METHODS AND APPARATUS FOR FUNCTIONAL INSERT WITH POWER LAYER

RELATED APPLICATIONS

This application claims priority to U.S. Patent Application Serial No. 13/401,959 filed February 22, 2012; and U.S. Provisional Application Serial No. 61/454,591filed March 21, 2011, entitled Methods and Apparatus for Functional Insert with Power Layer, the contents of which are incorporated herein by reference.

FIELD OF USE

This invention describes a functionalized insert for logic processing device formed from multiple functional layers which are stacked, wherein at least one layer includes a power source as well as, in some embodiments, methods and apparatus for the fabrication of an ophthalmic lens with a functionalized insert of multiple stacked layers.

BACKGROUND

Traditionally an ophthalmic device, such as a contact lens, an intraocular lens or a punctal plug included a biocompatible device with a corrective, cosmetic or therapeutic quality. A contact lens, for example, may provide one or more of: vision correcting functionality; cosmetic enhancement; and therapeutic effects. Each function is provided by a physical characteristic of the lens. A design incorporating a refractive quality into a lens may provide a vision corrective function. A pigment incorporated into the lens may provide a cosmetic enhancement. An active agent incorporated into a lens may provide a therapeutic functionality. Such physical characteristics are accomplished without the lens entering into an energized state. A punctal plug has traditionally been a passive device.

More recently, it has been theorized that active components may be incorporated into a contact lens. Some components may include semiconductor devices. Some examples have shown semiconductor devices embedded in a contact lens placed upon animal eyes. It has also been described how the active components

may be energized and activated in numerous manners within the lens structure itself. The topology and size of the space defined by the lens structure creates a novel and challenging environment for the definition of various functionality. Generally, such disclosures have included discrete devices. However, the size and power requirements for available discrete devices are not necessarily conducive for inclusion in a device to be worn on a human eye.

SUMMARY

Accordingly, the present invention includes designs of components that may be combined to form a stacked layer of substrates combined into a discrete package. The stacked layers will include one or more layers which include a power source for at least one component included in the stacked layers. In some embodiments, an insert is provided that may be energized and incorporated into an ophthalmic device. The insert may be formed of multiple layers which may have unique functionality for each layer; or alternatively mixed functionality but in multiple layers. The layers may in some embodiments have layers dedicated to the energization of the product or the activation of the product or for control of functional components within the lens body. In addition, methods and apparatus for forming an ophthalmic lens, with inserts of stacked functionalized layers are presented.

In some embodiments, the insert may contain a layer in an energized state which is capable of powering a component capable of drawing a current. Components may include, for example, one or more of: a variable optic lens element, and a semiconductor device, which may either be located in the stacked layer insert or otherwise connected to it.

In another aspect, some embodiments may include a cast molded silicone hydrogel contact lens with a rigid or formable insert of stacked functionalized layers contained within the ophthalmic lens in a biocompatible fashion, wherein at least one of the functionalized lens includes a power source.

Accordingly, the present invention includes a disclosure of an ophthalmic lens with a stacked functionalized layer portion, apparatus for forming an ophthalmic lens with a stacked functionalized layer portion and methods for the same. An insert may

be formed from multiple layers in various manners as discussed herein and the insert may be placed in proximity to one, or both of, a first mold part and a second mold part. A reactive monomer mix is placed between the first mold part and the second mold part. The first mold part is positioned proximate to the second mold part thereby forming a lens cavity with the energized substrate insert and at least some of the reactive monomer mix in the lens cavity; the reactive monomer mix is exposed to actinic radiation to form an ophthalmic lens. Lenses may be formed via the control of actinic radiation to which the reactive monomer mixture is exposed.

DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a block diagram of some embodiments of a power source layer.

FIG. 2 illustrates some exemplary embodiments of form factor for a wire based power source.

FIG. 3 illustrates a three dimensional representation of an insert formed of stacked functional layers which is incorporated within an ophthalmic lens mold part.

Fig. 4 illustrates a cross sectional representation of an ophthalmic lens mold part with an insert.

Fig. 5 demonstrates an exemplary embodiment of an insert comprising multiple stacked functional layers upon a supporting and aligning structure.

