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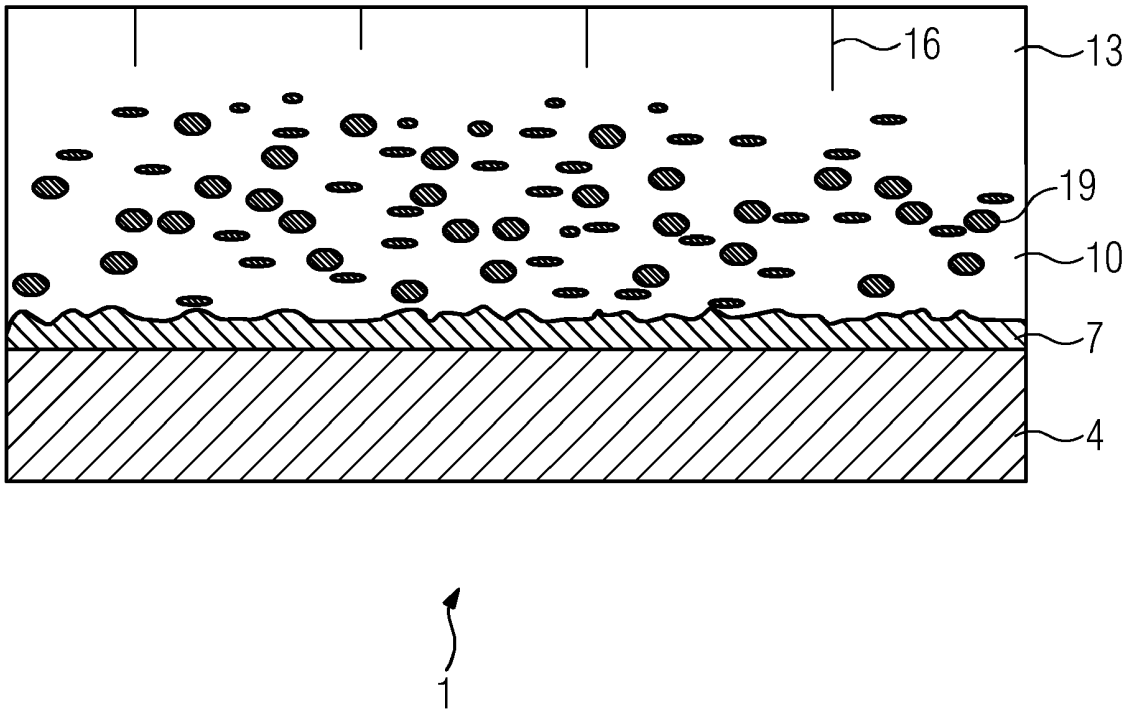
## (54) DVC-CERAMIC LAYER WITH UNDERLYING POROUS CERAMIC SUBLAYER

(57) Due to the combination of the dense vertical cracked outermost ceramic coating (13) and a high porosity ceramic sublayer (10) a good spallation and erosion resistance layer system is given.

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## Description

**[0001]** The invention relates to a ceramic layer system which has an outer ceramic thermal barrier coating with vertical cracks and an underlying high porous ceramic sublayer.

**[0002]** Components for the use at high temperatures are coated with metallic coatings in order to protect them against oxidation and corrosion.

**[0003]** The protection against the heat is performed by ceramic coatings, which are based mostly on zirconia.

**[0004]** Field feedback has shown that the current thermal barrier coatings (TBC) suffer from low erosion resistance. Turbine blades of stage 1 with high porosity coatings containing a large number of unmolten or semimolten particles have shown low erosion resistance. At certain gas turbine types and in specific turbine parts locations, such as the sections surrounding the leading edge, bond coat has evidently been exposed in early intervals due to the severe erosion rate of the TBC.

**[0005]** The development during the last years has pushed thermal spray coatings porosity upwards. However, that has caused the shrinkage of the sprayability window that allows coatings to receive both high porosity and good cohesion. In the continuous effort to increase porosity, coating's cohesion can be neglected and as a result, erosion has started manifesting itself as a major issue for coatings in specific parts and engines.

**[0006]** Nevertheless, due to the constantly increasing temperatures these turbine parts are exposed to, it is of imperative importance that the ceramic layer must demonstrate increased erosion resistance.

**[0007]** It is therefore the aim of the invention to reveal a ceramic layer system which overcomes the problems given above.

