METHOD AND APPARATUS FOR A VARIABLE POWER OPHTHALMIC LENS

FIELD OF USE

The disclosure relates generally to an Arcuate ophthalmic lens, which can include a series of Concentric Annular Sections. Said Concentric Annular Sections may comprise variable liquid meniscuses in between a front curve Arcuate optical defining surface and a back curve Arcuate defining surface to provide a thinner variable power ophthalmic lens.

BACKGROUND

Liquid meniscus lenses have been known in various industries. As discussed more fully below with reference to Figs. 1A and 1B, known liquid meniscus lenses were engineered in cylindrical shapes with a perimeter surface formed by points at a fixed distance from an axis which is a straight line. Known examples of the use of liquid meniscus lenses include devices such as electronic cameras and mobile phone devices.

Traditionally, an ophthalmic device, such as a contact lens and an intraocular lens include one or more biocompatible device(s) with corrective, cosmetic, or therapeutic functionality. A contact lens, for example, can provide one or more of: vision correcting functionality; cosmetic enhancement; and therapeutic effects. Each function provided by a physical characteristic of the lens. For example, a design incorporating a refractive quality into a lens can provide a vision corrective function, a pigment incorporated into the lens can provide a cosmetic enhancement, and an active agent incorporated into a lens can provide a therapeutic functionality.

One example of a contact lens includes an arcuate liquid meniscus lens with a single meniscus wall and physical features conducive to one or both of attraction and repulsion of a liquid contained within the lens and forming a meniscus boundary with another liquid. Such lenses include a first optic proximate to a second optic with a

cavity formed therebetween. A saline solution and an oil are maintained within the cavity. Application of an electrical charge to the meniscus wall generally located in a perimeter area of one or both of the first optic and the second optic changes the physical shape of a meniscus formed between the saline solution and oil maintained within the cavity thereby changing the power of the lens. However, some of these designs may suffer from limitations in some applications.

Consequently, what is needed are additional ophthalmic lens designs that can exploit the advantages of both diffractive and refractive variable optical structures for vision correction.

SUMMARY

According to a first aspect, there is provided an optical lens comprising:

a front curve lens and a back curve lens, wherein both said front curve lens and said back curve lens comprise an arcuate shape and are positioned proximate to each other forming a cavity therebetween;

a volume of oil and a volume of saline solution within the cavity; and

a conductive coating on at least one portion of one or both of said front curve lens or said back curve lens contiguous to the cavity;

wherein the optical lens is configured to form variable optical structures from concentric annular sections in the oil and saline solution, based upon an electrical charge applied to the conductive coating in order to change characteristics of the oil and saline.

Accordingly, there is provided a variable power ophthalmic Lens with physical and chemical features conducive for inclusion in an ophthalmic lens, for example a contact lens or an intraocular lens. More specifically, the ophthalmic Lens can exploit properties of both diffractive and refractive variable optical structures.

Application of electrical charge to at least one predetermined region of one or both of a first Arcuate optic defining surface and a second Arcuate optic defining surface can form or change the physical shape, in discrete steps, of a series of optical

Concentric Annular Sections. Said optical Concentric Annular Sections which can be formed or changed using an electric current via techniques such as, for example Electrowetting or Electrophoresis, to define liquid meniscuses between the saline solution and oil maintained within the cavity.

The physical change of the liquid meniscuses may form or vary optical structures as it may be predetermined to thereby provide variable optical characteristics which can provide for a change in focal length and allow for thinner Arcuate ophthalmic Lenses. Said Arcuate ophthalmic Lenses which respond providing one or both diffractive and refractive variable optical structures at different states.

The optical lens may comprise a controller configured to apply the electrical charge to change the variable optical structures using Electrowetting techniques or Electrophoresis techniques.

The variable optical structures may provide variable optical powers at discrete steps.

The volume of oil may comprise from 65% to 90% of the volume of the cavity as compared to the amount of saline solution. The oil may comprise a density within about 5% of a density of the saline solution.

