Claims

1. An aqueous slurry composition for production of a porous thermal or environmental barrier coating on a metallic or a ceramic substrate, comprising:

a first powder comprising an oxide material with a thermal conductivity lower than about 5 W/m K, coarse particles having a first median size ranging from about 5 microns to about 60 microns, with at least a portion of the coarse particles having a closed porosity that is temperature resistant and substantially impermeable to gas and liquid;

a second powder comprising an oxide material with a thermal conductivity lower than about 5 W/m K, the second powder characterized as fine particles having a second median size ranging from about .1 to about 5 microns, wherein the second median size is at least about 5 times smaller than the first median size of the first powder, whereby the coarse particles of the first powder and the fine particles of the second powder form a bimodal particle size distribution in the slurry;

a plurality of elemental Boron particles provided in an effective amount; and

an inorganic binder suspending at least a portion of the plurality of elemental Boron particles, the coarse particles and the fine particles in an aqueous solution;

wherein the closed porosity of the coarse particles is temperature resistant and imparts a non-collapsing closed porous structure to the coating.

2. The aqueous slurry composition of claim 1, the first median particle size ranging from about 20 microns to about 50 microns, and the second median particle size ranging from about 1.0 micron to about 4.0 microns, wherein the closed porosity of the coarse particles is no less than 14 percent.

3. The aqueous slurry composition of claim 1, the first median particle size ranging from about 20 microns to about 50 microns, and the second

median particle size ranging from about 1.0 micron to about 4.0 microns, wherein the coarse and the fine particles are composed of yttria-stabilized zirconia.

4. The aqueous slurry composition of claim 1, wherein the coarse particles and the fine particles are composed of yttria stabilized zirconia, calcia stabilized zirconia, magnesia stabilized zirconia or mixtures thereof.

5. The aqueous slurry composition of claim 1, wherein the first powder comprises from about 30 wt. % to about 60 wt. % of the aqueous slurry composition, and the first and the second powders in combination comprise a total of at least 55 wt. % up to about 85 wt. % of the aqueous slurry composition.

6. The aqueous slurry composition of claim 1, wherein the binder is selected from the group consisting of a metal silicate binder or a metal phosphate binder.

7. The aqueous slurry composition of claim 6, wherein the binder is a metal silicate binder with a SiO2/M2O ratio higher than about 2.5, wherein M is a metal selected from Na, K and Li or a combination thereof.

8. The aqueous slurry composition of claim 6, wherein the binder is a metal phosphate binder with a P2O5/M ratio of not less than 0.1, wherein M is a metal selected from Group I, II, III or IV of Periodic Chart of Elements or a combination thereof.

9. The aqueous slurry composition of claim 1, further comprising an anticorrosive pigment, a viscosity modifier or a combination thereof.

10. The aqueous slurry composition of claim 1, wherein the fine oxide particles comprise a mixture of oxide compound with a median particle size distribution ranging from about 0.1 microns to about 5 microns, the mixture of the oxide compounds having a pyrochlore-type crystal structure represented by the formula $Ln_2M_2O_7$, wherein

M is Zr, Ce, and/or Hf; and

Ln is La, Gd, Sm, Nd, Eu, Yb or any combination thereof.

11. The aqueous slurry composition of claim 1, wherein the fine oxide particles comprise a mixture of oxide compounds having a perovskite-type crystal structure represented by the formula AMO_3, and wherein

M is Zr and/or Ti;

A is an alkali earth element, rare earth element or any combination thereof.

12. The aqueous slurry composition of claim 1, wherein the fine oxide particles are a mixture of oxide compounds comprising aluminates of rare earth metals.

13. The aqueous slurry composition of claim 3, the first powder and the second powder comprise yttria stabilized zirconia, the binder selected from the group consisting of an alkali metal silicate binder and metal phosphate binder , wherein said first powder comprises from 35% to 55 % by weight, ratio of the second powder to the first powder is in the range from about 1:1 up to about 1: 2.5 by weight, and the first and the second powders combined comprise between about 60 % to about 80% by weight of the aqueous slurry composition.