Fig. 6 illustrates different shapes and embodiments of the components used for forming layers in a stacked functional layer insert.

DETAILED DESCRIPTION OF THE INVENTION

The present invention includes a substrate insert device formed through the stacking of multiple functionalized layers. Additionally the present invention includes methods and apparatus for manufacturing an ophthalmic lens with such a stacked functionalized layer substrate as an insert in the formed lens. In addition, some

embodiments of the present invention include an ophthalmic lens with a stacked functionalized layer substrate insert incorporated into the ophthalmic lens.

In the following sections detailed descriptions of embodiments of the invention will be given. The description of both preferred and alternative embodiments 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 said exemplary embodiments do not limit the scope of the underlying invention.

GLOSSARY

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

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

Energy: as used herein refers to the capacity of a physical system to do work. Many uses within this invention may relate to the said capacity being able to perform electrical actions in doing work.

Energy Source: as used herein refers to device or layer which is capable of supplying Energy or placing a logical or electrical device in an Energized state.

Energy Harvesters: as used herein refers to device capable of extracting energy from the environment and convert it to electrical energy.

Functionalized: as used herein refers to making a layer or device able to perform a function including for example, energization, activation, or control.

Lens: refers to any ophthalmic device that resides in or on the eye. These devices may provide optical correction or may be cosmetic. For example, the term lens may 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. In some embodiments, the preferred lenses of the invention are soft contact lenses are made from silicone elastomers or hydrogels, which include but are not limited to silicone hydrogels, and fluorohydrogels.

Lens forming mixture or "Reactive Mixture" or "RMM" (reactive monomer mixture): as used herein refers to a monomer or prepolymer material which may be cured and crosslinked or crosslinked to form an ophthalmic lens. Various embodiments may include lens forming mixtures with one or more additives such as: UV blockers, tints, photoinitiators or catalysts, and other additives one might desire in an ophthalmic lenses such as, contact or intraocular lenses.

Lithium Ion Cell: 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.

Substrate insert: as used herein refers to a formable or rigid substrate capable of supporting an Energy Source within an ophthalmic lens. In some embodiments, the Substrate insert also supports one or more components.

Mold: refers to a rigid or semi-rigid object that may be used to form lenses from uncured formulations. Some preferred molds include two mold parts forming a front curve mold part and a back curve mold part.

Optical Zone: as used herein refers to an area of an ophthalmic lens through 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 within this invention may relate to the capability of being restored with the ability to flow electrical current at a certain rate for a certain reestablished time period.

Reenergize or Recharge: To restore to a state with higher capacity to do work. Many uses within this invention may relate to restoring a device to the capability to flow electrical current at a certain rate for a certain, reestablished time period.

Released from a mold: means that a lens is either completely separated from the mold, or is only loosely attached so that it may be removed with mild agitation or pushed off with a swab.

Stacked: as used herein means to place at least two component layers in proximity to each other such that at least a portion of one surface of one of the layers contacts a first surface of a second layer. In some embodiments, a film, whether for

adhesion or other functions may reside between the two layers that are in contact with each other through said film.

Description

Powered Layers

Referring now to Fig. 1, in some embodiments, one or more layers of a functionalized stack of substrates may include a thin film electrical power source 100. The thin electrical power source may be viewed essentially as a battery on a substrate.

A thin film battery (sometimes referred to as a TFB) may be structured on a suitable substrate, such as silicon, using known deposition processes. Deposition may include, for example, sputter deposition and may be used to deposit various materials using one or more of masking and material removal techniques.

A wide variety of different materials have been studied and are possible. In some applications, such as for example, die stack and an ophthalmic device; a preferable substrate includes one that is able to withstand 800 deg. C without chemical change. In another aspect, a preferable substrate may be insulating. Optionally, the substrate may have vias that interconnect current collectors from a top side of the device to a bottom side.

A TFB according to the present invention will preferably be enclosed in a packaging to prevent ingress of one or more of: oxygen, moisture other gasses or liquids. Preferred embodiments may therefore include packaging in one or more layers wherein the packaging may include one or more of an insulative (e.g. parylene) and impermeable layer (e.g. metals, aluminum, titanium, etc.) . Layers may be applied by deposition over a TFB device.