At least a portion of the conductive coating may extend from an area interior to the cavity to an area external to the cavity. The area of conductive coating external to the cavity may form an electrical terminal for providing the electrical charge to the conductive coating.

The lens may be configured to form the saline solution and the oil into a series of meniscuses in concentric annular rings and to apply the electrical charge to the conductive coating in order to change the shape of the annular rings.

The electrical charge may comprise a direct current. The electrical charge may comprise from 3.5-22 volts.

One or both of the front curve lens and the back curve lens may comprise an optical power other than 0.

The optical lens may additionally comprise a channel through one or both of the front curve lens and the back curve lens and a conductive material filling the channel. The optical lens may additionally comprise a terminal in electrical communication with the conductive material in the channel.

The optical lens may comprise a controller configured to apply the electrical charge to the terminal to cause a change in the shape of the liquid meniscus diffractive structures.

The optical lens may additionally comprise an insulator coating along at least a portion of the front curve lens, wherein the insulator coating comprises an electrical insulator. The insulator may comprise one or more of Parylene C and Teflon AF. The insulator may comprise a boundary area to maintain separation between the conductive coating and the saline solution contained in the cavity between the front curve lens and the back curve lens.

A functional component that is not transparent may be placed within an innermost concentric annular section. The functional component may include a reservoir for a liquid.

DESCRIPTION OF THE DRAWINGS

Fig. 1A illustrates an example of a cylindrical liquid meniscus lens in a first state.

Fig. 1B illustrates the cylindrical liquid meniscus lens of Fig. 1A in a second state.

Fig. 2A illustrates a cross section of an exemplary ophthalmic lens in an energized state.

Fig. 2B illustrates a cross section of the ophthalmic lens of Fig. 2A in a de-energized state.

Fig. 3A illustrates a cross section of another exemplary ophthalmic lens in an energized state.

Fig. 3B illustrates a cross section of the ophthalmic lens of Fig. 3A in a de-energized state.

Fig. 4 illustrates an exemplary top view section of the lenses presented in Figs. 2A – 3B.

Fig. 5 illustrates method steps that may be implemented.

Fig. 6 illustrates a controller.

DETAILED DESCRIPTION

The disclosure relates to an ophthalmic lens with physical and chemical features conducive for inclusion in an ophthalmic lens, such as a contact lens or an intraocular lens. In the following sections detailed descriptions of embodiments of the invention will be given. The description of both preferred and alternative embodiments though are exemplary embodiments only, and it is understood that to those skilled in the art that variations, modifications, and alterations may be apparent. It is therefore to be understood that the exemplary embodiments do not limit the broadness of the aspects of the underlying invention as defined by the claims.

GLOSSARY

In this description and claims directed to the presented invention, various terms may be used for which the following definitions will apply:

"Arcuate" as used herein, refers to a curve or bend like a bow shape.

"Concentric Annular Sections" as used herein, refers to one or more formed ring or spiral shaped optical structures having a common center. For example, a series of ring shaped sections in the optical zone of an ophthalmic lens that may result in a diffractive lens which alters the power and the aberrations of the ophthalmic lens.

"Contact Angle" as used herein, refers to the angle at which the oil/saline solution interface, also referred to as the Liquid Meniscus Boundary, meets the Meniscus Wall. In the case of a linear Meniscus Wall, the contact angle is measured as the angle between the Meniscus Wall and the line tangent to the Liquid Meniscus Boundary at the point where the Liquid Meniscus Boundary meets the Meniscus Wall. In the case of a curved Meniscus Wall, the contact angle is measured as the angle between the lines tangent to the Meniscus Wall and the Liquid Meniscus Boundary at the point where they meet.

"Energized" as used herein, refers to the state of being able to supply electrical current to or have electrical energy stored within.

"Energy" as used herein, refers to the capacity of a physical system to do work, for example the capacity to perform electrical actions in doing work.

"Energy Source" as used herein, refers to the device capable of supplying Energy or placing a biomedical device in an Energized state.

