

[54] **CUTTING DEVICE AND METHOD FOR MAKING SAME**

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[58] Field of Search 30/346.53, 346.54, 350; 148/6.3; 51/206 R; 204/192

[56] **References Cited**
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[57] **ABSTRACT**

A cutting device which may have a fine cutting edge including a metal or alloy blade of the desired sharpened form on which is deposited a hard cutting layer of thickness less than one micron, the cutting layer being of hard particles having a Vickers microhardness greater than 1000 kg/mm² embedded in a codeposited metal or alloy matrix. Methods for producing such cutting devices are also disclosed.

5 Claims, 4 Drawing Figures

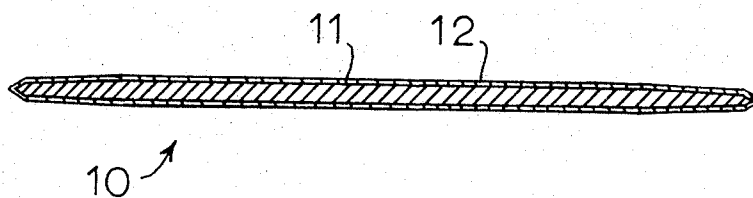


FIG. 1

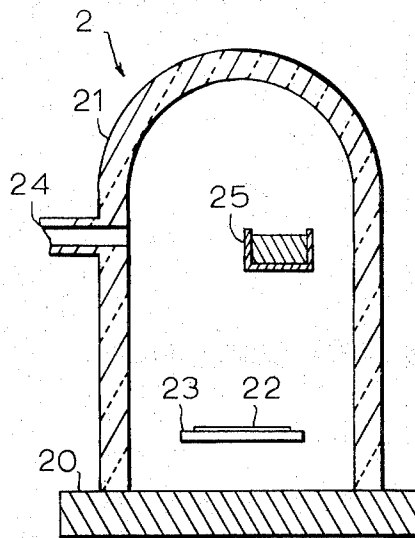
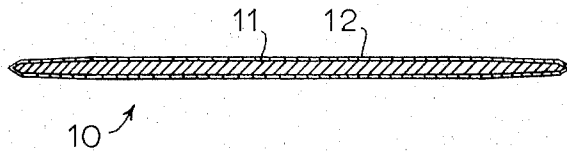


FIG. 2

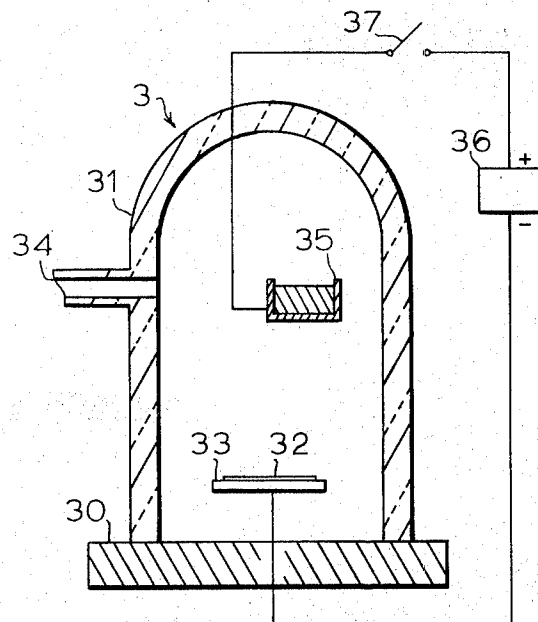


FIG. 3

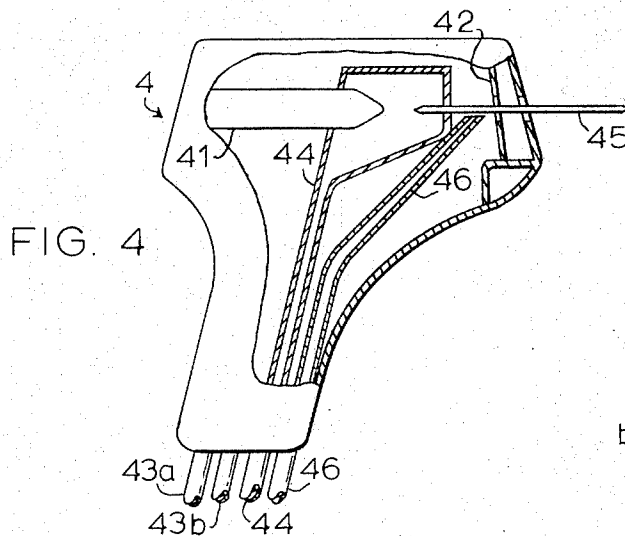


FIG. 4

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CUTTING DEVICE AND METHOD FOR MAKING SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to improvements in cutting devices and more particularly to improved cutting devices which have acute angle cutting edges coated with an extremely hard adherent layer.

