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(54) **ANTI-REFLECTIVE LENS AND METHOD FOR TREATING A LENS TO REDUCE LIGHT REFLECTIONS FOR ANIMALS AND DEVICES THAT VIEW THROUGH THE ULTRA VIOLET LIGHT SPECTRUM**

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(57) **ABSTRACT**

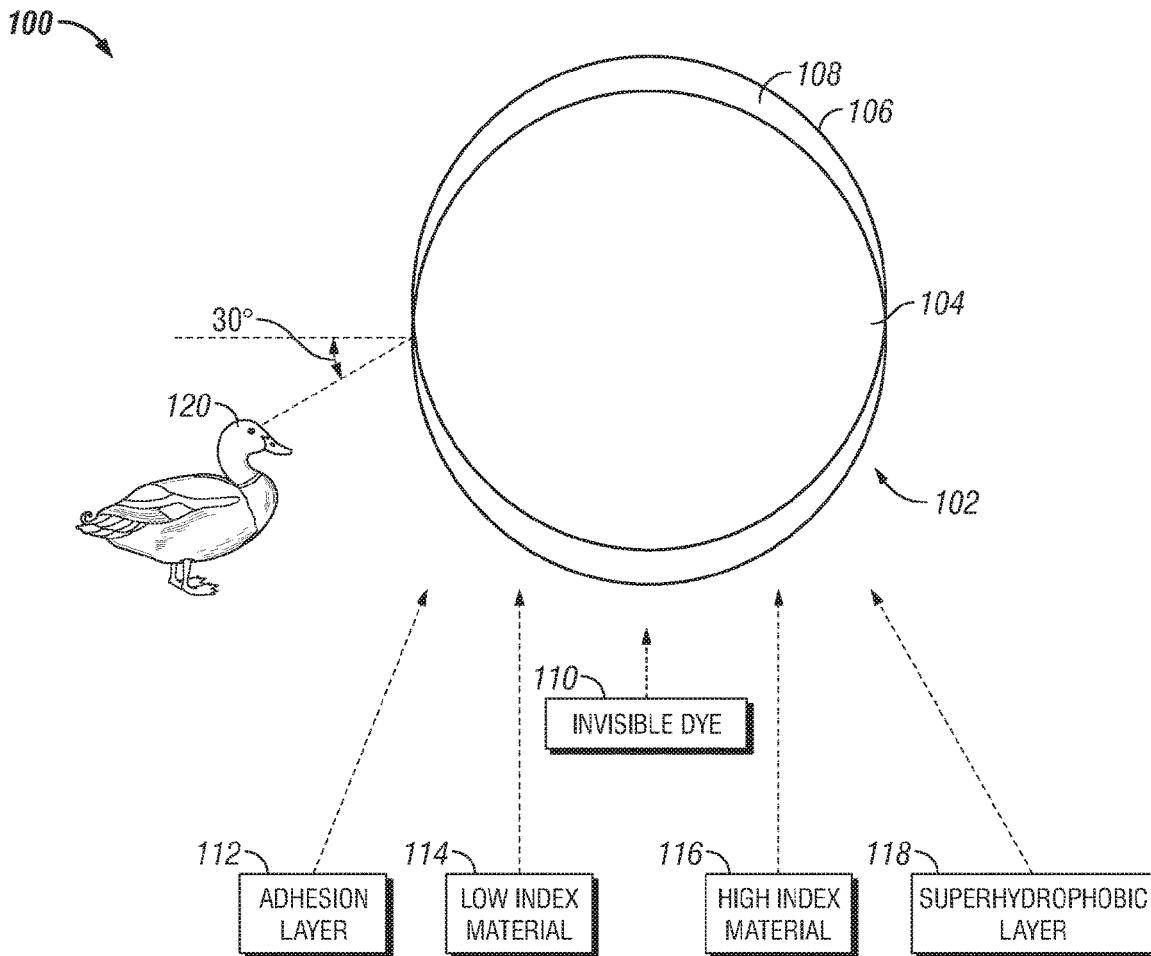
An anti-reflective lens and method for treating a lens to reduce visible light and ultraviolet light at levels perceptible to the vision system of an animal and a detection device having tetra-chromatic vision or di-chromatic vision. The treatment method produces an optical substrate that is less perceptible to an animal and detection device perceptible to view through the UV light spectrum. The method provides a substrate treated on opposite sides with an anti-reflective coating so that reflections from visible light and UV light are not visible to the animal and detection device, from incident angles between 0° to 60°. The anti-reflective coatings are applied in varying amounts of constituents and thicknesses, consisting of: adhesion layer, low index material (SiO₂), high index material (ZrO₂), and superhydrophobic layers. The substrate is initially UV treated, and then coated with the anti-reflective coating to minimize visible light and UV light reflection between 300-400 nanometers.