**[0008]** The problem is solved by a ceramic layer system according to claim 1.

**[0009]** The problems are preferably addressed by adopting a denser ceramic outer coating. Preferably this coating will be deposited as a segmented TBC to demonstrate compliance and strain tolerance. Additionally segmented TBCs have shown significantly lower erosion rates compared to their porous counterparts. That means for the same chemistry a porous coating will show more than 3x the erosion rate compared to the segmented's one.

**[0010]** In the subclaims further advantages are listed, which can be arbitrary combined with each other to yield further advantages.

**[0011]** The figure shows an example of the invention.

**[0012]** The description and the figure show only examples of the invention.

**[0013]** The novelty lies on the usage of DVC microstructure on top of a porous coating. The system comprises of a porous, especially partially stabilized zirconia as the low conductivity lower, especially thicker layer and a high toughness DVC upper, especially thin layer of especially partially stabilized zirconia (especially 8YSZ) to provide the high temperature capability.

**[0014]** The thickness of the upper DVC layer is preferably between 50μm - 250μm.

**[0015]** Unlike other possible bilayer coating approaches, the same chemistry between the two coatings can enhance their bonding. Appropriate preheating of the already deposited porous PSZ will prepare its surface to receive the fully molten particles for the DVC and due to the high local temperatures attained during spraying will allow better diffusion between the two similar materials. To reduce the cost ideally the two coatings can be obtained by using the same high power torch and by appropriate tailoring of the powder particle size and spraying parameters.

**[0016]** The advantages that arise are:

1) The erosion resistance of the coating system will be improved significantly. The dense upper coating is expected to drastically reduce the amount of material loss due to erosion and help preserve the porous ceramic sublayer 10.

**[0017]** The new coating system comprises segmented partially stabilized zirconia on porous partially stabilized zirconia (PSZ). The segmented coating is thinner than the porous. The porous can be HHP or coating of other similar or higher porosity for increased thermal protection. The bond coat can be a thermally sprayed typical MNiCoCrAlY.

**[0018]** The figure shows a metallic substrate 4 which is especially made of a nickel- or cobalt based superalloy.

**[0019]** On the surface of the substrate 4 there is a metallic bond coat 7, which is preferably made of a NiCoCrAlY alloy.

**[0020]** On this metallic bond coat 7, there is a thermal grown oxide layer (TGO), which is build up during further application of a ceramic layer or by oxidation or during use of the component.

**[0021]** The thermal grown oxide (TGO) is not further shown.

**[0022]** The ceramic layer is especially a bilayer and comprises a underlying porous ceramic sublayer 10.

**[0023]** The porous ceramic sublayer 10 has a high porosity and is thicker, that means at least 20% thicker than the outer ceramic layer 13.

**[0024]** The porosity of the porous ceramic sublayer 10 is mostly caused by pores. The porosity of the porous ceramic sublayer is between 8% - 20%.

**[0025]** The porous ceramic sublayer preferably has a thickness from 50μm to 500μm.

**[0026]** The porous ceramic sublayer 10 has a much higher porosity than the outermost ceramic sublayer 13, especially higher than 50% (relative), very especially higher than 70% (relative) of the outer ceramic outermost layer and shows vertical cracks 16.

**[0027]** The porosity of the outer ceramic layer 13 is especially lower than 6%, especially lower than 5%, wherein the outer ceramic layer is especially the outer-

most layer.

**[0028]** The vertical cracks 16 in the outermost ceramic layer (13) are mostly and especially at least 90% only in the outermost layer 13.

**[0029]** The outermost layer 13 has a thickness of 5μm to 250μm.

**[0030]** The ceramic for the porous ceramic sublayer 10 and the outer layer 13 is preferably zirconia ($ZrO_2$), which are both preferably stabilized by Yttria ($Y_2O_3$).

## Claims

1. Ceramic layer system (1),
at least comprising:

   a metallic substrate (4),
   especially made of a nickel- or cobalt based superalloy,
   a metallic bond coat (7),
   especially made of an NiCoCrAlY alloy,
   wherein a porous ceramic sublayer (10) is present on the metallic bond coat (7) and
   an outer ceramic layer (13),
   especially outermost ceramic layer (13),
   on the porous ceramic sublayer (10),
   wherein the outermost ceramic layer (13) has vertical cracks (16).

2. Layer system according to claim 1,
wherein the porous ceramic sublayer (10) is at least 20% thicker than the outermost ceramic layer (13).

3. Layer system according to one of the claims 1 or 2,
wherein the porosity of the porous ceramic sublayer (10) is at least 50%, especially at least 70% higher than the porosity of the outer ceramic layer (13).

