

Description

The present invention concerns a method for joining a plurality of ceramic particles to the surface of a metallic article used at elevated temperature according to the precharacterizing portion of claim 1. More specifically, it relates to a method for joining a single layer of closely spaced silicon carbide particles to the metallic surface of a turbine engine component.

Gas turbine engines and other turbomachines have rows of blades which rotate within a generally cylindrical case. As the blades rotate, their tips move in close proximity to the internal wall surface of the case. To maximize engine operating efficiency, the leakage of the gas or other working fluid between the blade tips and the case should be minimized. As has been known for some time, this may be achieved by blade and seal systems in which the blade tips rub against a seal attached to the interior of the case. Generally, the blade tip is made to be harder and more abrasive than the seal so that the tips cut into the seal during those portions of the engine operating cycle when they contact each other.

One type of blade tip which is particularly useful in the high temperature section of a gas turbine engine is described in US-A-4,249,913 to Johnson et al, entitled "Alumina Coated Silicon Carbide Abrasive", of common ownership herewith. In the Johnson et al invention, silicon carbide abrasive particles of about 0.20-0.75 mm average diameter are coated with a metal oxide such as alumina and incorporated by powder metal techniques in nickel or cobalt base matrix alloys. A powder metal compact containing up to about 45 volume percent of these ceramic particles may be made which is then bonded to the tip of the blade. The resulting abrasive blade tip is particularly well suited for rubbing metal as well as ceramic seals.

As described in greater detail in the EP-A-0166676 improved techniques for the fabrication of blade tips useful at high temperatures are desired. Specifically, the blade tip should be as thin as possible, and the amount of abrasive particles minimized. In order for the tip to provide the required abrasive characteristics, it is essential that the abrasive particles be securely bonded to the blade tip surface.

When an abrasive layer is provided on a superalloy turbine blade tip, its method of application must be metallurgically compatible with the superalloy substrate so that the properties of the substrate are not degraded. Such considerations place restraints on the kinds of materials and processing techniques which are useful in the fabrication of such abrasive layers.

The method for joining a plurality of ceramic particles to the surface of metallic article used at elevated temperature, according to the present invention is characterized in using as said binder solution a solution containing in addition metal particulates which are smaller than said ceramic particles and which are capable of diffusing into the article surface and into the metal layer on the ceramic particles and characterized in that during the disposition of said single layer of the ceramic particles a plurality of the metal particulates are attracted by capillarity into the joint between the ceramic particles and the article surface so that during the subsequent heating of the article the metal particulates diffuse in said joint into said metal layer and into the article surface.

The invention is particularly useful in the fabrication of an abrasive layer on the tip surface of a rotor blade used in a gas turbine engine. For desired operating characteristics, the particle density per unit area of blade tip surface should be maximized, while at the same time the interparticle contact should be minimized. Most importantly, the particles must be securely bonded to the blade tip to withstand the stresses of engine operation, particularly rubbing with air seals. In a preferred embodiment, the ceramic particles are silicon carbide which are coated with aluminum oxide and then overcoated with a nickel-boron alloy. The aluminum oxide prevents diffusion or dissolution of the silicon carbide at elevated temperatures, and the nickel-boron readily diffuses into the blade tip. The binder solution contains a mixture of toluene and diglyme as carrier liquids, polystyrene as an adhesive resin, and nickel flake or powder (both referred to as particulates) as a sintering aid. During the sintering operation, there is simultaneous diffusion of the nickel-boron coating as well as the nickel particulate into the blade tip surface at regions of point contact between each ceramic particle and the tip. Also, some of the nickel particulate diffuses into the nickel-boron coating which remains on each ceramic particle.

After the sintering operation, a matrix alloy is deposited onto the tip surface to cover the silicon carbide particles sintered thereto and to fill in the spaces between the particles. The matrix is then simultaneously heated and pressed to eliminate any voids which may be present, and to securely bond the matrix to the substrate and, by interdiffusion, to the metal coating on each particle. The abrasive layer is then machined to a relatively flat surface, and then part of the matrix is chemically removed to cause portions of the particles to project into space. When blades having such an abrasive layer are installed in an engine, these exposed particles can effectively rub an airseal during engine operation, and minimize the leakage of working fluids around the blade tips, thus improving engine operating efficiency.