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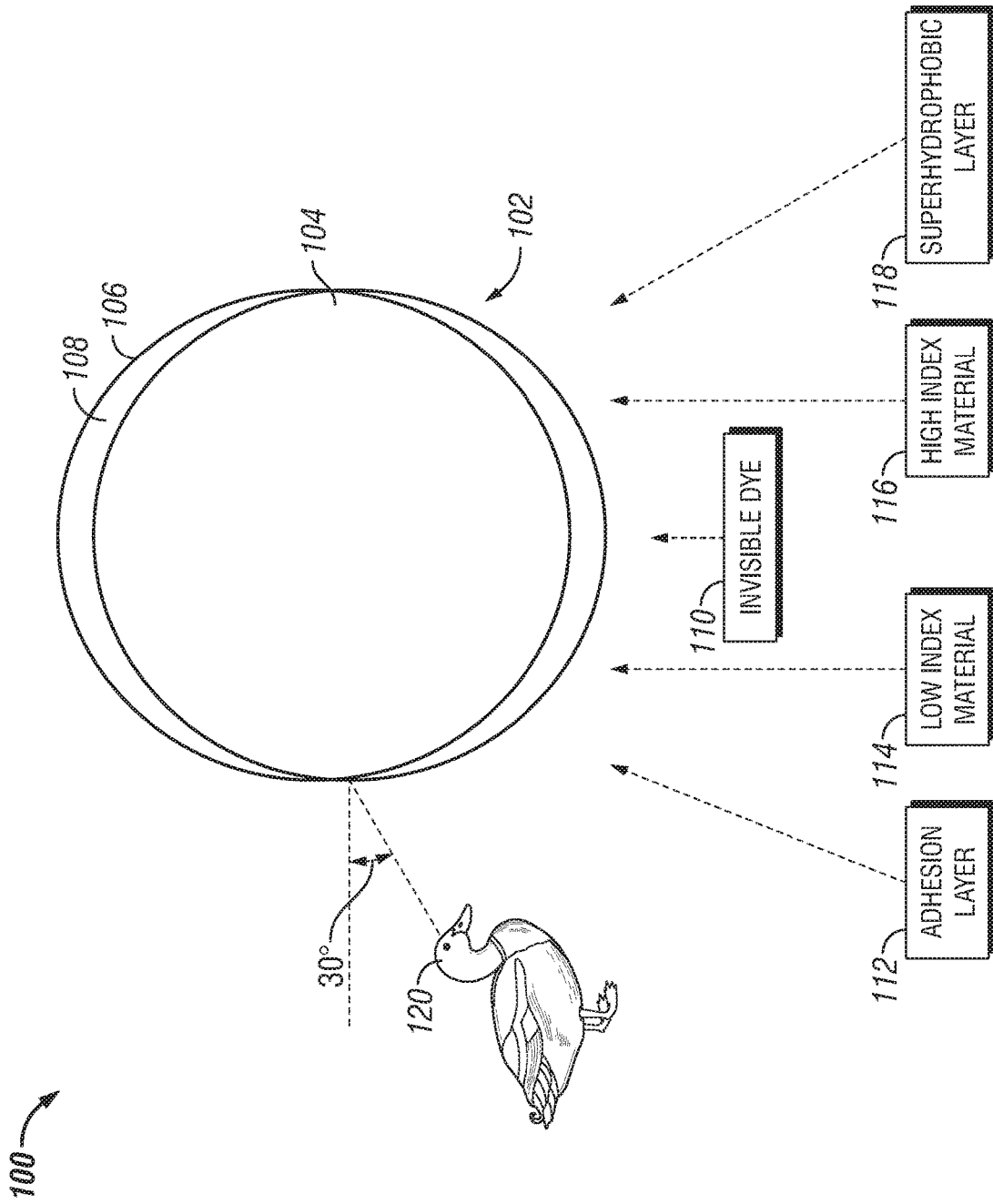