"Lens" as used herein, refers to an article with a front surface and a back surface that is optically transmissive to a predefined range of wavelengths of radiation, such as, by way of example, visible light. A lens may include one or both of a front surface and a back surface which are essentially flat or one or both of a front surface and a back surface which are Arcuate in shape. For example, the term lens can refer to a contact lens, intraocular lens, overlay lens, ocular insert, optical insert or other similar device through which vision is corrected or modified, or through which eye physiology is cosmetically enhanced (e.g. iris color) without impeding vision.

"Lens Cavity" as used herein, refers to the space in an Arcuate liquid meniscus lens between the front curve defining surface and the back curve defining surface in which oil and saline solution are maintained.

"Liquid Meniscus Boundary" as used herein, refers to one or more Arcuate surface interface(s) between the saline solution and the oil. For example, the surface can form one or more lens that is concave on one side and convex on the other.

"Lithium Ion Cell" as used herein, refers to an electrochemical cell where Lithium ions move through the cell to generate electrical energy. This electrochemical cell, typically called a battery, may be reenergized or recharged in its typical forms.

"Media Insert" as used herein, refers to a formable or rigid substrate capable of supporting an Energy Source within an ophthalmic lens. The Media Insert may also include one or more variable optic lenses.

"Meniscus Wall" as used herein, refers to a specific area on the interior of the front curve lens, such that it is within the meniscus cavity, along which the liquid meniscus boundary moves.

"Mold" as used herein, refers to a rigid or semi-rigid object that may be shaped to aid in the defining of physical properties of the diffractive structures. The Mold may also be one or both of the front curve or back curve defining surface(s) of the Lens.

"Optical Zone" as used herein, refers to an area of a lens through which a user of the lens sees through. For example, the area in an ophthalmic lens though which a wearer of the ophthalmic lens sees.

"Power" as used herein, refers to work done or energy transferred per unit of time.

"Rechargeable" or "Re-energizable" as used herein, refers to a capability of being restored to a state with higher capacity to do work. Many uses may relate to the capability of being restored with the ability to flow electrical current at a certain, reestablished time period.

"Reenergize" or "Recharge" as used herein, refers to the restoration of an Energy Source to a state with higher capacity to do work. Many uses may relate to restoring a device to the capability to flow electrical current at a certain rate for a certain, reestablished period.

"Sharp" as used herein, refers to a geometric feature of an internal surface of either a front curve or back curve lens defining surface sufficient to contain the location of a contact line of two predefined fluids on the optic. The Sharp is usually an outside corner rather than an inside corner. From a fluid standpoint can be an angle greater than 180 degrees.

"Substrate" as used herein, refers to a physical entity upon which other entities are placed or formed.

"Variable Optic" as used herein, refers to the capacity to change an optical quality, such as for example the optical structure of a lens.

An ophthalmic device may be provided with at least one of a front curve defining surface and a back curve defining surface to provide a Lens Cavity, wherein a series of Concentric Annual Sections can be formed, changed, or maintained to thereby provide for optical structures that may be capable of changing physical characteristics. The physical characteristics of the Concentric Annual Sections and overall shape of the ophthalmic lens which may be designed and internally controlled to provide an improved ophthalmic Lens with both refractive and diffractive properties.

Referring now to Fig. 1A, a cut away view of a lens 100 is illustrated with an oil 101 and a saline solution 102 contained within a cylinder 110. The cylinder 110 includes two plates of optical material 106. Each plate 106 includes a flat interior surface 113-114. The cylinder 110 includes an interior surface that is essentially rotationally symmetric. One or more surfaces may include a hydrophobic coating 103. Electrodes 105 are also included on or about the perimeter of the cylinder. An electrical insulator 104 may also be used proximate to the electrodes 105.

Each of the interior surfaces 113-114 is essentially flat or planar. An interface surface 112A is defined between the saline solution 102 and the oil 101. As illustrated in Fig. 1A, the shape of the interface 112A is combined with the refractive index properties of the saline solution 102 and the oil 101 to receive incident light 108 through a first interior surface 113 and provide divergent light 109 through a second interior surface 114 if the index of refraction of the oil is greater than the index of refraction of the saline. The shape of the interface surface between the oil 101 and the saline solution 102 may be altered with the application of an electrical current to the electrodes 105.

