsulated within a braze-encapsulation coatings to provide brazable diamond pellets. Methods for encapsulating diamond grains are disclosed in international patent applications publication numbers WO/2008/018048, WO/2009/013715 or WO/2009/101605.

With reference to Fig. 2, an example tool construction 20 may comprise a synthetic diamond grain 12 joined to a tool body 22 by means of a braze structure 24

comprising braze material. In various examples, the diamond grain may have a grain size in the range of about 5 microns to about 50 microns, in the range from about 50 microns to about of about 500 microns, or in the range from about 500 microns to about 4,000 microns.

With reference to Fig. 3, a wire saw construction 30 may comprise a plurality synthetic diamond grains 12 each joined to a wire 32 for a wire saw by means of respective braze structures comprising braze material. In various examples, the diamond grain 12 may have a grain size in the range of about 10 microns to about 60 microns.

With reference to Fig. 4, a braze paste construction 40 may comprise a plurality synthetic diamond grains 12 dispersed throughout a paste 42 comprising braze material. In various examples, each diamond grain 12 may have a grain size of about 10 microns, about 100 microns or about 400 microns.

An example method for making a tool construction may include providing a plurality of diamond pellet constructions, each comprising a diamond grain and braze material, contacting the pellets with a tool body and heating the braze material to above its melting point to braze the diamond grains to the tool body.

An example method of making a tool construction will now be described.

An example method may include providing a plurality of diamond grains, each comprising a chromium-coat structure, and providing braze material in powder form, flux material in powder form and adhesive material. The method may include disposing the adhesive material onto at least part of the tool body, dispersing the diamond grains onto the adhesive material, dispersing the braze powder onto the adhesive material between the diamond grains, and dispersing the flux powder over or amongst the particles of grains and braze material. The tool body may then be heated in air to melt the braze material. The adhesive material may be any adhesive material capable of adhering the grains and particles of braze material to the tool body. For example, the adhesive material may vaporise at a temperature above about 400 degrees Celsius and may not substantially chemically react with the braze material and the grains. Depending on the form of the adhesive material, it may be

applied to the tool body by dipping the tool body in the adhesive or by applying the adhesive by brush, roller or other applicator, or the adhesive may also be sprayed onto the tool body. In some examples, additional adhesive material may be introduced and additional braze powder may be dispersed onto the adhesive material prior to heating the tool body. The method may include the further steps of heating the flux to melt it and cooling the flux to solidify it before the step of heating the tool body to melt the braze material.

The example method may include placing diamond grains onto a tool body by spraying a thin layer of adhesive material, such as conventional spray adhesive for use in the office, and sprinkling the grains onto this adhesive material, allowing any excess grains to fall off and be caught by a container positioned beneath the body. In so doing a substantially uniform distribution of diamond grains on the surface of the tool is achieved. A second step of optionally spraying further adhesive and then sprinkling a finer grain of diamond on to the tool to fill the gaps between the larger diamond grains could also be effected. Braze material provided in powder form may then be sprinkled onto the tool surface, adhering to the adhesive material between the diamond grains. If more braze material is needed, further adhesive material may be sprayed on top and more braze material sprinkled on top again. Flux material may be deposited in the same manner as the braze material and the diamond grains. Once the diamond grains, adhesive material and braze material (in a layer or layers) have been deposited onto the tool body, the braze material is heated to above its melting point. This may be done by slowly heating the tool to melt the flux, transforming the flux from a powder into a transparent glassy layer on the tool, sealing in the braze material and the diamond grains. The tool may then be cooled and reheated to re-melt the flux and to melt the braze material, which wets the tool surface and the diamond grains and bonds the diamond grains in place on the tool.

The disclosed method may have the aspect of making it easier to provide fine diamond grains, of the order of microns in size, with coating structures capable of being brazed in air.

