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(54) Coated article and method for production coating

(57) A coated article (100) and a method for producing a coating (206) are disclosed. Producing the coating (206) includes providing a substrate (202) defining a substrate surface (204) having a substrate erosion resistance and applying a matrix (210) and ceramic particles (214) to the substrate surface (204). The matrix (210) includes an anodic material (212) having an anodic erosion resistance. The ceramic particles (214) include a first ceramic (216) having a first ceramic erosion resistance and a second ceramic (218) having a second ceramic erosion resistance. The first ceramic erosion resistance is greater than the second ceramic erosion resistance, greater than the anodic erosion resistance, and greater than the substrate erosion resistance. The second ceramic (218) interacts inchoately with the anodic material (212) during the applying to form modified ceramic particles (220) and modified anodic material formations (222). The modified ceramic particles (220) are capable of forming a passive oxide film (302). The coated article (100) includes the substrate (202) and the coating (206) on the substrate surface (204).

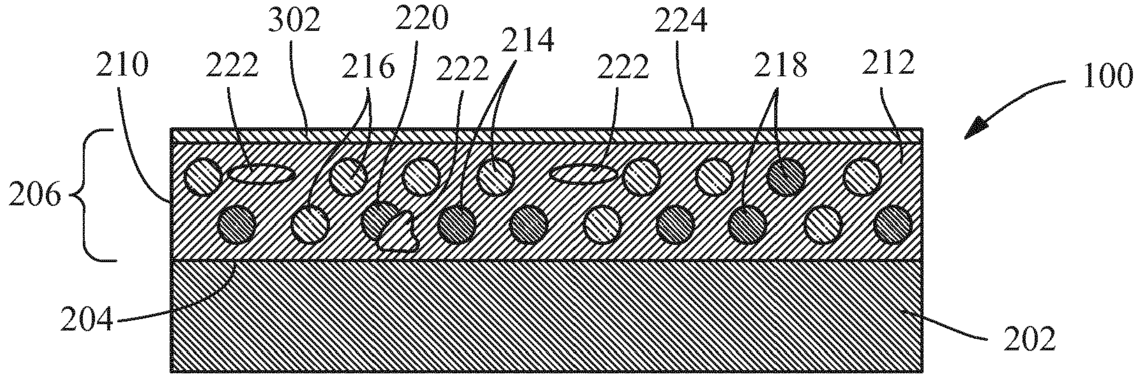

FIG. 3

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Description

FIELD OF THE INVENTION

[0001] The present invention is directed to a coated article and a method for producing a coating. More specifically, the present invention is directed to a coated article and a method for producing a coating containing an anodic material and ceramic particles.

BACKGROUND OF THE INVENTION

[0002] Gas and steam turbine components, particularly rear stage gas turbine compressor blades, rear stage gas turbine compressor vanes and centrifugal pump impellers, in addition to pipelines, are subjected to water droplet erosion, particulate deposition and corrosion pitting induced cracking issues caused by on-line water washing. The preceding surface degradation mechanisms may also result in undesirable increases in surface roughness.

[0003] Changing the material of the components may improve corrosion resistance but may not improve the roughening effect. Developing alternate alloys may not be cost effective and re-designing components to achieve better overall robustness may not be feasible due to the time and cost involved as well the design constraints imposed by the materials used and the operating requirements.

[0004] Fouling of components may cause corrosion of the components underneath the deposits through a crevice corrosion mechanism. Additionally, particulates in the intake air may cause erosion through foreign object damage to the components thereby causing corrosion. Water wash cycles are often performed to remove the particulates that have built up on the components. However, the water wash cycles expose the components to increased amounts of moisture, which may cause corrosion of the components by dissolving and leaching corrosive agents entrapped in the surface deposits, and accelerated corrosion to any portions of the components damaged by foreign object damage. Furthermore, the water wash cycles may utilize chemicals to remove complex particulate buildup. These chemicals may increase corrosion of the components and increase maintenance cost of the components. Coating systems which require more than one coating layer to address corrosion, oxidation, fouling and/or erosion are undesirable because multiple layers may result in excessive overall thickness of the component so coated. Additionally, multiple coatings may increase the likelihood of undesirable alterations in the aerodynamics or fluid dynamics of the component, or detrimental increases in the weight of the component.