FIG. 1

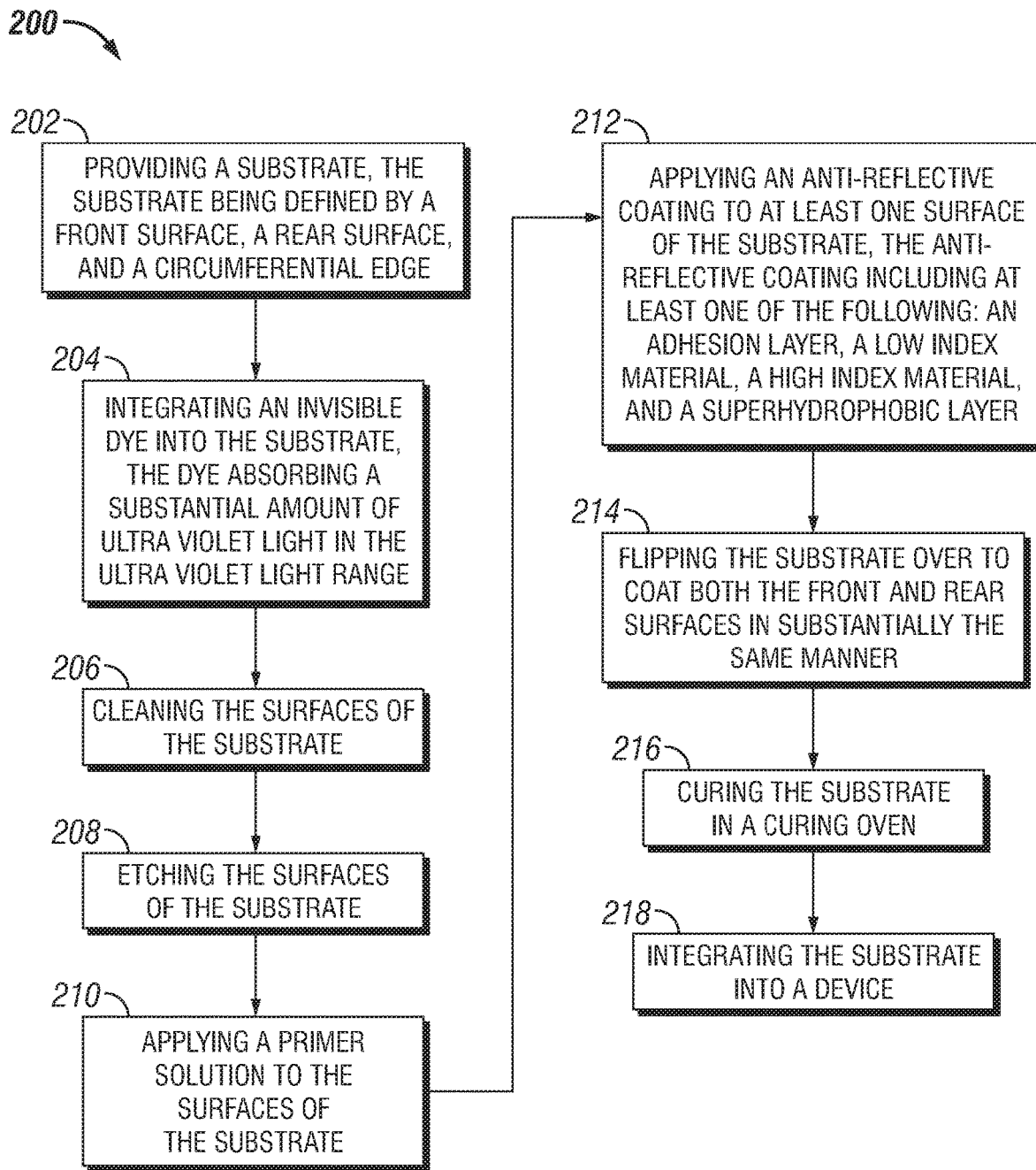


FIG. 2

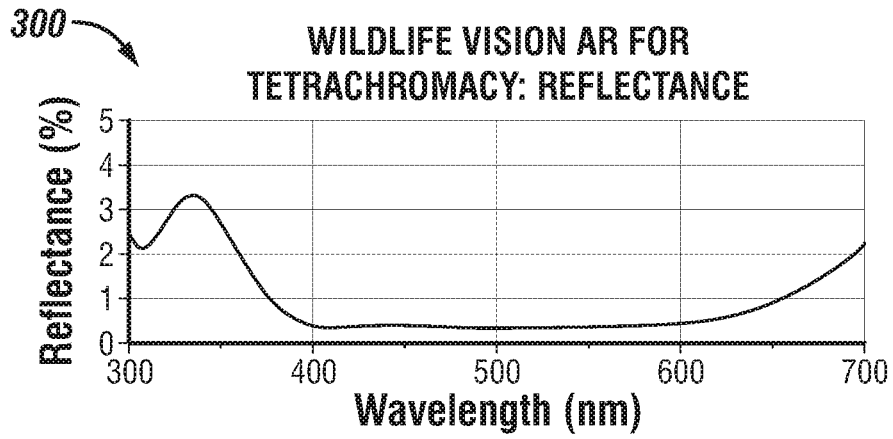


FIG. 3

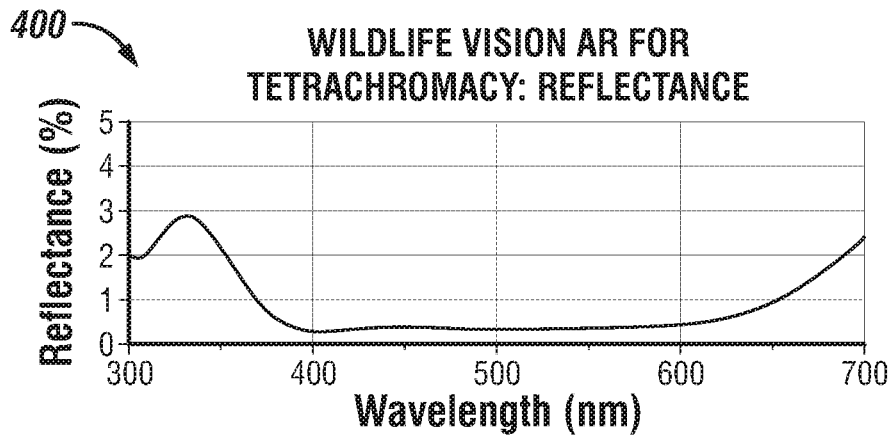


FIG. 4

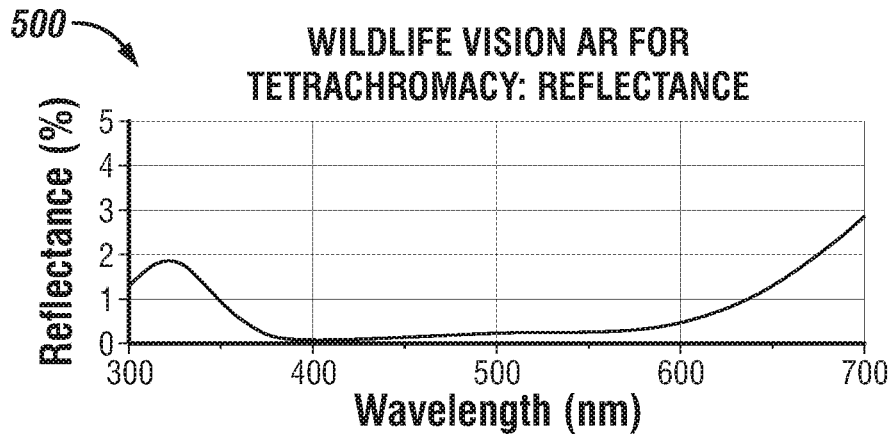


FIG. 5

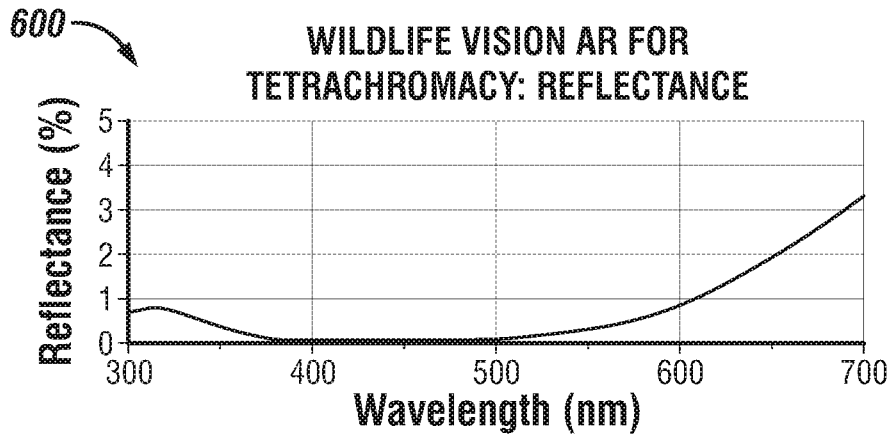


FIG. 6

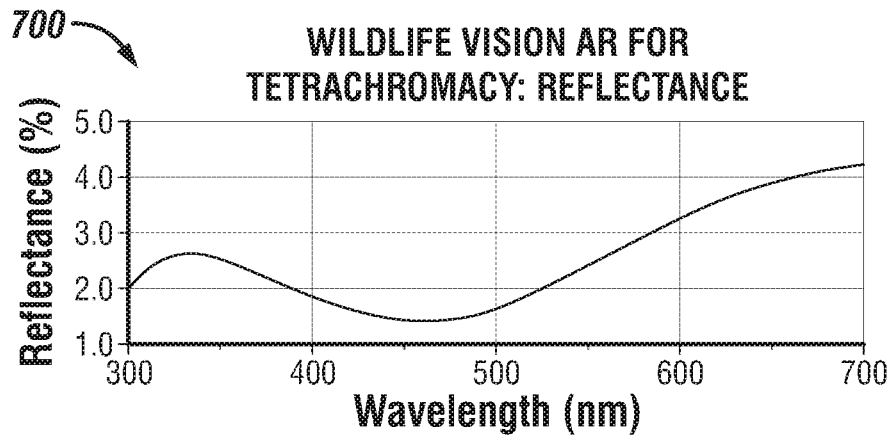


FIG. 7

**ANTI-REFLECTIVE LENS AND METHOD
FOR TREATING A LENS TO REDUCE
LIGHT REFLECTIONS FOR ANIMALS AND
DEVICES THAT VIEW THROUGH THE
ULTRA VIOLET LIGHT SPECTRUM**

**CROSS-REFERENCE TO RELATED
APPLICATIONS**

[0001] This application claims the benefits of U.S. provisional application No. 62/819,891, filed Mar. 18, 2019 and entitled OPTICAL LENS AND METHOD FOR TREATING A LENS TO REDUCE LIGHT REFLECTIONS FOR LENSES, DETECTION DEVICES, AND ANIMALS THAT VIEW THROUGH ULTRA VIOLET LIGHT SPECTRUM, which provisional application is incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates generally to an anti-reflective lens and method for treating a lens to reduce visible and ultra violet light reflections for animals and detection devices that view through the ultra violet light spectrum. More so, the present invention relates to a substrate that is UV treated, and subsequently coated with an anti-reflective coating to minimize visible light and UV light at an incident angle from 0° to 60° relative to the animal having tetra-chromatic and di-chromatic vision that can see in UV light spectrum; whereby the anti-reflective coating is applied in multiple coats, comprising: an adhesion layer, a low index material, a high index material, and a superhydrophobic layer in varying amounts of constituents and nanometer thicknesses.

