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(54) Title: METHOD FOR CREATING A TEXTURED BOND COAT SURFACE

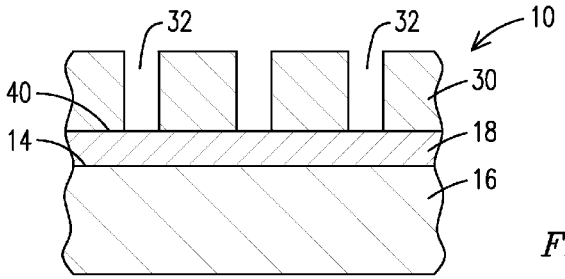


FIG. 3

(57) Abstract: A method for creating a textured surface (52) of bond coat material (18) for improving the performance of a thermal barrier coating system (12). A plurality of columns (62) of bond coat material are formed by spraying (52) the material through a corresponding plurality of openings (32) in a mask (30) applied to a surface (40) to be textured. The openings may be formed in only a region (34) of the mask in response to an image of the surface to be textured. The mask and excess material (54) applied over the mask are then removed to reveal the textured surface.

METHOD FOR CREATING A TEXTURED BOND COAT SURFACE

FIELD OF THE INVENTION

This invention relates generally to the field of materials technology, and more particularly to a method for creating a textured surface in a bond coat of a thermal barrier coating system.

BACKGROUND OF THE INVENTION

Ceramic thermal barrier coating systems are used on gas turbine engine hot gas path components to protect the underlying metal alloy substrate from combustion gas temperatures that exceed the safe operating temperature of the alloy. A typical thermal barrier coating system may include a bond coat, such as an MCrAlY material, deposited onto the substrate alloy and a ceramic topcoat, such as yttria stabilized zirconia, deposited onto the bond coat. It is known that strong adhesion between the layers of such systems is critical for proper functioning and long life of the coating system, and that a degree of surface roughness in the interface between the layers provides a beneficial mechanical interlock in that regard.

Bond coat material is often deposited by a spray process, such as High Velocity Oxy-Fuel (HVOF) or Air Plasma Spray (APS). It is known to control spray parameters when depositing a bond coat layer in order to achieve a degree of surface roughness in the deposited coating. However, the degree of roughness and the shape of the surface features in the deposited coating that are created by controlling the spray parameters are limited.

It is also known to texture the surface of a bond coat layer prior to the deposition of a ceramic insulating layer by using a material removal process, such as laser ablation, micromachining or photolithography, such as described in United States Patent Number 5,723,078. As the firing temperatures of advance gas turbine engines continue to increase, further improvements in thermal barrier coating systems and methods of applying such coatings are desired.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is explained in the following description in view of the drawings that show:

FIG. 1 is a partial cross-sectional view of a gas turbine component having a damaged thermal barrier coating on a metal alloy material surface as known in the art.

FIG. 2 is a top view of a mask having a pattern of holes corresponding to a desired pattern of bond coat surface features.

FIG. 3 is a partial cross-sectional view of the mask of FIG. 2 applied to the surface of the component of FIG. 1 after damaged thermal barrier coating material has been removed.

FIG. 4 illustrates a bond coat material being applied over the mask and component of FIG 3.

FIG. 5 illustrates the component of FIG. 4 after excess bond coat material has been removed from the mask.

FIG. 6 illustrates the component of FIG. 5 after the mask has been removed to reveal the desired pattern formed on the bond coat surface.

FIG. 7 illustrates the component of FIG. 6 after an abradable material has been deposited over the patterned bond coat surface.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 is a partial cross-sectional view of a gas turbine component 10 having a thermal barrier coating 12 deposited on a surface 14 of a superalloy substrate material 16 as known in the art. The thermal barrier coating 12 includes a layer of bond coat material 18 deposited onto the superalloy substrate surface 14 and a layer of ceramic insulating material 20 deposited onto the bond coat material 18. The region of the component 10 that is illustrated in FIG. 1 exhibits damage such as spalling 22 and cracking 24 as may be experienced during operation of the component 10. It is known to remove the damaged material and to recoat the component 10 before returning it to service, however, the recoated component would be subject to the same type and rate of degradation as was the original coating. Accordingly, the present inventors have developed the methods disclosed herein whereby a textured surface is applied to the

replacement bond coat material in order to make the replacement thermal barrier coating more durable than the original coating. The methods disclosed herein may also be used for manufacturing new components so that the benefits of the textured bond coat layer are achieved for factory-fresh components.

