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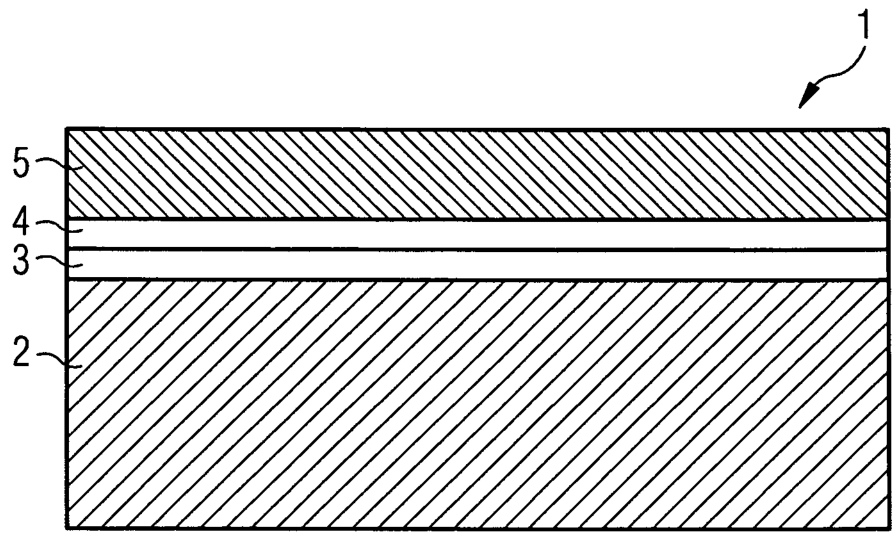
(54) Thermal barrier coating system for a high Titanium content superalloy substrate and method for applying the substrate with the thermal barrier system

(57) Thermal barrier coating system for a high Titanium content superalloy substrate and method for applying the substrate with the thermal barrier system

A thermal barrier coating system for a high Titanium content superalloy substrate comprises a first bondcoat layer being applied to the substrate surface and adhering thereon, a second bondcoat layer being applied to the first bondcoat layer and adhering thereon, and a thermal barrier topcoat layer made of a ceramic material and being applied to the second bondcoat layer and adhering thereon in such a way that the surface of said substrate is protected from corrosion, oxidation and high temperature thermal exposure, wherein the first bondcoat layer and the second bondcoat layer are made of metal material alloys having similar compositions but different phase structures so that the combination of both bondcoat layers is to inhibit diffusion of Titanium from the substrate material into the second bondcoat layer surface beneath the topcoat layer and to keep bondcoat functions.



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Description

[0001] The invention relates to a thermal barrier coating system for a high Titanium content superalloy substrate and a method for applying the substrate with the thermal barrier system.

[0002] An internal combustion engine, in particular a gas turbine, is desirably operated at a combustion temperature which is close to the maximum allowable temperature of hot gas bearing internal pars of the gas turbine in order to obtain a high thermal efficiency. In particular parts down stream of a combustion are subject to high temperatures. In order to increase the maximum allowable operating temperature the hot gas bearing parts are provided with measures protecting the parts from excessive heat. In particular, it is common to protect the hot gas bearing parts with a protective coating on basis of a ceramic thermal barrier coating with a thermal insulation and a corrosion and oxidation protection function.

[0003] It is common to provide the ceramic thermal barrier coating with a metallic bondcoat layer which is located between the ceramic thermal barrier coating and the surface of the hot gas bearing part. During operation the hot gas bearing part is highly stressed and therefore manufactured with a high Titanium content superalloy, since the higher Titanium content results in a higher volume fraction of strengthening Gamma prime particles in the superalloy. However, when the rich Titanium superalloy hot gas bearing part is applied with the thermal barrier coating, Titanium diffuses from the substrate through the metallic bondcoat layer and forms Titanium rich inclusions at the interface between the metallic bondcoat layer and the ceramic thermal barrier coating. These inclusions affect the bonding capability of the metallic bondcoat layer. Therefore, the lifespan of the ceramic thermal barrier coating is reduced and consequently the life cycle of the highly stressed parts is limited.

[0004] A remedy to overcome this problem is to reduce the Titanium content in the highly stressed parts. However, disadvantageously this remedy can reduce the stability of these highly stressed parts.

[0005] It is an object of the invention to provide a thermal barrier coating system for a high Titanium content superalloy substrate and a method for applying the substrate with the thermal barrier system, wherein the substrate has a long life cycle and a high stability.