At 100A, a perspective view of the lens 100 is illustrated.

Referring now to Fig. 1B, the lens 100 is illustrated in an energized state. The energized state is accomplished by applying voltage V_{114} across the electrodes 105. The shape of the interface surface 112B between the oil 101 and the saline solution 102B is altered with the application of an electrical current to the electrodes 105. As illustrated in Fig. 1B, incident light 108B passing through the oil 101 and the saline solution 102B is focused into a convergent light pattern 111.

In some lenses that are generally Arcuate in shape, through Meniscus Wall manipulations, use of one or more Sharp(s) in one or more Meniscus Wall(s), Power control, etc. the physical properties of the liquid meniscus can be changed and controlled. Exploiting the advantages of the disclosed control parameters and designs, described herein are novel lenses that may be significantly thinner and/or more powerful.

Thinner ophthalmic lenses can result from using an internally controlled series of Concentric Annular Sections formed by liquid meniscuses that are formed into a structure that repeats radially with either increasing or decreasing radial sizes to form a diffractive optical element or diffractive lens. A feature of a diffractive lens is that the focusing power can be achieved with a thin structure, with the total height of the structure being on the order of $\lambda/\Delta n$ where λ is the wavelength of light (~ 550 nm) and Δn is the change in index of refraction across the interface.

Referring now to Fig. 2A, a cross section of an exemplary ophthalmic lens is depicted in an Energized state. At 200, a cross section of an Arcuate lens with a front curve defining surface 201 and a back curve defining surface 202 is depicted. Each of said front curve and back curve defining surfaces may be made up of a rigid optical material that is at least partially transmissive to light. The front curve lens 201 and the back curve lens 202 may be positioned proximate to each other and form a cavity 210 therebetween.

The back curve lens 202 may include a convex Arcuate interior lens surface 203 and a concave Arcuate exterior lens surface 204. The convex Arcuate lens surface 203 may have one or more coatings (not illustrated in Fig. 2A). Coatings may include, for example, one or more of electrically conductive materials or electrically insulating materials, hydrophobic materials or hydrophilic materials. One or both of the Arcuate lens surface 203 and the coatings may be in liquid and optical communication with an oil 208 contained within the cavity 210.

The front curve optical defining surface 201 may include a concave Arcuate interior lens surface 205 and a convex Arcuate exterior lens surface 206. The concave Arcuate lens surface 205 may have one or more coatings (not illustrated in Fig. 2). Coatings may include, for example, one or more of electrically conductive materials or electrically insulating materials, hydrophobic materials or hydrophilic materials. At least one of the concave Arcuate lens surface 205 and the coatings are in liquid and optical communication with a saline solution 207 contained within the cavity 210. The saline solution 207 can include one or more salts or other components which are

electrically conductive and as such may be either attracted to or repulsed by an electric charge using Electrowetting or Electrophoresis techniques.

The Lens may be Energized and accordingly can further comprise an electrically conductive coating 209 which may be located along at least a portion of a periphery of one or both of the front curve lens 201 and the back curve lens 202. The electrically conductive coating 209 may include gold or silver and is preferably biocompatible. Application of an electrical charge to the electrically conductive coating 209 may cause a change in contact angle or either an attraction or a repulsion of the electrically conductive salts or other components in the saline solution as it may be predetermined.

The front and back curve lenses 201, 202 may have optical powers in relation to the light refracting through the either or both the Arcuate interior lens surfaces and the Arcuate exterior lens surfaces 203-206. The optical power may be 0 diopters or may be a plus or minus power. The optical power may be a power typically found in corrective contact lenses, such as, by way of non-limiting example, a power between -8.0 and +8.0 diopters.

