Claims

1. A thermal barrier modified composite coating, comprising:

a first coating layer bonded to a surface of a ~~substrate~~gas turbine blade having a roughness Ra of less than 3.18 µm (125 µin), said first coating layer comprising macro columnar features characterized by a predetermined distribution of peaks and valleys at their corresponding free surfaces to create improved mechanical bonding between the first layer and a second layer; said second layer being a dense columnar coating or a Densely Vertically Cracked coating being less columnar than the first coating layer;

said macro columnar features comprising microstructural features that include ~~derived from a precursor liquid suspension of~~ nano-sized and/or submicron-sized splats derived from a precursor liquid suspension to form a thermomechanical compliant interface at the substrate surface, said splats being randomly oriented to produce an isotropic crystallographic orientation for the first coating; said precursor liquid suspension formed by a suspension plasma spray (SPS) method;

said splats comprising non-equiaxed columnar grains that grow opposite to a direction of heat flow upon cooling to produce an anisotropic crystallographic grain orientation; and

wherein said second coating layer is bonded to the corresponding free surfaces of the first coating layer, said second coating layer at the bulk and/or free surface having at least one improved coating property in comparison to the first coating layer, said improved coating property comprising a lower porosity than that of the first coating layer and an improved mechanical erosion barrier in comparison to the first coating layer.

~~2. The thermal barrier modified composite coating of claim 1, wherein said coating property is selected from the group consisting of thermal conductivity, erosion resistance, corrosion resistance and thermomechanical compliance.~~

~~3. The thermal barrier modified composite coating of claim 1, wherein said first coating layer further comprises built in porosity in an amount greater than that of the second coating.~~

~~4. The thermal barrier modified composite coating of claim 1, wherein said second coating layer is selected from the group consisting of a dense vertically cracked coating, an abradable coating, an environmental barrier coating a densified columnar coating, an atmospheric plasma sprayed coating and any combinations thereof~~

~~5. The thermal barrier modified composite coating of claim 1, wherein said substrate comprises a smooth surface.~~

~~6.~~2. The thermal barrier modified composite coating of claim 1, wherein at least a portion of said peaks and valleys have a non-uniformity in width and height ~~substantially non-uniform~~ to form an interfacial boundary with tortuosity.

~~7~~3. The thermal barrier modified composite coating of claim 1, wherein said coating property is graded in a continuous manner within said second coating layer, wherein said coating property has a first value at first location adjacent to the interface of the first and the second coating layer, said property changing from said first value along a path starting at said first location and extending in a direction towards a point on the free surface of the second coating layer.

~~8~~4. The thermal barrier modified composite coating of claim 1, wherein said coating property has a first value at a first location adjacent to the surface of the substrate and a second value at a point along a free surface of said second coating layer, wherein said coating property changes from said first value to said second value in a discrete manner.

~~9~~5. The thermal barrier modified composite coating of claim 1, wherein said first coating layer comprises microstructural features of less than about 25 microns.

~~10~~6. The thermal barrier modified composite coating of claim 1, wherein said first coating layer comprises microstructural features ranging from about 10 microns to about 50 nm.

~~11. A thermal barrier modified composite coating, comprising:~~

~~a first coating layer bonded to a surface of a smooth substrate, said first coating layer having a size less than about 10 µm;~~

~~said first coating layer comprising macro columnar features characterized by a predetermined distribution of peaks and valleys at their corresponding free surfaces to create improved mechanical bonding between the first layer and a second layer;~~

~~said columnar features derived from a precursor liquid suspension of nano-sized and/or submicron-sized splats to form a thermomechanical compliant interface at the substrate surface, said splats being randomly oriented to produce an isotropic crystallographic orientation for the first coating;~~

~~said splats comprising non-equiaxed columnar grains that grow opposite to a direction of heat flow upon cooling to produce an anisotropic crystallographic grain orientation; and~~

~~said second layer comprising a densified coating layer bonded to the corresponding free surfaces of the first coating layer, said densified coating having a lower porosity than that of the first coating layer, said densified coating having an improved mechanical erosion barrier in comparison to the first coating layer.~~

12. The thermal barrier modified composite coating of claim 11, wherein said microstructural features of said first coating layer have a size less than about 10 µm and equal to or greater than about 50 nm.

13. The thermal barrier modified composite coating of claim 11, wherein said densified coating is derived from a second precursor liquid suspension of nano-sized and/or submicron-sized particles.

14. The thermal barrier modified composite coating of claim 11, wherein said predetermined distribution of peaks and valleys are arranged to form an irregular interface having tortuosity.

15. The thermal barrier modified composite coating of claim 1, said first coating layer has built-in porosity in an amount greater than that of the densified coating.

16. A thermal barrier modified composite coating, comprising:

a first coating layer bonded to a surface of a smooth substrate, said fist coating layer having a size less than about 10 µm;

said first coating layer comprising macro columnar features characterized by a predetermined distribution of peaks and valleys at their corresponding free surfaces to create improved mechanical bonding between the first layer and a second layer;

said columnar features derived from a precursor liquid suspension of nano-sized and/or submicron-sized splats to form a thermomechanical compliant interface at the substrate surface, said splats being randomly oriented to produce an isotropic crystallographic orientation for the first coating;

said splats comprising non-equiaxed columnar grains that grow opposite to a direction of heat flow upon cooling to produce an anisotropic crystallographic grain orientation; and

~~said second layer comprising a densified coating layer bonded to the corresponding free surfaces of the first coating layer, said densified coating having a lower porosity than that of the first coating layer, said densified coating derived from a dry powder applied by atmospheric spraying, said coating comprising partially molten and fully molten particles having an improved mechanical erosion barrier in comparison to the first coating layer.~~

~~17. The thermal barrier modified composite coating of claim 16, wherein said particles of the densified coating layer have a size greater than about 10 µm.~~

~~18. The thermal barrier modified composite coating of claim 16, wherein said smooth substrate has a Ra of less than about 125 µin.~~

~~19. The thermal barrier modified composite coating of claim 18, wherein said smooth substrate has a Ra of less than about 80 µin.~~

~~20. The thermal barrier modified composite coating of claim 16, wherein said densified coating layer comprises at least one improved coating property in comparison to the first coating layer and further wherein said improved coating property is graded.~~

~~21. The thermal barrier modified composite coating of claim 16, wherein said densified coating layer produces a densely vertically cracked microstructure.~~