Preferably interconnects remain accessible to electrical communication outside the package. In some embodiments, electrical communication may include a conductive path. In other embodiments, electrical communication may include a wireless transport of energy, such as via a radio frequency or light wavelength.

Other methods include applying organic materials (e.g. epoxy) in conjunction with pre-shaped impermeable materials (e.g. the next layer of the die stack, or a precision formed /cut glass , alumina, or silicon cover layer.

Wire Formed Power Source

Referring now to Fig. 2A, an exemplary design of some embodiments of a power source which includes a battery formed about a conductive wire. Preferably the battery will include a high aspect ratio wire battery.

In some embodiments, a fine gauge copper wire may be used as a support. Various battery component layers may be built up using batch or continuous wire coating processes. In this manner, a very high volumetric efficiency (> 60 %) of active battery materials can be achieved in a convenient form factor that is flexible. In some embodiments, a thin wire may be utilized to form small batteries, such as, for example, a battery in a range measured by Milliamp hours. Voltage capacities may be targeted to be approximately 1.5 volts, direct current. Larger batteries and higher voltages may also be scaled and are within the scope of the present invention.

Typically, a wire formed battery provides a significant improvement (~40x or more) over an incumbent thin film 6-pack.

Referring now to Fig. 2B, a method is illustrated for forming some embodiments of a wire based battery. A copper wire of high purity such as those available from commercial source, such as McMaster Carr Corp. may be used coated with one or more layers.

In some embodiments, a zinc anode coating may be formulated from zinc metal powder, polymer binders, solvents, and additives. The coating may be applied and immediately dried. Multiple passes of the same coating may be used to achieve the desired thickness.

A separator coating may be formulated from non-conductive filler particles, polymer binders, solvents, and additives. Application method may be the same.

A silver oxide cathode coating may be formulated from Ag2O powder, graphite, polymer binders, solvents, and additives. Application method may be the same.

The wire battery may be coated with current collector (e.g. carbon conductive adhesive, silver conductive adhesive, or the like).

Electrolyte (potassium hydroxide solution with additives) may be applied to the finished battery to complete construction.

The cell should remain "open" (i.e. non-hermetic) so as to allow any evolved gases to safely leave. Silicone or fluoropolymer coatings may be used to protect the battery from mechanical damage, and to contain liquid electrolyte within.

The battery may have an open circuit voltage of ~ 1.5 V or greater.

Referring now to Fig. 3 a three dimensional representation is illustrated of some embodiments of a fully formed ophthalmic lens using a stacked layer substrate insert of the time in item 210 is demonstrated as item 300. The representation shows a partial cut out from the ophthalmic lens to realize the different layers present inside the device. Item 320 shows the body material in cross section of the encapsulating layers of the substrate insert. This item surrounds the entire periphery of the ophthalmic lens. It may be clear to one skilled in the arts that the actual insert may comprise a full annular ring or other shapes that still may reside within the constraints of the size of a typical ophthalmic lens.

Items 330, 331 and 332 are meant to illustrate three of numerous layers that may be found in a substrate insert formed as a stack of functional layers. In some embodiments, a single layer may include one or more of: active and passive components and portions with structural, electrical or physical properties conducive to a particular purpose.

In some embodiments, a layer 330 may include an energization source, such as, for example, one or more of: a battery, a capacitor and a receiver within the layer 330. Item 331 then, in a non limiting exemplary sense may comprise microcircuitry in a layer that detects actuation signals for the ophthalmic lens. In some embodiments, a power regulation layer 332, may be included that is capable of receiving power from external sources, charges the battery layer 330 and controls the use of battery power from layer 330 when the lens is not in a charging environment. The power regulation may also control signals to an exemplary active lens, demonstrated as item 310 in the center annular cutout of the substrate insert.

An energized lens with an embedded Substrate insert may include an Energy Source, such as an electrochemical cell or battery as the storage means for the energy and in some embodiments, encapsulation and isolation of the materials comprising the Energy Source from an environment into which an ophthalmic lens is placed.

