CLAIMS

1. An optical element with an operating wavelength λ, the optical element comprising a multilayer stack consisting of alternating layer pairs, each layer pair having a first layer and a second layer:

a substrate; and

a first layer above the substrate, wherein the thickness of every first layer in the multilayer stack is ~~similar~~ the same and the thickness of every second layer in the multilayer stack is ~~similar~~ the same;

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

wherein the first layer is composed of ~~containing~~ either a group 1 element, alkali metal, ~~noble gas,~~ halogen, non-beryllium alkaline earth metals, or their combinations;

wherein the first layer has a lower absorption at λ than a non-porous stoichiometric silicon layer of equal thickness; and

wherein 0.1nm ≤ λ ≤ 250 nm.

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

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

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 nm ≤ λ ≤ 250 nm.

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. The optical element according to claim 1, further comprising:

a protective capping layer formed above ~~the~~ a top layer, the protective capping layer constructed as a single capping layer;

wherein the capping layer ~~contains~~ is composed of either an 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. The optical element according to claim 1, further comprising:

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

wherein the second layer is non-porous; and

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

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

16. A method for making an optical element with an operating wavelength λ, the optical element comprising a multilayer stack consisting of alternating layer pairs, each layer pair having a first layer and a second layer, comprising:

preparing a substrate: and

forming a first layer above the substrate, wherein the thickness of every first layer in the multilayer stack is ~~similar~~ the same and the thickness of every second layer in the multilayer stack is ~~similar~~the same;

wherein the first layer contains either a group 1 element, alkali metal, ~~noble gas,~~ halogen, alkaline earth metal except for beryllium or one of their combinations;

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

wherein 0.1nm ≤ λ ≤ 250 nm.

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, lanthanide, actinide, or one of their combinations;

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

wherein 0.1 nm ≤ λ ≤ 250 nm.

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 transition metal, lanthanide, actinidor their combinations; and

wherein 0.1 nm $\leq \lambda \leq$ 250 nm.

22. The optical element of claim 1 or claim 16, wherein the combination or combinations <u>for the first layer</u> includes an element compound, alloy, mixture, micro- or nanolaminate, isotopes, ions, ternary material or, a non-stoichiometric material.

<u>23. The optical element of claim 1 or claim 16, wherein the combination or combinations for the second layer includes an element compound, alloy, mixture, micro- or nanolaminate, isotopes, ions, ternary material or, a non-stoichiometric material.</u>