4. Layer system according to any of the claims 1, 2 or 3,
wherein the material of the porous ceramic sublayer (10) and the outer layer (13) is made of zirconia,
especially stabilized by yttria ($Y_2O_3$),
especially partially stabilized zirconia ($ZrO_2$).

5. Layer system according to any of the claims 1, 2, 3 or 4,
wherein the outer ceramic layer (13) has a thickness of 50μm to 250μm.

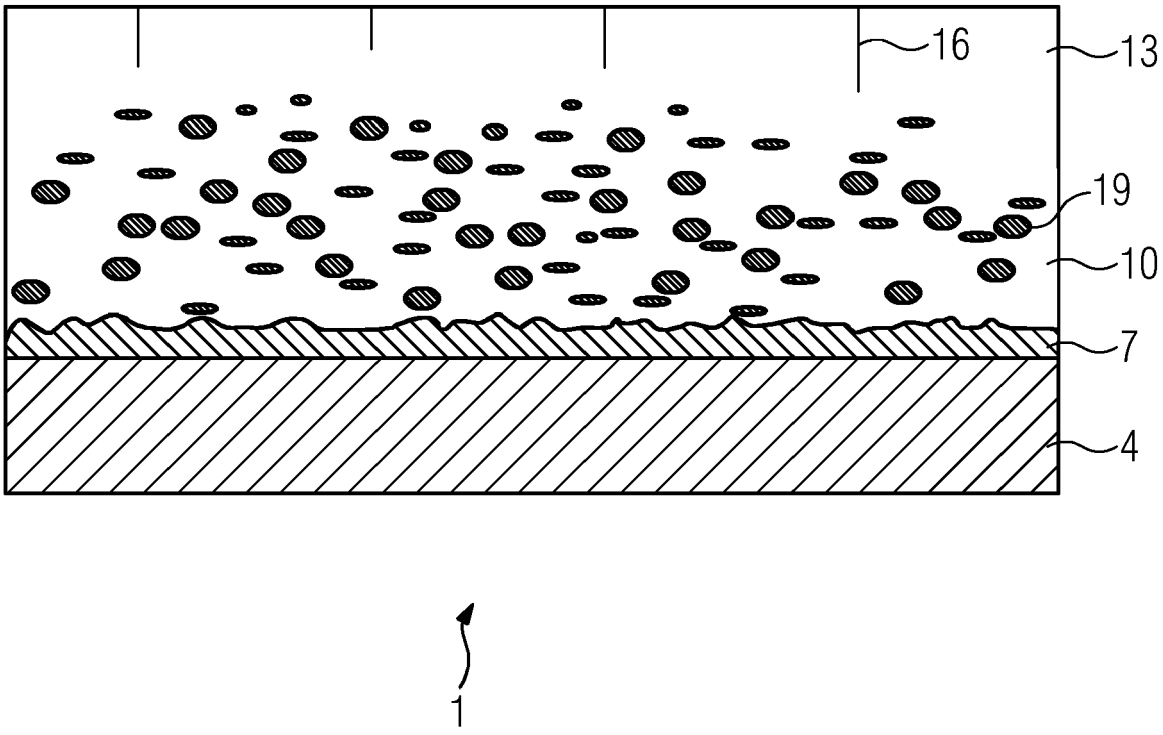
6. Layer system according to any of the claims 1, 2, 3, 4 or 5,
wherein the porosity of the porous ceramic sublayer (10) is mostly caused by pores.

7. Layer system according to any of the claims 1, 2, 3, 4, 5 or 6,
wherein the porosity of the porous ceramic sublayer (10) is between 8% and 20%,
especially 10% to 20%.

8. Layer system according to any of the claims 1, 2, 3, 4, 5, 6 or 7,
wherein the outer ceramic (13) layer has a porosity lower than 6%,
especially lower than 5%.

9. Layer system according to any of the claims 1, 2, 3, 4, 5, 6, 7 or 8,
wherein the ceramic of the layer system (1) consists of an oxide layer of the metallic bond coat (7), the porous ceramic sublayer (10) and the outer layer (13).

10. Layer system according to any of the claims 1, 2, 3, 4, 5, 6, 7, 8 or 9,
wherein the thickness of the porous ceramic sublayer (10) is at least 100μm, especially at least 300μm.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# EUROPEAN SEARCH REPORT

Application Number
EP 15 18 8703

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
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C23C
C04B
F01D

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 28 January 2016 | Ruiz Martinez, Maria |

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28-01-2016

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