The foregoing and other objects, features and advantages of the present invention will become more

apparent from the following description of preferred embodiments and accompanying drawings.

Figure 1 generally shows the radially outer portion of a typical gas turbine blade having an abrasive layer made according to the invention;

Figure 2 shows in cross section the appearance of an abrasive layer produced according to the teachings of the present invention;

Figure 3 shows in cross section the appearance of a prior art abrasive layer;

Figure 4 shows in cross section coated ceramic particles useful in the invention;

Figure 5 shows in side view the metal particulates attracted towards the ceramic particles; and

Figure 6 shows in side view the abrasive layer after application of a metal matrix.

The invention is described with reference to the fabrication of an abrasive layer on a gas turbine blade tip. However, those skilled in the art will recognize that the invention is useful in other applications where small ceramic particles or components need to be securely bonded to a metal substrate.

In an example of the practice of the invention, and referring to Figures 1 and 2, an abrasive layer 10 is formed on the tip surface 11 of the airfoil portion 12 of a gas turbine blade 14. The blade 14 is preferably made of a nickel base superalloy (such as the alloy described in U.S. Patent No. 4,209,348), while the abrasive layer 10 contains ceramic silicon carbide particles 18 in a nickel base superalloy matrix 16. As is described below, an important feature of the abrasive layer 10 fabricated according to this invention is that each of the particles 18 is securely bonded to the blade tip surface 11.

The abrasive layer 10 is subject to high stresses during engine operation, and therefore it is important that the layer 10 have a certain configuration and properties so as to perform its function. In particular, the particles 18 must be disposed on and secured to the tip surface 11 in a certain manner to obtain optimum performance.

In a prior art abrasive layer 20 for a turbine blade 21 shown in Figure 3 and discussed in the Background section above, the abrasive particles 22 are randomly dispersed within a matrix metal 24. The abrasive particles 22 are not individually bonded to the blade tip surface 23 as in the invention; rather, the particles 22 are preferably spaced from the surface 23 for reasons related to the bonding process used to join the layer 20 to the surface 23.

Referring again to Figures 1 and 2, the abrasive layer 10 made according to the invention is characterized by a single layer of closely spaced abrasive particles 18 surrounded by matrix material 16. The matrix metal 16 has a thickness W which is preferably less than the overall thickness T of the particles 18. As a result, a portion of each particle 18 projects into space, thereby enabling favorable rubbing interaction with air seals during engine operation. For optimum performance, the particles 18 as well as matrix metal 16 must be securely bonded to the blade tip 11. Furthermore, the unexposed portion of the particles 18 must be surrounded by matrix metal 16, and the particles 18 must be closely spaced apart from each other. Use of a single layer of abrasive 18 minimizes the mass of the entire layer 10, thus reducing the centripetal force on the blade 14 as it rotates during engine operation. Also, it allows each particle 18 to be enveloped in matrix material 16 (except the outermost region on each particle 18), thereby enhancing the integrity and strength of the layer 10. In the blade tip made in accordance with the invention, each abrasive particle 18 is sinter bonded to the blade tip 11, and the majority (preferably at least about 80-90%) of the particle surface area (excluding that surface area exposed at the blade tip) is surrounded by matrix metal 16 rather than being in contact with another particle 18. Thus, the particles 18 are all securely joined to the tip 11. Also, the particles 18 are, in general, evenly and densely spaced apart on the blade tip 11. Densities of about 35-110 particles per cm^2 of tip surface 11 are preferred, with about 50 particles per cm^2 being most preferred.

As shown in Figure 2, the particles 18 have a thickness (length), T, and the matrix thickness W is about 50-90 percent of the particle thickness T. Silicon carbide particles (nominally about 0.20-0.75 mm in size) have been found to be particularly useful in the practice of the invention, although other sizes might be useful.

Summarizing the fabrication of the abrasive layer 10 according to this invention, the particles 18 are placed in a single layer on the surface of the blade tip 11 which has previously been coated with a low viscosity binder solution which contains fine metal particulates. The blade 14 is then heated to an elevated temperature which sinter bonds each particle 18 to the tip surface 11, and the metal particulates to both the particles 18 and tip surface 11.