The present invention envisions depositing a layer of bond coat material over and through a mask containing a plurality of openings formed there through such that the bond coat material is deposited onto the underlying surface in a pattern corresponding to the plurality of openings. In this manner, a predetermined surface pattern can be achieved with a high degree of precision and with vertical dimensions that exceed those achievable by simply varying the spray parameters when depositing the coating.

FIG. 2 is a top view of one such mask 30 having a pattern of thru-thickness openings 32. The openings 32 correspond to a desired pattern of surface features to be created on a bond coat material surface, as described more fully below. The openings 32 may be round holes, as illustrated, or they may be any other desired shape. The mask 30 may be formed of any material capable of surviving the process steps described below, and may be a metal alloy, ceramic, or high temperature polymer material in some embodiments.

For component repair applications, a damaged region of a thermal barrier coating system is removed, such as by grinding, and that region must be recoated. In one embodiment, the region to be recoated is imaged, such as with a digital camera or other scanning device, and the image is used to determine a corresponding region 34 of the mask 30 into which are formed the openings 32. Regions 36 of the mask 30 surrounding or remote from the region 34 of the openings 32 remain effectively solid. The mask 30 of FIG. 2 is formed to be generally rectangular and may be used to repair a portion of a leading edge of an airfoil-shaped component such as a gas turbine blade or vane.

After the damaged region of thermal barrier coating 12 is removed from the component 10 of FIG. 1, the mask 30 is attached to the surface 40 to be repaired, as illustrated in FIG. 3. In the embodiment of FIG. 3, the surface 40 is a top surface of an existing bond coat material 18. If during the removal of the damaged material the entire thermal barrier coating 12 were removed to expose the underlying superalloy material

surface 14, the surface 40 could be restored by applying a replacement layer of bond coat material using traditional spraying techniques, or the mask 30 could be attached directly to the underlying superalloy material surface 14. The mask 30 is positioned so that the openings 32 overly the surface 40 where it is desired to create the textured bond coat material surface.

Attachment of the mask 30 to the surface 40 may be accomplished by any known technique and will depend upon the material of construction of the mask 30. For example, a polymer or ceramic mask 30 may be attached with an adhesive, and a metallic or ceramic mask may be attached by brazing. The selection of attachment method is made with consideration of the fact that the mask must be removed from the component surface 40 at a later stage of the process. For example, if a polymer mask 30 is attached with an adhesive, it may be advantageous to select an adhesive that will volatize at a temperature near the volatization temperature of the polymer so that both can be removed in a single heating step.

The next step is to apply a bond coat material 50, such as with a known thermal spray process 52, as illustrated in FIG. 4. The bond coat material 50 is applied onto the mask 30 and through the openings 32 onto the surface 40. The mask 30 functions to allow the bond coat material 50 to bond to the surface 40 only at predetermined locations as defined by the openings 32. Only enough bond coat material 50 sufficient to fill the openings 32 to a desired depth need be applied, but typically it may be desired to completely fill the openings.

The bond coat material 50 that adheres to the top of the mask 30 is considered excess material 54, and it is removed to again expose the mask 30, as illustrated in FIG. 5. The excess bond coat material 54 may be removed by grinding, for example.

The mask 30 is then removed from the component 10 to reveal a textured surface 56 including the desired pattern 60 of bond coat material formed on the surface 40, as illustrated in FIG. 6. The mask may be removed by any known mechanical, chemical or thermal process appropriate for the material of construction of the mask 30. The pattern 60 illustrated is a plurality of columns 62 of bond coat material spaced according to the pattern of openings 32 formed in the mask 30. Other patterns of other shapes of surface features may be envisioned within the scope of the present invention. A layer of ceramic insulating material (not shown) may then be deposited over the

patterned surface to achieve an improved degree of adherence and tolerance to thermal transients than would otherwise be achieved by applying the ceramic insulating material directly onto the unimproved surface 40.