2. Description of the Prior Art

Razor blades made of a thin alloy base, such as stainless steel, for example, provided with a thin coating which is harder than the base, are known in the prior art. Such thin hard coatings of the known razor or industrial blades are, however, generally of a metal or alloy, such as, for example, chromium or the like.

Also, it has been proposed to produce razor blades and other devices requiring fine cutting edges by mixing binder particles, such as metals or ceramic oxides, with a metal carbide. Such blades, however, have never been successfully manufactured because the metal carbides, like many binders, are of ceramic nature, and a very thin cutting edge of these materials is not self-supporting, even with an unacceptably large percentage of binder.

Others have recommended coating flat cutting edges, such as dry shaver heads, with a thin layer of titanium carbide or titanium boride. Such coatings, also being of ceramic nature, do not adhere well to the base, and, being very brittle, crumble easily.

In the past, metal hard particulate material composites have been used successfully only in grinding tools or devices which have an adequate supporting thickness. For example, in grinding wheels having a coating thickness of 10 mm or more, and even in very small grinding wheels of such thickness of 2 mm or more (these dimensions are about 100,000 greater than the desirable coating thickness of a razor blade), the ceramic-like materials of interest herein are useable since they are self-supporting in such large thicknesses.

BRIEF DESCRIPTION OF THE INVENTION

In light of the above, it is a general object of the invention to provide a cutting device which has a very hard, acute angle cutting edge.

It is another object of the invention to provide a hard, long-lasting cutting edge including hard cutting particles which resist crumbling.

A further object of the invention is to provide a coating of hard particles and binding metal or alloy to produce a cutting edge having a fine texture for very smooth cutting.

Still another object is to provide methods by which thin and very hard cutting coatings can be deposited upon a base of the desired shape, like razor or industrial blades, microtome blades, or other such blades having such fine cutting edges.

These and other objects, features, and advantages, will become apparent to those skilled in the art from the following description, read in conjunction with the accompanying drawings and appended claims.

It has been found that the foregoing objects may be attained by introducing onto a metal base or substrate a codeposition of a thin metal or alloy layer and hard particulate material embedded therein. The base or substrate may be shaped to define an acute angle cut-

ting edge of the desired ultimate shape or configuration.

The thickness of the hard coating, determined by elasticity and strength requirements of the fine cutting edge desired, may be less than 1 micron thick and in many cases may be even less than 0.1 micron.

Such cutting edges are generally not re-grindable, due to the very thin coating which in many cases will be removed by grinding. Therefore, they may be particularly advantageously employed as disposable cutting devices such as razor blades, industrial blades, microtome knives and other devices with insertable blades, although thicker bladed or larger knives such as kitchen knives and the like may also be supplied with such cutting coatings, which, nonetheless, may withstand quite a few sharpenings when needed, since such cutting devices may not require resharpener for many years of usage. Such hard coating displaying cutting surfaces may also be employed in other acute angle cutting devices, such as scissors, electric carving knives, or the like.

Thus, in accordance with the invention, a new cutting device is disclosed which is formed of a shaped and sharpened metal or alloy base on which a fine texture of particles selected from the group consisting of metal oxides, carbides, borides, nitrides, and silicides, having a Vickers microhardness greater than 1000 kg/mm² and a binding metal or alloy matrix are codeposited.

BRIEF DESCRIPTION OF THE DRAWING

The invention is shown in the accompanying drawing, wherein:

FIG. 1 illustrates a cross-section of a razor blade having a hard cutting coating in accordance with a preferred embodiment of the invention;

FIG. 2 shows a low pressure evaporating-gas plating apparatus in accordance with the invention for forming the razor blade of FIG. 1;

FIG. 3 shows a cathode sputtering-gas plating apparatus in accordance with another preferred embodiment in practicing the method of the invention in forming the razor blade of FIG. 1; and

FIG. 4 shows a plasma gun for still another preferred method for forming the razor blade of FIG. 1.

