~~What is claimed is:~~**Claims**

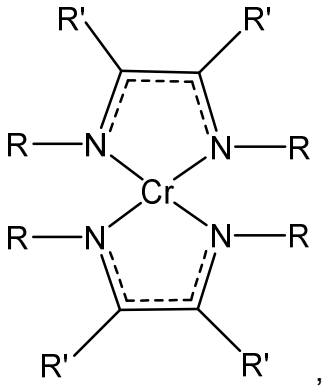
1. A method for depositing a coating on an aerospace component, comprising:

sequentially exposing the aerospace component to a chromium precursor and a reactant to form a chromium-containing layer on a surface of the aerospace component by an atomic layer deposition process~~.~~; and

forming a nanolaminate film stack on the surface of the aerospace component, wherein the nanolaminate film stack comprises alternating layers of the chromium-containing layer and a second deposited layer.

2. The method of claim 1, wherein the chromium precursor comprises bis(cyclopentadiene) chromium, bis(pentamethylcyclopentadiene) chromium, bis(isoproplycyclopentadiene) chromium, bis(ethylbenzene) chromium, chromium hexacarbonyl, chromium acetylacetonate, chromium hexafluoroacetylacetonate, a chromium diazadienyl, isomers thereof, complexes thereof, abducts thereof, salts thereof, or any combination thereof.

3. The method of claim 2, wherein the chromium diazadienyl has a chemical formula of:



,

wherein each R and R' is independently selected from H, C1-C6 alkyl, aryl, acyl, alkylamido, hydrazido, silyl, aldehyde, keto, C2-C4 alkenyl, alkynyl, or substitutes thereof.

4. The method of claim 1, wherein the reactant comprises a reducing agent and the chromium-containing layer comprises metallic chromium~~, and~~.

5. The method of claim 4, wherein the reducing agent comprises hydrogen ($H_2$), ammonia~~, hydrazine~~, a hydrazine, an alcohol, a cyclohexadiene, a dihydropyrazine, an aluminum containing compound, abducts thereof, salts thereof, plasma derivatives thereof, or any combination thereof.

~~5~~6. The method of claim 1, wherein the reactant comprises an oxidizing agent and the chromium-containing layer comprises chromium oxide~~, and~~.

7. The method of claim 6, wherein the oxidizing agent comprises water, oxygen ($O_2$), atomic oxygen, ozone, nitrous oxide, a peroxide, an alcohol, plasmas thereof, or any combination thereof.

~~6~~8. The method of claim 1, wherein the reactant comprises a nitriding agent and the chromium-containing layer comprises chromium nitride~~, and~~.

9. The method of claim 8, wherein the nitriding agent comprises ammonia, atomic nitrogen, a hydrazine, plasmas thereof, or any combination thereof.

~~7~~10. The method of claim 1, wherein the reactant comprises a carbon precursor or a silicon precursor and the chromium-containing layer comprises chromium carbide or chromium silicide.

~~8. The method of claim 1, further comprising forming a nanolaminate film stack on the surface of the aerospace component, wherein the nanolaminate film stack comprises alternating layers of the chromium-containing layer and a second deposited layer, and~~11. The method of claim 1, wherein the second deposited layer comprises aluminum oxide, aluminum nitride, silicon oxide, silicon nitride, silicon carbide, yttrium oxide, yttrium nitride, yttrium silicon nitride, hafnium oxide, hafnium nitride, hafnium silicide, hafnium silicate, titanium oxide, titanium nitride, titanium silicide, titanium silicate, or any combination thereof.

~~9. The method of claim 1, further comprising forming a nanolaminate film stack on the surface of the aerospace component, wherein the nanolaminate film stack comprises alternating layers of the chromium-containing layer and a second deposited layer~~12. The method of claim 1, wherein the chromium-containing layer comprises chromium oxide, chromium nitride, or a combination thereof, and wherein the second deposited layer comprises aluminum oxide, silicon nitride, hafnium oxide, hafnium silicate, or any combination thereof.

~~10. The method of claim 1, further comprising forming a nanolaminate film stack on the surface of the aerospace component, wherein the nanolaminate film stack comprises alternating layers of the chromium-containing layer and a second deposited layer, and~~ 13. The method of claim 1, wherein the alternating layers in the nanolaminate film stack ~~comprises~~comprise from 1 pair to about 50 pairs of the chromium-containing layer and the second deposited layers.

~~11~~14. The method of claim 1, further comprising~~:~~

~~forming a nanolaminate film stack on the surface of the aerospace component, wherein the nanolaminate film stack comprises alternating layers of the chromium-containing layer and a second deposited layer; and~~

annealing the aerospace component and converting the nanolaminate film stack into a coalesced film.

~~12~~15. 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.

16. The method of claim 1, wherein the surface of the aerospace component is an interior surface of the aerospace component, and wherein the surface of the aerospace component comprises nickel, nickel superalloy, aluminum, chromium, iron, titanium, hafnium, alloys thereof, or any combination thereof.

~~13~~17. A method for depositing a coating on an aerospace component, comprising:

forming a nanolaminate film stack on a surface of the aerospace component, wherein the nanolaminate film stack comprises alternating layers of a chromium-containing layer and a second deposited layer;

sequentially exposing the aerospace component to a chromium precursor and a first reactant to form the chromium-containing layer on the surface by atomic layer deposition, wherein the chromium-containing layer comprises chromium oxide, chromium nitride, or a combination thereof; and

sequentially exposing the aerospace component to a metal or silicon precursor and a second reactant to form the second deposited layer on the surface by atomic layer deposition, wherein the second deposited layer comprises aluminum oxide, aluminum nitride, silicon oxide, silicon nitride, silicon carbide, yttrium oxide, yttrium nitride, yttrium silicon nitride, hafnium oxide, hafnium nitride, hafnium silicide, hafnium silicate, titanium oxide, titanium nitride, titanium silicide, titanium silicate, or any combination thereof.

~~14. An~~18. A method for depositing a coating on an aerospace component, comprising:

~~a surface comprising~~ sequentially exposing the aerospace component to a chromium precursor and a reactant to form a chromium-containing layer on a surface of the aerospace component by atomic layer deposition, wherein the surface of the aerospace component comprises nickel, nickel superalloy, ~~aluminum,~~ chromium, iron, titanium, ~~hafnium,~~ alloys thereof, or any combination thereof; ~~and~~

~~a coating having a thickness of less than 10 μm~~forming a second deposited layer on the chromium-containing layer, wherein the second deposited layer comprises aluminum oxide, aluminum nitride, silicon oxide, silicon nitride, silicon carbide, yttrium oxide, yttrium nitride, yttrium silicon nitride, hafnium oxide, hafnium nitride, hafnium silicide, hafnium silicate, titanium oxide, titanium nitride, titanium silicide, titanium silicate, or any combination thereof; and ~~disposed~~

forming a nanolaminate film stack on the surface of the aerospace component, wherein the ~~coating~~nanolaminate film stack comprises ~~a~~alternating layers of the chromium-containing layer~~,~~ and the second deposited layer.

19. The method of claim 18, wherein the surface of the aerospace component is an interior surface of the aerospace component, and 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 18, wherein the chromium-containing layer comprises metallic chromium, chromium oxide, chromium nitride~~,~~ chromium carbide, or chromium silicide~~, or any combination thereof~~.

~~15. The aerospace component of claim 14, wherein the surface of the aerospace component is an interior surface within a cavity of the aerospace component, wherein the cavity has an aspect ratio of about 5 to about 1,000, and wherein the coating has a uniformity of less than 30% of the thickness across the interior surface.~~