Claims

1. A method for producing a protective coating on an aerospace component, comprising:

depositing a metal oxide template layer comprising chromium oxide on the aerospace component comprising nickel and aluminum by an atomic layer deposition (ALD) process or a chemical vapor deposition (CVD) process, wherein the metal oxide template layer further comprises tungsten oxide, molybdenum oxide, vanadium oxide, or any combination thereof; and

heating the aerospace component containing the metal oxide template layer during a thermal process comprising:

diffusing aluminum contained within the aerospace component towards a surface of the aerospace component containing the metal oxide template layer;

oxidizing the diffused aluminum to produce an aluminum oxide layer disposed between the aerospace component and the metal oxide template layer, wherein the aluminum oxide layer comprises α-Al_2O_3, wherein the metal oxide template layer and the aluminum oxide layer have a corundum crystal structure, and wherein the metal oxide template layer and the aluminum oxide layer have crystal structures with a lattice mismatch of 0.1% to 10%; and

removing at least a portion of the metal oxide template layer while leaving the aluminum oxide layer by converting the chromium oxide to chromium oxide hydroxide during the thermal process.

2. The method of claim 1, wherein the metal oxide template layer has a thickness of about 10 nm to about 2,000 nm, and wherein the aluminum oxide layer has a thickness of about 10 nm to about 1,000 nm.

3. The method of claim 1, wherein the metal oxide template layer is removed by sublimation or evaporation or oxidation during the thermal process.

4. The method of claim 1, wherein the aerospace component is heated to a temperature of about 800°C to about 1,500°C for about 20 minutes to about 100 hours during the thermal process.

5. The method of claim 1, wherein oxygen is diffused through the metal oxide template layer before reacting with the aluminum to produce the aluminum oxide layer, and wherein the aerospace component and the metal oxide template layer are exposed to air containing the oxygen during the thermal process.

6. The method of claim 1, further comprising powering a jet engine or a turbine containing the aerospace component while performing the thermal process, wherein thermal energy from the jet engine or the turbine is used to heat the aerospace component and the metal oxide template layer during the thermal process.

7. The method of claim 1, wherein the aerospace component and the metal oxide template layer are heated in a processing chamber or furnace during the thermal process.

8. The method of claim 7, wherein the aerospace component and the metal oxide template layer are preheated for a first period, maintained at a predetermined temperature for a second period, and cooled for a third period during one heat cycle of the thermal process.

9. The method of claim 8, wherein the first period is about 1 minute to about 30 minutes, the second period is about 15 minutes to about 120 minutes, and the third period is about 0.5 minutes to about 15 minutes.

10. The method of claim 8, wherein the heat cycle is repeated from 2 times to about 300 times, and wherein the predetermined temperature is about 900°C to about 1,200°C.

11. The method of claim 1, wherein the metal oxide template layer is deposited on the aerospace component by the ALD process.

12. The method of claim 1, wherein the aerospace component is a turbine blade, a turbine vane, a support member, a frame, a rib, a fin, a pin fin, a combustor fuel nozzle, a combustor shield, an internal cooling channel, or any combination thereof.

13. The method of claim 1, wherein the aerospace component comprises a nickel superalloy, and wherein the nickel superalloy comprises nickel, aluminum, and one or more metals selected from chromium, cobalt, titanium, molybdenum, tungsten, or alloys thereof.

14. The method of claim 13, wherein the nickel superalloy comprises about 40 wt% or greater of nickel and about 0.5 wt% to about 15 wt% of aluminum.

15. A method for producing a protective coating on an aerospace component, comprising:

depositing a metal oxide template layer on the aerospace component comprising nickel and aluminum by an atomic layer deposition (ALD) process or a chemical vapor deposition (CVD) process, wherein the metal oxide template layer comprises chromium oxide and a metal oxide selected from tungsten oxide, molybdenum oxide, vanadium oxide, or any combination thereof; and

heating the aerospace component containing the metal oxide template layer to a temperature of about 900°C to about 1,200°C during a thermal process comprising:

diffusing aluminum contained within the aerospace component towards a surface of the aerospace component containing the metal oxide template layer;

oxidizing the diffused aluminum to produce an aluminum oxide layer disposed between the aerospace component and the metal oxide template layer, wherein the aluminum oxide layer comprises α-Al_2O_3, wherein the metal oxide template layer and the aluminum oxide layer have a corundum crystal structure, and wherein the metal oxide template layer and the aluminum oxide layer have crystal structures with a lattice mismatch of 0.1% to 10%; and

removing at least a portion of the metal oxide template layer while leaving the aluminum oxide layer by converting the chromium oxide to chromium oxide hydroxide during the thermal process.

16. The method of claim 15, wherein the aerospace component is a turbine blade, a turbine vane, a support member, a frame, a rib, a fin, a pin fin, a combustor fuel nozzle, a combustor shield, an internal cooling channel, or any combination thereof.

17. A method for producing a protective coating on an aerospace component, comprising:

depositing a metal oxide template layer on the aerospace component comprising nickel and aluminum by an atomic layer deposition (ALD) process or a chemical vapor deposition (CVD) process, wherein the metal oxide template layer comprises chromium oxide and a metal oxide selected from tungsten oxide, molybdenum oxide, vanadium oxide, or any combination thereof; and

powering a jet engine or a turbine containing the aerospace component while performing a thermal process, wherein thermal energy from the jet engine or the turbine heats the aerospace component and the metal oxide template layer to a temperature of 900° C to 1,200° C during the thermal process, where in the thermal process further comprises:

diffusing aluminum contained within the aerospace component towards a surface of the aerospace component containing the metal oxide template layer; and

oxidizing the diffused aluminum to produce an aluminum oxide layer disposed between the aerospace component and the metal oxide template layer, wherein the metal oxide template layer and the aluminum oxide layer have a corundum crystal structure, and wherein the metal oxide template layer and the aluminum oxide layer have crystal structures with a lattice mismatch of 0.1% to 10%.

18. The method of claim 17, wherein the metal oxide template layer is deposited on the aerospace component by the ALD process.

19. The method of claim 17, wherein the aerospace component is a turbine blade, a turbine vane, a support member, a frame, a rib, a fin, a pin fin, a combustor fuel nozzle, a combustor shield, an internal cooling channel, or any combination thereof.

20. The method of claim 17, wherein the aerospace component comprises a nickel superalloy comprising 40 wt % or greater of nickel, 0.5 wt % to 15 wt % of aluminum, and one or more metals selected from chromium, cobalt, titanium, molybdenum, tungsten, or alloys thereof.