In some embodiments, a Substrate insert also includes a pattern of circuitry, components and Energy Sources. Various embodiments may include the Substrate insert locating the pattern of circuitry, components and Energy Sources around a periphery of an optic zone through which a wearer of a lens would see, while other embodiments may include a pattern of circuitry, components and Energy Sources which are small enough to not adversely affect the sight of a contact lens wearer and therefore the Substrate insert may locate them within, or exterior to, an optical zone.

In general, according to these embodiments previously described, a Substrate insert 111 is embodied within an ophthalmic lens via automation which places an Energy Source a desired location relative to a mold part used to fashion the lens.

Fig. 4 illustrates a closer view of some embodiments of a stacked functional layer insert 400 seen in cross section. Within the body of the ophthalmic lens 410 is embedded the functionalized layer insert 420 which surrounds and connects to an active lens component 450, in some embodiments. It may be clear to one skilled in the arts, that this example shows but one of numerous embodiments of embedded function that may be placed within an ophthalmic lens.

Within the stacked layer portion of the insert are demonstrated numerous layers. In some embodiments the layers may comprise multiple semiconductor based layers. For example, item 440, the bottom layer in the stack, may be a thinned silicon layer upon which circuits have been defined for various functions. Another thinned silicon layer may be found in the stack as item 441. In a non-limiting example, such a layer may have the function of energization of the device. These silicon layers will in some embodiments be electrically isolated from each other through an intervening insulator layer shown as item 450. The portions of the surface layers of items 440, 450 and 441 that overlap each other may be adhered to each other through the use of a thin film of adhesive. It may be obvious to one skilled in the arts that numerous adhesives may have the desired characteristics to adhere and passivate the thin silicon layers to the insulator, as in an exemplary sense an epoxy might.

A multiple stacked layer may include additional layers 442, which in an non limiting example may include a thinned silicon layer with circuitry capable of activating and controlling an active lens component. As mentioned before, when the stacked layers need to be electrically isolated from each other, stacked insulator layers

may be included between the electrically active layer and in this example item 451 may represent this insulator layer comprising part of the stacked layer insert. In some of the examples described herein, reference has been made to layers formed from thin layers of silicon. The general art may be extended to different embodiments where the material definitions of the thin stacked layers include, in a non limiting sense, other semiconductors, metals or composite layers. And the function of the thin layers may include electrical circuitry, but also may include other functions like signal reception, energy handling and storage and energy reception to mention a few examples. In embodiments with different material types, the choice of different adhesives, encapsulants and other materials which interact with the stacked layers may be required. In an example embodiment, a thin layer of epoxy may adhere three silicon layers shown as 440, 441 and 442 with two silicon oxide layers 450 and 451.

As mentioned in some of the examples the thinned stacked layer may comprise circuits formed into silicon layers. There may be numerous manners to fabricate such layers, however, standard and state of the art semiconductor processing equipment may form electronic circuits on silicon wafers using generic processing steps. After the circuits are formed into the appropriate locations on the silicon wafers, wafer processing equipment may be used to thin the wafers from hundreds of microns thick to thicknesses of 50 microns or less. After thinning the silicon circuits may be cut or "diced" from the wafer into the appropriate shapes for the ophthalmic lens or other application. In later section, different exemplary shapes of the stacked layer invention disclosed herein are shown in Fig. 6. These will be discussed in detail later; however, the "dicing" operation may use various technical options to cut out thin layers with curved, circular, annular, rectilinear and other more complicated shapes.

When the stacked layers perform a function relating to electrical current flow, in some embodiments, there may be a need to provide electrical contact between the stacked layers. In the general field of semiconductor packaging this electrical connection between stacked layers has generic solutions comprising wire bonding, solder bumping and wire deposition processes. Some embodiments of wire deposition may use printing process where electrically conductive inks are printed between two connection pads. In other embodiments, wires may be physically defined by an energy source, like for example a laser, interacting with a gaseous, liquid or solid chemical

intermediate resulting in an electrical connection where the energy source irradiates. Still further interconnection definition embodiments may derive from photolithographic processing before or after metal films are deposited by various means.

