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(54) **HYBRID THERMAL BARRIER COATING AND PROCESS OF MAKING SAME**

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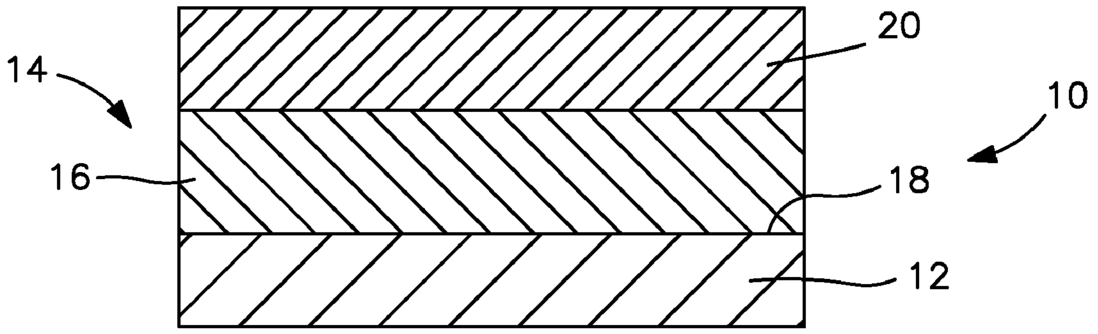
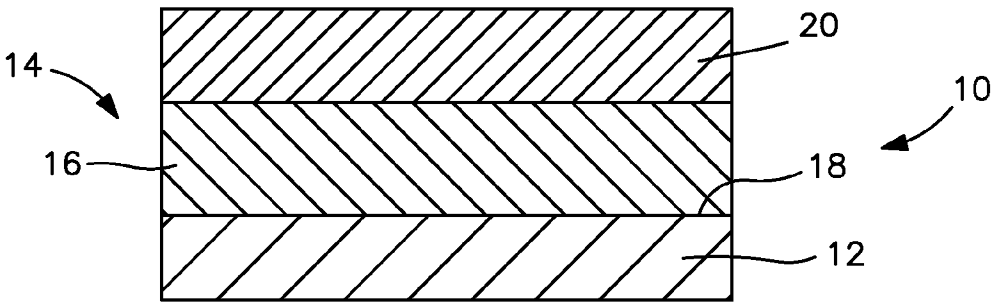
(57) **ABSTRACT**

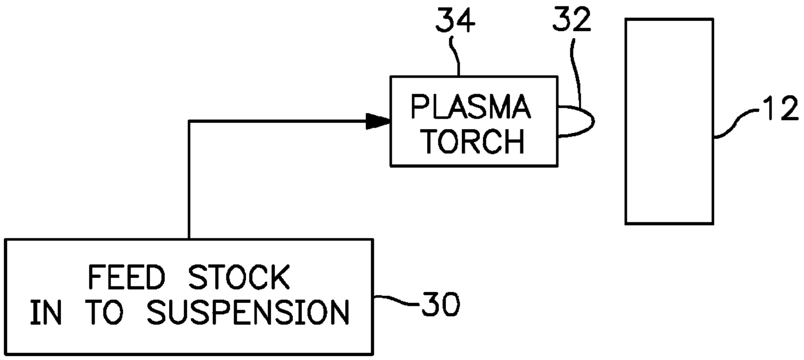
A thermal barrier coating is applied to a turbine engine component having a substrate. The thermal barrier coating has a first layer which has a strain tolerant columnar microstructure at an interface with the substrate for spallation resistance and a second layer which is porous conduction and radiation thermally resistant at an outer surface of the thermal barrier coating.





14
20
10
16
18
12

FIG. 1



34
32
PLASMA TORCH
12
FEED STOCK IN TO SUSPENSION
30

FIG. 2

HYBRID THERMAL BARRIER COATING AND PROCESS OF MAKING SAME

BACKGROUND

[0001] The present disclosure relates to a thermal barrier coating for use on a turbine engine component and to a process of making the thermal barrier coating.