Each of the particles 18 is coated with a multiple layer coating. The first layer 30 (Figure 4) is an oxide coating which is stable at elevated temperatures; this coating prevents the particles 18 from dissolving or diffusing into the blade tip 11 during the elevated sintering (bonding) operation and during service operation. The preferred oxide coating 30 for silicon carbide particles is aluminum oxide, 0.005-0.025 mm thick, applied in accordance with the aforementioned Johnson et al patent. As shown in Figure 4, the aluminum oxide coating 30 substantially encapsulates the silicon carbide particle 18. This is necessary to best prevent

dissolution and/or diffusion of the particles 18 at high temperatures. The second layer 32 is metallic and capable of diffusing into the tip surface 11 during the high temperature sintering operation. The metallic layer 32 must be compatible with the substrate, i.e., not form any phases or compounds which would degrade the properties of the blade. In general, the layer 32 is selected from the transition elements of the periodic table, or any alloy thereof, when nickel, cobalt, or iron base matrix and blade alloys are used. The metallic layer 32 substantially encapsulates the oxide layer 30. As discussed above, the sinter bond which forms between each particle 18 and the blade tip 11 must have high strength in order for the abrasive layer 10 to have the required characteristics. When an abrasive layer 10 containing silicon carbide particles 18 is made on a nickel base superalloy, these properties are achieved by using a nickel-boron alloy as the metal layer 32. The boron content should be, by weight percent, about 2 to 4%, preferably about 3%. The thickness of the layer 32 should be about 0.005 to 0.015 mm, preferably about 0.008 mm.

Formation of the sinter bond is further improved by coating the blade tip surface 11 with a binder solution before the ceramic particles 18 are placed on the tip 11. The solution contains a thermoplastic resin and fine metallic particulates in a low viscosity carrier liquid. When the particles 18 are placed on the tip surface 11 which has been coated with the binder solution, the resin adhesively bonds each particle 18 to the tip 11. Then, with the passage of time and due to the low viscosity of the carrier liquid, the carrier liquid and particulates 34 are drawn by capillarity into the region of point contact between each ceramic particle 18 and tip surface 11. See Figure 5. During the high temperature sintering operation, in addition to the aforementioned nickel-boron layer 32 diffusion, the particulates 34 diffuse into the tip surface 11 and into the metal layer 32 on each ceramic particle 18, bridging the gap between each particle 18 and the surface 11, thereby resulting in an even higher strength bond.

The particles 18 may be placed on the blade tip surface 11 in any convenient fashion. The preferred practice is discussed in more detail in the copending and commonly assigned application "Method for Depositing a Layer of Abrasive Material on a Substrate", US-A-46080 199 to Vontell et al, filed March 21, 1986. In this method a vacuum (suction) is drawn through a transfer tool which has spaced apart perforations therein. The tool is then placed over a container of loose particles 18, and the suction draws and holds one particle 18 over each perforation. (Of course, the perforations are smaller than the nominal size of each particle 18.) The tool is then positioned over the blade tip 11 and the suction level is adjusted so that the particles 18 drop onto the tip surface 11.

While the particles 18 lie on the surface of the binder solution coated blade tip 11, the carrier liquid and the metal particulates 34 are drawn into the areas of point contact 36 (i.e., into the joint) between the particles 18 and the tip surface 11. For this movement to take place, the viscosity of the carrier liquid must be low and the particulates 34 must be small. The preferred carrier liquid consists essentially of about 100 cc of toluene and 1 cc of diglyme. It also contains an adhesive resin, preferably about 5 g of polystyrene. The particular choice of this thermoplastic resin is important in the practice of the invention. As has been noted above, the composition of the blade alloy reflects a highly refined metallurgical design which results in the achievement of particular properties. Fabrication of the blade tip must not detrimentally affect these properties. Polystyrene is chosen as the resin binder because when it volatilizes, it depolymerizes and leaves behind no carbon residue. Thermosetting resins are not useful since they do not depolymerize, but rather crosslink, and leave a carbon residue when they volatilize. The presence of carbon on the blade tip surface would result in carburization of the tip during the high temperature sintering operation, which would likely degrade mechanical properties.