In the invention herein, if one or more of the layers needs to communicate electrical signals outside itself, it may have a metal contact pad that is not covered with passivating and insulating layers. In many embodiments these pads would be located on the periphery of the layer where subsequent stacked layers do not cover the region. In an example of this type of embodiment, in Fig. 4 interconnect wires 430 and 431 are demonstrated as electrically connecting peripheral regions of layers 440, 441 and 442. It may be apparent to one skilled in the art that numerous layouts or designs of where the electrical connection pads are located and the manner of electrically connecting various pads together. Furthermore, it may be apparent that different circuit designs may derive from the choice of which electrical connect pads are connected and to which other pads they are connected. Still further, the function of the wire interconnection between pads may be different in different embodiments including the functions of electrical signal connection, electrical signal reception from external sources, electrical power connection and mechanical stabilization to mention a few examples.

In a previous discussion, it was presented that non semiconductor layers may comprise one or more of the stacked layers in the inventive art. It may be apparent that there could be a great diversity of applications which may derive from nonsemiconductor layers. In some embodiments, the layers may define energizing sources like batteries. This type of layer in some cases may have a semiconductor acting as the supporting substrate for the chemical layers, or in other embodiments may have metallic or insulating substrates. Other layers may derive from layers which are primarily metallic in nature. These layers may define antennas, thermal conductive paths, or other functions. There may be numerous combinations of semiconducting and non semiconducting layers that comprise useful application within the spirit of the inventive art herein.

In some embodiments where electrical connection is made between stacked layers the electrical connection will need to be sealed after connection is defined.

There are numerous methods that may be consistent with the art herein. For example, the epoxy or other adherent materials used to hold the various stacked layers together could be reapplied to the regions with electrical interconnect. Additionally, passivation films may, in some embodiments, be deposited across the entire device to encapsulate the regions that were used for interconnection. It may be apparent to one skilled in the art that numerous encapsulating and sealing schemes may be useful within this art to protect, strengthen and seal the stacked layer device and its interconnections and interconnection regions.

Assembling Stacked Functionalized Layer Inserts

Proceeding to Fig. 5, item 500, a close up view of an exemplary apparatus to assemble stacked functionalized layer inserts is demonstrated. In the example, a stacking technique where the stacked layers do not align on either side of the layer is shown. Items 440, 441 and 442 again may be silicon layers. On the right side of the Fig. it may be seen that the right side edge of the items 440, 441 and 442 do not align with each other, as they may in alternative embodiments. Such a stacking methodology may allow the insert to assume a three dimensional shape similar to that of the general profile of an ophthalmic lens. In some embodiments as well, such a stacking technique may allow for the layers to be made from the largest surface area as possible. In layers that are functional for energy storage and circuitry such surface area maximization may be important.

In general many of the features of the previously described stacked inserts may be observed in Fig. 5 including stacked functional layers 440, 441 and 442; stacked insulating layers 450 and 451; and interconnections 430 and 431. Additionally a supporting jig, item 510, may be observed to support the stacked functionalized layer insert as it is being assembled. It may be apparent that the surface profile of item 510 may assume a large number of shapes which will change the three dimensional shape of inserts made thereon.

In general, a jig 510 may be provided with a predetermined shape. It may be coated with different layers, item 520, for a number of purposes. In a non limiting exemplary sense, the coating may first comprise a polymer layer that will allow easy incorporation of an insert into the base material of an ophthalmic lens, and may even be formed from a polysilicone material in some embodiments. An epoxy coating may

then be deposited upon the polysilicone coating to adhere the bottom thin functional layer 440 to the coating 520. The bottom surface of a next insulating layer 450 may then be coated with a similar epoxy coating and then placed into its appropriate location upon the jig. It may be clear that the jig may in some embodiments have the function of aligning the correct placement of the stacked layers relative to each other as the device is assembled. In repetitious fashion, the rest of the insert may then be assembled, the interconnections defined and then the insert encapsulated. In some embodiments, the encapsulated insert may then be coated from the top with a polysilicone coating. In some embodiments that use a polysilicone coating for item 520, the assembled insert may be dissociated from the jig 510 by hydration of the polysilicone coating.