[0006] According to the invention the thermal barrier coating system for a high Titanium content superalloy substrate comprises a first bondcoat layer being applied to the substrate surface and adhering thereon, a second bondcoat layer being applied to the first bondcoat layer and adhering thereon, and a thermal barrier topcoat layer made of a ceramic material and being applied to the second bondcoat layer and adhering thereon in such a way that the surface of said substrate is protected from corrosion, oxidation and high temperature thermal exposure, wherein the first bondcoat layer and the second bondcoat layer are made of metal material alloys having similar compositions but different phase structures so that the combination of both bondcoat layers is to inhibit diffusion of Titanium from the substrate material into the second bondcoat layer surface beneath the topcoat layer and to keep bondcoat functions.

[0007] Therefore, the first bondcoat layer and the second bondcoat layer provide a two-bondcoat layer to be arranged between the substrate and the thermal barrier topcoat layer. By means of the two-layer bondcoat layer Titanium diffusion from the substrate to the thermal barrier topcoat layer is reduced without deteriorating the bondcoat functions such as oxidation and corrosion protection as well as bonding the thermal barrier topcoat layer. The combination of both layers is to reduce the Titanium diffusion and to keep bondcoat functions, so that an early failure of the ceramic thermal barrier layer is prevented.

[0008] It is preferred that the first bondcoat layer and the second bondcoat layer comprise the same chemical elements. Further, preferably the first bondcoat layer has a Gamma prime phase structure and the second bondcoat layer preferably has a Beta phase structure. Alternatively, it is preferred that the second bondcoat layer has a Gamma prime phase structure and the first bondcoat layer has a Beta phase structure. Additionally, it is preferred that the thermal barrier topcoat layer is manufactured by an electronic beam physical vapour deposition method.

[0009] According to the invention the method for applying the substrate with the thermal barrier system comprises the steps:

> applying a first metallic bondcoat layer on the surface of the substrate and applying a second metallic bondcoat layer on the first metallic bondcoat layer, wherein the first bondcoat layer and the second bondcoat layer have similar compositions but different phase structures; applying a ceramic thermal barrier topcoat layer by an electronic beam physical vapour deposition method.

[0010] Preferably the first bondcoat layer and the second bondcoat layer comprise the same chemical elements. As a first alternative the first bondcoat layer has preferably a Gamma prime phase structure and the second bondcoat layer has preferably a Beta phase structure. As a second alternative, the second bondcoat layer has preferably a Gamma prime phase structure and the first bondcoat layer has preferably a Beta phase structure.

[0011] In the following the invention is explained on the basis of a preferred embodiment with reference to the drawing. In the drawing Fig. 1 shows a cut out of a cross section of the inventive thermal barrier coating system.

[0012] According to Fig. 1 a thermal barrier coating system 1 comprises a first bondcoat layer 3, a second bondcoat layer 4 and a thermal barrier topcoat layer 5.

The thermal barrier coating system 1 is applied to the surface of a substrate 2. The substrate 2 is for example a hot gas bearing part of a gas turbine and is manufactured from a high Titanium content superalloy.

[0013] The first bondcoat layer 3 is applied to the substrate 2 surface and adheres thereon. On the surface of the first bondcoat layer 3 the second bondcoat layer 4 is applied and adheres thereon. The thermal barrier topcoat layer 5 is made of a ceramic material and is applied to the second bondcoat 4 layer and adheres thereon. By means of the thermal barrier topcoat layer 5 the surface of the substrate 2 is protected from corrosion and oxidation caused by hot gas contacting the free surface of the thermal barrier topcoat layer 5.

[0014] The first bondcoat layer 3 and the second bondcoat layer 4 are made of metal material alloys having similar compositions but different phase structures, wherein the first bondcoat layer 3 and the second bondcoat layer 4 comprise the same chemical elements. Further, the first bondcoat layer 3 has a Gamma prime phase structure and the second bondcoat layer 4 has a Beta phase structure, or, alternatively, the second bondcoat layer 4 has a Gamma prime phase structure and the first bondcoat layer 3 has a Beta phase structure. The thermal barrier topcoat layer 5 is applied to the second bondcoat layer 4 by an electronic beam physical vapour deposition method.

[0015] The first bondcoat layer 3 and the second bondcoat layer 4 provide a two-bondcoat layer which is arranged between the substrate 2 and the thermal barrier topcoat layer 5. The Titanium diffusion from the substrate to the thermal barrier topcoat layer is reduced by means of the two-layer bondcoat layer, wherein the bondcoat functions, in particular the oxidation and the corrosion protection, as well as bonding the thermal barrier topcoat layer 5 are not deteriorated. The bondcoat layer containing Gamma prime phase is to inhibit diffusion of Titanium from the substrate 2 material into the second bondcoat surface beneath the topcoat 5. The bondcoat layer containing Beta phase is more active on corrosion and oxidation protection than the gamma prime one. The second bondcoat layer 4 is to keep bonding functions in order to attach the thermal barrier coating system 1 to the substrate 1. Thus, an early failure of the ceramic thermal barrier layer 5 is prevented.