Pure nickel flake particulates, nominally about 0.5 to 1.0 microns in size, preferably 0.8 microns, are useful in the invention when the blade is a nickel base superalloy and the ceramic particles are nickel-boron coated silicon carbide. Nickel is preferred since it does not appreciably change the composition of the blade alloy when it diffuses into the tip surface 11.

During the time required for the nickel particulates 34 to coalesce around the abrasive particles 18 (usually about 15-20 minutes for the particular binder solution described above), the diglyme-toluene carrier liquid evaporates, and the particles 18 and particulates 34 become adhesively bonded to the blade tip surface 11. Then, the blade 14 is heated to a temperature sufficient to volatilize the resin and cause the metal layer 32 on the particles 18 to diffuse into the tip surface 11 at regions of point contact. The preferred sintering conditions are about 1,080° C for 1-6 hours in a non-oxidizing atmosphere. Some of the particulates 34 in the joint diffuse into the tip surface 11 and others diffuse into the metal layer remaining on the particles 18, thereby bridging the joint gap and improving the particle-surface sinter bond. This may be appreciated by examining the bond which forms in the absence of the particulate: since the particles 18 tend to be irregularly shaped, the sinter bond which forms as a result of diffusion of only the Ni-B alloy into the tip surface exists only at the regions of point contact of each particle and the tip. Increasing the Ni-B coating thickness, in an attempt to increase the amount of alloy available for diffusion, does not appreciably

increase the bond strength; it only adds unnecessary Ni-B coating thickness to each particle 18. However, when nickel particulates 34 are added to the binder solution, a significantly greater amount of diffusible metal is available to form the sinter bond.

Accordingly, each particle 18 is securely bonded to the tip surface 11 and is thereby capable of providing the required abrasive characteristics to the blade tip 10. Also, few, if any, of the particles 18 are dislodged from the tip surface 11 during a subsequent matrix application step, described below.

Following the sintering operation, the particles 18 are oversprayed with a layer of matrix material 16 deposited by plasma arc spraying or physical vapor deposition to a thickness T' as shown in Figure 6. A nickel base superalloy of the type generally described in the aforementioned Johnson et al patent may be used. The preferred matrix composition is, by weight percent, about 25 Cr, 8 W, 4 Ta, 6 Al, 1.0 Hf, 0.1 Y, 0.23 C, balance Ni. Of course, other matrix alloys may be equally useful, such as Hastelloy X, Haynes 188, IN100, or other similar materials.

Although the sprayed layer of matrix material 16 will have about 95 percent theoretical density, it may contain some porosity or voids, which could reduce the mechanical properties of the overall abrasive layer 10. To eliminate such voids, the blade 14 is then subjected to a hot isostatic pressing (HIP) procedure. The HIP treatment also enhances the bond between the matrix 16, particles 18, and blade tip 11. For the specific superalloy matrix material described above, a temperature of about $1,100^{\circ}\text{C}$ and a gas pressure of about 138 MPa applied for two hours is sufficient. Other hot pressing procedures may be used to consolidate the matrix material 16 and achieve the object of densification and bonding.

Next, the surface of the abrasive layer 10 is machined using a conventional procedure such as grinding to produce a smooth, planar surface. Finally, the surface of the abrasive layer 10 is contacted with a chemical etchant or other substance which will attack and remove some of the matrix material 16, causing a portion of each of the particles 18 to project into space. For example, electrochemical machining can be used, as is described in US-A- 4,522,692 to Joslin. This step reduces the matrix thickness to a dimension W, which is about 50-90 percent of the dimension T, and results in an abrasive layer 10 having the shape schematically shown in Figure 2.

When the particles are long and thin (i.e., have a high aspect ratio), they tend to lie on their sides either when first placed on the blade tip surface 11 or in the interval between the volatilization of the adhesive agent and the attainment of a metallic bond. Such laying-at-length causes undue interparticle contact, and reduces the abrasive nature of the layer 10. Thus, according to a preferred embodiment the invention is best practiced when the aspect ratio of the particles is less than about 1.9 to 1 and preferably is about 1.5 to 1 or less. The aspect ratio is defined herein as the average ratio of the longest particle dimension to the cross sectional dimension, as such is measured on a Quantimet Surface Analyzer (Cambridge Instruments, Cambridge, England).