In the drawing, various sizes and shapes of the parts have been exaggerated or distorted, or omitted entirely, for clarity of illustration and ease of description as will become apparent below.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the invention is illustrated in FIG. 1 in cross-section, showing therein a razor blade 10 having a base 11 provided with a cutting coating 12. The base 11 of the razor blade 10 may be made of a reasonably hard metal or alloy, such as stainless steel, or the like, and is coated with the cutting layer 12 containing the very fine hard particles in a metal or alloy matrix. The ultimate desired shape of the cutting edge is formed on the base 11 before the deposition of the very thin coating, although in some cases, it may be refined by grinding after the deposition and by possible diffusion alloying.

The binding metal or alloy in layer 12 serves primarily to fortify the cutting edge and its adherence to the base 11, the cutting role being practically negligible. Its adherence may be additionally increased in many cases

by a diffusion alloying. Practically any metal or alloy may be used for the binding material; however, metals or alloys of greater hardness and stronger resistance to atmospheric influences such as chromium, nickel, cobalt, noble metals, alloys like stainless steel, and so forth, are preferred.

The resistance to atmospheric influences is also very important in the selected hard particles, for if the thin composite layer is attacked by materials present in the atmosphere, the occurring chemical changes may ruin the shape and composition of the overall cutting layer. The hard particles embedded in the binder may be selected from the group consisting of metal oxides, carbides, borides, nitrides, and silicides. Table I shows the Vickers microhardness of some exemplary hard particles which may be advantageously employed.

TABLE I

Material	Vickers microhardness
	kg/mm ²
Molybdenum Disilicide, MoSi ₂	1100
Zirconium Dioxide, ZrO ₂	1300
Chromium Carbide, Cr ₃ C ₂	1300
Chromium Carbide, Cr ₇ C ₃	1500
Molybdenum Carbide, Mo ₂ C	1500
Zirconium Diboride, ZrB ₂	1800
Tungsten Carbide, WC	2000
Titanium Nitride, TiN	2100
Alumina, Al ₂ O ₃	2200
Chromium Trioxide, Cr ₂ O ₃	2250
Tungsten Boride, W ₂ B ₅	2650
Silicon Carbide, SiC	2700
Boron, B	2700
Titanium Carbide, TiC	2900
Hafnium Carbide, HfC	2900
Hafnium Diboride, HfB ₂	2900
Vanadium Carbide, VC	3000
Boron Carbide, B ₄ C	3000
Titanium Diboride, TiB ₂	3600

The method by which the composite layer of fine hard particles and the binding metal or alloy is codeposited, is of great importance. Such method should produce a strong and dense interwoven system of very fine particles of the hard material and binder, with the different materials wetting each other well to be bonded together with great adhesion forces.

It is also important that the percentages of the constituents of the cutting layer be within certain limits. Sufficient quantity of binding metal or alloy should be present to secure the coherence of the composite system to prevent the hard particles from crumbling away. On the other hand, sufficient quantity of hard particles should be in the composite system to obtain the desired hardness of the cutting edge. A volume percentage between 20 and 80 per cent fine hard particles has been found to be satisfactory in most cases to obtain the non-crumbling edge of desired hardness.

To obtain this hard edge, deposition processes are employed in which the deposited metals, alloys and compounds are formed on the surface of the base from individual neutral or ionized atoms, thereby creating a very strong adherence to the base and between the constituents of the coating, but which, at the same time, ensure that the interwoven texture of hard particles and binding metal or alloy is very fine. Consequently, the individually observable hard particles are extremely small (smaller than 500 Angstroms and, in most cases, smaller than 100 Angstroms), a precondition in many cases for a smooth and effective cutting surface.

