

AUSTRALIA

Patents Act 1990

654588

## REQUEST FOR A STANDARD PATENT

The Applicant identified below requests the grant of a patent to the nominated person identified below for an invention described in the accompanying standard complete patent specification.

[70,71]Applicant and Nominated Person:

De Beers Industrial Diamond Division (Proprietary) Limited  
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[54]Invention Title:

TOOL INSERT

[72]Names Of Actual Inventors:

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[31,33,32]

Details of basic application(s):-

|           |                |    |                   |
|-----------|----------------|----|-------------------|
| 9122963.1 | UNITED KINGDOM | GB | 30 October 1991   |
| 9219775.5 | UNITED KINGDOM | GB | 18 September 1992 |

The nominated person is not an opponent or eligible person described in section 33-36 of the Act

28 October 1992

PHILLIPS ORMONDE & FITZPATRICK

Attorneys for:

De Beers Industrial Diamond Division (Proprietary) Limited

By:

*David B Fitzpatrick*

Our Ref : 308817

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NOTICE OF ENTITLEMENT

INSTRUCTIONS

(a) Name of person making statement.

(b) Position of that person.

(c) Name of applicant

(d) Address of applicant

(e) Delete as necessary

(f) Insert details if not covered by (i) or (ii)

(g) Delete as necessary

(h) Delete for non-convention applications

(i) Insert DATE of signing

(j) Signature(s) of person making statement

I (a) PIETER DE JAGER

(b) DIRECTOR

of (c) DE BEERS INDUSTRIAL DIAMOND DIVISION  
(PROPRIETARY) LIMITED

of (d) DEBID HOUSE, CORNER AMETHYST STREET & CROWNWOOD ROAD,  
THETA, JOHANNESBURG, TRANSVAAL, SOUTH AFRICA

State the following:-

1. The nominated person (applicant) is entitled to the grant of a patent  
(e) (i) as assignee of the actual inventor(s)  
(ii) ~~by contract of employment of the actual inventor(s)~~  
or (iii) (f)

2. The nominated person (applicant) is entitled to claim priority from the basic convention application(s).  
(g) (i) as applicants of the said application(s)  
(ii) ~~as the assignee of the applicants of the said application(s)~~  
(iii) ~~with the consent of the applicants of the said application(s)~~

3. The basic convention application(s) was/were the first made in a Convention country in respect of the invention the subject of the application. (h)

Dated (i) 21 OCTOBER, 1992

(j)

PIETER DE JAGER

Note: No legalization or other witness required

To: The Commissioner of Patents

PHILLIPS ORMONDE AND FITZPATRICK  
Patent and Trade Mark Attorneys  
367 Collins Street  
Melbourne, Australia



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(12) PATENT ABRIDGMENT (11) Document No. AU-B-27375/92  
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 654588

(54) Title  
TOOL INSERT

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(71) Applicant(s)  
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(56) Prior Art Documents  
US 5137398  
US 4497639  
US 4301132

(57) A tool insert comprises a diamond layer (10) bonded to a surface (12) of a substrate (14), the substrate (14) being a bonded silicon carbide ceramic containing 7 to 12 percent by mass free silicon. The diamond of the layer (10) is preferably CVD diamond.

**Claim**

1. <sup>layer of</sup>  
A tool insert comprises a <sup>layer of</sup> diamond ~~layer~~ bonded to a surface of a substrate, the substrate being a bonded silicon carbide ceramic containing 7 to 12 percent by mass free silicon.

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COMPLETE SPECIFICATION  
(ORIGINAL)

654588

Application Number:  
Lodged:

Class

Int. Class

Complete Specification Lodged:  
Accepted:  
Published:

Priority

Related Art:

Name of Applicant:

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Invention Title:

TOOL INSERT

Our Ref : 308817  
POF Code: 1503/78726

The following statement is a full description of this invention, including  
the best method of performing it known to applicant(s):

### BACKGROUND OF THE INVENTION

This invention relates to a tool insert and more particularly to an insert for a cutting tool.

Tool inserts are known in which a full layer of diamond is applied to a surface of a suitable substrate using chemical vapour deposition (hereinafter referred to as "CVD"). The substrates for such tool inserts are generally ceramic in nature such as cemented carbide, silicon nitride, sialon, silicon carbide, or the like.

One of the major problems with tool inserts of this nature is that it is difficult to achieve a good and consistent bond between the diamond layer and the substrate and in some cases the bond may degrade.

Japanese Patent Abstract No. 61-291493 describes the use of a silicon nitride or silicon carbide substrate as a base for depositing a layer of CVD diamond thereon. No mention is made of the nature of the silicon carbide.

### SUMMARY OF THE INVENTION

According to the present invention, there is provided a tool insert comprising a <sup>layer of</sup> diamond layer, preferably a CVD diamond layer, bonded to a surface of a substrate, the substrate being a bonded silicon carbide ceramic containing 7 to 12 percent, preferably 10 to 11,5 percent, by mass of free silicon.

