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(11)

EP 3 170 918 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
24.05.2017 Bulletin 2017/21

(51) Int Cl.:
C23C 28/00 (2006.01) C23C 30/00 (2006.01)

(21) Application number: **15195270.2**

(22) Date of filing: **19.11.2015**

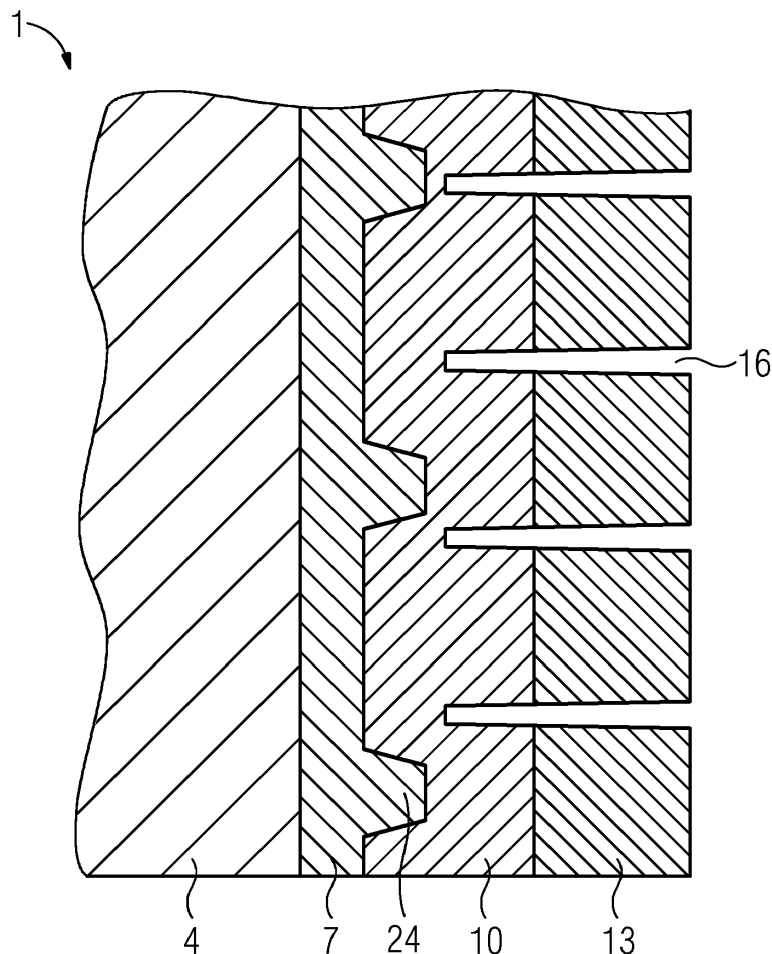
(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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yet been filed**

(54) **DVC-COATING WITH FULLY AND PARTIALLY STABILIZED ZIRCONIA**

(57) A dense vertical cracked microstructure in a ceramic layer system made of an underline partially stabilized zirconia layer and an above laying fully stabilized zirconia layer show good erosion resistance and long life time.



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Description

[0001] The invention relates to a ceramic layer-system with partially and fully stabilized zirconia which has also a dense vertical cracked microstructure (DVC).

[0002] Field feedback has shown that the current Thermal Barrier Coatings (TBC) of turbines suffer from issues related to:

1) Erosion: turbine blades with high porosity coatings containing a large number of unmolten or semimolten particles show low erosion resistance.

The development during the last years has pushed thermal spray coatings porosity upwards. However, that has caused the shrinkage of the spray ability window that allows coatings to receive high porosity and good cohesion. As a result, erosion has started manifesting itself as a major issue for coatings in specific parts and engines.

2) Drilling damage: High porosity coatings contain less intimate contacts between splats or splat and substrate and thus the required energy for a crack to propagate is relatively low.

This problem has been addressed by drilling before the coating deposition and reopening of the holes after coating deposition. This approach minimizes the interaction between coating and laser and that reduces significantly the coating delamination around the drilled holes. However, since each part has to be processed twice, this solution is associated with longer drilling times that are reflected as increased cost.

3) Coating life: thermal sprayed porous coatings do not demonstrate at the same level the high strain tolerance along the coating thickness which can be seen in other coating types such as EB-PVD.

The thermal barrier coatings porosity has been increased to improve strain tolerance. However as mentioned above, that can reduce the spray ability process window and influence negatively the cohesion and erosion resistance of the coatings.

4) YSZ for TBC chemistries are currently limited to 1528K maximum temperature due to phase transformation issues.