The sintering aspect of the invention will be better understood by referring to the following example which is intended to be illustrative, and not limiting in scope.

Nominal 0.30 mm silicon carbide particles were coated with a dual layer coating of 0.0015 cm aluminum oxide and 0.0008 cm nickel-3% boron. A binder solution containing nickel flake having a size range of about 0.5-1.0 microns, polystyrene, toluene and diglyme was prepared and applied to the tip surface of nickel base superalloy test blades. Binder solutions containing varying amounts of nickel flake were evaluated to examine the effect of such variation on the strength of the sinter bond which formed. The binder solutions were brushed on the blade tip surface and then the ceramic particles placed thereon. The particle density was ranged between about 50-100 per square cm^2 . After about 20 minutes, the blade was heated at 1080°C ($1,975^{\circ}\text{F}$) in argon and held for 1-6 hours, as shown in Table I. To examine the strength of sinter bonds, impact tests were conducted. In these tests, a 4.5kg (ten pound) weight was dropped onto each test blade from a height of about 28 cm. The strength of the bond was characterized by comparing the number of particles bonded to the tip before the test with the number bonded to the tip after the test. This ratio is presented in Table I as "% Grit Retention". Of course, high percentages are indicative of good bonds. As is seen, when no nickel flake was added to the binder solution, many particles were dislodged during the impact test, indicating a poor bond. Improved results were achieved as the amount of nickel flake increased. The maximum amount of nickel flake which will be useful is dictated by two factors: (1) how the diffusion of such flake alters the composition of the blade tip, and (2) how the viscosity of the binder solution is affected by addition of the flake. Between about 0.5 and 15 grams of the 0.5-1.0 μm (micron) nickel powder or nickel flake will be useful when the diffusion heat treatment is about 1080°C ($1,975^{\circ}\text{F}$) for 1-6 hours. The preferred range is 0.5-4 grams for 1-2 hours at 1080°C ($1,975^{\circ}\text{F}$).

Carrier liquids other than the preferred toluene-diglyme mixture may be used, such as, e.g., xylene or mixtures of xylene and toluene. They must have a low viscosity, for reasons discussed above, of no greater than about 1-10 centistokes. Also, they should have the same evaporation characteristics as the preferred

mixture. Thermoplastic resins such as polymethylstyrene may be used rather than polystyrene.

TABLE I

Effect of Nickel Flake Content and Sintering Time on Grit Retention

<u>Specimen</u>	<u>Ni Flake Content* grams</u>	<u>Sintering Time at (1,975°F, 1080°C) Hours</u>	<u>% Grit Retention</u>
A	0	6	65
B	0.25	2	93.6
C	0.5	2	99
D	1	2	97
E	1	1	81
F	2	1	95.5
G	3	1	96
H	3	2	100
I	4	1	98.4
J	8	6	100

* Amount of nickel flake added to 30 cc of a binder solution containing 100 cc toluene, 1 cc diglyme, and 5 grams polystyrene.

Claims

1. A method for joining a plurality of ceramic particles (18) to the surface of a metallic article used at elevated temperature comprising the steps of:
 - a) depositing on each particle (18) a multiple layer coating (30,32) comprising a first oxide layer (30) stable at elevated temperatures and a second metal layer (32) compatible with and capable of diffusing into the article;
 - b) coating the article surface with a binder solution comprising a low viscosity carrier liquid and a thermoplastic resin wherein the resin leaves no carbon residue on the article surface after volatilization.
 - c) disposing a single layer of the ceramic particles (18) in closely spaced relation on the article surface and
 - d) heating the article to diffuse at least a portion of the metal layer (32) on each ceramic particle into the article surface characterized in using as said binder solution a solution containing in addition metal particulates (34) which are smaller than said ceramic particles (18) and which are capable of diffusing into the article surface and into the metal layer on the ceramic particles (18) and characterized in that during the disposition of said single layer of the ceramic particles (18) a plurality of the metal particulates (39) are attracted by capillarity into the joint between the ceramic particles (18) and the article surface so that during the subsequent heating of the article the metal particulates (34) diffuse in said joint into said metal layer and into the article surface.
2. A method for joining a plurality of silicon carbide particles (18) the tip surface(11) of a nickel base superalloy article comprising the steps of:
 - a) depositing on each particle a two layer coating wherein the first layer (30) is an aluminum oxide