BACKGROUND OF THE INVENTION

[0003] The following background information may present examples of specific aspects of the prior art (e.g., without limitation, approaches, facts, or common wisdom) that, while expected to be helpful to further educate the reader as to additional aspects of the prior art, is not to be construed as limiting the present invention, or any embodiments thereof, to anything stated or implied therein or inferred thereupon.

[0004] Typically, ultra violet light falls in the range of the EM spectrum between visible light and X-rays, having frequencies of about 8×10^{14} to 3×10^{16} cycles per second, or hertz (Hz), and wavelengths of about 380 nanometers (1.5×10^{-5} inches) to about 10 nm (4×10^{-7} inches). It is known in the art that optical lenses and viewing surfaces reflect varying amounts of visible light and ultra violet light across the ultraviolet light range. Thus, when optical lenses and viewing surfaces are treated, in order to create visual effects or increased light transmission or sensitivity, this is generally in a spectral range and does not account for all of the wavelengths of light that tetrachromacy and dichromacy allow.

[0005] Generally, humans see a wide range of color as a result of three types of cones in our eyes: one that's sensitive to short-wavelength light in the blue portion of the color spectrum, one sensitive to middle-wavelength light in the green portion and a third type receptive to long-wavelength light in the red portion. In contrast to humans' "trichromatic" vision, birds, ducks, amphibians, and other tetrachromatic organisms have "tetra-chromatic" vision. This is

because birds have much different eyes and vision systems than humans. They see color more intensely and vibrantly as well as having the ability to see into the UV range.

[0006] For example, deer have "dichromatic" vision because they have only two types of cones, lacking the cone that's sensitive to longer wavelengths such as red and orange. This does not mean deer don't see red and orange hues, only that deer perceives the colors differently, likely the same way as a color-blind person. Thus, the hoofed ruminant mammals see color more intensely and vibrantly as well as having the ability to see into the UV range. The human eye does not perceive the UV wavelengths of light.

[0007] Generally, tetrachromacy is the condition of possessing four independent channels for conveying color information, or possessing four types of cone cells in the eye. Organisms with tetrachromacy vision are called tetrachromats. In tetrachromatic organisms, the sensory color space is four-dimensional, meaning that to match the sensory effect of arbitrarily chosen spectra of light within their visible spectrum requires mixtures of at least four primary colors. It is also known that animals with dichromatic vision have two receptor types—light-sensitive cells in the retina of the eye used in color vision. This gives such animals limited color vision, with the ability to see only one or two colors, such as blue and yellow. Conversely, animals such as humans and apes are trichromatic. Meaning they see three colors.

[0008] Typically, the human eye does not perceive the UV wavelengths of light. Current anti-reflective lenses and viewing surfaces reflect varying amounts of light. When anti-reflective lenses and viewing surfaces are treated in order to create visual effects or increased light transmission or sensitivity, this is generally in a spectral range and does not account for all of the wavelengths of light that tetrachromacy allows.

[0009] Other proposals have involved viewing lenses used for discretely viewing game animals. The problem with these lenses is that they do not utilize a UV treated substrate, and then subsequently coat the substrate with an anti-reflective coating consisting of: an adhesion layer, a low index material, a high index material, and a superhydrophobic layer in varying amounts of constituents and nanometer thicknesses. Even though the above cited viewing lenses used for discretely viewing game animals meet some of the needs of the market, an anti-reflective lens and method for treating a lens to reduce visible and ultra violet light reflections for animals and detection devices that view through the ultra violet light spectrum, is still desired.

SUMMARY

[0010] Illustrative embodiments of the disclosure are generally directed to an anti-reflective lens and method for treating a lens to reduce visible light and ultra violet light across the ultraviolet light range for animals and devices that view through the ultra violet light spectrum.

[0011] The anti-reflective lens is a general viewing lens that has anti-reflective properties. The anti-reflective lens comprises a substrate that is UV treated, or has integrated therein, an invisible dye used for absorbing a substantial portion of the UV spectrum. The substrate is treated on opposite sides with an anti-reflective coating, which enables the substrate to minimize light reflections, and especially visible light or ultraviolet light at levels perceptible to the vision system of an animal having tetra-chromatic and di-chromatic vision, and a detection device with a viewing

system in the ultra violet light spectrum. The animal may include tetra-chromatic and di-chromatic organisms that can see in UV spectrum of light, such as a game bird or a deer. The detection device may include a motion detector that senses UV light.

[0012] The treated substrate helps block UV light passing therethrough. The anti-reflective lens prevents visible light and UV light from reflecting off the substrate at an incident angle from 0° to 60° when viewed by the animal and detection device. The reduction of light reflection/glare from this incident angle at the 0° to 60° range is ideal for reducing light glare from the lens, even when the animal (or detection device) is positioned towards, away from, directly over, and in moving directions in relation to the anti-reflective lens.

[0013] The anti-reflective lens is treated by applying an anti-reflective coating in multiple coats. The anti-reflective coating includes of the following constituents: an adhesion layer, a low index material comprising SiO₂, a high index material comprising ZrO₂, and a superhydrophobic layer. Each ingredient is applied in subsequent layers of varying nanometer thicknesses. In this manner, the treated anti-reflective lens exhibits minimal reflection properties in the visible range of the electromagnetic spectrum and almost no reflection in the UV range between 300-400 nanometers. This reduces the probability of the exposing UV light being reflected off the anti-reflective lens.