In accordance with the invention, one method for obtaining a hard cutting edge includes the combination of metal evaporation and gas plating. As shown in FIG. 2, a low pressure evaporating-gas plating apparatus, generally denoted by the reference numeral 2, which includes on a base 20 a glass container 21 placed on the base 20. The cutting device 22 is located on a heatable holder 23 within the glass container 21 (heaters are not shown). The plating gases are fed into the glass container 21 through a tube 24. A boat 25 suspended within the container 21 is heated above the melting point of the bonding metal or alloy to a temperature at which, at the particular pressure within the chamber, the constituents of the binding alloy begin to evaporate. The base 22 for the cutting device to be plated is placed on the holder 23 within the container 21, and the apparatus is closed and evacuated. The holder 23 and the boat 25 are then heated to the required temperatures, and the plating gas mixture is entered through tube 24 into the apparatus. A composite layer containing the evaporated metal or alloy incorporating the fine hard particles is then deposited on one surface of the base 22. Dependant on the metals in the binding alloy the constituents of the plating gas, and the temperature of holder 23, a reaction between the metal atoms and plating gas constituents may also take place. In most cases, the presence of these additional compounds will not deteriorate the performance of the cutting device. However, such additional constituents should be limited only to acceptable ones or be completely averted by proper selection of the reacting materials and gases and of the temperature of the holder 23.

A second method for fabricating a fine-cutting edge by a cathode sputtering - gas plating apparatus 3 is shown in FIG. 3. A base 30 holds a glass container 31, and the cutting device 32 is placed on a heatable holder 33 (the heaters are not shown) within the container 31, and the container closed and evacuated. A tube 34 is provided into the interior chamber within the container 31, through which the plating gases may be entered and exhausted. A boat 35 is disposed above the holder 33 within the chamber 31. The holder 33 and the boat 35 are then heated to the required temperature, to vaporize the metals and alloys at the particular chamber pressure, and the plating gas mixture is entered into the apparatus through the tube 34. The current source 36 is then connected between the boat 35 and the holder 33 by switch 37, thus enabling the codeposition of the sputtered metal or alloy in boat 35 and of a hard compound deriving from the plating gases to take place on the working piece 32. Again, additional alloys or compounds may be deposited by reactions, between the plating gases and the evaporated metal atoms, which, of course, may be controlled by the proper selection of the starting materials and plating gases.

The current source 36 may be direct current if a continuous metal or alloy — fine particles structure is desired. On the other hand, if it is desired to develop larger particles of the hard cutting substance, the current source may be alternating current or pulses in one or two directions, etc., to temporarily slow down the metal or alloy deposition.

A third method for fine-cutting edge fabrication is by the combination of plasma-plating of the hard particles and the binding metal or alloy. A typical plasma-plating gun employable in the production of the cutting coating in accordance with the invention is shown in FIG.

4. The negative pole of the direct current source (not shown) is connected to the cathode 41 and the positive pole (not shown) to the anode 42, which also forms the nozzle of the gun. (The connecting cables are not shown.) The plasma producing area is water-cooled (not shown). The cooling water flows through the gun by entering through hose 43a and leaving through outlet hose 43b. A noble gas may be fed in through pipe 44 conducted to the area where the plasma 45 is generated. The material to be deposited, if solid, is furnished through tube 46. (If the material to be deposited is supplied in gas form, it enters together with the noble gas through pipe 44.)

Quite a number of atoms can be supplied to the plasma area in gas form, such as carbon as hydrocarbons, boron as boranes, germanium, silicon as hydrides or certain halides, tungsten as tungsten hexafluoride, WF_6 , and the like.

After deposition of the composite layer, in many cases it is desirable to fortify the bond between the base and coating. This can be accomplished, for example, by diffusion alloying the base with the binding metal or alloy of the coating. After the coating has been completed, the cutting device is heated up for this purpose in a protective atmosphere to a temperature at which the needed diffusion can be achieved in a reasonable time.

In the following examples, the coatings and processes according to this invention are illustrated. It is understood that the examples are presented herein only for the better understanding of the principles of the invention and it is not intended to limit the scope of the invention thereto. Other examples will become apparent to those knowledgeable in the art, based on generally discussed details of the invention.

EXAMPLE 1

The cutting layer of a razor blade is 0.04 micron thick and its composition is 70 percent by weight titanium diboride and 30 percent by weight rhodium. The base of the blade is a tantalum containing stainless steel type No. 347.

The deposition is carried out in a low pressure evaporating-gas plating combination apparatus 2 shown in FIG. 2. The tungsten boat 25 holding rhodium metal is heated up to 3200°C. The blade 22 is placed on holder 23 which is heated up to 1200°C. The following gas mixture is fed into the apparatus through tube 24:

50 cm^3/min boron trichloride, BCl_3

30 cm^3/min titanium tetrachloride, $TiCl_4$

2000 cm^3/min hydrogen, H_2 ,

while the pump of the apparatus (not shown in the drawing) is operated at a rate that the pressure in the chamber should be between 20 and 35 torr. The desired layer thickness is deposited in approximately 10 seconds. (The rhodium atoms do not react with the titanium and boron atoms at the temperature of 1200°C.)