While wishing not to be bound by a particular theory, the presence of the chromium may enhance oxidation resistance. The chromium may function to enhance the wetting the diamond body by the braze. At least part of chromium layer or

substantially all of the chromium layer may dissolve or dissipate once the braze material has melted. For example, substantially all of the chromium may alloy with the braze material. The dissolution, dissipation or alloying of the chromium would likely allow the molten braze material to react with carbon at the surface of the diamond body, resulting in a construction comprising a layer of braze material bonded to the diamond body once the braze material has solidified.

A non-limiting example is described in more detail below.

Example

The following materials and components were provided: a tool body for a twist drill, comprising high speed steel and having a diameter of about 10 millimetres; a plurality of synthetic diamond grains having mean size in the range of about 400 microns to about 600 microns; high temperature flux material in powder form and a sprayable adhesive material suitable for general purpose arts and crafts were also provided; and braze material in powder form, consisting of about 7 weight per cent chromium, about 3 weight per cent boron, about 4.5 weight per cent silicon, about 3 weight per cent iron and rest of the braze material consisting of nickel (the braze material used was commercially available under the trade Nicrobraze™). An induction brazing apparatus was used.

The tool body was sandblasted with glass (although shot could also be used), ultrasonically cleaned in alcohol for about 5 minutes and then rinsed. The adhesive material was applied onto a region of the tool body intended for the diamond grains to be bonded thereon. The purpose of the adhesive was to hold the diamond grains in place on the drill bit.

While the adhesive was still sticky, the diamond grains were sprinkled onto the drill bit while the drill bit was being rotated. The process was repeated to achieve substantially uniform coverage of diamond grains on the tool body.

While the adhesive material was still sticky, the braze powder was sprinkled over the tool body to attach the powder to the tool body in the spaces between the diamond

grains. The tool body was again sprayed with adhesive material and more braze powder sprinkled onto it.

After the braze powder was applied, the body was again sprayed with adhesive and the flux powder was then sprinkled over the tool body while it was being rotated, achieving a substantially uniform coverage of flux powder.

The tool body was secured by means of a clamping mechanism. An induction coil was placed proximate the tool body and the power applied to the coil was increased in stages. Initially a relatively low power was applied, sufficient for partially melting the braze material such that the diamond grains were retained on the tool body. The power was then increased sufficiently for completely melting the flux material on the drill bit, after which the power was increased to melt all of the braze.

The tool body was allowed to cool, providing a drill bit comprising a substantially uniform layer of diamond grains brazed onto the tool body.

Certain terms and concepts as used herein are briefly explained below.

Brazing is process for joining one body to another, including disposing braze material between the bodies and heating it to slightly above its melting (liquidus) temperature. The brazing process may be carried out in the presence of flux material.

Braze material generally comprises or consists of metal alloy material capable of bonding chemically to the bodies to be joined, and will generally be selected such that in the molten state, the braze material will be suitable for flowing over and wetting the surfaces of the bodies to be joined, which may be suitably prepared for the braze material (as used herein, an alloy is a solid or liquid mixture of a metal material with a second material, which may be a non-metal material, such as carbon, a metal material). When the braze material is subsequently cooled to solidify, it will provide a braze structure connecting the bodies.

Certain examples of braze material may comprise nickel and chromium, such braze materials being designated to the BNi family of braze material according to the American Welding Society (AWS) specification. Braze materials containing nickel

and chromium, and example of which is available in powder form under the trade name Nicrobraz™ LM™, are likely to exhibit superior resistance to oxidation resistance.

Flux material may function to removing oxide compounds from the surfaces to be brazed and may provide a kind of seal operative to preventing or reduce oxidation. The flux material may have the effect of cleaning contamination from the surfaces to be brazed. Flux material can be applied in any number of forms including flux paste, powder or pre-made brazing pastes comprising flux material with braze material. Flux materials may generally be selected based on their suitability for use with particular base metals, and their compatibility with the materials comprised in the bodies to be joined and the braze material.