Additionally, when the lens is energized as depicted in Fig. 2A, Concentric Annular Sections of liquid meniscuses may be formed, as it may be predetermined, to enable additional diffractive physical properties. This may allow the Optical Zone of the Lens to function as a Variable Optic in discrete steps.

Accordingly, the optical power of the Lens may be controlled by design parameters such as: angle of curvature of each defining surface and the refractive index of the defining surfaces of the device and the saline/oil, the contact angle and chemical properties of the saline and oil in the lens cavity, the voltage applied to the zones comprising the electric coating, and the physical characteristics of the predetermined Concentric Annular Sections of the Lens.

Diffractive Lenses diffract the incident light into multiple orders. Each order has a different power. The diffraction efficiency into the various orders is controlled by the shape of the structure within each concentric annular section to provide high

diffraction efficiency into the power(s) of interest when the device is in the energized (diffractive lens "on") state.

In some diffractive arrangements the innermost Concentric Annular Section being the center of the Lens may be aligned with the pupil. Because of large depth of field of the lens within this small central pupil, any structure on the innermost Concentric Annular Section may not have a dramatic negative effect on the optical properties of the Lens. Consequently, an integrated reservoir 211 for the oil 208 may be placed there and along the edges of the ophthalmic device, with the electronics/power source 212, where vision of a user may not be significantly affected.

Referring now to Fig. 2B, the cross section described in Fig. 2A is depicted in a de-energized state. In this state, the liquid meniscus diffractive structures are non-existing thereby providing a different power than the one provided by the energized state (i.e. the power of the diffractive physical properties). The oil 208 may be contained in the oil reservoirs 211 as described above. The saline may be indexed matched to the defining surfaces to provide, when de-energized, the refractive power desired of the Arcuate shape and optical lens material. The oil may flow through energized channels 213 that may cause the oil to flow to the reservoirs 211. Accordingly, the energized channels 213 may function as a pumping device depending on the power and the electrochemical characteristics of the saline 207 and/or of the oil 208.

One or both of said Lens defining surfaces 201, 202 may comprise optical quality molded regions with electrical conductors to change the properties of the oil and saline, as it may be predetermined. Different variations of the molded parts, materials of the defining surfaces, saline and oil and more specifically their respective diffractive index and contact angles may be possible to create a variable optical power Lens with refractive and diffractive properties without having to displace the oil to reservoirs.

Referring now to Fig. 3A, a cross section of another exemplary ophthalmic lens that uses a molded optical defining surface in an energized state is depicted. The back curve optical defining surface 305 of the Lens includes at least a molded portion 302

that may contain a significant amount of oil 303 in different sections within the Lens cavity when the lens is not energized (shown in Fig. 3B). The oil 303 may be index matched with the molded portion 302 and may cover the diffractive optical structures 307 of the molded portion 302. The diffractive optical properties of the lens are passive and may not have an effect. (The molded defining surface may additionally or alternatively include either the front defining surface 306 or both the back defining surface 305 and the front defining surface 306.) Furthermore, the molded portion 302 can include a series of diffractive structures 307 which may additionally serve as meniscus walls that can support conductors of electricity for the implementation of Electrowetting or Electrophoresis techniques.

The walls may be energized to cause the volume of oil 303 to cover the diffractive structures 307, for example the peaks shown in the molded portion 302 in Fig. 3A. Further, as it may be apparent to someone skilled in the art, the spacing of the diffractive structures along the Lens may be closer to each other to design a higher efficiency Lens, i.e. higher power and aberration correction. Because the saline solution 304 and the molded portion 302 may have a different refractive index, light would be diffracted as it may be predetermined when the diffractive properties are exposed to the saline solution 304 as depicted in Fig. 3B where the lens is de-energized. In this de-energized estate, the diffractive structures 307 are uncovered. When uncovered the index of refraction changes at those portions thereby providing a lens that may provide both refractive and diffractive characteristics.

As depicted in Fig. 3A and in Fig. 3B, the saline solution 304 used may be displaced by the oil 303 when energized or de-energized. Integrated circuits, sensors, batteries and other non-optical component may be included in the outer diameter (edges) 301 of the lens where the vision of the user may not be significantly affected.