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Claims

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 - b) coating the article surface with a binder solution comprising a low viscosity carrier liquid and a thermoplastic resin wherein the resin leaves no carbon residue on the article surface after volatilization.
 - c) disposing a single layer of the ceramic particles (18) in closely spaced relation on the article surface and
 - d) heating the article to diffuse at least a portion of the metal layer (32) on each ceramic particle into the article surface characterized in using as said binder solution a solution containing in addition metal particulates (34) which are smaller than said ceramic particles (18) and which are capable of diffusing into the article surface and into the metal layer on the ceramic particles (18) and characterized in that during the disposition of said single layer of the ceramic particles (18) a plurality of the metal particulates (39) are attracted by capillarity into the joint between the ceramic particles (18) and the article surface so that during the subsequent heating of the article the metal particulates (34) diffuse in said joint into said metal layer and into the article surface.
2. A method for joining a plurality of silicon carbide particles (18) the tip surface(11) of a nickel base superalloy article comprising the steps of:
 - a) depositing on each particle a two layer coating wherein the first layer (30) is an aluminum oxide



and the second layer (32) is a metal alloy, wherein the aluminum oxide encapsulates the silicon carbide particle (18) and the metal alloy coating encapsulates the aluminumoxide coating;

b) coating the blade tip surface(11) with a binder solution;

c) disposing a single layer of the silicon carbide particles (18) in spaced apart relation on the tip surface (11) and

d) heating the article to volatilize the binder solution and to diffuse a portion of the metal alloy layer (32) on each silicon carbide particle (18) into the tip surface(11) characterized in using as said metal alloy layer (32) a nickel-boron alloy and in using as said binder solution a solution containing toluene, diglyme, polystyrene and nickel particulates (34) wherein the particulates(34) are much smaller than the silicon carbide particles (18) and characterized in that during the disposition of said single layer of the silicon carbide particles (18) on the tip surface (11) a plurality of the nickel particulates (34) are attracted by capillarity into the joint between each silicon carbide particle (18) and the tip surface(11) so that during the subsequent heating of the article the toluene diglyme and polystyrene volatilize and the nickel particulates (34) diffuse in said joint into the nickel-boron coating and into the tip surface (11).

3. The method of claim 2, further comprising the steps of:

a) depositing on the tip surface (11) a metallic matrix material (16) to fill in the spaces between the silicon carbide particles; and

b) removing a portion of the matrix material (16) to cause a portion of each of the particles (18) to project into space.

4. The method of claim 3, wherein the matrix material (16) is plasma sprayed.

5. The method of claim 3, wherein the superalloy article is a gas turbine engine blade.

6. The method of claim 2, wherein the silicon carbide particles are about 0.2-0.5 mm and the nickel particulates are about 0.5-1.0 microns.

Revendications

1. Procédé destiné à assembler plusieurs particules de céramique (18) à la surface d'un article métallique utilisé à des températures élevées, ce procédé comprenant les étapes consistant à:

a) déposer sur chaque particule (18) un revêtement multicouches (30, 32) constitué par une première couche d'oxyde (30) stable à des températures élevées et par une seconde couche métallique (32) compatible avec l'article et apte à diffuser au sein de ce dernier;

b) revêtir la surface de l'article à l'aide d'une solution d'agent liant comprenant un liquide de support à faible viscosité et une résine thermoplastique, la résine ne laissant aucun résidu carboné à la surface de l'article suite à la volatilisation;

c) disposer une couche unique de particules de céramique (18) en agencement mutuel serré, à la surface de l'article; et