As used herein, joining a diamond body to another body by means of brazing involves formation of covalent chemical bonds between carbon comprised at the surface of the diamond body and braze material, in which carbide compounds are produced at the surface of the diamond body. Braze material may comprise metal alloy suitable for brazing and may include compatible flux and or additive material.

Claims

1. A method of making a construction comprising a diamond body joined to carrier body, the method including disposing chromium adjacent a surface of diamond material comprised in the diamond body, and joining the diamond body to the carrier body by means of braze material, in an atmosphere containing oxygen.

2. A method as claimed in claim 1, in which the construction is comprised in a component for a tool

3. A method as claimed in claim 1 or claim 2, including depositing material comprising chromium directly onto the surface of the diamond material, the chromium being in elemental form, and forming a layer structure comprising the chromium on the surface of the diamond body.

4. A method as claimed in claim 3, in which the layer structure has a mean thickness in the range of 0.01 micron to 5 microns.

5. A method as claimed in any of the preceding claims, in which the braze material comprises nickel.

6. A method as claimed in any of the preceding claims, in which the melting point of the braze material is at most 1,200 degrees Celsius.

7. A method as claimed in any of the preceding claims, in which the diamond body is joined to the carrier body by a braze structure.

8. A method as claimed in claim 1, in which the construction is comprised in a component for a tool, in which the diamond body is joined to the carrier body by a braze structure; the method including depositing a layer comprising chromium in elemental form directly onto the surface of the diamond material, the layer having a mean thickness in the range of 0.01 micron to 5 microns; the braze material comprising nickel and having a melting point of at most about 1,200 degrees Celsius.

9. A method as claimed in any of the preceding claims, including forming a pellet comprising the diamond body and the braze material.

10. A method as claimed in any of the preceding claims, in which the braze material comprises chromium.

11. A method as claimed in any of the preceding claims, including depositing chromium onto a surface of the diamond body by means of physical vapour deposition.

12. A method as claimed in any of the preceding claims, in which the diamond body comprises a diamond grain.

13. A method as claimed in any of the preceding claims, including combining a plurality of diamond grains with a paste comprising the braze material.

14. A method as claimed in any of the preceding claims, in which the diamond body comprises directly inter-bonded diamond grains.

15. A method as claimed in any of the preceding claims, in which the diamond body comprises a plurality of diamond grains dispersed in a matrix.

16. A method as claimed in any of the preceding claims, in which the carrier body comprises a bead for a wire saw, a segment for a saw blade, a grinding wheel, or a drill body.

17. A method as claimed in any of claims 1 to 15, in which the construction is comprised in a saw tool, a drill, a wear part, a grinding tool, a dresser tool, a router, a polishing tool, a single point turning tool, a gauge component, a hard facing structure, a sintered segment containing natural or synthetic diamond, a bushing, a cutting disc, a dental burr or an edge profiler.