Referring now to Fig. 4, an exemplary top view section of the lenses presented in Figs. 2A – 3B is depicted. At, 401 the edge of the Lens is shown. At, 402 an outer edge portion of the Lens is depicted wherein the electronics, pumps, reservoirs and any non-optical components of the lens may be placed without significantly affecting the

vision of the user. At 403-405 an exemplary concentric pattern for the conductive material used for the diffractive structure to be Energized.

The pattern may be important to control the voltage of each lens or specified regions as it may be desired. For example, to resemble a Fresnel lens and obtain the refractive properties of it, where diffractive structures comprise liquid meniscuses formed by energizing predetermined regions, all diffractive structures may be aligned. One way of achieving this is to consider the pinning effect and amount of current directed towards each predetermined region. Consequently, some predetermined regions may require more power to provide for the added volume of oil to form the diffractive structure as it may be designed to correct specific aberrations/provide optimal optic power. As a result, the charge can be applied so that it travels in concentric circles to the center decreasing progressively to align the height of the meniscuses of the oil.

In lenses such as the one depicted in Figs. 2A and 2B the center portion 405 of the lens may be used as a reservoir. Variations are possible and depend on the desired design of the lens. However, it may be apparent to those skilled in the art after reading this disclosure that by forming and/or controlling diffractive optical structures that resemble the Fresnel lens, a functional Lens with variable optical structures may be designed. Moreover, the variable optical power lens may incorporate a controller and a source of power in its design to be autonomous in the process.

Although hard or soft contact lenses may be provided made of any known lens material, or material suitable for manufacturing such lenses, preferably, the lenses are soft contact lenses having water contents of about 0 to about 90 percent. More preferably, the lenses are made of monomers containing hydroxy groups, carboxyl groups, or both or be made from silicone-containing polymers, such as siloxanes, hydrogels, silicone hydrogels, and combinations thereof. Material useful for forming the lenses may be made by reacting blends of macromers, monomers, and combinations thereof along with additives such as polymerization initiators. Suitable materials include, without limitation, silicone hydrogels made from silicone macromers and hydrophilic monomers.

Referring now to Fig. 5, method steps that may be implemented are illustrated. These method steps described are listed in a logical sequence in this discussion. However, this sequence by no means limits the order in which they may be implemented unless specifically stated.

At 501, a Variable Optic portion is placed within an ophthalmic lens, as discussed above. At 502, the Variable Optic portion is placed in electrical communication with an Energy Source. Electrical communication can be accomplished, for example, via circuitry incorporated into the variable optic portion or via pathways ink jetted or otherwise formed directly upon lens material.

At 503, electrical energy is directed through predetermined sections of the variable optic portion in the Lens. The energy can be directed, for example, via electrical circuitry capable of conducting the electrical charge. At 504 the variable optic can change at least one optical quality structure of the lens as previously described to be able of providing different optical power at discrete steps.

Referring now to Fig. 6 a controller 600 is illustrated. The controller 600 includes a processor 610, which may include one or more processor components coupled to a communication device 620. The controller 600 can be used to transmit energy to the Energy Source placed in the ophthalmic lens.

The controller can include one or more processors, coupled to a communication device configured to communicate energy via a communication channel. The communication device may be used to electronically control one or more of: the placement of a variable optic insert into the ophthalmic lens and the transfer of a command to operate a Variable Optic device.

The communication device 620 may also be used to communicate, for example, with one or more controller apparatus or manufacturing equipment components.

The processor 610 is also in communication with a storage device 630. The storage device 630 may comprise any appropriate information storage device, including combinations of magnetic storage devices, optical storage devices, and/or

semiconductor memory devices such as Random Access Memory (RAM) devices and Read Only Memory (ROM) devices.