[0005] Unchecked corrosion, oxidation, fouling and/or erosion of the exposed surfaces of the gas turbine or steam turbine components, or of pipelines, may result in undesirable increases in surface roughness, thereby decreasing the efficiency.

[0006] Coated components and methods for producing coated components that do not suffer from one or more of the above drawbacks would be desirable in the art.

BRIEF DESCRIPTION OF THE INVENTION

[0007] In one embodiment, a method for producing a coating includes providing a substrate defining a substrate surface having a substrate erosion resistance and applying a matrix and ceramic particles to the substrate surface. The matrix includes an anodic material having an anodic erosion resistance. The ceramic particles include a first ceramic having a first ceramic erosion resistance and a second ceramic having a second ceramic erosion resistance. The first ceramic erosion resistance is greater than the second ceramic erosion resistance, greater than the anodic erosion resistance, and greater than the substrate erosion resistance. The second ceramic interacts inchoately with the anodic material during the applying to form modified ceramic particles and modified anodic material formations. The modified ceramic particles are capable of forming a passive oxide film.

[0008] In another embodiment a coated article includes a substrate defining a substrate surface having a substrate erosion resistance and a coating on the substrate surface. The coating includes a matrix and ceramic particles. The matrix includes an anodic material having an anodic erosion resistance. The ceramic particles include a first ceramic having a first ceramic erosion resistance and a second ceramic having a second ceramic erosion resistance. The coating also includes modified ceramic particles and modified anodic material formations formed by an inchoate interaction between the second ceramic and the anodic material. The first ceramic erosion resistance is greater than the second ceramic erosion resistance, greater than the anodic erosion resistance, and greater than the substrate erosion resistance. The modified ceramic particles are capable of forming a passive oxide film.

[0009] Other features and advantages of the present invention will be apparent from the following more detailed description, taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 is a perspective view of a coated article, according to an embodiment of the disclosure.

FIG. 2 is a sectional view along lines 2-2 of FIG. 1 of the coated article, according to an embodiment of the disclosure.

FIG. 3 is a sectional view of a coated article including a passive oxide film, according to an embodiment of the disclosure.

[0011] Wherever possible, the same reference numbers will be used throughout the drawings to represent the same parts.

DETAILED DESCRIPTION OF THE INVENTION

[0012] Provided are a coated article and a method for producing a coating. Embodiments of the present disclosure, in comparison to methods and articles not using one or more of the features disclosed herein, decrease substrate corrosion, decrease substrate oxidation, decrease substrate fouling, decrease substrate erosion, decrease the rate at which the surface roughness of a substrate increases, decrease maintenance costs, increase efficiency, or a combination thereof.

[0013] Referring to FIG. 1, in one embodiment, a coated article 100 is depicted. In one embodiment, the coated article 100 is any suitable component, for example, a compressor blade 102 (shown), a compressor vane, a centrifugal pump impeller or a pipeline. The term "blade" as used herein is intended to be synonymous with the term "bucket."

[0014] Referring to FIG. 2, in one embodiment the coated article 100 includes a substrate 202 defining a substrate surface 204 having a substrate erosion resistance, and a coating 206 on the substrate surface 204. The coating 206 includes a matrix 210 including an anodic material 212 having an anodic erosion resistance, and ceramic particles 214. The anodic material 212 may be anodic with respect to the substrate 202. The ceramic particles 214 include a first ceramic 216 having a first ceramic erosion resistance and a second ceramic 218 having a second ceramic erosion resistance. The coating 206 also includes modified ceramic particles 220 and modified anodic material formations 222 formed from an inchoate interaction between the second ceramic 218 and the anodic material 212. The coating 206 defines a coating surface 224 which is exposed to the external environment. In a further embodiment, the first ceramic erosion resistance is greater than the second ceramic erosion resistance, greater than the anodic erosion resistance, and greater than the substrate erosion resistance.

