Claims

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

exposing the aerospace component to a cleaning process to produce a cleaned surface on the aerospace component, wherein the aerospace component is a fuel nozzle, a combustor liner, a combustor shield, a heat exchanger, a fuel line, a fuel valve, or any combination thereof, the aerospace component has an aspect ratio of about 8 to about 1,000, wherein the cleaned surface of the aerospace component is an interior surface of the aerospace component, and wherein the cleaning process comprises exposing the aerospace component to a solvent clean, an acid clean, a basic clean, a wet clean, or any combination thereof; and

sequentially exposing the aerospace component to a precursor and a reactant to form a protective coating on the cleaned surface of the aerospace component by an atomic layer deposition (ALD) process, wherein the protective coating comprises aluminum oxide, silicon oxide, chromium oxide, tantalum oxide, alloys thereof, or any combination thereof.

2. The method of claim 1, wherein the aerospace component is a fuel nozzle.

3. The method of claim 1, wherein the cleaned surface of the aerospace component has an aspect ratio of about 12 to about 1,000.

4. The method of claim 1, wherein the cleaned surface of the aerospace component comprises nickel, nickel superalloy, stainless steel, cobalt, chromium, molybdenum, iron, titanium, alloys thereof, or any combination thereof.

5. The method of claim 1, wherein a contaminant is removed from the aerospace component to produce the cleaned surface during the cleaning process, and wherein the contaminant comprises an oxide, an organic residue, carbon, particulates, or any combination thereof.

6. The method of claim 1, wherein the cleaning process further comprises exposing the aerospace component to an ozone clean, a plasma clean, a sonication, or any combination thereof.

7. The method of claim 1, wherein the protective coating further comprises aluminum nitride, aluminum oxynitride, silicon nitride, silicon oxynitride, tantalum nitride, alloys thereof, or any combination thereof.

8. The method of claim 1, wherein the protective coating reduces or suppresses coke formation when the aerospace component is heated in the presence of a fuel.

9. The method of claim 1, wherein the protective coating has a thickness of about 10 nm to about 5,000 nm.

10. The method of claim 1, wherein the protective coating has a thickness variation of less than 5%.

11. The method of claim 1, wherein the precursor comprises trimethyl aluminum, and wherein the trimethyl aluminum has a purity of about 99.9 wt% to about 99.999 wt%.

12. The method of claim 1, wherein the reactant comprises an oxidizing agent, and wherein the oxidizing agent comprises water, ozone, oxygen (O_2), atomic oxygen, nitrous oxide, a peroxide, an alcohol, plasmas thereof, or any combination thereof.

13. The method of claim 1, wherein the reactant comprises a nitriding agent, and wherein the nitriding agent comprises ammonia, atomic nitrogen, a hydrazine, plasmas thereof, or any combination thereof.

14. The method of claim 1, wherein the precursor comprises an aluminum precursor, and wherein the aluminum precursor comprises a tris(alkyl) aluminum, a tris(alkoxy) aluminum, aluminum diketonates, complexes thereof, abducts thereof, salts thereof, or any combination thereof.

15. The method of claim 1, wherein the protective coating comprises a nanolaminate film stack, and wherein the nanolaminate film stack comprises a first deposited layer and a second deposited layer, and the method further comprises depositing from 2 pairs to about 500 pairs of the first deposited layer and the second deposited layer while increasing a thickness of the nanolaminate film stack.

16. The method of claim 15, wherein each pair of the first deposited layer and the second deposited layer has a thickness of about 0.2 nm to about 500 nm.

17. The method of claim 15, further comprising annealing the aerospace component and converting the nanolaminate film stack into a coalesced film or a crystalline film.

18. A method for depositing a coating on an aerospace component, comprising:

exposing the aerospace component to a cleaning process to produce a cleaned surface on the aerospace component, wherein:

the aerospace component is a fuel nozzle, a combustor liner, a combustor shield, a heat exchanger, a fuel line, a fuel valve, or any combination thereof,

the cleaned surface of the aerospace component is an interior surface of the aerospace component,

the cleaned surface of the aerospace component has an aspect ratio of about 40 to about 1,000; and

the cleaning process comprises exposing the aerospace component to a solvent clean, an acid clean, a basic clean, a wet clean, or any combination thereof; and

sequentially exposing the aerospace component to a precursor and a reactant to form a protective coating on the cleaned surface of the aerospace component by an atomic layer deposition (ALD) process, wherein the protective coating comprises aluminum oxide, silicon oxide, chromium oxide, tantalum oxide, alloys thereof, or any combination thereof.

19. A method for depositing a coating on an aerospace component, comprising:

exposing the aerospace component to a cleaning process to produce a cleaned surface on the aerospace component, wherein the cleaning process comprises exposing the aerospace component to a solvent clean, an acid clean, a basic clean, a wet clean, or any combination thereof, wherein the aerospace component is a fuel nozzle, a combustor liner, a combustor shield, a heat exchanger, a fuel line, a fuel valve, or any combination thereof, wherein the cleaned surface of the aerospace component is an interior surface of the aerospace component, and wherein the cleaned surface of the aerospace component has an aspect ratio of about 5 to about 1,000; and

sequentially exposing the aerospace component to a precursor and a reactant to form a protective coating on the cleaned surface of the aerospace component by an atomic layer deposition (ALD) process, wherein the protective coating comprises aluminum oxide, silicon oxide, chromium oxide, tantalum oxide, alloys thereof, or any combination thereof, wherein the protective coating has a thickness of about 10 nm to about 5,000 nm, and wherein the protective coating has a thickness variation of less than 50%.

20. The method of claim 19, wherein the cleaned surface of the aerospace component has an aspect ratio of about 12 to about 1,000.