The storage device 630 can store a program 640 for controlling the processor 610. The processor 610 performs instructions of the program 640. For example, the processor 610 may receive information descriptive of variable optic insert placement, processing device placement, and the like. The storage device 630 can also store ophthalmic related data in one or more databases 650, 660. The databases 650,660 may include specific control logic for controlling energy to and from a Variable Optic lens.

Conclusion

The present invention provides an optical lens as claimed. The variable optical structures may vary to provide diffractive and/or refractive properties as may be predetermined.

The following non-exhaustive list are aspects of the invention:

Aspect 1. An optical lens comprising:

a front curve optic defining surface,

a back curve optic defining surface comprising a back curve lens interior surface and a back curve lens exterior surface, wherein both said optic defining surfaces comprise an Arcuate shape and are positioned proximate to each other forming a cavity therebetween,

the cavity comprising a conductive coating on at least one portion of one or both of said front curve or back curve defining surfaces contiguous to the cavity, a volume of oil and a volume of saline solution;

and wherein the oil and saline are capable of forming an internally controlled Concentric Annular Sections with variable optical structures, based upon an applied electrical charge used to change characteristics of the oil, saline and the applied electrical charge.

Aspect 2. The optical lens of Aspect 1 wherein the electrical charge is applied to change the optical structures of the lens using Electrowetting techniques.

Aspect 3. The optical lens of Aspect 1 wherein the electrical charge is applied to change the optical structures of the lens using Electrophoresis techniques.

Aspect 4. The optical lens of Aspect 1 wherein the variable optical structures are capable of providing a lens with variable optical powers at discrete steps.

Aspect 5. The optical lens of Aspect 1 wherein the volume of oil comprises from 65% to 90% of the volume as compared to the amount of saline solution.

Aspect 6. The optical lens of Aspect 1 wherein the volume of oil comprises a density within about 5% of a density of the saline solution.

Aspect 7. The optical lens of Aspect 1 wherein at least a portion of the conductive coating extends from an area interior to the cavity to an area external to the cavity.

Aspect 8. The optical lens of Aspect 7, wherein the area of conductive coating external to the cavity forms an electrical terminal for providing an electrical charge to the liquid meniscus diffractive structure.

Aspect 9. The optical lens of Aspect 8 wherein the saline solution and the oil form a series of meniscuses in concentric annular rings and an application of an electrical charge to the area of conductive coating external to the cavity causes a change in the shape of the annular rings.

Aspect 10. The optical lens of Aspect 1 wherein the electrical charge comprises a direct current.

Aspect 11. The optical lens of Aspect 8 wherein the electrical charge comprises from 3.5-22 volts.

Aspect 12. The optical lens of Aspect 1 wherein the front curve defining surface comprises an optical power other than 0.

Aspect 13. The optical lens of Aspect 1 wherein the back curve defining surface comprises an optical power other than 0.

Aspect 14. The optical lens of Aspect 1 additionally comprising a channel through one or both of the front curve lens and the back curve defining surfaces and a conductive material filling the channel.

Aspect 15. The optical lens of Aspect 14 additionally comprising a conductive material inside the channel.

Aspect 16. The optical lens of Aspect 15 additionally comprising a terminal in electrical communication with the conductive material in the channel.

Aspect 17. The optical lens of Aspect 16 wherein application of an electrical charge to the terminal causes a change in the shape of the liquid meniscus diffractive structures.

Aspect 18. The optical lens of Aspect 1 additionally comprising an insulator coating along at least a portion of the front curve defining surface, wherein the insulator coating comprises an electrical insulator.

Aspect 19. The optical defining surface of Aspect 18, wherein the insulator comprises one of Parylene C.

Aspect 20. The optical defining surface of Aspect 19, wherein the insulator comprises Teflon AF.

Aspect 21. The optical lens of Aspect 18 wherein the insulator comprises a boundary area to maintain separation between the conductive coating and a saline solution contained in the cavity between the front curve lens and the back curve lens.

Aspect 22. The ophthalmic lens of Aspect 1 wherein the innermost Concentric Annular Section can be used to place a functional component that is not transparent.