14. The aqueous slurry composition of claim 13 comprising elemental Boron in the amount from 0.2 to 2.0 weight %

15. A slurry composition for the production of a thermal or environmental barrier coating comprising:

a first ceramic material comprising oxide-based particles having a first median particle size ranging from about 5 microns to about 60 microns, the particles being temperature resistant and substantially impermeable to gas and liquid;

a second ceramic material comprising oxide-based particles that are substantially solid, the substantially solid particles having a second median particle size ranging from about .1 to about 5 microns; and

a binder in combination with at least a portion of the first and the second materials in relative proportions to form a bimodal particle distribution therein;

wherein in a cured state the closed porosity of the first ceramic material provides a non-degrading, high temperature stable porous structure to the produced thermal barrier coating

16. The slurry composition of claim 15, further comprising elemental Boron.

17. The aqueous slurry composition of claim 15, wherein a portion of the closed-containing pores of the first ceramic material are submicron sized, nanoscale sized or a mixture thereof.

18. The aqueous slurry composition of claim 15, the first median particle size ranging from about 20 microns to about 50 microns, and the second median particle size ranging from about 1.0 micron to about 4.0 microns.

19. The aqueous slurry composition of claim 15, wherein the first and the second ceramic materials comprise yttria stabilized zirconia.

20. A thermal or environmental barrier coating comprising:

a glass-ceramic matrix, said matrix is formed by a binder and a fine fraction of powder particles, said particles having a first median particle size; and

a plurality of particles having a closed porosity that is non-collapsing at elevated temperatures of at least about 1000°C, and substantially impermeable to gas and liquid, the plurality of closed porosity containing particles having a second median particle size that is substantially non-overlapping with the first median particle size to form a bimodal particle distribution, the second median particle size being at least about five times larger than the first median particle size,

wherein the plurality of closed porosity containing particles are dispersed in the glass-ceramic matrix in an effective amount to lower a thermal conductivity of the coating to about 2 W/m K or lower.

21. The coating of claim 20, wherein the plurality of closed porosity containing particles comprise yttria-stabilized zirconia, calcia-stabilized zirconia, magnesia-stabilized zirconia or a mixture thereof.

22. The coating of claim 20, wherein glass-ceramic matrix further comprises Boron.

23. The coating of claim 20, wherein the weight ratio of the closed porosity-containing particles of the coarse fraction to the powder particles of the fine fraction in the bimodal particle size distribution is in the range from about 1:1 to about 2.5 : 1.

24. The coating of claim 20, wherein the mean particle size of the fine particles is in the range of 1.0 – 4.0 microns and the mean particle size of the coarse, closed porosity containing particles is in the range of 20 – 50 microns.

25. The coating of claim 20, wherein the closed porosity of the coarse particles is no less than 14 percent,

26. The coating of claim 20, disposed along a surface of a substrate.

27. A method for the production of an aqueous slurry comprising:

introducing into an aqueous binder a first powder and a second powder, wherein each of the first and the second powders comprise oxide materials, with a thermal conductivity of not higher than about 5 W/m K, further wherein the first powder is composed of a first plurality of particles comprising closed porosity with a median particle size in the range of about 10 micron to about 60 micron and the second powder is composed of a second plurality of dense particles with a median particle size in the range of about 0.1 micron to about 5.0 micron;

forming a bimodal particle size distribution comprising the first plurality of particles and the second plurality of particles,

introducing elemental Boron;

mixing the first and the second powders and the elemental Boron with the aqueous, mostly inorganic binder to form a particle suspension in the aqueous binder.

28. A method for applying a thermal or a environmental barrier coating with an aqueous slurry comprising:

providing an aqueous slurry comprising:

a first ceramic powder comprising particles having closed porosity and having a first median particle size between about 10 micron to about 60 micron;

a second ceramic powder comprising dense particles having a second median particle size between about .1 micron to about 5 micron, whereby the first and the second powders form a bimodal particle size distribution;

elemental Boron;

an aqueous, substantially inorganic binder;

applying the aqueous slurry onto a surface of a substrate; and

curing the slurry into the coating.