[0002] A thermal barrier coating (TBC) is created to meet one or more performance requirements including, but not limited to, spallation life, calcia-magnesia-alumina-silicate (CMAS) resistance, foreign object damage (FOD) resistance, erosion, and low conductivity. A turbine barrier coating is applied to a turbine engine component, such as a turbine blade/vane, to help the component withstand the relatively high temperatures of its operational environment.

[0003] TBCs are often formed using a singular coating process such as an electron beam physical vapor deposition (EB-PVD) process. For example, a TBC may be formed from two separate EB-PVD layers formed from two different materials, such as 7 wt % yttria stabilized zirconia and gadolinia stabilized zirconia in order to improve the thermal conductivity properties of the coating. The strain-tolerant columnar structure of an EB-PVD coating helps to increase the TBC spallation life. A more porous TBC however may minimize the TBC thermal conductivity and possibly the thermal radiation through the coating.

[0004] In one TBC, there is a porous outer layer over a more dense inner layer made by an EB-PVD process. In some TBCs, the two layers have different porosity levels. Such a structure can be formed by changing the coating temperature. More power equals more density but also more temperature. It is also known to form a dense vertically cracked microstructure for the TBC where the deposition is conducted at a two inch stand-off for the dense layer and a six inch stand-off for the porous layer.

SUMMARY

[0005] In accordance with the present disclosure, there is provided a thermal barrier coating which is applied to a turbine engine component having a substrate, which thermal barrier coating broadly comprises a first layer which has a strain tolerant columnar microstructure at an interface with the substrate for spallation resistance and a second layer which is porous conduction and radiation thermally resistant at an outer surface of the thermal barrier coating.

[0006] In another and alternative embodiment, the first and second layers are formed from the same material.

[0007] In another and alternative embodiment, the first and second layers are formed from different compositions.

[0008] In another and alternative embodiment, the second layer has a porosity in the range of from 10 to 40%.

[0009] In another and alternative embodiment, each of the first and second layers is formed from 7 wt % yttria stabilized zirconia.

[0010] In another and alternative embodiment, the first layer is formed from 7 wt % yttria stabilized zirconia and the second layer is formed from gadolinia stabilized zirconia.

[0011] In another and alternative embodiment, the first layer has a first thermal conductivity and the second layer has a second thermal conductivity which is at least 10% lower than the first thermal conductivity.

[0012] Further in accordance with the present disclosure, there is provided a process for applying a thermal barrier coating to a turbine engine component which broadly comprises the steps of: forming a first layer which has a strain tolerant columnar microstructure at an interface of the first layer and a substrate using a suspension plasma spray technique; and forming a second layer which is porous and radiation thermally resistant at an outer surface of the thermal barrier coating using one of the suspension plasma spray technique and an air spray plasma technique.

[0013] In another and alternative embodiment, the process further comprises forming a continuously graded microstructure from the interface to the outer surface.

[0014] In another and alternative embodiment, the first layer forming step comprises suspending a powder feedstock in a liquid suspension and injecting the powder feedstock and the suspension into a plasma jet under conditions where the first layer is formed with the strain-tolerant columnar microstructure.

[0015] In another and alternative embodiment, the second layer forming step comprises changing spray parameters so as to form the porous and radiation thermally resistant second layer.

[0016] In another and alternative embodiment, the first and second layer forming steps comprises forming the first and second layers from the same material.

[0017] In another and alternative embodiment, the first layer is formed from a first material having a first composition and the second layer is formed from a second material having a second composition which is different from the first composition.

[0018] In another and alternative embodiment, the second layer is formed using the air spray plasma technique.

[0019] In another and alternative embodiment, the second layer forming step comprises forming the second layer so as to have a porosity of from 10 to 40%.

[0020] In another and alternative embodiment, the second layer forming step comprises forming the second layer so as to have a thermal conductivity which is at least 10% lower than a thermal conductivity of the first layer.