[0015] In one embodiment, the anodic material 212 includes $Cr_{70\%}Ni_{30\%}$ (wt%), a mixture of $Ni_{80}\%Al_{20}\%$ (wt%) and $Ni_{95\%}Al_{5\%}$ (wt%), cobalt and aluminum particles in a sacrificial metallic undercoat with a ceramic overcoat, a metallurgically bonded aluminide with an aluminum surface layer, NiCrAl, or a combination thereof. In one embodiment the anoidic material is $Cr_{70\%}Ni_{30\%}$ (wt%). In a further embodiment, the anodic material 212 is operative to protect the substrate surface 204 from corrosion during downtime, which is endemic in peaking turbine components and not uncommon even in base loaded turbine components.

[0016] In one embodiment, the first ceramic 216 is tungsten carbide and the second ceramic 218 is chromium carbide, chromium nitride or a combination of chromium carbide and chromium nitride. In a further embodiment, the anodic material 212 contains chromium and nickel, and the second ceramic interacts inchoately with the chromium and nickel in the anodic material 212 during the applying to form the modified ceramic particles 220 and the modified anodic material formations 222. The modified ceramic particles 220 include at least one of modified chromium carbide particles having a range of chromium carbide stoichiometries and modified chromium nitride particles having a range of chromium nitride stoichiometries. Without being bound by theory, it is believed that a portion of the second ceramic dissolves during thermal spray processing, releasing free chromium and at least one of carbon and nitrogen. The free chromium may push the electrochemical potential of the matrix toward being more anodic. Nitrogen when dissolved in the matrix may improve pitting resistance of the matrix under corrosive conditions.

[0017] In one embodiment, the coating 206 contains from about 30% to about 60% by weight tungsten carbide, alternatively from about 30% to about 40%, alternatively from about 40% to about 50%, alternatively from about 50% to about 60%. In an additional embodiment, the coating 206 further contains from about 20% to about 50% by weight of one or both of chromium carbide and chromium nitride, alternatively from about 20% to about 30%, alternatively from about 30% to about 40% alternatively from about 40% to about 50%. In a further embodiment, the coating 206 also contain balance essentially anodic material 212.

[0018] Referring to FIG. 3, in one embodiment, the modified ceramic particles 220 are capable of forming a passive oxide film 302. In a further embodiment, the passive oxide film 302 forms under standard rear stage turbine compressor operating conditions. Known rear stage turbine compressor operating conditions include, for example, elevated pressures 10-25 times atmospheric pressure, and being subjected to adiabatic heating to 250-677 °C. For example, when formed, the passive oxide film 302 defines the coating surface 224. The passive oxide film 302 resists increases in the roughness of the coating surface 224 caused by oxidation. Without being bound by theory, it is believed that because the passive oxide film 302 include materials which are oxides, these materials will not undergo further oxidation.

[0019] In one embodiment, the passive oxide film 302 is uniformly, or substantially uniformly, distributed on the matrix 210. In another embodiment, the passive oxide film 302 has a thickness of between about 0.1 μm to about 3 μm, alternatively between about 0.1 μm to about 2 μm, alternatively between about 0.1 μm to about 1 μm, alternatively between about 1 μm to about 2 μm, alternatively between about 2μ m to about 3 μm, alternatively between about 0.1 μm to about 1.5 μm, alternatively between about 1.5 μm to about 3 μm, alternatively between about 0.1 μm to about 0.5 μm, alternatively between about 0.5 μm to about 1 μm, alternatively between about

1 μm to about 1.5 μm, alternatively between about 1.5 μm to about 2 μm.

[0020] The coating 206 is produced by any suitable method. In one embodiment, a method for applying the coating 206 includes providing the substrate 202 defining the substrate surface 204 and applying the matrix 210 and the ceramic particles 214 to the substrate surface 204. Applying the matrix 210 and the ceramic particles 214 to the substrate surface 204 may be accomplished by any suitable coating techniques, such as, but not limited to, thermal spray, air plasma spray (APS), high velocity oxygen fuel (HVOF) thermal spray, high velocity air fuel spraying (HVAF), vacuum plasma spray (VPS), electron-beam physical vapor deposition (EBPVD), chemical vapor deposition (CVD), ion plasma deposition (IPD), combustion spraying with powder or rod, cold spray, sol gel, electrophoretic deposition, tape casting, polymer derived ceramic coating, slurry coating, dip-application, vacuum-coating application, curtain-coating application, brush-application, roll-coat application, and agglomeration and sintering followed by spray drying.