New chemistries have been adopted that present phase stability in higher temperatures. However they show significantly lower fracture toughness compared to the partially stabilized zirconia and it is certain that their erosion resistance will be even less.

[0003] The task of the invention is therefore to solve the problems given above.

[0004] The problem is solved by a ceramic layer system according to claim 1.

[0005] In the subclaims further advantages are given

which can be abitrality combined with each other to yield additional advantages.

[0006] The figure and the description show only examples of the invention.

[0007] The problems named under point 1 are addressed by adopting engraved coatings.

1) Erosion. Such thermal barrier coatings have shown significantly lower rates compared to their porous counterparts.

2) Such coatings have increased cohesion and adhesion compared to the typical porous coatings. The reason is that a very high ratio of fully molten particles deposit on hot substrate or hot previously deposited splats which promotes a good intimate bonding to develop between them. Improved adhesion requires high energy for a horizontal crack to propagate so that guarantees a lower delamination.

3) Coating life. Due to the intimate contact between splats, the DVC coatings show high fracture toughness along the parallel to the substrate plane. That, combined with their ability to accommodate thermal strain along the coating thickness due to their columnar microstructure ensures a high TBC life.

4) The lower layer will accommodate CTE mismatch with the bond coat and the TGO while the upper layer will provide the higher temperature capability.

[0008] The system comprises of partially stabilized zirconia, especially 8YSZ as the high fracture toughness lower layer to accommodate the CTE mismatch with bond coat and TGO and a lower toughness upper layer of fully stabilized zirconia, especially 48YSZ to provide the high temperature capability. Unlike other possible bilayer coating approaches, the similar chemistry between the two coatings enhances their bonding.

[0009] The advantages that arise are:

1) The low fracture toughness of the FSZ with the adoption of engravings will significantly increase. That will improve the erosion resistance of the coating.

2) A good bonding between the two layers and as well with the bond coat will increase the drilling damage tolerance. Less delamination will be observed compared to other bilayer coating systems which have suffered in the past from drilling.

3) The columnar microstructure along the bilayer coating thickness will allow improved strain tolerance, thus increased coating life.

4) Higher temperature capability compared to single layer DVC coatings.

[0010] The figure shows a layer system 1.

[0011] The layer system 1 comprises a substrate 4 which is preferably metallic and very preferably made of a nickel or cobalt based super alloy.

[0012] On the substrate 4 a bond coat 7, especially a metallic bond coat 7 and very especially a NiCoCrAlY-based bond coat 7 is applied on.

[0013] The bond coat 7 reveals an engineered surface, here in the form of bumps 24.

The engineered surface or bumps 24 are yielded during coating by additional means or working the bond coat 7 after having fully coated the bond coat 7 and can have any geometry.

The bumps 24 are not caused by the roughness of the bond coat 7.

[0014] On this bond coat 7 there is a thermally grown oxide layer (TGO, not shown) which is formed during further application of following ceramic layers or by an additional oxidation step or at least during use of the layer system 1.

[0015] On the bond coat 7 there is applied a first zirconia layer 10 made of a partially stabilized zirconia. The thickness of the partially stabilized zirconia layer 10 is preferable between 75µm - 800µm.

The porosity of the partially stabilized zirconia 10 is preferably lower than 5% and very preferably lower than 3%.

[0016] As an outer ceramic layer there is applied a fully stabilized zirconia layer 13, which is especially the outer most layer of the layer system 1.

[0017] The porosity of the fully stabilized zirconia 13 is lower than 5% and preferably lower than 3%.

[0018] The thickness of the fully stabilized zirconia 13 is preferable between 50µm - 800µm.

[0019] The stabilization in this zirconia based system can be reached by yttria or by any other rare earth element or mixtures as known by the state of the art.

[0020] Preferably yttrium (Y) is used for stabilization.

[0021] In this layers 10, 13 there are engravings 16 present, which are mostly present in the outer most layer 13 and preferably some of them are present in both layers 10, 13 and very preferably all engravings 16 are in both layers 10, 13.

[0022] The engravings 16 are especially made by a laser.