[0021] In another and alternative embodiment, the first and second layer forming steps comprise using a powdered feedstock having a particle size in the range of from 10 nm to 10 microns.

[0022] In another and alternative embodiment, the first and second layer forming steps comprises using a powdered feedstock having a particle size in the range of from 10 nm to 2.0 microns.

[0023] Other details of the hybrid thermal barrier coating and the process of making same are set forth in the following detailed description and the accompanying drawings wherein like reference numerals depict like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIG. **1** illustrates a turbine engine component having a thermal barrier coating in accordance with the present disclosure deposited thereon; and

[0025] FIG. **2** illustrates a system for forming the coating on the turbine engine component.

DETAILED DESCRIPTION

[0026] Referring now to FIG. **1**, there is shown a turbine engine component **10**. The turbine engine component may be any component which requires a thermal barrier coating such as a blade/vane. The turbine engine component **10** may have a substrate **12** formed from any suitable material known in the art including, but not limited to, a nickel based alloy, a cobalt based alloy, a titanium based alloy, a ceramic material, and an organo-matrix composite material.

[0027] A thermal barrier coating **14** may be deposited on the substrate **12**. The thermal barrier coating **14** may have a first layer **16** which interfaces with the surface **18** of the substrate **12** and an outer second layer **20**. The first layer **16** may be formed so as to have a strain-tolerant columnar microstructure at the interface with the surface **18** of the substrate. The second layer **20** may be formed to have a porous thermal conduction and radiant heat transfer resistant microstructure at an outer surface **22** of the thermal barrier coating.

[0028] The first layer **16** and the second layer **20** may formed from a material having the same composition. For example, each of the layers **16** and **20** may be formed from a wt % yttria stabilized zirconia (7YSZ). In another embodiment, the first layer **16** may be formed from a first material having a first composition and the second layer **20** may be formed from a second material having a second composition which is different from the first composition. For example, the first layer **16** may be formed from 7YSZ, while the second layer **20** is formed from gadolinia stabilized zirconia.

[0029] Each of the layers **16** and **20** may be formed using suspension plasma spray (SPS) technique such as that shown in FIG. **2**. In this technique, a powdered feedstock is suspended in a liquid suspension **30**. For example, the powdered feedstock may be 7YSZ which may be suspended in ethanol, water, or other alcohols such as methanol. The powdered feedstock may have a particle size in the range of from 10 nm to 10 microns mean size diameter. In another non-limiting embodiment, the particles size may be in the range of from 10 nm to 2.0 microns. The powdered feedstock in the suspension is injected into a plasma jet **32** created by a plasma torch **34** and thus deposited onto the substrate **12**. The spray conditions are such that the first layer **16** is formed to have the desired strain tolerant columnar microstructure. The deposition technique may have a short stand off (similar to that used in dense vertically cracked coatings) and high power/enthalpy plasma conditions. After the first layer **16** has been formed, the spray conditions may be changed so as to form the second layer **20** with the porous thermal conduction and radiant heat transfer resistant microstructure. To add porosity, (1) the angle of the spray nozzle could be changed from normal relative to the surface on which the layer **20** is being deposited; (2) the stand off may be increased; and/or (3) the plasma power/enthalpy may be reduced. More porosity in the second layer **20** than in the first layer **16** creates a reduction in thermal conductivity. The second layer **20** may have a reduction of at least 10% in thermal conductivity. This may come purely from a porosity increase or a change in the structure from columnar to more splat like. An increase in porosity increases the erosion rate. A useful limit may be 10 to 40% porosity in the second layer **20**.

[0030] The columnar structure SPS gives a thermal cyclic spallation resistance similar to EB-PVD (much higher than APS and higher than dense vertically cracked). Erosion is a function of porosity content and can be greater or less than EB-PVD (generally higher than APS and more like dense vertically cracked). Thermal conductivity, as discussed above, follows the porosity content.

