A method of producing metal coated diamond particles in which the coatings are strongly bonded to the diamond particles characterised in that a layer of an alloy consisting of a major proportion of a metal such as copper, nickel or iron and a minor proportion of a carbide-forming metal such as titanium, chromium or vanadium is applied to the uncoated particles and then the coated particles are heat treated to a temperature of between 500°C and a temperature just below the melting point of the alloy for a time sufficient to enable a bonding carbide layer to form at the alloy/diamond interface, the steps being carried out in a non-oxidising atmosphere. The invention further provides diamond particles having bonded thereto an alloy comprising a major proportion of nickel and a minor proportion of a carbide-forming metal such as titanium, chromium or vanadium, the bonding being achieved by means of a carbide layer, which is preferably continuous, at the alloy/diamond interface.
METHOD FOR METAL COATING DIAMONDS SO AS TO IMPROVE THE INTERFACIAL BOND STRENGTH

This invention relates to the metal coating of diamond.

Very extensive use is made of diamond in abrasive tools such as crowns, single point tools, resin and metal bond wheels, saws and compacts. Considerable amount of research has gone into improving the bonding properties of the diamond to the matrices of these tools as a poor bond at the diamond/matrix interface leads to dislodgment of the diamond from the matrix during the abrading operation. This research has led to the development of metal coated diamond particles which find application particularly in resin bond wheels. Such metal coated particles have been found to have retention properties in resin bond wheels which are superior to uncoated diamond particles. However, research continues in an effort to improve the bond strength of the metal/diamond interface, thereby to improve the retention properties of diamond in the matrices of abrasive tools.

It is an object of this invention to provide a method of bonding an alloy to diamond which provides a strong interfacial bond between the alloy and the diamond.

It is a further object of the invention to provide a novel metal coated diamond particle. According to the invention, there is provided a method of producing a metal coated diamond particle including the steps of applying a layer of an alloy comprising a major proportion of a first metal and a minor proportion of a carbide-forming metal to an uncoated particle and heat treating the particle at a temperature in the range of from 500°C to a temperature just below the melting point of the alloy for a time sufficient to enable a bonding carbide layer to form at the alloy/diamond interface, the steps being carried out in a non-oxidising atmosphere.

It has been found that the bond strength of the alloy/diamond interface is a function of the temperature of heat treatment, the period of heat treatment and the concentration of carbide-forming metal in the alloy and that by suitably controlling these factors the bond strength can be maximised. Bond strengths in excess of 10 kg/mm² can be achieved.

In order to achieve maximum bond strength it is preferred to provide sufficient carbide-forming metal in the alloy for a continuous carbide layer to be formed at the diamond/alloy interface. The amount necessary to achieve this will vary with the depth of the alloy layer. For example it has been found that for alloy depths of about 1000 A, a carbide-forming metal content of between 10 and 30 percent by weight of the alloy produces a continuous layer of carbide at the diamond/alloy interface after the heat treatment.

The first metal may be any suitable metal for coating diamonds, for example copper, nickel or iron.

The carbide-forming metal is preferably a transition metal and preferably one selected from the group of titanium, vanadium and chromium.

The amount of alloy layer which is applied to the diamond particle will vary according to the particle and the application to which the coated particle is to be put. The choice of a particular amount for a particular situation is, however, well within the knowledge of one skilled in the art.

The particles may be in the form of large particles or grit such as RD, SD, or MD grit. The coated grit is particularly suited for use in resin bond and metal bond wheels, saws and compacts. The coated larger particles find application in crowns and single point tools.

The non-oxidising atmosphere may be provided by helium, argon, hydrogen, nitrogen or a vacuum of the order of 10⁻² mm Hg.

The layer of alloy may be applied to the diamond particles using known deposition techniques such as vacuum evaporation or sputtering techniques. These techniques are well known in the art and descriptions of them can be found in such references as "Vacuum Deposition of Thin Films" by L. Holland, Chapman and Hall, 1st Edition 1956.

Any temperature in the above described range can be used. The upper limit of the range of preferably about 50°C below the melting point of the alloy. However, where high melting alloys are used, the temperature is preferably maintained below the graphitization temperature of diamond.

According to another aspect of the invention, there is provided a diamond particle having bonded thereto a layer of an alloy comprising a major proportion of nickel and a minor proportion of a carbide-forming metal, the bonding being achieved by means of a carbide layer at the alloy/diamond interface. The bonding carbide layer is preferably a continuous layer.

The carbide forming metal is preferably chosen from those described above.

An outer layer of nickel or metal capable of alloying with nickel will preferably be provided on the outer surface of the alloy layer. The choice of metal and the amount of it in the outer layer will depend on the application to which the coated particle will be put. One skilled in this art can, however, readily make these choices. The outer layer can be deposited on the alloy-coated particle using known deposition techniques such as electrolytic or electroless deposition techniques or the vacuum deposition techniques described above.