CLAIMS

1. An aqueous slurry composition for production of a porous thermal or environmental barrier coating on a metallic or a ceramic substrate, comprising:

a first powder comprising an oxide material with a thermal conductivity lower than about 5 W/m K, coarse particles having a first median size ranging from about 5 microns to about 60 microns, with at least a portion of the coarse particles having a closed porosity that is temperature resistant and substantially impermeable to gas and liquid;

a second powder comprising an oxide material with a thermal conductivity lower than about 5 W/m K, the second powder characterized as fine particles having a second median size ranging from about .1 to about 5 microns, wherein the second median size is at least about 5 times smaller than the first median size of the first powder, whereby the coarse particles of the first powder and the fine particles of the second powder form a bimodal particle size distribution in the slurry;

a plurality of elemental Boron particles provided in an effective amount, wherein said elemental Boron is contained in an amount from 0.2 to 2.0 weight %; and

an inorganic binder suspending at least a portion of the plurality of elemental Boron particles, the coarse particles and the fine particles in an aqueous solution;

wherein the closed porosity of the coarse particles is temperature resistant and imparts a non-collapsing closed porous structure to the coating.

2. The aqueous slurry composition of claim 1, the first median particle size ranging from about 20 microns to about 50 microns, and the second median particle size ranging from about 1.0 micron to about 4.0 microns, wherein the closed porosity of the coarse particles is no less than 14 percent.

3. The aqueous slurry composition of claim 1, the first median particle size ranging from about 20 microns to about 50 microns, and the second median particle size ranging from about 1.0 micron to about 4.0 microns, wherein the coarse and the fine particles are composed of yttria-stabilized zirconia.

4. The aqueous slurry composition of claim 1, wherein the coarse particles and the fine particles are composed of yttria stabilized zirconia, calcia stabilized zirconia, magnesia stabilized zirconia or mixtures thereof.

5. The aqueous slurry composition of claim 1, wherein the first powder comprises from about 30 wt. % to about 60 wt. % of the aqueous slurry composition, and the first and the second powders in combination comprise a total of at least 55 wt. % up to about 85 wt. % of the aqueous slurry composition.

6. The aqueous slurry composition of claim 1, wherein the binder is selected from the group consisting of a metal silicate binder or a metal phosphate binder.

7. The aqueous slurry composition of claim 6, wherein the binder is a metal silicate binder with a SiO2/M2O ratio higher than about 2.5, wherein M is a metal selected from Na, K and Li or a combination thereof.

8. The aqueous slurry composition of claim 6, wherein the binder is a metal phosphate binder with a P2O5/M ratio of not less than 0.1, wherein M is a metal selected from Group I, II, III or IV of Periodic Chart of Elements or a combination thereof.

9. The aqueous slurry composition of claim 1, further comprising an anticorrosive pigment, a viscosity modifier or a combination thereof.

10. The aqueous slurry composition of claim 1, wherein the fine oxide particles comprise a mixture of oxide compound with a median particle size distribution ranging from about 0.1 microns to about 5 microns, the mixture of the oxide compounds having a pyrochlore-type crystal structure represented by the formula $Ln_2M_2O_7$, wherein

M is Zr, Ce, and/or Hf; and

Ln is La, Gd, Sm, Nd, Eu, Yb or any combination thereof.

11. The aqueous slurry composition of claim 1, wherein the fine oxide particles comprise a mixture of oxide compounds having a perovskite-type crystal structure represented by the formula AMO3, and wherein

M is Zr and/or Ti ;

A is an alkali earth element, rare earth element or any combination thereof.

12. The aqueous slurry composition of claim 1, wherein the fine oxide particles are a mixture of oxide compounds comprising aluminates of rare earth metals.

13. The aqueous slurry composition of claim 3, the first powder and the second powder comprise yttria stabilized zirconia, the binder selected from the group consisting of an alkali metal silicate binder and metal phosphate binder , wherein said first powder comprises from 35% to 55 % by weight, ratio of the second powder to the first powder is in the range from about 1:1 up to about 1: 2.5 by weight, and the first and the second powders combined comprise between about 60 % to about 80% by weight of the aqueous slurry composition.