[0031] If desired, the spray conditions may be discreetly or incrementally changed throughout the spray run. For example, the spray conditions may be changed so that a continuously graded microstructure is formed where there is the strain-tolerant columnar microstructure at the interface with the substrate **12** for thermal barrier coating spallation resistance and a porous thermal conduction and radiation thermally resistant layer at the outer surface **22**.

[0032] If desired, the first layer **16** may be formed using the above discussed SPS technique and the second layer **20** may be formed using a porous air plasma spray (APS) technique.

[0033] One of the advantages of the process described herein is that the thermal barrier coating can be formed using a single piece of equipment and in a single coating run.

[0034] Another advantage is that one can easily change the composition of the second layer **20** so that it is different than the composition of the first layer **16**. This can easily be done by changing the composition of the feedstock being injected into the plasma jet.

[0035] There has been described herein a hybrid thermal barrier coating and a process for making same. While the coating and process have been described in the context of specific embodiments thereof, other unforeseen alternatives, modifications, and variations may become apparent to those skilled in the art having read the foregoing description. Accordingly, it is intended to embrace those alternatives, modifications, and variations as fall within the broad scope of the appended claims.

What is claimed is:

1. A thermal barrier coating applied to a turbine engine component having a substrate, said coating comprising:

a first layer which has a strain tolerant columnar microstructure at an interface with the substrate for spallation resistance; and

a second layer which is porous conduction and radiation thermally resistant at an outer surface of the thermal barrier coating.

2. The thermal barrier coating of claim **1**, wherein said first and second layers are formed from the same material.

3. The thermal barrier coating of claim **1**, wherein said first and second layers are formed from different compositions.

4. The thermal barrier coating of claim **1**, wherein said second layer has a porosity in the range of from 10 to 40%.

5. The thermal barrier coating of claim **1**, wherein each of said first and second layers is formed from 7 wt % yttria stabilized zirconia.

6. The thermal barrier coating of claim **1**, wherein said first layer is formed from 7 wt % yttria stabilized zirconia and the second layer is formed from gadolinia stabilized zirconia.

7. The thermal barrier coating of claim **1**, wherein said first layer has a first thermal conductivity and said second layer has a second thermal conductivity which is at least 10% lower than the first thermal conductivity.

8. A process for applying a thermal barrier coating to a turbine engine component comprising:

forming a first layer which has a strain tolerant columnar microstructure at an interface of the first layer and a substrate using a suspension plasma spray technique; and

forming a second layer which is porous and radiation thermally resistant at an outer surface of the thermal barrier coating using one of said suspension plasma spray technique and an air spray plasma technique.

9. The process of claim **8**, further comprising:

forming a continuously graded microstructure from said interface to said outer surface.

10. The process of claim **8**, wherein said first layer forming step comprises suspending a powder feedstock in a liquid suspension and injecting said powder feedstock and said suspension into a plasma jet under conditions where said first layer is formed with said strain-tolerant columnar microstructure.

11. The process of claim **10**, wherein said second layer forming step comprises changing spray parameters so as to form said porous and radiation thermally resistant second layer.

12. The process of claim **8**, wherein said first and second layer forming steps comprises forming said layers from the same material.

13. The process of claim **8**, wherein said first layer is formed from a first material having a first composition and said second layer is formed from a second material having a second composition which is different from said first composition.

14. The process of claim **8**, wherein said second layer is formed using said air spray plasma technique.

15. The process of claim **8**, wherein said second layer forming step comprises forming said second layer so as to have a porosity of from 10 to 40%.

16. The process of claim **8**, wherein said second layer forming step comprises forming said second layer so as to have a thermal conductivity which is at least 10% lower than a thermal conductivity of said first layer.

17. The process of claim **8**, wherein said first and second layer forming steps comprise using a powdered feedstock having a particle size in the range of from 10 nm to 10 microns.

18. The process of claim **8**, wherein said first and second layer forming steps comprises using a powdered feedstock having a particle size in the range of from 10 nm to 2.0 microns.

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