[0014] In one embodiment, the method for treating a lens to reduce light reflections for animals and devices that view through the ultra violet light spectrum, comprises:

[0015] providing a substrate, the substrate being defined by a front surface, a rear surface, and a circumferential edge;

[0016] integrating an invisible dye into the substrate, the dye absorbing at least 97 percent of ultra violet light in the ultra violet light range;

[0017] cleaning the surfaces of the substrate;

[0018] etching the surfaces of the substrate;

[0019] applying a primer solution to the surfaces of the substrate;

[0020] applying an anti-reflective coating to the surfaces of the substrate, the anti-reflective coating including at least one of the following: an adhesion layer, a low index material, a high index material, and a superhydrophobic layer, the anti-reflective coating being applied in the following sequence:

[0021] applying the adhesion layer;

[0022] applying about 164.53 nm of the low index material;

[0023] applying about 14.16 nm of the high index material;

[0024] applying about 23.5 nm of the low index material;

[0025] applying about 101 nm of the high index material;

[0026] applying about 76.19 nm of the low index material;

[0027] applying the superhydrophobic layer;

[0028] if the anti-reflective coating is applied to one surface, flipping the UV treated substrate and coating the opposite surface in the same manner;

[0029] integrating the UV treated substrate into a device or substrate; and

[0030] inhibiting glare and reflections for an animal having tetra-chromatic vision or di-chromatic vision.

[0031] In another aspect, the substrate includes at least one of the following: a trivex lens, a polycarbonate lens, a UV treated Cr-39 lens, and a UV treated glass lens.

[0032] In another aspect, the application of the anti-reflective coating comprises a vacuum coating.

[0033] In another aspect, the vacuum coating comprises an electron beam gun evaporation technique or a magnetron sputtering technique.

[0034] In another aspect, the low index material comprises SiO₂.

[0035] In another aspect, the high index material comprises ZrO₂.

[0036] In another aspect, the method further comprises dipping the substrate into a primer solution if the UV treated substrate is not hard-coated.

[0037] In another aspect, the method further comprises spinning the primer solution onto the UV treated substrate, if the UV treated substrate is not hard-coated.

[0038] In another aspect, the method further comprises etching, with an ultrasonic etching device, the surfaces of the substrate.

[0039] In another aspect, the method further comprises curing the UV treated substrate in an oven, if the UV treated substrate is not hard-coated.

[0040] In another aspect, the method further comprises applying the anti-reflective coating to the surfaces in multiple coats.

[0041] In another aspect, the method further comprises plasma etching the surfaces of the substrate.

[0042] In one aspect, an anti-reflective substrate for treating a substrate to reduce the light wavelengths to make the anti-reflective substrate less perceptible to mammals with tetra-chromatic vision, comprises: a UV treated substrate comprising a substrate element having a first surface and a second surface, the surfaces being defined by UV absorbing properties; the first surface of the UV treated substrate comprising an anti-reflective coating configured to minimize reflection of light in the UV range between 300-400 nanometers; the second surface of the UV treated substrate comprising an anti-reflective coating configured to minimize reflection of light in the UV range between 300-400 nanometers; whereby the internal absorption of the substrate absorbs 97%+ of the UV in all ranges.

[0043] One objective of the present invention is to minimize light reflections and glare from an anti-reflective lens for animal having tetra-chromatic vision or di-chromatic vision.

[0044] Another objective is to minimize light reflections and glare from an anti-reflective lens for a detection device, such as a UV-sensing motion detector.

[0045] Another objective is to reduce the wavelengths of light reflected, such that any and all lenses, detection devices, and animals that view through the UV spectrum cannot see the light reflections from the lens.

[0046] Yet another objective is to produce an anti-reflective lens that has the appearance of little to no reflection in the visible range of the electromagnetic spectrum.

[0047] Yet another objective is to help better conceal hunters in hunting animals with tetra-chromatic vision or di-chromatic vision.

[0048] Yet another objective is to provide an inexpensive to manufacture UV blocking, anti-reflection lens.

[0049] Other systems, devices, methods, features, and advantages will be or become apparent to one with skill in

the art upon examination of the following drawings and detailed description. It is intended that all such additional systems, methods, features, and advantages be included within this description, be within the scope of the present disclosure, and be protected by the accompanying claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0050] The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

[0051] FIG. 1 shows an exemplary anti-reflective lens, showing a substrate coated with an anti-reflective coating, in accordance with an embodiment of the present invention;

[0052] FIG. 2 shows a flowchart of an exemplary method for treating a lens to reduce light wavelengths to make the anti-reflective lens less perceptible to any and all lenses, detection devices, and animals that view through the UV spectrum, in accordance with an embodiment of the present invention;

[0053] FIG. 3 shows a reflectance graph of an anti-reflective coating that reflects 2.1% in 700 nm range and 3.2% in the 350 nm range at a 0° angle of incidence, in accordance with an embodiment of the present invention;

[0054] FIG. 4 shows a reflectance graph of an anti-reflective coating that reflects 2% in the 700 nm range and 2.9% in the 340 nm range at a 15° angle of incidence, in accordance with an embodiment of the present invention;

[0055] FIG. 5, a reflectance graph of an anti-reflective coating that reflects 2.8% in the 700 nm range and 1.9% in the 325 nm range at a 30° angle of incidence, in accordance with an embodiment of the present invention;

[0056] FIG. 6, a reflectance graph of an anti-reflective coating that reflects 3.2% at 700 nm's and 1.8% at 310 nm range at a 45° angle of incidence, in accordance with an embodiment of the present invention; and

[0057] FIG. 7, a reflectance graph of an anti-reflective coating that reflects 4.2% at the 700 nm range and 2.6% at 240 nm range at 60° angle of incidence, in accordance with an embodiment of the present invention.

[0058] Like reference numerals refer to like parts throughout the various views of the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0059] The following detailed description is merely exemplary in nature and is not intended to limit the described embodiments or the application and uses of the described embodiments. As used herein, the word “exemplary” or “illustrative” means “serving as an example, instance, or illustration.” Any implementation described herein as “exemplary” or “illustrative” is not necessarily to be construed as preferred or advantageous over other implementations. All of the implementations described below are exemplary implementations provided to enable persons skilled in the art to make or use the embodiments of the disclosure and are not intended to limit the scope of the disclosure, which is defined by the claims. For purposes of description herein, the terms “upper,” “lower,” “left,” “rear,” “right,” “front,” “vertical,” “horizontal,” and derivatives thereof shall relate to the invention as oriented in FIG. 1. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding

technical field, background, brief summary or the following detailed description. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification, are simply exemplary embodiments of the inventive concepts defined in the appended claims. Specific dimensions and other physical characteristics relating to the embodiments disclosed herein are therefore not to be considered as limiting, unless the claims expressly state otherwise.