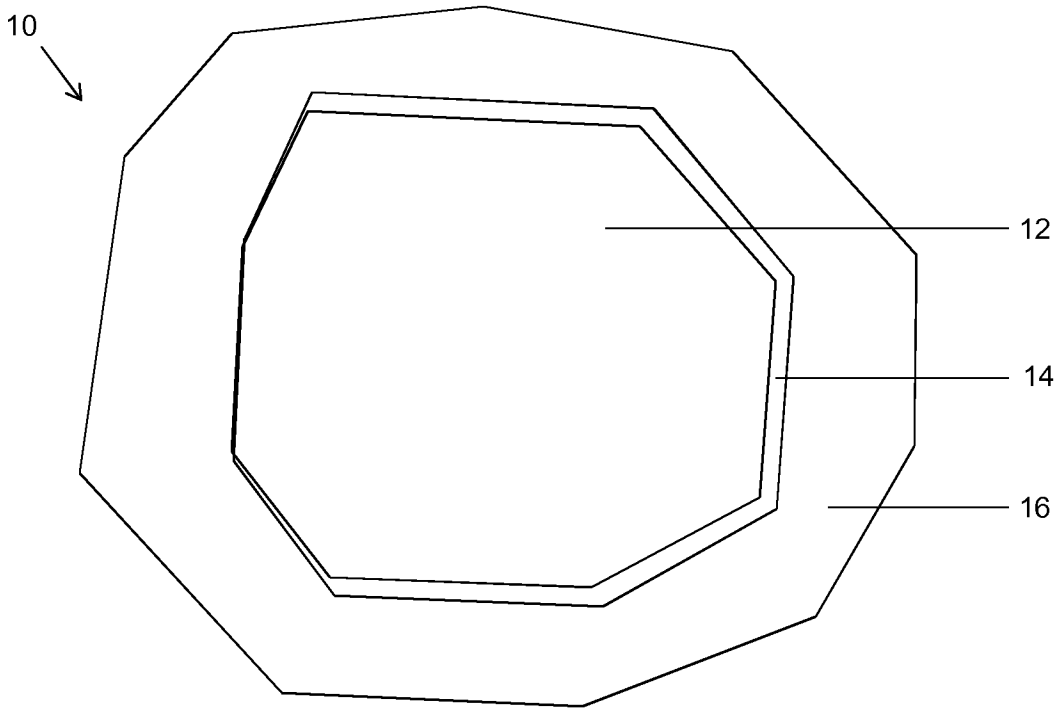


Fig. 1

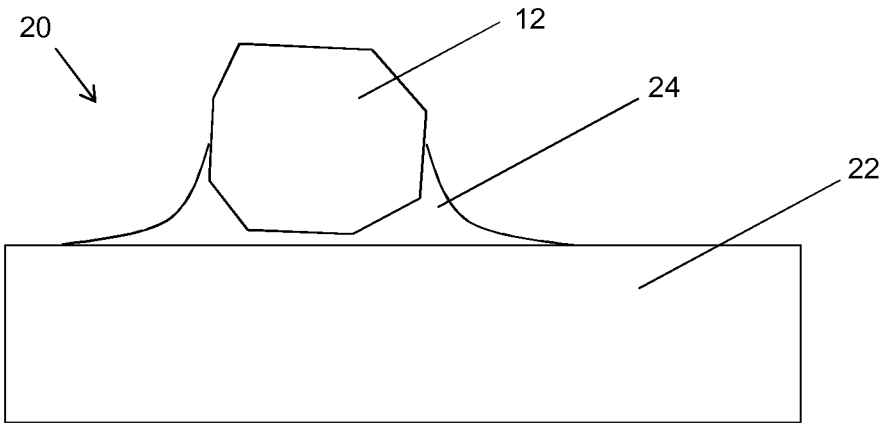


Fig. 2

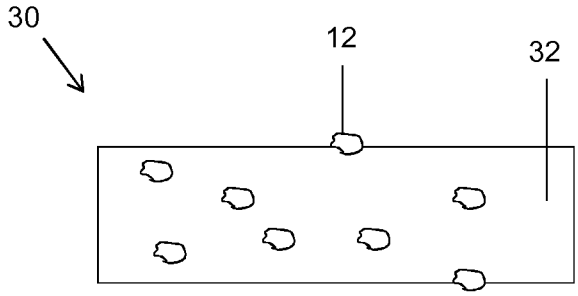


Fig. 3

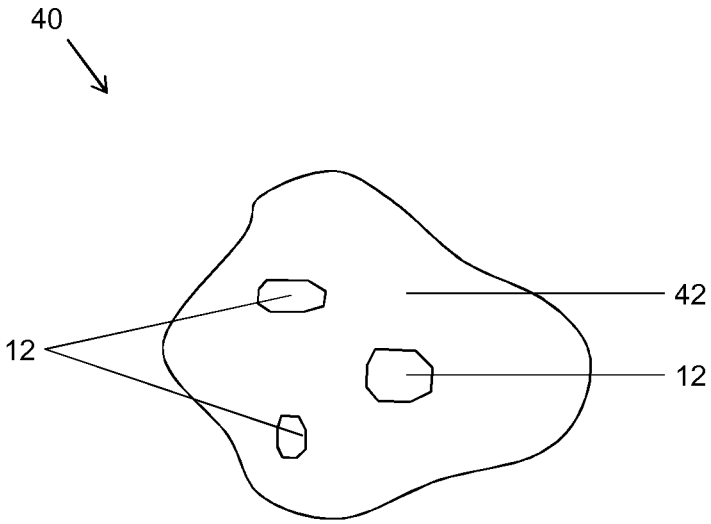


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/067851

A. CLASSIFICATION OF SUBJECT MATTER
INV. B23K35/32 B22F1/02 B24D3/06 B23K35/02 B24D18/00
C22C26/00
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B24D C22C B23K C09K B22F E21D B23D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 529 805 A (IACOVANGELO CHARLES D [US] ET AL) 25 June 1996 (1996-06-25) column 1, lines 14-17 column 2, lines 40-63 column 3, lines 3-19 column 4, lines 1-20 column 4, line 40 - column 5, line 3 column 5, line 14 - column 6, line 67 -----	1-4,6-8, 11,14, 16,17
X	EP 0 533 444 A2 (GEN ELECTRIC [US]) 24 March 1993 (1993-03-24) column 1, lines 8-16 column 2, line 53 - column 3, line 12 column 4, line 32 - column 7, line 47 column 9, lines 24-34 claims 1-5,7,9,13,16 ----- -/--	1-3, 5-10,12, 13,15-17

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 November 2013	22/11/2013

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/067851

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 117 968 A (NAIDICH JURY VLADIMIROVICH ET AL) 3 October 1978 (1978-10-03) column 1, lines 5-16 column 2, line 23 - column 3, line 24 column 3, line 50 - column 6, line 7 -----	1-4,6-8, 11,14,17