Claims

1. Thermal barrier coating system for a high Titanium content superalloy substrate (2), comprising a first bondcoat layer (3) being applied to the substrate (2) surface and adhering thereon, a second bondcoat layer (4) being applied to the first bondcoat layer (3) and adhering thereon, and a thermal barrier topcoat layer (5) made of a ceramic material and being applied to the second bondcoat (4) layer and adhering thereon in such a way that the surface of said substrate (2) is protected from corrosion, oxidation and high temperature thermal exposure, wherein the first bondcoat layer (3) and the second bondcoat layer (4) are made of metal material alloys having similar compositions but different phase structures so that the combination of both bondcoat layers (3, 4) is to inhibit diffusion of Titanium from the substrate (2) material into the second bondcoat layer (4) surface beneath the topcoat layer (5) and to keep bondcoat functions.

2. Thermal barrier coating system according to claim 1, wherein the first bondcoat layer (3) and the second bondcoat layer (4) comprise the same chemical elements.

3. Thermal barrier coating system according to claim 1 or 2, wherein the first bondcoat layer (3) has a Gamma prime phase structure and the second bondcoat layer (4) has a Beta phase structure.

4. Thermal barrier coating system according to claim 1 or 2, wherein the second bondcoat layer (4) has a Gamma prime phase structure and the first bondcoat layer (3) has a Beta phase structure.

5. Thermal barrier coating system according any of claims 1 to 4, wherein the thermal barrier topcoat layer (5) is manufactured by an electronic beam physical vapour deposition method.

6. Method for applying a substrate with a thermal barrier system according to any of claims 1 to 5, comprising the steps:

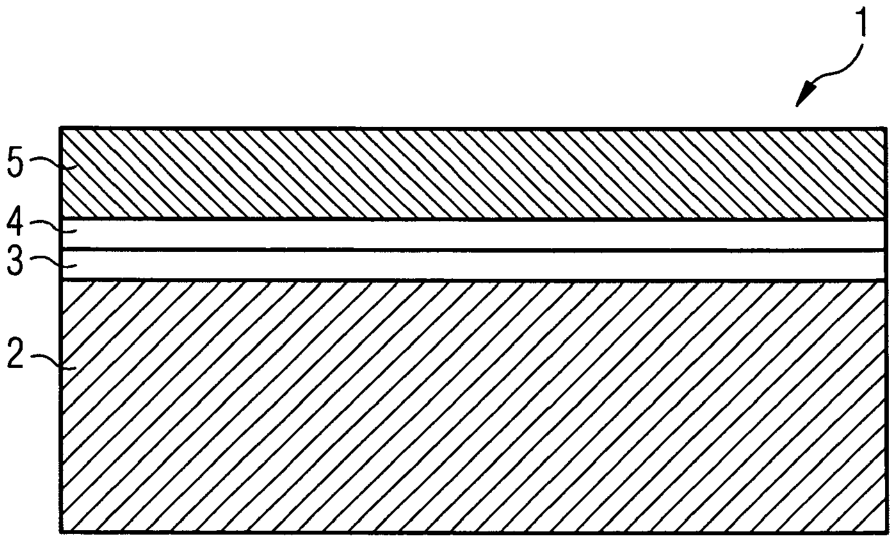
   - applying a first metallic bondcoat layer (3) on the surface of the substrate and applying a second metallic bondcoat layer (4) on the first metallic bondcoat layer, wherein the first bondcoat layer (3) and the second bondcoat layer (4) have similar compositions but different phase structures;
   - applying a ceramic thermal barrier topcoat layer (5) by an electronic beam physical vapour deposition method.

7. Method according to claim 6, wherein the first bondcoat layer (3) and the second bondcoat layer (4) comprise the same chemical elements.

8. Method according to claim 6 or 7, wherein the first bondcoat layer (3) has a Gamma prime phase structure and the second bondcoat layer (4) has a Beta phase structure.

9. Thermal barrier coating system according to claim 6 or 7, wherein the second bondcoat layer (4) has a Gamma prime phase structure and the first bondcoat

layer (3) has a Beta phase structure.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EUROPEAN SEARCH REPORT

Application Number
EP 09 00 4849

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	7 July 2009	Chalaftris, Georgios

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 00 4849

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07-07-2009

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