[0060] An anti-reflective lens **100** and method **200** for treating a lens to reduce light reflections for animals and devices that view through the ultra violet light spectrum is referenced in FIGS. 1-7. The anti-reflective lens **100** comprises a substrate **102** that is initially UV treated, and then coated with the anti-reflective coating to minimize visible light and UV light reflection between 300-400 nanometers. The substrate **102** is uniquely designed to be fitted into a device, such as a lens sight, a rifle sight, glasses, or in any viewing device in which it is advantageous to minimize visible light and ultraviolet light at levels perceptible to the vision system of an animal having tetra-chromatic vision or di-chromatic vision. The anti-reflective lens **100** is also efficacious for reducing light glare and light reflections when viewed from a detection device that detects the ultra violet light spectrum, e.g., a UV motion detector. This creates an optical substrate **102** that reflects almost no light in the visible range of light between 400-700 nanometers, and the ultra violet light range between 300-400 nanometers, so as to make it difficult for animals with tetra-chromatic and di-chromatic vision to detect the anti-reflective lens via light and UV reflections/glare. Further, the anti-reflective lens **100** inhibits light glare and light reflections at an incident angle from 0° to 60° from the point of view of the animal **120** and a detection device. Thus, the light glare is not viewable from the sides, or from an upper or lower vantage point.

[0061] Those skilled in the art will recognize that it can be advantageous to avoid detection from animals and detection devices—especially, for hunters and military personnel. For example, the anti-reflective lens **100** minimizes visible and ultra violet light reflections off the substrate **102**, as viewed from the vantage point of birds with tetra-chromatic vision, and deer with dichromatic vision. Thus, the anti-reflective lens **100** can be integrated into a gunsight or scope lens used with hunting rifles, where reflections and glare is minimized, from the point of view of the animal and detection device.

[0062] The anti-reflective lens **100**, when fully treated, has the unique characteristic of minimizing glare at an incident angle between 0° to 60° relative to the animal **120** or detection device. This can be useful, for example, in preventing detection of a hunter by game birds flying directly above the anti-reflective lens **100**, or game deer located at a lower elevation from the hunter and anti-reflective lens **100**. Thus, it is one objective of the present invention to help better conceal hunters while hunting animals with tetra-chromatic vision or di-chromatic vision that see the ultra violet light spectrum.

[0063] It is known in the art that ultra violet light falls in the range of the EM spectrum between visible light and X-rays, having frequencies of about 8×10^{14} to 3×10^{16} cycles per second, or hertz (Hz), and wavelengths of about 380 nanometers (1.5×10^{-5} inches) to about 10 nm (4×10^{-7} inches). The present invention details optical lens and viewing surface treatments that allow for reductions in all wavelengths of light in order to make it difficult for any and all

lenses, detection devices, and animals **120** that view through the ultra violet light spectrum to discover these devices via reflection that are perceptible to an animal **120** that exhibit both tetra-chromatic and dichromatic vision.

[0064] As FIG. 1 references, the anti-reflective lens **100** comprises a substrate **102**, such as known in the art of both short-range and long-range viewing lenses. In some embodiments, the lens may include, without limitation, a trivex lens, a polycarbonate lens, a UV treated Cr-39 lens, and a UV treated glass lens. The anti-reflective lens **100** comprises a substrate **102**, which may be fabricated from glass, polymer, synthetic plastic, or combinations thereof. The substrate **102** may have various shapes and thicknesses that are efficacious for enhancing viewing of an object from a distance. In some embodiments, the substrate **102** is defined by a front surface **104**, a rear surface **106**, and a circumferential edge **108**. The surfaces **104**, **106** of the substrate **102** may be flat, concave, or convex. The circumferential edge **108** of the substrate **102** may be of various thicknesses. These characteristics of the substrate **102** may form a generally circular or disc-shaped lens.

[0065] It is significant to note that the substrate **102** is initially UV-treated prior to the application of the anti-reflective coating, discussed below. Thus, treating the substrate **102** for UV protection involves integrating an invisible dye **110** into the substrate **102**. The dye **110** is configured to allow the substrate **102** to absorb at least 97% of the ultra violet light found in the ultra violet light range. Thus, in some embodiments, the present invention may utilize a pre-fabricated UV-treated substrate, or may treat the substrate **102** with the dye **110**, so as to create a UV-treated substrate **102**. In either case, the anti-reflective lens **100** is UV-treated to absorb a substantial amount of the ultra violet light striking the front surface **104** of the substrate **102**.

[0066] The surfaces **104**, **106** of the substrate **102** are further cleaned, etched, and coated with a primer prior to coating with the anti-reflective coating. The cleaning may be performed with a cloth or liquid means known in the art of lenses. The surfaces **104**, **106** of the substrate **102** may be etched with an ultrasonic etching device. The etching helps prepare the surfaces for receiving the various layers of the anti-reflective composition.

[0067] A primer may then be added, if the substrate **102** is not hard-coated. The primer may be added by dipping the substrate **102** into a primer solution. In other embodiments, the primer solution is spun onto the substrate **102**; especially if the substrate **102** is not of the hard-coated variety. Additional treatment may include curing the substrate **102** in a curing oven. In one embodiment, the cleaning, etching, and priming treatments are performed prior to application of the anti-reflective coating.

[0068] Looking again at FIG. 1, an anti-reflective coating is applied in multiple coats to at least one of the surfaces of the substrate **102**. In some embodiments, the anti-reflective coating may also be applied to the circumferential edge **108** of the substrate **102**. Various substrate-coating means known in the art may be used to apply the coating, including vacuum coating through an electron beam gun evaporation technique or a magnetron sputtering technique.

[0069] In some embodiments, the ingredients/compositions of the anti-reflective coating may include, without limitation: an adhesion layer **112**, a low index material **114** comprising SiO₂, a high index material **116** comprising ZrO₂, and a superhydrophobic layer **118**. The layers may be

applied to the substrate **102** in the above sequential order. In alternative embodiments, the ingredients of the anti-reflective coating are applied on the surfaces of the substrate **102** in reverse or alternating orders of application.

[0070] After receiving the UV-treatment, and the anti-reflective coating, the surfaces of the substrate **102** are operable to minimize reflection/glare in the visible light range and the ultraviolet light range, such as ultra violet light between 300 to 400 nanometers, from the vantage point of the animal **120** or detection device. Additionally, the anti-reflective coating configures the surfaces **104**, **106** of the substrate **102** to have an internal absorption of at least 97% of the ultra violet light range between about 300 to 400 nanometers. The substrate **102** may then be fitted into a device, such as a rifle sight, binoculars, or other lens-adaptable device known in the art. The substrate **102** may also be stacked onto additional substrates, both with or without treatment.