### BRIEF DESCRIPTION OF THE DRAWINGS

- Figure 1 is a plan view of an embodiment of a tool insert;  
Figure 2 is a section along the line 2-2 of Figure 1; and  
Figure 3 is a perspective view of a ~~third~~<sup>second</sup> embodiment of a tool insert.

### DESCRIPTION OF EMBODIMENTS

It has been found that if the free silicon content of the bonded silicon carbide ceramic substrate is within the range specified above, a consistently strong bond between the diamond layer and the substrate can be achieved, particularly for CVD diamond layers. The free silicon will be uniformly distributed through the ceramic with a substantial absence of any pools of free silicon.

The diamond layer may be deposited on a surface of the bonded silicon carbide ceramic substrate using any known CVD method. In CVD methods, a gaseous carbon compound in the presence of hydrogen or oxygen is decomposed creating a plasma containing carbon ions or



radicals which deposit on the surface of the substrate to form diamond. The gaseous carbon compound may be decomposed by RF or microwave energy, or by heat using a hot filament. These methods are all well established and described in the literature.

The silicon carbide particle size of the bonded silicon carbide ceramic is preferably fine to minimise edge chipping of the tool insert in use. The preferred particle size range for the silicon carbide is 2 to 50 microns, preferably 5 to 30 microns.

The diamond layer may have any suitable thickness, but will generally have a thickness of less than 100 microns. Diamond layer thicknesses of 20 to 30 microns have proven to be particularly suitable. The diamond particles in the layer will typically have a size of 2 to 10 microns.

The substrate has a layer of the diamond deposited on a surface thereof. The diamond layer presents a cutting edge or point for the tool insert. In one preferred form of the invention, the substrate has major flat surfaces joined by a side surface, the diamond layer being applied to at least part of one of the major flat surfaces. Generally, that diamond layer will cover the entire major flat surface to which it is applied. It is preferred that the diamond layer is polished.

In another preferred form of the invention, the substrate has major flat surfaces joined by a side surface and a diamond layer is applied to at least part of one of the major flat surfaces such that it continues over an edge between that major flat surface and the side surface. The edge

may have a radius in which event the portion of the diamond layer applied to the edge will have a complementary radius. If the diamond layer which is applied to the major flat surface is polished, polishing has the effect of reducing and sharpening the diamond layer radius. Improved cutting edge sharpness is achieved.

The tool insert may be used for a variety of cutting operations such as turning, milling and drilling. The tool inserts are particularly useful for cutting non-ferrous abrasive materials.

An example of a suitable bonded silicon carbide ceramic is one which has a free silicon content of 11,4 percent by mass and 87,9 percent by mass of silicon carbide uniformly distributed through the ceramic and the following physical, mechanical and thermal properties:

#### **Physical Properties**

|                      |                        |
|----------------------|------------------------|
| Density              | 3,10 g/cm <sup>3</sup> |
| Open porosity        | 0%                     |
| Grain size (average) | 10μm                   |

#### **Mechanical Properties**

|                                  |         |    |        |
|----------------------------------|---------|----|--------|
| Flexural strength (3 point bend) | 400 MPa | at | 20°C   |
| Flexural strength (3 point bend) | 400 MPa | at | 1000°C |
| Tensile modulus                  | 390 GPa | at | 20°C   |
| Poissons ratio                   | 0.24    |    |        |
| Compressive strength             | 2000MPa | at | 20°C   |

|                             |                        |    |      |
|-----------------------------|------------------------|----|------|
| Fracture toughness $K_{Ic}$ | 4 MPam <sup>1/2</sup>  | at | 20°C |
| Hardness Hv (50g load)      | 3000Kg/mm <sup>2</sup> |    |      |

### Thermal Properties

|                               |                                     |    |      |
|-------------------------------|-------------------------------------|----|------|
| Thermal conductivity          | 150Wm <sup>-1</sup> K <sup>-1</sup> | at | 20°C |
| Specific heat                 | 1100 J/kg°C                         |    |      |
| Thermal expansion coefficient | 4.3x10 <sup>-6</sup> /°C            |    |      |

The product Refel F® is an example of such a bonded silicon carbide ceramic.

Embodiments of the invention will now be described with reference to the accompanying drawings. Referring first to Figures 1 and 2, a tool insert comprises a diamond layer 10 bonded to the top flat surface 12 of a substrate 14. The substrate also has a bottom flat surface 15. The diamond layer 10 continues over the edge 16 of the substrate and down at least part of the side surface 18. The edge 16 has a radius and the portion 20 of the diamond layer which passes over the edge 16 has a complementary radius.