[0021] In one embodiment, the ceramic particles 214 have an average particle diameter ranging from about 0.3 μm to about 5 μm, alternatively from about 0.3 μm to about 2.5 μm, alternatively from about 2.5 μm to about 5 μm, alternatively from about 0.3 μm to about 2 μm, alternatively from about 2 μm to about 3.5 μm, alternatively from about 3.5 μm to about 5 μm, alternatively from about 0.3 μm to about 1 μm, alternatively from about 2 μm to about 3 μm, alternatively from about 3 μm to about 4 μm, alternatively from about 4 μm to about 5 μm.

[0022] In one embodiment, the coating 206 has an average distance between the ceramic particles 214 ranging from about 0.2 μm to about 2 μm, alternatively from about 0.2 μm to about 1 μm, alternatively from about 1 μm to about 2 μm, alternatively from about 0.2 μm to about 0.8 μm, alternatively from about 0.8 μm to about 1.4 μm, alternatively from about 1.4 μm to about 2 μm.

[0023] In one embodiment, the coating 206 has a thickness of between about 50 μm to about 250 μm, alternatively between about 50 μm to about 150 μm, alternatively between about 100 μm to about 200 μm, alternatively between about 150 μm to about 250 μm, alternatively between about 50 μm to about 100 μm, alternatively between about 100 μm to about 150 μm, alternatively between about 150 μm to about 200 μm, alternatively between about 200 μm to about 250 μm.

[0024] In one embodiment, the coating 206 consists essentially of a single matrix 210 of anodic material 212 with a plurality of ceramic particles 214 dispersed therein. A single matrix 210 of anodic material 212, as opposed to multiple layers of anodic material 212, allows for the thickness of the coating 206 to be minimized.

[0025] In one embodiment, the ceramic particles 214 including the first ceramic 216 having a first ceramic erosion resistance are capable of resisting increases in the roughness of the coating surface 224. Without being bound by theory, it is believed that the increased hardness of the first ceramic 216 relative to the hardness of the second ceramic 218 and the anodic material 212 confers resistance to deposition of particles and subsequent corrosion of the coating surface 224.

[0026] In one embodiment, wherein the coating 206 has a thickness less than about 250 μm, alternatively less than about 150 μm, the property corresponding to erosion resistance includes erosion of the coating 206 of less than about 76 μm over about 48,000 hours of operation under standard rear stage turbine compressor operating conditions.

[0027] In one embodiment, the anodic material 212 in the matrix 210 is capable of resisting increases in the roughness of the coating surface 224. Without being bound by theory, it is believed that the anodic material 212 protects the substrate 202 from corrosion by undergoing anodic dissolution preferentially as the substrate 202 is placed at a nobler cathodic potential compared to the matrix 210. The anodic material 212 is metallic in nature and possesses necessary toughness and ductility. However to resist deposition, particulate and water droplet erosion the matrix 210 is strengthened by ceramic particles 214. The first ceramic 216 in the ceramic particles 214 address erosion resistance. The second ceramic 218 in the ceramic particles 214, such as chromium carbide and chromium nitride dissolves during application, such as by thermal spray, to release free chromium, which further augments the anodic nature of the matrix 210. While the invention has been described with reference to one or more embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

Claims

1. A method for producing a coating, comprising:

providing a substrate defining a substrate surface having a substrate erosion resistance; and applying a matrix and ceramic particles to the substrate surface, wherein:

the matrix includes an anodic material having an anodic erosion resistance; and the ceramic particles include:

a first ceramic having a first ceramic erosion resistance; and

a second ceramic having a second ceramic erosion resistance,
wherein the first ceramic erosion resistance is:

greater than the second ceramic erosion resistance;
greater than the anodic erosion resistance; and
greater than the substrate erosion resistance,
wherein the second ceramic interacts inchoately with the anodic material during the applying to form modified ceramic particles and modified anodic material formations, and
wherein the modified ceramic particles are capable of forming a passive oxide film.