Aspect 23. The ophthalmic lens of Aspect 22 wherein the functional component includes a reservoir for a liquid.

CLAIMS

1. An optical lens comprising:

a front curve optic defining surface;

a back curve optic defining surface, wherein both said optic defining surfaces comprise anarcuate shape and are positioned proximate to each other forming a cavity therebetween;

a conductive coating on at least one portion of one or both of said defining surfaces contiguous to the cavity; and

a volume of oil and a volume of saline solution within said cavity, wherein the oil and saline solution provide a series of meniscus boundaries which each define internally controlled concentric annular rings with variable optical structures, upon the application of an electrical charge to said conductive coating.

2. The optical lens of claim 1, wherein the application of the electrical charge changes the variable optical structures of the optical lens via Electrowetting techniques.

3. The optical lens of claim 1, wherein the application of the electrical charge changes the variable optical structures of the optical lens via Electrophoresis techniques.

4. The optical lens of claim 1, wherein the variable optical structures are capable of providing the optical lens with variable optical powers at discrete steps.

5. The optical lens of claim 1, wherein the volume of oil is from 65% to 90% of the volume of saline solution.

6. The optical lens of claim 1, wherein the oil has a density within about 5% of a density of the saline solution.

7. The optical lens of claim 1, wherein at least a portion of the conductive coating extends from an area interior to the cavity to an area external to the cavity.

8. The optical lens of claim 7, wherein the area of conductive coating external to the cavity forms an electrical terminal for providing the electrical charge to the variable optical structures.

9. The optical lens of claim 8, the application of the electrical charge to the area of conductive coating external to the cavity causes a change in the shape of the meniscuses.

10. The optical lens of claim 1, wherein the electrical charge comprises a direct current.

11. The optical lens of claim 10, wherein the direct current comprises from 3.5 to 22 volts.

12. The optical lens of claim 1, wherein the front curve optic defining surface comprises an optical power other than 0.

13. The optical lens of claim 1, wherein the back curve optic defining surface comprises an optical power other than 0.

14. The optical lens of claim 1, additionally comprising a channel through one or both of the optic defining surfaces.

15. The optical lens of claim 14, additionally comprising a conductive material inside the channel.

16. The optical lens of claim 15, additionally comprising a terminal in electrical communication with the conductive material inside the channel.

17. The optical lens of claim 16, wherein the application of the electrical charge to the terminal causes a change in the shape of the variable optical structures.

18. The optical lens of claim 1, additionally comprising an insulator coating along at least a portion of the front curve optic defining surface, wherein the insulator coating comprises an electrical insulator.

19. The optical lens of claim 18, wherein the electrical insulator comprises Parylene C.

20. The optical lens of claim 19, wherein the electrical insulator comprises Teflon AF.

21. The optical lens of claim 18, wherein the electrical insulator comprises a boundary area to maintain separation between the conductive coating and the saline solution contained in the cavity.

22. The optical lens of claim 1, wherein an innermost concentric annular section comprises a functional component.

23. The optical lens of claim 22, wherein the functional component includes a reservoir for a liquid.

24. The optical lens of claim 1, wherein the concentric annular sections repeat radially with either increasing or decreasing radial sizes.

25. The optical lens of claim 15, additionally comprising a first fluid reservoir at the peripheral edge of the optical lens.

26. The optical lens of claim 25, wherein an inner most concentric annular section comprises a second fluid reservoir.

27. The optical lens of claim 26, wherein the oil may flow between the first fluid reservoir, the variable optical structures and the second fluid reservoir.

29. An optical lens comprising:

a front curve optic defining surface;

a back curve optic defining surface;

a conductive coating on at least a portion of one or both of the optic defining surfaces;

a volume of oil; and

a volume of saline solution,

wherein both optic defining surfaces comprise an arcuate shape and are positioned proximate to each other forming a cavity therebetween,

wherein the oil and the saline solution are disposed within said cavity, and

wherein an application of an electrical charge to said conductive coating causes the oil and the saline solution to form a series of meniscuses in concentric annular sections with different optical properties.