The portion of the diamond layer 10 which is bonded to the surface 12 is polished creating a polished table 22. Figure 2 shows the original top surface of the diamond layer 10 in dotted lines, while the solid line 22 illustrates the polished table. It will be noted that polishing has the effect of reducing the diamond edge radius 20 and thus improves the edge sharpness. It is this diamond edge 20 which provides the cutting edge for the tool insert.

The tool insert illustrated by Figures 1 and 2 has a triangular shape in plan. The tool insert may have other shapes such as square and rectangular.

Further, the surface 12 of the substrate 14 of Figures 1 and 2 is flat. This surface may have other shapes. The diamond layer 10 will follow such other shapes.

A second embodiment of the invention is illustrated by Figure 3. In this embodiment, a diamond layer 24 is bonded to the top surface 26 of a substrate 28. The diamond layer and substrate are cut away along line 30 to produce a sharp diamond cutting edge 32. The sharpness of the edge 32 is dictated by the angle of cut-away 30. The dotted lines illustrate the original shape of the bonded product from which the tool insert was produced.

The diamond layer in the embodiments illustrated in Figures 1 to 3 is preferably a CVD diamond layer. The method of producing the CVD diamond layer may be any known in the art.

In an embodiment of the invention, a tool insert of the type illustrated by Figures 1 and 2 was manufactured by providing a bonded silicon carbide ceramic substrate having the composition and the physical, mechanical and thermal properties as set out above. A layer of CVD diamond was deposited on the surface 12 of the substrate using microwave energy to decompose a hydrogen/carbon monoxide mixture (80sccm hydrogen and 20sccm carbon monoxide) at a pressure of 20 Torr. A 20 to 30 micron thick diamond layer was deposited on the

surface 12. It was found that the diamond layer adhered strongly to the substrate and performed well in the cutting of an aluminium-20 percent silicon test piece. This was so not only immediately after the tool insert had been produced, but even after a period of five months. Further, ageing, tensile fractures and delamination of the diamond film on the silicon carbide substrate had not manifested themselves either optically or by SEM (scanning electron microscopy) after a period of five months.

Similar tool inserts were produced using different gaseous carbon/hydrogen mixtures. For example, the following mixtures and pressures were used:

| $H_2$<br>(sccm) | Ar<br>(sccm) | $CH_4$<br>(sccm) | Pressure<br>(Torr) |
|-----------------|--------------|------------------|--------------------|
| 200             | 200          | 60               | 80                 |
| 200             | 200          | 4                | 75                 |
| 200             | 200          | 6                | 150                |
| 750             | 1440         | 14               | 130                |

In each case, a tool insert comprising a CVD diamond layer strongly bonded to the silicon carbide substrate was produced.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1.  
A tool insert comprises a <sup>layer of</sup> diamond ~~layer~~ bonded to a surface of a substrate, the substrate being a bonded silicon carbide ceramic containing 7 to 12 percent by mass free silicon.
2.  
A tool insert according to claim 1 wherein the <sup>layer of</sup> diamond is CVD diamond.
3.  
A tool insert according to claim 1 or claim 2 wherein the bonded silicon carbide ceramic contains 10 to 11,5 percent by mass free silicon.
4.  
A tool insert according to any one of the preceding claims wherein the particle size of the silicon carbide is in the range 2 to 50 microns.
5.  
A tool insert according to any one of claims 1 to 3 wherein the particle size of the silicon carbide is in the range 5 to 30 microns.
6.  
A tool insert according to any one of the preceding claims wherein the thickness of the diamond layer is less than 100 microns.



7.

A tool insert according to claim 6 wherein the thickness of the diamond layer is in the range 20 to 30 microns.

8.

A tool insert according to any one of the preceding claims wherein the size of the particles in the diamond layer are in the range 2 to 10 microns.

9.

A tool insert according to any one of the preceding claims wherein the substrate has major flat surfaces joined by a side surface, the diamond layer being applied to at least part of one of the major flat surfaces.

10.

A tool insert according to claim 9 wherein the diamond layer covers the entire major flat surface to which it is applied.

11.

A tool insert according to claim 9 or claim 10 wherein the diamond layer is polished.

12.

A tool insert according to claim 9 or claim 10 wherein the diamond layer continues over an edge between the major flat surface to which it is applied and the side surface of the substrate.

13.

A tool insert according to claim 12 wherein the portion of the diamond layer which is applied to the major flat surface is polished.

14.

A tool insert according to claim 13 wherein the edge of the substrate has a radius and the portion of the diamond layer applied to the edge has a complementary radius, the diamond layer radius being reduced and sharpened by the polishing.

15.

A tool insert substantially as herein described with reference to any one of Figures 1 to 3 of the accompanying drawings.

DATED: 27th October, 1992

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### ABSTRACT

A tool insert comprises a diamond layer (10) bonded to a surface (12) of a substrate (14), the substrate (14) being a bonded silicon carbide ceramic containing 7 to 12 percent by mass free silicon. The diamond of the layer (10) is preferably CVD diamond.

27375/92