d) chauffer l'article afin de diffuser au moins une partie de la couche métallique (32) disposée sur chaque particule de céramique, au sein de la surface de l'article, caractérisé en ce qu'on utilise, comme solution d'agent liant, une solution contenant, en outre, des matières particulaires métalliques (34) de dimension inférieure à celle des particules de céramique (18) et qui sont aptes à diffuser au sein de la surface de l'article et au sein de la couche métallique déposée sur les particules de céramique (18), et caractérisé en ce que, lorsqu'on dispose la couche unique des particules de céramique (18), plusieurs matières particulaires métalliques (34) sont attirées par capillarité au sein du joint ménagé entre les particules de céramique (18) et la surface de l'article, tant et si bien qu'au cours du chauffage ultérieur de l'article, les matières particulaires métalliques (34) diffusent dans le joint au sein de la couche métallique et au sein de la surface de l'article.

2. Procédé destiné à assembler plusieurs particules (18) de carbure de silicium à la surface (11) de la pointe d'un article en superalliage à base de nickel, ce procédé comprenant les étapes consistant à:

a) déposer sur chaque particule un revêtement à deux couches (30, 32), la première couche (30) étant un oxyde d'aluminium et la seconde couche (32) étant un alliage métallique, l'oxyde d'aluminium encapsulant les particules (18) de carbure de silicium et le revêtement en alliage



métallique encapsulant le revêtement d'oxyde d'aluminium;

b) recouvrir la surface (11) de la pointe d'aube avec une solution d'agent liant;

c) déposer une couche unique de particules (18) de carbure de silicium écartées l'une de l'autre, à la surface (11) de la pointe; et

d) chauffer l'article afin de volatiliser la solution d'agent liant et de diffuser une partie de la couche (32) en alliage métallique déposée sur chaque particule (18) de carbure de silicium, au sein de la surface (11) de la pointe, caractérisé en ce qu'on utilise, comme couche (32) en alliage métallique, un alliage de nickel-bore et en ce qu'on utilise, comme solution d'agent liant, une solution contenant du toluène, du diglyme, du polystyrène et des matières particulières de nickel (34), les matières particulières (34) étant beaucoup plus petites que les particules (18) de carbure de silicium, et caractérisé en ce que, tandis que l'on dispose la couche unique des particules (18) de carbure de silicium à la surface (11) de la pointe, plusieurs matières particulières de nickel (34) sont attirées par capillarité au sein du joint ménagé entre chaque particule (18) de carbure de silicium et la surface (11) de la pointe, tant et si bien que, lors du réchauffement ultérieur de l'article, le toluène, le diglyme et le polystyrène se volatilisent et les matières particulières de nickel (34) diffusent dans le joint au sein du revêtement en nickel-bore et au sein de la surface (11) de la pointe.

3. Procédé selon la revendication 2, comprenant, en outre, les étapes consistant à:

a) déposer à la surface (11) de la pointe une matière matricielle métallique (16) destinée à remplir les espaces ménagés entre les particules (18) de carbure de silicium; et

b) éliminer une partie de la matière matricielle (16) pour provoquer le fait qu'une partie de chacune des particules (18) fasse saillie dans l'espace.

4. Procédé selon la revendication 3, dans lequel la matière matricielle (16) est pulvérisée au plasma.

5. Procédé selon la revendication 3, dans lequel l'article en superalliage est une aube pour moteur de turbine à gaz.

6. Procédé selon la revendication 2, dans lequel la dimension des particules de carbure de silicium est d'environ 0,2-0,5 mm et celle des matières particulières de nickel est d'environ 0,5-1,0 micron.

Ansprüche

1. Verfahren zum Verbinden einer Vielzahl von Keramikpartikeln (18) mit der Oberfläche eines metallischen Gegenstands, der bei erhöhter Temperatur benutzt wird, beinhaltend die Schritte:

a) Auftragen eines mehrschichtigen Überzugs (30, 32) auf jedes Partikel (18), der eine erste Oxidschicht (30), welche bei erhöhten Temperaturen stabil ist, und eine zweite Metallschicht (32), welche mit dem Gegenstand kompatibel ist und in denselben eindiffundieren kann, umfaßt;

b) Überziehen der Gegenstandsoberfläche mit einer Bindemittellösung, die eine Trägerflüssigkeit geringer Viskosität und ein thermoplastisches Harz umfaßt, wobei das Harz nach der Verfluchtigung keinen Kohlenstoffrest auf der Gegenstandsoberfläche zurückläßt;