2. The method of claim 1, wherein the anodic material is selected from a group consisting of $Cr_{70}\%Ni_{30}\%$ (wt%), a mixture of $Ni_{80\%}Al_{20\%}$ (wt%) and $Ni_{95\%}Al_{5\%}$ (wt%), cobalt and aluminum particles in a sacrificial metallic undercoat with a ceramic overcoat, a metallurgically bonded aluminide with an aluminum surface layer, NiCrAl and combinations thereof.

3. The method of claim 1 or claim 2, wherein the first ceramic is tungsten carbide and the second ceramic is chromium carbide, chromium nitride or a combination of chromium carbide and chromium nitride.

4. The method of any preceding claim, wherein:

the anodic material contains chromium and nickel;
the second ceramic interacts inchoately with the chromium and nickel in the anodic material during the applying to form the modified ceramic particles and the modified anodic material formations; and
the modified ceramic particles include at least one of modified chromium carbide particles having a range of chromium carbide stoichiometries and modified chromium nitride particles having a range of chromium nitride stoichiometries.

5. The method of claim 3 or claim 4, wherein the coating contains from about 30% to about 60% by weight tungsten carbide, from about 20% to about 50% by weight of one or both of chromium carbide and chromium nitride, and balance essentially anodic material.

6. The method of any preceding claim, wherein the ceramic particles have an average particle diameter ranging from about 0.3 μm to about 5 μm, and the coating has an average distance between the ceramic particles ranging from about 0.2 μm to about 2 μm.

7. The method of any preceding claim, wherein producing the coating consists essentially of applying a single matrix of anodic material with ceramic particles dispersed therein.

8. A coated article, comprising:

a substrate defining a substrate surface having a substrate erosion resistance; and
a coating on the substrate surface, wherein the coating includes:

a matrix including an anodic material having an anodic erosion resistance;
ceramic particles including:

a first ceramic having a first ceramic erosion resistance; and
a second ceramic having a second ceramic erosion resistance; and
modified ceramic particles and modified anodic material formations formed by an inchoate interaction between the second ceramic and the anodic material,
wherein the first ceramic erosion resistance is:

greater than the second ceramic erosion resistance;
greater than the anodic erosion resistance; and
greater than the substrate erosion resistance, and
wherein the modified ceramic particles are capable of forming a passive oxide film.

9. The coated article of claim 8, wherein the anodic material is selected from a group consisting of $Cr_{70\%}Ni_{30\%}$ (wt%), a mixture of $Ni_{80}\%Al_{20}\%$ (wt%) and $Ni_{95}\%Al_{5\%}$ (wt%), cobalt and aluminum particles in a sacrificial metallic undercoat with a ceramic overcoat, a metallurgically bonded aluminide with an aluminum surface layer, NiCrAl, and combinations thereof.

10. The coated article of claim 8 or claim 9, wherein the first ceramic is tungsten carbide and the second ceramic is chromium carbide, chromium nitride or a combination of chromium carbide and chromium nitride.

11. The coated article of any one of claims 8 to 10, wherein:

the anodic material contains chromium and nickel;
the modified ceramic particles and the modified anodic material formations are formed by the inchoate interaction of the second ceramic with the chromium and nickel in the anodic material; and
the modified ceramic particles include at least one of modified chromium carbide particles having a range of chromium carbide stoichiometries and modified chromium nitride particles having a range of chromium nitride stoichiometries.

12. The coated article of any one of claims 8 to 11, wherein the coating contains from about 30% to about 60% by weight tungsten carbide, from about 20% to about 50% by weight of one or both of chromium carbide and chromium nitride, and balance essentially anodic material.

13. The coated article of any one of claims 8 to 12, wherein the ceramic particles have an average particle diameter ranging from about 0.3 μm to about 5 μm, and the coating has an average distance between the ceramic particles ranging from about 0.2 μm to about 2 μm.

14. The coated article of any one of claims 8 to 13, wherein the substrate is selected from a group consisting of a compressor blade, a compressor vane, a centrifugal pump impeller, and a pipeline.