[0071] FIG. 2, references a flowchart of an exemplary method **200** for treating a lens to reduce light reflections for animals and devices that view through the ultra violet light spectrum. The substrate **102** described above is treated, in the following manner. In one embodiment, the method **200** comprises an initial Step **202** of providing a substrate **102**, the substrate **102** being defined by a front surface **104**, a rear surface, and a circumferential edge **108**. The surfaces **104**, **106** of the substrate **102** may be flat, concave, or convex. The circumferential edge **108** of the substrate **102** may be of various thicknesses.

[0072] The substrate **102** is initially UV-treated to reduce ultra violet light reflections. Thus, the method **200** includes a Step **204** of integrating an invisible dye **110** into the substrate **102**, the dye **110** absorbing a substantial amount of ultra violet light in the ultra violet light range. The invisible dye **110** is a known means to UV-treat the substrate **102**, such that a substantial amount of ultra violet light is absorbed by the substrate **102**. In one non-limiting embodiment, 97% of ultra violet light is blocked/absorbed by the substrate **102** after treatment. In other embodiments, the substrate **102** is pre-manufactured to be UV-treated, or may require application of Step **204** to integrate the dye **110** therein. It is significant to note that UV-treatment works to reduce glare and reflection from the substrate **102**.

[0073] In some embodiments, a Step **206** includes cleaning the surfaces of the substrate. The substrate **102** may be hand cleaned to remove all debris and contaminants that may create defects in the final anti-reflective lens product. Another Step **208** comprises etching the surfaces of the substrate **102**. In one embodiment, the etching of the surfaces is performed with an ultrasonic etching device. A further Step **210** includes applying a primer solution to the surfaces of the substrate. In conditions where the substrate **102** is not hard-coated, a primer solution is applied to the substrate **102** through dipping directly into the primer solution, or spinning the primer solution onto the substrate **102**.

[0074] In some embodiments, a Step **212** may include applying an anti-reflective coating to at least one surface of the substrate **102**, the anti-reflective coating including at least one of the following: an adhesion layer **112**, a low index material **114**, a high index material **116**, and a superhydrophobic layer **118**. Each layer applied to the substrate **102** provides unique anti-reflection characteristics to the substrate **102**.

[0075] For example, the adhesion layer **112** is a substance that helps other layers to adhere to the surfaces of the substrate **102**. The low index material **114** comprises a SiO_2 , and other elements or compounds complimentary to low index functions. The high index material **116** comprises a ZrO_2 , and other elements or compounds complimentary to high index functions. The superhydrophobic layer **118** inhibits moisture from clouding the substrate **102**. In one non-limiting embodiment, a water droplet striking the substrate **102** on the superhydrophobic layer **118** strikes at a contact angle that exceeds 150° . This is known in the art as the “lotus effect”.

[0076] In one non-limiting embodiment, the anti-reflective coating is applied in the following sequence: applying the adhesion layer **112**; applying about 164.52 nm of the low index material **114**; applying about 14.16 nm of the high index material **116**; applying about 22.5 nm of the low index material **114**; applying about 101 nm of the high index material **116**; applying about 76.19 nm of the low index material **114**; and applying the superhydrophobic layer **118**. In other embodiments, different sequences of layers, and different thicknesses of layers can be applied to the surface (s) of the substrate **102**. Furthermore, different variations of nanometer thickness, low index material **114**, and high index material **116** may also be used.

[0077] In the above-mentioned combination of constituents that make up the anti-reflective composition, the substrate **102** creates little to no reflection in the visible range of the electromagnetic spectrum and little to no reflection in the UV range from angles between 0° to 60° . This lack of reflective properties from the point of view of a mammal with tri-chromatic and di-chromatic eyesight as well as detection devices is also at normal angles of incidence as well as off axis angles of incidence up to 60° .

[0078] The constituents of the anti-reflective coating can be, however, adjusted to vary the amount of light being reflected or creating glare off the substrate, from the point of view of the animal. The constituents of the anti-reflective coating can also be varied to increase or decrease the angle of incidence of light reflection, which the animal **120** and detection device having a viewing system through the ultra violet light spectrum.

[0079] FIGS. 3-7 reference multiple graphs that show the percentage of ultra violet light reflecting off the substrate **102** at different wavelength of the ultraviolet light range, based on the configuration of the anti-reflective coating. The amount of reflection and glare from the substrate **102** varies as a result of the different configurations of layering the anti-reflective coating. Thus, as the quantity of each ingredient is changed, there are different amounts of visible light reflections and glare, from the point of view of the animal or detection device. For example, increasing the amount of high index layer **116** reduces light reflection off the substrate. And increasing the amount of superhydrophobic layer **118** can result in moisture build up on the substrate, which creates more light reflections and glare for the animal.

[0080] FIG. 3 shows a reflectance graph **300** in which the surfaces **104**, **106** of the substrate **102** are coated with a first embodiment of the anti-reflective coating that is designed to reflect minimal amount of light between 400-700 nm, or the ultra violet light range between 300-400 nm. In this example, the same anti-reflective coating reflects 2.1% in 700 nm range and 3.2% in the 350 nm range and 0° of incidence. In another embodiment, FIG. 4 shows a reflectance graph **400** in which the surfaces **104**, **106** of the substrate **102** are coated with a second embodiment of the anti-reflective coating. In this configuration, the same anti-reflective coating reflects 2% in the 700 nm range and 2.9% in the 340 nm range at 15° angle of incidence.

[0081] Looking now at a reflectance graph **500** in FIG. 5, the same anti-reflective coating as shown in FIG. 4 reflects 2.8% in the 700 nm range and 1.9% in the 325 nm range at 30° angle of incidence. Yet another reflectance graph **600** shown in FIG. 6 references the ultra violet light reflectance when the angle of incidence is at 45° . This 45° angle of incidence is used in the same anti-reflective coating reflecting 3.2% at 700 nm and 1.8% at 310 nm range at the 45° angle of incidence. In yet another example of a reflectance graph **700** shown in FIG. 7, the same anti-reflective coating reflects 4.2% at the 700 nm range and 2.6% at 240 nm range at 60° angle of incidence.