The jig 510 may be formed from numerous materials. In some embodiments, the jig may be formed and made of similar materials that are used to make molding pieces in the manufacture of standard contact lenses. Such a use could support the flexible formation of various jig types for different insert shapes and designs. In other embodiments the jig may be formed from materials that either in their own right or with special coatings will not adhere to the chemical mixtures used to adhere the different layers to each other. It may be apparent that numerous options may exist for the configuration of such a jig.

Another aspect of the jig demonstrated as item 510 is the fact that its shape physically supports the layers upon it. In some embodiments the interconnection between the layers may be formed by wirebonding connection. In the process of wirebonding significant force is applied the wire to ensure it forms a good bond. Structural support of the layers during such bonding could be important and could be performed by the supporting jig 510.

Still another function of the jig demonstrated as item 510 is that the jig may have alignment features on it that allow for the alignment of pieces of the functionalized layers to be aligned both relative to each other linearly and radially along the surfaces. In some embodiments, the jig may allow the alignment of azimutal angle of the functional layers relative to each other around a center point. Regardless of the ultimate shape of the insert produced it may be apparent that the assembly jib

may be useful in insuring that the pieces of the insert are properly aligned for their function and correct interconnection.

Proceeding to Fig. 6, a more generalized discussion of shapes of stacked layer inserts may be had. In a subset of the generality of shapes consistent with the art, some sample variation in shape is shown. For example, item 610 shows a top view of a stacked insert which has been formed from essentially circular layer pieces. In some embodiments, the region shown with cross hatching 611 may be an annular region where layer material has been removed. However, in other embodiments, it may be apparent that the pieces of the stacked layers used form the insert could be disks without an annular region. Although, such a non annular insert shape may be of limited utility in an ophthalmic application the spirit of the inventive art herein is not intended to be limited by the presence of an internal annulus.

Item 620 may in some embodiments demonstrate different embodiments of a stacked functional layer insert. As shown in item 621, in some embodiments the layer pieces may be discrete not only in the stacking direction but also around the azimuthal direction perpendicular to the stacking direction. In some embodiments, semicircular pieces may be used to form the insert. It may be apparent that in shapes that have an annular region, which partial shapes could be useful to reduce the amount of material that would need to be "diced" or cut out after the layer material is formed into its function.

Proceeding further, item 630 demonstrates that non radial, non elliptical and non circular insert shapes could be defined. As shown in item 630, rectilinear shapes may be formed, or as in item 640 other polygonal shapes. In a three dimensional perspective pyramids, cones and other geometrical shapes could result from the different shapes of the individual layer pieces used to form the insert. In a more general sense it may be apparent to one skilled in the arts that a vast diversity of shapes may be formed into shapes and products to make o discuss the more general case of shapes that may be made with the functionality, energization, activation etc…

Conclusion

The present invention, as described above and as further defined by the claims below, provides devices and methods for stacked functional layer inserts and apparatus

for implementing such methods, as well as ophthalmic lenses formed including the stacked layers.

CLAIMS

1. A stacked functionalized layer device comprising:

a first thin layer substrate comprising an energy source;

a first adhesive film upon a first surface of the first thin layer; and

a second thin layer shaped into a circular annulus with an external radius smaller than that of the first layer.

2. The device of claim 1 wherein:

the second thin layer comprises a semiconductor substrate with electronic circuitry in proximity to its first surface.

3. The device of claim 2 wherein:

the first thin layer comprises a substrate with layers comprising an electrochemical energizing component.

4. The device of claim 2 additionally comprising a wire based power source in electrical communication with the electronic circuitry.

5. The device of claim 4 additionally comprising an encapsulation comprising parylene.

6. The device of claim 4 additionally comprising an encapsulation comprising one or more metals.

7. The device of claim 6 additionally wherein the one or more metals comprises one or both of: aluminum and titanium

8. The device additionally comprising an encapsulation comprising a polysilicone based polymer.

9. An ophthalmic lens comprising

a silicon substrate insert comprising stacked electrically functional layers, wherein at least one of the functional layers comprises an electrical energy source; and

a polymeric lens form in which the substrate insert is embedded.