A subsequent diffusion alloying is then carried out at 1300°C. in vacuum.

EXAMPLE 2

The cutting layer of a razor blade is 0.035 micron thick and its composition is 65 percent by weight silicon carbide and 35 percent by weight an alloy of 30 percent by weight tungsten and 70 percent by weight

cobalt. The base of the razor is stainless steel type No. 302.

The deposition of the cutting layer is accomplished in apparatus 3 shown in FIG. 3. The hafnia boat 35 containing the tungsten-cobalt alloy is heated up to 2400°C. A razor blade 32 is placed on holder 33 and is heated up to 1150°C. Through the tube 34, the following gas mixture is entered into the apparatus:

35 cm^3/min silicon tetrachloride, $SiCl_4$

10 30 cm^3/min methane, CH_4

1500 cm^3/min hydrogen, H_2 ,

while the pump of the apparatus (not shown) is operated at a rate to keep the pressure of the chamber between 40 and 60 torr. The current source 36 delivers a pulse of 1000 VDC for 0.1 second during which the holder 33 is the negative pole and 200 VDC for 0.03 second while 33 is the positive pole.

Although the cutting layer may contain a small percentage of tungsten carbide and tungsten silicide, the cutting quality of the blade will not be adversely influenced thereby.

EXAMPLE 3

The cutting coating of a razor blade is deposited by plasma gun 4 depicted in FIG. 4. The deposited coating consists of 40 percent weight chromium and 60 percent by weight titanium carbide. A powder mixture of this composition is fed into tube 46. The noble gas, for example, argon, enters through tube 44 into the plasma plating gun. (The deposit may contain some chromium carbide particles too which do not appreciably decrease the cutting performance.) The particle sizes in the interwoven texture are less than 30 Angstroms.

EXAMPLE 4

In this example, the cutting layer of the razor blade is 50 percent by weight cobalt and 50 percent by weight boron carbide. The cobalt particles are provided through tube 46 of the plasma plating gun 4 of FIG. 4, while a gas mixture of argon, borane and methane are fed into the tube 44. The supplied rate of the plating gases are:

100 cm^3/min borane, B_2H_6

30 cm^3/min methane, CH_4 .

The particle sizes of the interwoven texture are in this example also less than 30 Angstroms. If the base of the razor blade was correctly sharpened, the 300 Angstrom thickness of the coating forms a radius of approximately 300 Angstroms at the coated edge of the blade.

Although the processes above discussed have been in connection with the manufacture of razor blades, it should be understood that the principles of the invention are equally applicable to other acute angle edged cutting devices. Razor ribbons can also be produced by the disclosed methods, for instance, by depositing the hard layer on a continuous metal alloy band from which the individual razor ribbons are cut. Other cutting devices which have acute angle cutting edges of special configurations can be first formed, sharpened, then coated with the extremely hard layers according to the invention.

Although the invention has been described and illustrated with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing

from the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. A cutting device comprising:

- a. a preshaped and sharpened base composed of metal and having an acute angle cutting edge; and
- b. a composite coating formed on the cutting edge of said base and having a thickness of less than one micron;
- c. said composite coating comprising hard particles of a size less than 500 Angstrom and having a Vickers micro-hardness greater than 1000 kg/mm²;
- d. said composite coating further comprising a metal matrix having said hard particles embedded and substantially uniformly distributed therein and being effective to form a finely interwoven structure in which said hard particles are bound to-

gether and to said base;

e. said metal matrix being of a corrosion resistant metal;

f. said hard particles having a volume percentage between 20 and 80 percent of said composite coating.

2. A cutting device as defined in claim 1 wherein said hard particles are selected from a group of materials consisting of metal oxides, carbides, borides, nitrides and silicides.

3. A cutting device as defined in claim 2, said base being of stainless steel.

4. A cutting device as defined in claim 3, said metal matrix being of a metal alloy.

5. A cutting device as defined in claim 4, said metal matrix having a diffusion alloy bond to said base.

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