[0082] Because the substrate **102** is coated with multiple layers, and in multiple passes to achieve the desired anti-reflective properties for at least one surface **104**, **106**, a Step **214** may require flipping the substrate **102** over to coat both the front and rear surfaces **104**, **106** in substantially the same manner. Flipping the substrate **102** may be performed through automated means, such as robotic manipulation, or simply manual flipping the substrate **102**. After coating, a Step **216** involves curing the substrate **102** in a curing oven, or through other lens drying means known in the art. The curing Step **216** is especially useful when the substrate **102** is not the hard-coated variety.

[0083] When treated in this manner, light glare and the light reflections that reflect off the substrate **102** are not visible for an animal having tetra-chromatic vision or dichromatic vision, and specifically from an incident angle from 0° to 60° from the point of view of the animal. Finally, a Step **218** includes integrating the substrate **102** into a device. This may include fitting the substrate **102** into a rifle sight, pair of binoculars, and lens-adaptable devices known in the art. The substrate **102** may also be stacked onto additional substrates, both with or without treatment.

[0084] Although the process-flow diagrams show a specific order of executing the process steps, the order of executing the steps may be changed relative to the order shown in certain embodiments. Also, two or more blocks shown in succession may be executed concurrently or with partial concurrence in some embodiments. Certain steps may also be omitted from the process-flow diagrams for the sake of brevity. In some embodiments, some or all the process steps shown in the process-flow diagrams can be combined into a single process.

[0085] These and other advantages of the invention will be further understood and appreciated by those skilled in the art by reference to the following written specification, claims and appended drawings.

[0086] Because many modifications, variations, and changes in detail can be made to the described preferred embodiments of the invention, it is intended that all matters in the foregoing description and shown in the accompanying drawings be interpreted as illustrative and not in a limiting sense. Thus, the scope of the invention should be determined by the appended claims and their legal equivalence.

What is claimed is:

1. A method for treating a lens to reduce light reflections for animals and devices that view through the ultra violet light spectrum, the method comprising:

providing a substrate, the substrate being defined by a front surface, a rear surface, and a circumferential edge;
 cleaning the surfaces of the substrate;
 etching the surfaces of the substrate;
 applying a primer solution to the surfaces of the substrate;
 and
 applying an anti-reflective coating to at least one surface of the substrate, the anti-reflective coating including at least one of the following: an adhesion layer, a low index material, a high index material, and a superhydrophobic layer.

2. The method of claim 1, wherein the anti-reflective coating is applied in the following sequence:

applying the adhesion layer;
 applying about 164.53 nm of the low index material;
 applying about 14.16 nm of the high index material;
 applying about 23.5 nm of the low index material;
 applying about 101 nm of the high index material;
 applying about 76.19 nm of the low index material; and
 applying the superhydrophobic layer.

3. The method of claim 1, further comprising integrating an invisible dye into the substrate, the dye absorbing a substantial amount of ultra violet light in the ultra violet light range.

4. The method of claim 1, further comprising inhibiting the light glare and the light reflections from the substrate for an animal having tetra-chromatic vision or di-chromatic vision, the inhibition of the light glare and the light reflections being at an incident angle from 0° to 60° from the point of view of the animal.

5. The method of claim 1, further comprising integrating an invisible dye into the substrate, the dye absorbing at least 97 percent of ultra violet light in the ultra violet light range.

6. The method of claim 1, wherein the application of the anti-reflective coating further comprises applying the anti-reflective coating through vacuum coating.

7. The method of claim 6, wherein the vacuum coating comprises an electron beam gun evaporation technique or a magnetron sputtering technique.

8. The method of claim 1, wherein the low index material comprises SiO₂.

9. The method of claim 1, wherein the high index material comprises ZrO₂.

10. The method of claim 1, further comprising dipping the substrate into a primer solution, if the substrate is not hard-coated.

11. The method of claim 10, further comprising spinning the primer solution onto the substrate, if the substrate is not hard-coated.

12. The method of claim 1, further comprising etching, with an ultrasonic etching device, the surfaces of the substrate.

13. The method of claim 1, further comprising curing the substrate in an oven, if the substrate is not hard-coated.

14. The method of claim 1, further comprising plasma etching the surfaces of the substrate.

15. The method of claim 1, further comprising flipping the substrate to coat both surfaces in substantially the same manner.

16. The method of claim 1, further comprising integrating the substrate into a device.

17. The method of claim 1, wherein the lens includes at least one of the following: a trivex lens, a polycarbonate lens, a UV treated Cr-39 lens, and a UV treated glass lens.

18. A method for treating a lens to reduce light reflections for animals and devices that view through the ultra violet light spectrum, the method comprising:

providing a substrate, the substrate being defined by a front surface, a rear surface, and a circumferential edge;
 integrating an invisible dye into the substrate, the dye absorbing at least 97 percent of ultra violet light in the ultra violet light range;

cleaning the surfaces of the substrate;

plasma etching, with an ultrasonic etching device, the surfaces of the substrate;

applying a primer solution to the surfaces of the substrate;
 applying multiple coats of an anti-reflective coating to the surfaces of the substrate by vacuum coating, the anti-reflective coating including at least one of the following: an adhesion layer, a low index material comprising SiO₂, a high index material comprising ZrO₂, and a superhydrophobic layer, the anti-reflective coating being applied in the following sequence:

applying the adhesion layer;
 applying about 164.53 nm of the low index material;
 applying about 14.16 nm of the high index material;
 applying about 23.5 nm of the low index material;
 applying about 101 nm of the high index material;
 applying about 76.19 nm of the low index material;
 applying the superhydrophobic layer; and

inhibiting light glare and light reflections from the substrate for an animal having tetra-chromatic vision or di-chromatic vision, the inhibition of light glare and light reflections being at an incident angle from 0° to 60° when viewed by the animal.

19. The method of claim 1, further comprising inhibiting light glare and light reflections from the substrate for a detection device operable to view in the ultra violet light range.

20. An anti-reflective lens for reducing light reflections for animals and devices that view through the ultra violet light spectrum, the anti-reflective substrate comprising:

a substrate defined by a front surface, a rear surface, and a circumferential edge;

an invisible dye integrated into the substrate, the dye absorbing at least 97 percent of ultra violet light in the ultra violet light range; and

an anti-reflective coating applied in multiple coats to the surfaces of the substrate, the anti-reflective coating including at least one of the following: an adhesion layer, a low index material comprising SiO₂, a high index material comprising ZrO₂, and a superhydrophobic layer,

whereby the anti-reflective coating configures the surfaces of the substrate to minimize reflection of light in the ultraviolet light range between about 300 to 400 nanometers, whereby the anti-reflective coating configures the surfaces of the substrate to have an internal absorption of at least 97 percent of the ultra violet light range between about 300 to 400 nanometers.

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