The invention will be illustrated by the following non-limitative examples.

EXAMPLE 1

In order to illustrate the maximisation of the bond strengths at the diamond/alloy interface certain experiments were carried out on diamond plaques.

Nickel and copper based alloys were bonded to the diamond plaques. In each case, the relevant alloy was made in a conventional manner and then swaged into an ingot of a desired diameter, e.g. 1.5 mm. The ingot was then cut into required lengths and a length placed on the diamond which in turn rested on a graphite anvil in a chamber consisting of a quartz tube clamped between water cooled top and bottom brass plates. The chamber was evacuated by a rotary pump to 10⁻¹⁹ mm Hg or better pressure and maintained at this pressure during heating. A silica piston entered the vacuum chamber through a Wilson seal in the top plate and was used to apply pressure to the samples on the anvils. The pressure applied was sufficient to provide intimate contact between the alloy and the diamond equivalent to coating. The pressures used varied between about 3 to about 7.5 kg/mm². Induction heating was then used to raise the temperature of the chamber to the desired temperature i.e., 700°C or 800°C. Excellent solid phase
bonding between the alloy and the diamond resulted in each case.

Using this method optimum conditions have been determined for a number of nickel and copper based alloys.

In all cases, the temperature was 800°C, save for the Cu-Ti alloy in which the temperature was 700°C.

1. Cu-Ti: 0.54 wt % Ti. Optimum time about 5 hours.
   Bond strength 24.2 kg/mm².
2. Cu-Cr: 0.22 wt % Cr. Optimum time about 1.5 to 2.0 hours. Bond strength 21.4 kg/mm².
3. Nichrome V (80% by weight nickel and 20% by weight chromium): Optimum time about 2 hours.
   Bond strength 14.2 kg/mm².
4. Ni-Ti: 1 wt % Ti. Optimum time about 0.5 hours.
   Bond strength 28.3 kg/mm².
5. Ni-V: 0.83 wt % V. Optimum time about 2 hours.
   Bond strength 26.2 kg/mm².

The bond strengths i.e. interfacial tensile strengths, were measured in a standard manner using a shearing jig to which was attached a Hounsfield tensometer.

EXAMPLE 2

40–50 mesh MD diamond grit was coated with a layer of nickel-titanium alloy (1 percent by weight titanium) using known vacuum sputtering techniques described in the Holland reference mentioned above. A layer amounting to 1 to 2 percent by weight of the uncoated particle was deposited. The coated particles were heat treated at a temperature of 800°C for half an hour in a vacuum furnace (10–4 mm/Hg).

A layer of nickel was then deposited on the treated grit using known electroless deposition techniques. The nickel layer amounted to 20 percent by weight of the alloy-coated particle.

For purposes of comparison, pure nickel coated grit of the same size was prepared using the same electroless deposition techniques. The nickel coating amounted to 20 percent by weight of the uncoated grit.

The two types of coated grit were incorporated in saws and sawing tests carried out. It was found that the saw containing the grit having the alloy layer showed twelve percent less wear than the other saw.

EXAMPLE 3

RD diamond grit was coated with a nickel-titanium alloy (1 percent by weight titanium) and a nickel outer coat using the same method as in Example 2, except that the nickel layer amounted to a 55 percent by weight of the alloy-coated grit.

Similarly, RD grit was coated with a 55 percent pure nickel coating. The two types of grit were incorporated in resin bond wheels. During grinding tests it was observed that the diamond grit was never pulled out of its coating in the case of the alloy coatings, whereas this did occur with the pure nickel coated particles. This test illustrates the strength of the diamond/alloy interfacial bond.

EXAMPLE 4

A layer of nickel-chromium alloy (10 percent by weight nickel) was deposited on diamond plaques using sputtering techniques. The coated plaques were heat treated at 800°C for 2 hours. A nickel overlayer was electrolytically deposited on the alloy layer.

The diamond/alloy interfacial tensile strength or bond strength was found to be 10 kg/mm² using the same apparatus as that described in Example 1.

We claim:

1. A method of producing a metal coated diamond particle including the steps of applying to an uncoated diamond particle a layer which in the as-applied condition is an alloy comprising a major proportion of a metal selected from copper, nickel and iron and a minor proportion of a carbide-forming metal selected from titanium, chromium and vanadium sufficient to form a continuous carbide layer around the diamond particle, and heat treating the particle to a temperature in the range of from 500°C to a temperature just below the melting point of the alloy for a time sufficient to produce a continuous bonding carbide layer at the alloy/diamond interface and an interface bond strength in excess of 10 kg/mm², the steps being carried out in a non-oxidizing atmosphere.

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