X	WO 01/23630 A1 (3M INNOVATIVE PROPERTIES CO [US]) 5 April 2001 (2001-04-05) page 1, lines 5-33 page 2, line 25 - page 6, line 9 page 7, line 7 - page 10, line 20 claims 1,7,11,15,17 -----	1-4,7,8, 11-13, 15-17
X	US 5 609 286 A (ANTHON ROYCE A [US]) 11 March 1997 (1997-03-11) column 1, lines 10-15 column 2, lines 3-63 column 3, line 10 - column 4, line 58 -----	1-3,5-8, 11-13, 15-17

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2013/067851

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5529805 A	25-06-1996	NONE	
EP 0533444 A2	24-03-1993	AT 147308 T	15-01-1997
		AU 2355992 A	25-03-1993
		BR 9203671 A	13-04-1993
		CN 1071113 A	21-04-1993
		DE 69216519 D1	20-02-1997
		DE 69216519 T2	26-06-1997
		DK 0533444 T3	30-06-1997
		EP 0533444 A2	24-03-1993
		ES 2096046 T3	01-03-1997
		IL 103119 A	18-06-1996
		JP 3431646 B2	28-07-2003
		JP H05202353 A	10-08-1993
		US 5405573 A	11-04-1995
US 4117968 A	03-10-1978	NONE	
WO 0123630 A1	05-04-2001	AU 4064700 A	30-04-2001
		CA 2388457 A1	05-04-2001
		EP 1218556 A1	03-07-2002
		JP 4611590 B2	12-01-2011
		JP 2003510193 A	18-03-2003
		US 6416560 B1	09-07-2002
		WO 0123630 A1	05-04-2001
US 5609286 A	11-03-1997	AU 1507297 A	10-09-1998
		CA 2198985 A1	03-09-1998
		NZ 314392 A	26-06-1998
		US 5609286 A	11-03-1997