Surface features having a height (direction perpendicular to the coating surface) of up to 25 microns may be achieved by controlling thermal spray parameters. The present invention enables the production of surface features with heights of greater than 25 microns and up to about 400 microns, or in the range of 200-400 microns. And while the embodiment illustrated herein incorporates round openings 32 and a circular cross-section in the columns 62 at equidistant spacings, surface features having various other cross-sectional shapes may be formed, and particularly shapes that inhibit the growth of cracks parallel to bond surface. Moreover, the pattern 60 of surface features 62 may vary from one region of the component 10 to another, either within the same mask 30 or by using different masks in different regions. In one embodiment, at least one of a cross-sectional shape of the openings or a spacing between openings is varied across the mask 30.

The process described herein may be applied to other layered coating systems. For example, hard wear surfaces and abradable coatings are used in various regions of components of gas turbine engines subjected to mechanical wear. The size, shape, number and/or pattern of surface features that may be achieved using the processes described herein may be useful in achieving particular mechanical properties within a coating system. For example, an abradable ceramic material 70 may be deposited over the structure of FIG. 6 to achieve the structure of FIG. 7. The term "abradable ceramic material" as used herein refers to those materials known in the art to provide a reduced resistance to abrasion as a result of their porosity or chemical composition when compared to a typical thermally insulating ceramic material. The resulting system will have a first degree of abradability in its topmost region 72 where there is only abradable ceramic material 70, and it may have a reduced second degree of abradability in underlying region 74 which includes both abradable ceramic material 70 and bond coat material 50.

While various embodiments of the present invention have been shown and described herein, it will be obvious that such embodiments are provided by way of example only. Numerous variations, changes and substitutions may be made without

departing from the invention herein. Accordingly, it is intended that the invention be limited only by the spirit and scope of the appended claims.

CLAIMS

The invention claimed is:

1. A method comprising:

removing a portion of an existing thermal barrier coating from a gas turbine engine component to reveal a region of a surface to be coated;

forming a mask comprising a plurality of openings formed therethrough corresponding to a desired pattern of surface features to be created in a replacement bond coat layer;

applying the mask to the region of the surface to be coated;

depositing bond coat material over the mask and onto the surface through the openings in the mask; and

removing the mask and excess bond coat material deposited over the mask to reveal the replacement bond coat layer having the desired pattern of surface features.

2. The method of claim 1, further comprising:

removing all layers of the portion of the existing thermal barrier coating to reveal a region of a superalloy material surface of the component; and

applying a base layer of the bond coat material onto the superalloy material surface prior to the step of applying the mask.

3. The method of claim 1, further comprising:

forming the mask of a polymer material;

removing the excess bond coat material using a mechanical process; and

removing the mask using a heating step.

4. The method of claim 1, further comprising:

obtaining an image of the region of the surface to be coated;

using the image to form the mask to comprise openings only in a region of the mask corresponding to the region of the surface to be coated.

5. The method of claim 1, further comprising varying at least one of a cross-sectional shape of the openings or a spacing between openings across the mask.

6. A method comprising:

forming a mask comprising a plurality of holes corresponding to a desired pattern of surface features of a bond coat of a thermal barrier coating system;

applying the mask to a surface to be coated;

directing a spray of bond coat material over the mask and onto the surface through the holes in the mask;

removing bond coat material deposited onto the mask; and

removing the mask to reveal the desired pattern of surface features in the bond coat material deposited onto the surface.

7. The method of claim 6, further comprising forming the plurality of holes in the mask in response to an image of the surface to be coated.

8. The method of claim 6, further comprising varying a size, shape or spacing of the holes across the mask.

9. A method comprising:

forming a mask comprising a plurality of openings;

applying the mask to a surface of a gas turbine engine component;

directing a spray of an alloy material through the openings of the mask and onto the surface;

removing the mask and any excess alloy material deposited onto the mask to reveal a pattern of the alloy material on the surface; and

applying a ceramic material over the patterned alloy material.

10. The method of claim 9, further comprising applying a ceramic insulating material over the patterned alloy material.

11. The method of claim 9, further comprising applying an abradable ceramic material over the patterned alloy material.

12. The method of claim 9, further comprising forming the plurality of holes in the mask in response to an image of the surface to be coated.