15. The coated article of any one of claims 8 to 14, wherein the coating consists essentially of a single matrix of anodic material with ceramic particles dispersed therein.

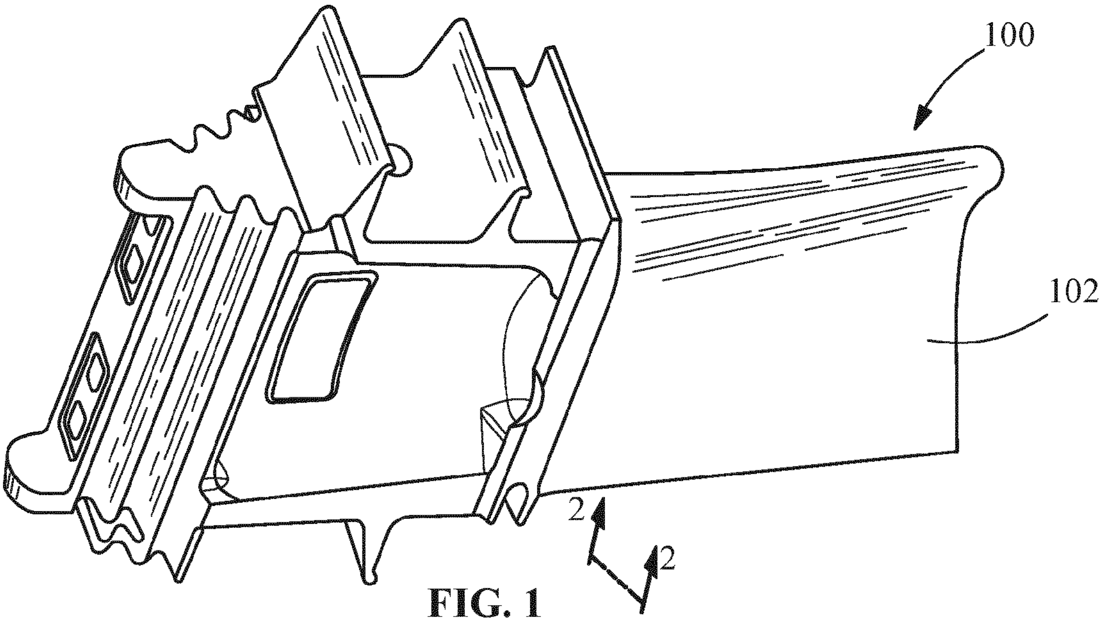

FIG. 1

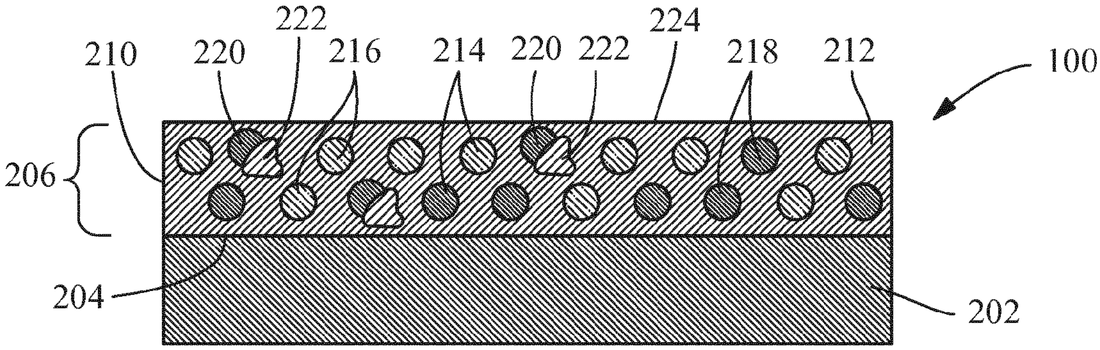

FIG. 2

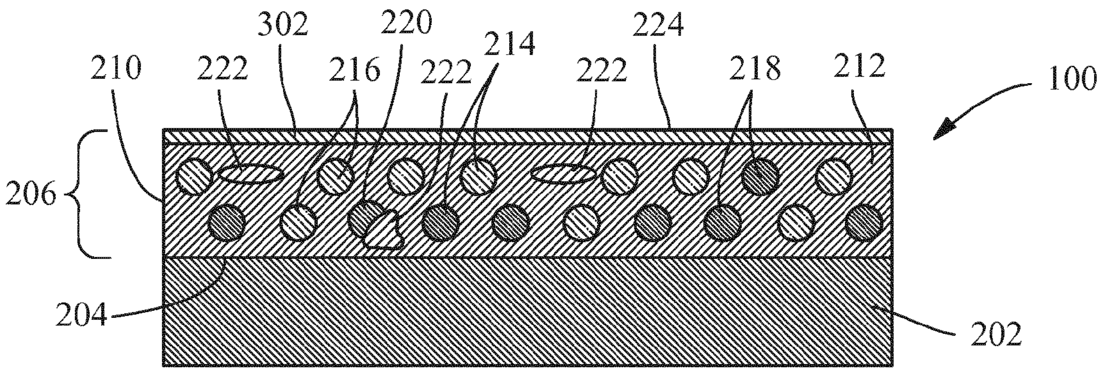

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 15 15 6132

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 395 123 A1 (GEN ELECTRIC [US]) 14 December 2011 (2011-12-14) * paragraph [0002] - paragraph [0020]; claims *	1-15	INV. C23C4/06 C23C4/08 C23C24/04 C23C30/00 F01D5/28
X	EP 1 227 169 A2 (FUJIMI INC [JP]) 31 July 2002 (2002-07-31) * claims; examples *	1-15	
X	US 2009/297720 A1 (RAMGOPAL THODLA [US] ET AL) 3 December 2009 (2009-12-03) * claims; examples *	1-15	
X	FANG W ET AL: "Processing optimization, surface properties and wear behavior of HVOF spraying WC-CrC-Ni coating", JOURNAL OF MATERIALS PROCESSING TECHNOLOGY, ELSEVIER, NL, vol. 209, no. 7, 1 April 2009 (2009-04-01), pages 3561-3567, XP026076692, ISSN: 0924-0136, DOI: 10.1016/J.JMATPROTEC.2008.08.024 [retrieved on 2008-09-03] * 2. Experiment, 4. Conclusion *	1,3,7,8, 10,15	TECHNICAL FIELDS SEARCHED (IPC) C23C F01D
X	EP 2 226 409 A2 (GEN ELECTRIC [US]) 8 September 2010 (2010-09-08) * claims; examples *	1-6,8-14	
