CLAIMS

1. An optical element with an operating wavelength λ, the optical element comprising:

a substrate; and

a uniformly deposited first layer above the substrate, the first layer and a second layer forming a layer-pair in a multi-layer stack, wherein the ratio of the thickness of the first layer to the thickness of the second layer in each layer pair is constant throughout the multi-layer stack;

wherein a thickness of the first layer is less than the wavelength λ;

wherein the first layer is essentially composed of group 1 alkali metal, noble gas, halogen, non-beryllium alkaline earth metals, or their combination;

wherein the first layer has a lower absorption at λ than a non-porous

stoichiometric silicon layer of equal thickness; and

wherein $0.1\text{nm} \leq \lambda \leq 192\text{ nm}$.

2. The optical element of claim 1, further comprising an oxygen barrier above or below the first layer.

3. The optical element of claim 1, further comprising a hydrophobic layer adjacent to the first layer.

4. The optical element of claim 3, wherein the hydrophobic layer comprises a nanostructure.

5. The optical element of claim 1, further comprising:

wherein a thickness of the second layer thickness is less than the wavelength λ;

wherein the second layer is composed essentially of transition metal, , actinide, or one of their combinations; and

wherein $0.1\text{nm} \leq \lambda \leq 192$.

6. The optical element of claim 5, further comprising a laminate of 41 to 400 additional layers having optical properties of the first layer alternating with additional layers having optical properties of the second layer.

7. The optical element of claim 5, wherein at least one of the first layer or the second layer comprises a nanostructure that reduces the visibility of defects.

8. A product, comprising:

a substrate;

a top layer of optical material formed above the substrate and compatible with wavelengths between 0.1nm and 250nm; and

a protective capping layer formed adjacent to the top layer, the protective capping layer constructed as a single capping layer or as base layer of a binary capping layer;

wherein the capping layer consists essentially of alkali metal, noble gas, halogen, non-beryllium alkaline earth metals, or their combination.

9. The product of claim 8, wherein the capping layer has an atomic number greater than an atomic number of ruthenium.

10. The product of claim 8, wherein the capping layer is charged at a same polarity as particles present in an operating environment.

11. The product of claim 10, wherein the capping layer comprises ions.

12. The product of claim 10, wherein the capping layer is electrically coupled to an ungrounded voltage source.

13. The product of claim 8, further comprising a hydrophobic layer above the capping layer.

14. An optical reflector, comprising:

a substrate;

a first layer above the substrate; and

a second layer above the substrate and above or below the first layer;

wherein the first layer is porous;

wherein the first layer has a lower absorption coefficient at an operating wavelength λ than the second layer;

wherein the second layer is non-porous;

wherein a thickness of the first layer is less than λ; and

wherein a thickness of the second layer is less than λ.

15. The optical reflector of claim 14, wherein the first layer comprises a 2-D or 3-D nanostructure including spaces that render the layer porous.

16. A method, comprising:

preparing a substrate: and

forming a first layer above the substrate, the first layer and a second layer forming a layer-pair in a multi-layer stack, wherein the ratio of the thickness of the first layer to the thickness of the second layer in each layer pair is constant throughout the multi-layer stack;

wherein the first layer is essentially composed of group 1, alkali metal, noble gas, halogen, alkaline earth metal except for beryllium and lithium fluoride, or one of their combinations;

wherein a thickness of the first layer is less than an operating wavelength λ; and

wherein $0.1\text{nm} \leq \lambda \leq 192\text{mm}$.

17. The method of claim 16, further comprising:

forming the second layer above or below the first layer;

wherein the second layer is essentially composed of transition metal, actinide, or one of their combinations;

wherein a thickness of the second layer is less than an operating wavelength λ; and

wherein $0.1\text{nm} \leq \lambda \leq 192$.

18. The method of claim 16, wherein the layer is formed by a technique comprising at least one of sputtering, evaporation, wide angle deposition, rotational sputtering evaporation, pulsed laser deposition, atomic layer deposition, pulsed CVD, chemical vapor deposition, molecular layer deposition, atomic layer epitaxy, ion beam deposition, e-beam deposition, electrodeposition, electro-formation, chemical vapor deposition, plasma enhanced deposition, vapor deposition, laser excitation or epitaxy.

19. A system, comprising:

a process chamber;

a workpiece holder in the process chamber;

a light source radiating a first portion of source light into the process chamber;

a photomask positioned in the process chamber to pattern the light illuminating a workpiece in the workpiece holder; and

a collector redirecting a second portion of the source light along a first optical path from the source to the photomask;

wherein the source light comprises a wavelength between 0.1 nm and 250 nm; and

wherein at least one of the collector, the photomask, or another optical element are constructed as the optical element of claim 1 and arranged for intercepting the source light.

20. The system of claim 19, further comprising a reflective, transmissive, diffractive, or scattering optical element in the first optical path from the source to the photomask or in a second optical path between the photomask and the workpiece.

21. The optical element of claim 1, further comprising:

a second layer formed on the first layer;

wherein a thickness of the second layer thickness is less than the wavelength λ;

wherein the second layer is composed essentially of, lanthanide, or their combinations; and

wherein $0.1\text{nm} \leq \lambda \leq 8.9$ nm.