Claims:

1. A method of forming a protective coating within a processing chamber, comprising:

depositing a cerium oxide layer on a chamber surface or a chamber component during an atomic layer deposition (ALD) process, wherein the ALD process comprises:

heating the chamber surface or the chamber component to a temperature of 30°C to 500°C;

sequentially exposing the chamber surface or the chamber component to a cerium precursor, a purge gas, an oxidizing agent, and the purge gas during an ALD cycle, wherein the cerium precursor comprises an alcohol, wherein the cerium precursor comprises a cerium cyclopentadienyl compound, a cerium alkoxide compound, a cerium amide compound, or any combination thereof, and wherein the cerium precursor comprises the cerium cyclopentadienyl compound, the cerium cyclopentadienyl compound is $(Cp)_3Ce$, $(MeCp)_3Ce$, $(EtCp)_3Ce$, $(BuCp)_3Ce$, or any combination thereof; and

repeating the ALD cycle to deposit the cerium oxide layer.

2. The method of claim 1, wherein the alcohol comprises methanol, ethanol, propanol, butanol, or any combination thereof.

3. The method of claim 1, wherein the cerium precursor comprises the cerium cyclopentadienyl compound.

4. The method of claim 3, wherein the cerium cyclopentadienyl compound is $(Cp)_3Ce$, $(MeCp)_3Ce$, or any combination thereof.

5. The method of claim 1, wherein the cerium precursor comprises the cerium alkoxide compound.

6. The method of claim 5, wherein the cerium alkoxide compound is $Ce(mmp)_4$ (cerium tetra(1-methoxy-2-methyl-2-propanolate)), $Ce(dmap)_4$ (cerium tetra(1-(dimethylamino)propan-2-olate)), $Ce(dmop)_4$ (cerium tetra(2-(4,4-dimethyl-4,5-dihydrooxazol-2-yl)propan-2-olate)), or any combination thereof.

7. The method of claim 1, wherein the cerium precursor comprises the cerium amide compound.

8. The method of claim 7, wherein the cerium precursor is $(hmdsa)_3Ce$.

9. The method of claim 1, wherein the oxidizing agent comprises water, oxygen (O_2), atomic oxygen, ozone, nitrous oxide, a peroxide, a plasma thereof, or any combination thereof.

10. The method of claim 1, wherein the ALD cycle is repeated until the cerium oxide layer has a thickness of 1 nm to 100 nm.

11. The method of claim 1, wherein the temperature is 50°C to 400°C during the ALD process.

12. The method of claim 11, wherein the temperature is 100°C to 350°C during the ALD process.

13. The method of claim 1, wherein the chamber surface or the chamber component contains an intermediate oxide film disposed thereon, and wherein the cerium oxide is deposited on the intermediate oxide film.

14. The method of claim 13, wherein the intermediate oxide film comprises aluminum oxide, lanthanum oxide, hafnium oxide, yttrium oxide, zirconium oxide, alloys thereof, dopants thereof, or any combination thereof.

15. A method of forming a protective coating within a processing chamber, comprising:

depositing a cerium oxide layer on a chamber surface or a chamber component during an atomic layer deposition (ALD) process, wherein the chamber surface or the chamber component is heated to a temperature of 50°C to 400°C during the ALD process, and wherein the ALD process comprises:

sequentially exposing the chamber surface or the chamber component to a cerium precursor, a purge gas, an oxidizing agent, and the purge gas during an ALD cycle, wherein the cerium precursor comprises an alcohol selected from methanol, ethanol, propanol, butanol, or any combination thereof, and wherein the cerium precursor comprises a cerium alkoxide compound, a cerium amide compound, or any combination thereof; and

repeating the ALD cycle to deposit the cerium oxide layer.

16. The method of claim 15, wherein the temperature is 100°C to 350°C during the ALD process.

17. A method of forming a protective coating within a processing chamber, comprising:

depositing an intermediate oxide film on a chamber surface or a chamber component; and

depositing a cerium oxide layer on the intermediate oxide film during an atomic layer deposition (ALD) process, wherein the ALD process comprises:

heating the chamber surface or the chamber component to a temperature of 30°C to 500°C;

sequentially exposing the chamber surface or the chamber component to a cerium precursor, a purge gas, an oxidizing agent, and the purge gas during an ALD cycle, wherein the cerium precursor comprises an alcohol, and wherein the cerium precursor comprises $(Cp)_3Ce$, $(MeCp)_3Ce$, $(EtCp)_3Ce$, $(BuCp)_3Ce$, $Ce(mmp)_4$ (cerium tetra(1-methoxy-2-methyl-2-propanolate)), $Ce(dmap)_4$ (cerium tetra(1-(dimethylamino)propan-2-olate)), $Ce(dmop)_4$ (cerium tetra(2-(4,4-

dimethyl-4,5-dihydrooxazol-2-yl)propan-2-olate)), $(hmdsa)_3Ce$, or any combination thereof; and

repeating the ALD cycle to deposit the cerium oxide layer to a thickness of 1 nm to 100 nm.

18. The method of claim 17, wherein the intermediate oxide film comprises aluminum oxide, lanthanum oxide, hafnium oxide, yttrium oxide, zirconium oxide, alloys thereof, dopants thereof, or any combination thereof.