X	WO 2010/094256 A1 (MTU AERO ENGINES GMBH [DE]; UIHLEIN THOMAS [DE]; EICHMANN WOLFGANG [DE) 26 August 2010 (2010-08-26) * claims; examples *	1-6,8-14	

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	8 July 2015	Mauger, Jeremy

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EP 15 15 6132

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08-07-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2395123 A1	14-12-2011	CN 102277548 A	14-12-2011
		EP 2395123 A1	14-12-2011
		JP 2011256462 A	22-12-2011
		US 2011305873 A1	15-12-2011
EP 1227169 A2	31-07-2002	AT 282722 T	15-12-2004
		CA 2369257 A1	25-07-2002
		CN 1367209 A	04-09-2002
		DE 60201922 D1	23-12-2004
		DE 60201922 T2	01-12-2005
		EP 1227169 A2	31-07-2002
		JP 3952252 B2	01-08-2007
		JP 2002220652 A	09-08-2002
		KR 20020062855 A	31-07-2002
		TW 583341 B	11-04-2004
		US 2002136894 A1	26-09-2002
US 2009297720 A1	03-12-2009	NONE	
EP 2226409 A2	08-09-2010	CN 101876327 A	03-11-2010
		EP 2226409 A2	08-09-2010
		JP 2010209913 A	24-09-2010
		US 2010226783 A1	09-09-2010
WO 2010094256 A1	26-08-2010	CA 2753268 A1	26-08-2010
		DE 102009010110 A1	02-09-2010
		EP 2398936 A1	28-12-2011
		US 2011299996 A1	08-12-2011
		WO 2010094256 A1	26-08-2010

EPO FORM P0459

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