Claims

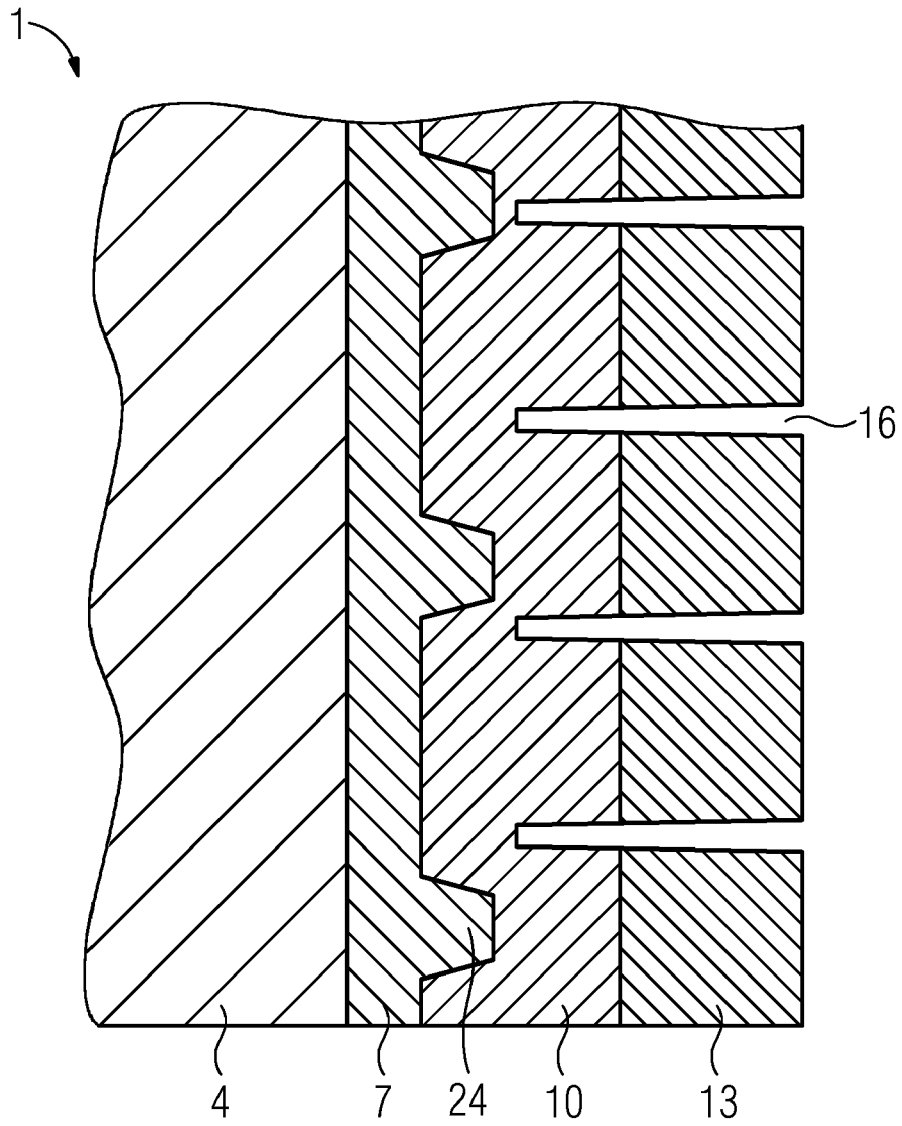
1. Ceramic layer system,
at least comprising:

a substrate (4),
especially a metallic substrate (4),
very especially made of a nickel or cobalt based super alloy,
a metallic bond coat (7) on the substrate (4),
which is especially metallic and
very especially made of a NiCoCrAlY-based al-

loy,

wherein the metallic bond coat (7) has a structured surface with bumps (24),
an inner partially stabilized zirconia layer (10) on the metallic bond coat (7) and
on the inner partially stabilized zirconia layer (10) a fully stabilized zirconia layer (13),
wherein engravings (16) are present in the fully stabilized zirconia layer (13).

2. Ceramic layer system according to claim 1,
wherein the engravings (16) are only present in the fully stabilized zirconia layer (13).
3. Ceramic layer system according to claim 1,
wherein the engravings (16) are present in both layers (10, 13).
4. Ceramic layer according to any of the preceding claims, wherein the porosity of the fully stabilized zirconia layer (13) is lower than 5%, especially lower than 3%.
5. Ceramic layer system according to any of the preceding claims,
wherein the thickness of the partially stabilized zirconia layer (10) is between 75µm - 800µm.
6. Ceramic layer system according to any of the preceding claims,
wherein the thickness of the fully stabilized zirconia layer (13) is between 50µm - 800µm.
7. Ceramic layer system according to any of the preceding claims,
wherein the zirconia of the zirconia layers (10, 13) is stabilized by yttria,
especially only by yttria.
8. Ceramic layer system according to any of the preceding claims,
wherein the porosity of the partially stabilized zirconia layer is lower than 5%, especially lower than 3%.
9. Ceramic layer system according to any of the preceding claims,
wherein the partially stabilized zirconia is stabilized by yttria,
especially is 8YPSZ.





EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 April 2016	Examiner Brisson, Olivier
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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