c) Anordnen einer einzelnen Schicht der Keramikpartikel (18) in engem gegenseitigen Abstand auf der Gegenstandsoberfläche; und

d) Erhitzen des Gegenstands, um wenigstens einen Teil der Metallschicht (32) auf jedem Keramikpartikel in die Gegenstandsoberfläche eindiffundieren zu lassen, dadurch gekennzeichnet, daß als Bindemittellösung eine Lösung benutzt wird, die zusätzlich Metallteilchen (34) enthält, welche kleiner als die Keramikpartikel (18) sind und in die Gegenstandsoberfläche sowie in die Metallschicht auf den Keramikpartikeln (18) eindiffundieren können, und daß während des Anordnens der einzelnen Schicht der Keramikpartikel (18) eine Vielzahl der Metallteilchen (34) durch Kapillarkirkung in die Verbindung zwischen den Keramikpartikeln (18) und der Gegenstandsoberfläche hineingezogen wird, so daß während des anschließenden Erhitzens des Gegenstands die Metallteilchen (34) in der Verbindung in die Metallschicht und in die Gegenstandsoberfläche diffundieren.

2. Verfahren zum Verbinden einer Vielzahl von Siliciumcarbidpartikeln (18) mit der Spitzenoberfläche (11) eines Hickelsuperlegierungsgegenstands, beinhaltend die Schritte:

a) Auftragen eines zweischichtigen Überzugs (30, 32) auf jedes Partikel, wobei die erste Schicht (30) ein Aluminiumoxid und die zweite Schicht (32) eine Metallegierung ist, wobei das Aluminiumoxid das



Siliciumcarbidpartikel (18) umhüllt und der Metallegierungsüberzug den Aluminiumoxidüberzug umhüllt;

b) Überziehen der Schaufelspitzenoberfläche (11) mit einer Bindemittellösung;

c) Anordnen einer einzelnen Schicht der Siliciumcarbidpartikel (18) mit Abstand auf der Spitzenoberfläche (11); und

d) Erhitzen des Gegenstands, um die Bindemittellösung zu verdampfen und einen Teil der Metallegierungsschicht (32) auf jedem Siliciumcarbidpartikel (18) in die Spitzenoberfläche (11) eindiffundieren zu lassen, dadurch gekennzeichnet, daß als Metallegierungsschicht (32) eine Nickel-Bor-Legierung und als Bindemittellösung eine Lösung benutzt wird, die Toluol, Diglyme, Polystyrol und Nickelteilchen (34) enthält, wobei die Teilchen (34) viel kleiner als die Siliciumcarbidpartikel (18) sind, und daß während des Anordnens der einzelnen Schicht der Siliciumcarbidpartikel (18) auf der Spitzenoberfläche (11) eine Vielzahl der Nickelteilchen (34) durch Kapillarwirkung in die Verbindung zwischen jedem Siliciumcarbidpartikel (18) und der Spitzenoberfläche (11) hineingezogen wird, so daß während des anschließenden Erhitzens des Gegenstands Toluol, Diglyme und Polystyrol verdampfen und die Nickelteilchen (34) in der Verbindung in den Nickel-Bor-Überzug und in die Spitzenoberfläche (11) diffundieren.

3. Verfahren nach Anspruch 2, weiter beinhaltend die Schritte:

a) Anordnen eines metallischen Matrixmaterials (16) auf der Spitzenoberfläche (11), um die Zwischenräume zwischen den Siliciumcarbidpartikeln (18) zu füllen; und

b) Entfernen eines Teils des Matrixmaterials (16), damit ein Teil jedes Partikels (18) in den Raum vorsteht.

4. Verfahren nach Anspruch 3, wobei das Matrixmaterial (16) plasmagespritzt wird.

5. Verfahren nach Anspruch 3, wobei der Superlegierungsgegenstand eine Gasturbinentriebwerksschaufel ist.

6. Verfahren nach Anspruch 2, wobei die Siliciumcarbidpartikel etwa 0,2-0,5 mm und die Nickelteilchen etwa 0,5-1,0 μm betragen.