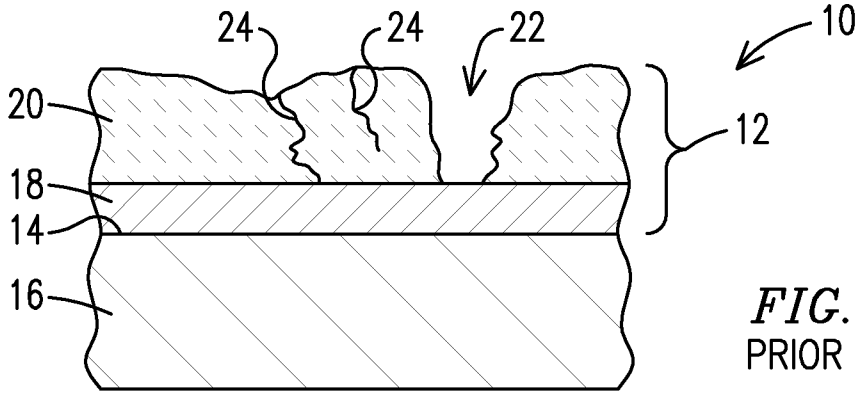


FIG. 1
PRIOR ART

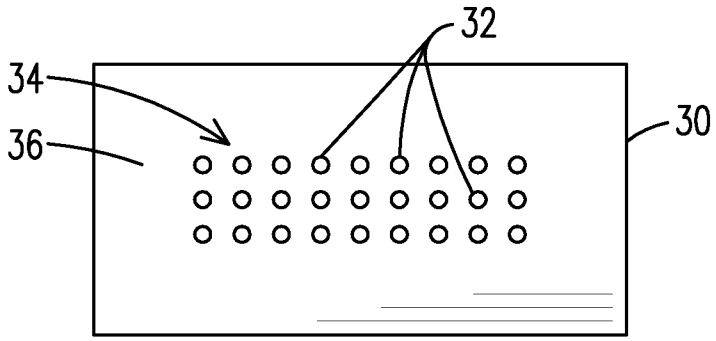


FIG. 2

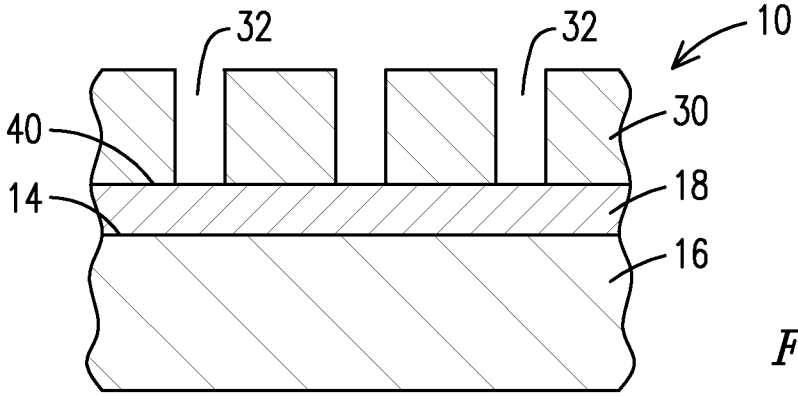


FIG. 3

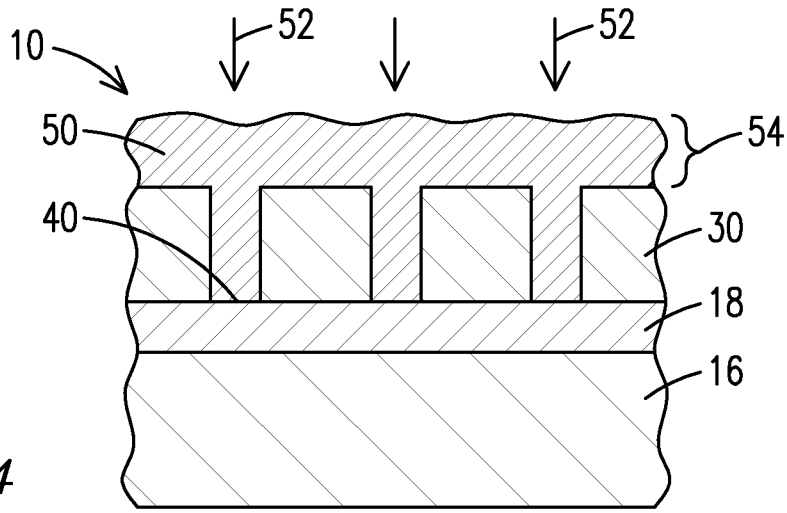


FIG. 4

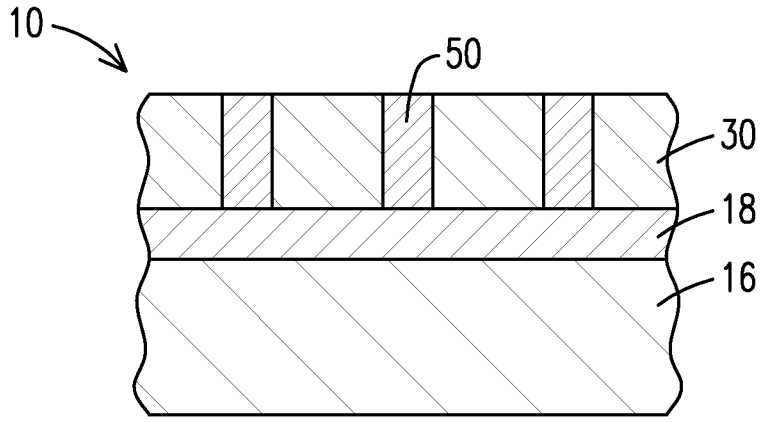


FIG. 5

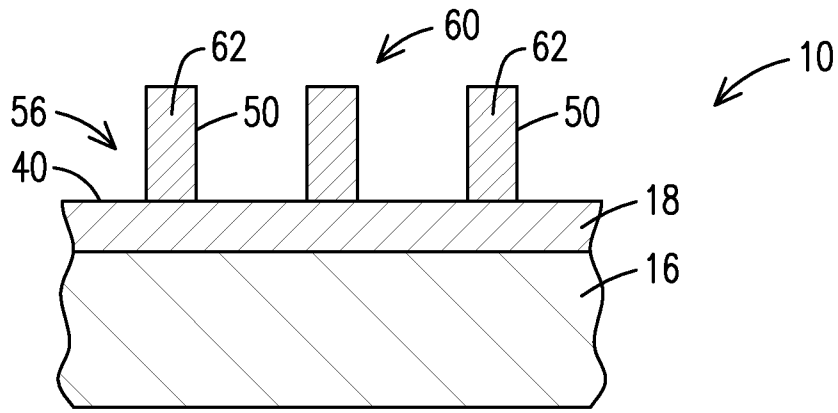


FIG. 6

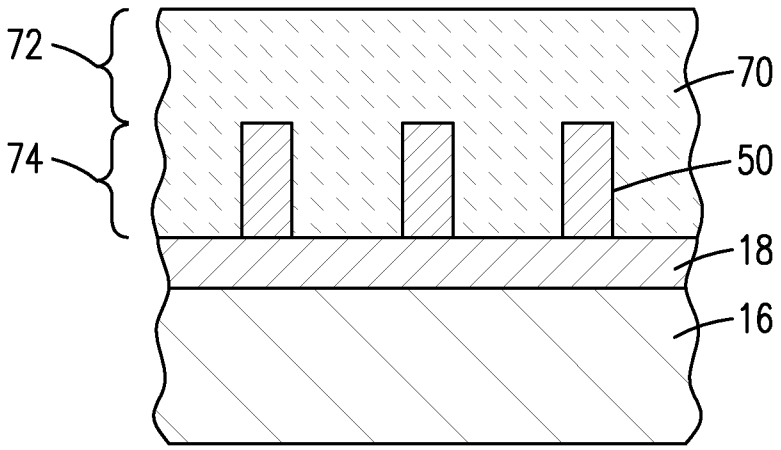


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/041483

A. CLASSIFICATION OF SUBJECT MATTER
INV. C23C4/00 C23C4/02 C23C4/08 C23C4/18 C23C28/02
C23C28/00 F01D5/28
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C23C F01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 2004/115351 A1 (LAU YUK-CHIU [US] ET AL) 17 June 2004 (2004-06-17) paragraphs [0006] - [0010], [0016], [0017], [0025], [0026], [0029], [0040] - paragraph [0042]; figures 3a,3b; example 1	1-12
X	GB 2 117 269 A (ROLLS ROYCE) 12 October 1983 (1983-10-12) the whole document	1-12

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
22 September 2014	06/10/2014

Name and mailing address of the ISA/	Authorized officer
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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2014/041483

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