10. The ophthalmic lens of claim 9 wherein:

The electrical energy source comprises at least one layer within the substrate insert comprising one or more electrochemical cells.

11. The ophthalmic lens of claim 10 wherein:

at least one layer within the substrate insert comprises a semiconductor layer with electronic circuitry capable to control electric current flow from the electrochemical cells.

12. The ophthalmic lens of claim 11 wherein:

the electronic circuitry is electrically connected to an electroactive lens component within the lens.

13. The ophthalmic lens of claim 10 additional comprising an electroactive lens.

14. The ophthalmic lens of claim 13 additionally comprising a metallic layer which functions as an antenna.

FUNCTIONAL INSERT WITH POWER LAYER

RELATED APPLICATIONS

This application claims priority to U.S. Patent Application Serial No. 13/401,959 filed February 22, 2012; and U.S. Provisional Application Serial No. 61/454,591filed March 21, 2011, entitled Methods and Apparatus for Functional Insert with Power Layer, the contents of which are incorporated herein by reference.

FIELD OF USE

This invention describes a functionalized insert for logic processing device formed from multiple functional layers which are stacked, wherein at least one layer includes a power source as well as, in some embodiments, methods and apparatus for the fabrication of an ophthalmic lens with a functionalized insert of multiple stacked layers.

BACKGROUND

Traditionally an ophthalmic device, such as a contact lens, an intraocular lens or a punctal plug included a biocompatible device with a corrective, cosmetic or therapeutic quality. A contact lens, for example, may provide one or more of: vision correcting functionality; cosmetic enhancement; and therapeutic effects. Each function is provided by a physical characteristic of the lens. A design incorporating a refractive quality into a lens may provide a vision corrective function. A pigment incorporated into the lens may provide a cosmetic enhancement. An active agent incorporated into a lens may provide a therapeutic functionality. Such physical characteristics are accomplished without the lens entering into an energized state. A punctal plug has traditionally been a passive device.

More recently, it has been theorized that active components may be incorporated into a contact lens. Some components may include semiconductor devices. Some examples have shown semiconductor devices embedded in a contact lens placed upon animal eyes. It has also been described how the active components

may be energized and activated in numerous manners within the lens structure itself. The topology and size of the space defined by the lens structure creates a novel and challenging environment for the definition of various functionality. Generally, such disclosures have included discrete devices. However, the size and power requirements for available discrete devices are not necessarily conducive for inclusion in a device to be worn on a human eye.

SUMMARY

Accordingly, the present invention includes designs of components that may be combined to form a stacked layer of substrates combined into a discrete package. The stacked layers will include one or more layers which include a power source for at least one component included in the stacked layers. In some embodiments, an insert is provided that may be energized and incorporated into an ophthalmic device. The insert may be formed of multiple layers which may have unique functionality for each layer; or alternatively mixed functionality but in multiple layers. The layers may in some embodiments have layers dedicated to the energization of the product or the activation of the product or for control of functional components within the lens body. In addition, methods and apparatus for forming an ophthalmic lens, with inserts of stacked functionalized layers are presented.

In some embodiments, the insert may contain a layer in an energized state which is capable of powering a component capable of drawing a current. Components may include, for example, one or more of: a variable optic lens element, and a semiconductor device, which may either be located in the stacked layer insert or otherwise connected to it.

In another aspect, some embodiments may include a cast molded silicone hydrogel contact lens with a rigid or formable insert of stacked functionalized layers contained within the ophthalmic lens in a biocompatible fashion, wherein at least one of the functionalized lens includes a power source.

Accordingly, the present invention includes a disclosure of an ophthalmic lens with a stacked functionalized layer portion, apparatus for forming an ophthalmic lens with a stacked functionalized layer portion and methods for the same. An insert may

be formed from multiple layers in various manners as discussed herein and the insert may be placed in proximity to one, or both of, a first mold part and a second mold part. A reactive monomer mix is placed between the first mold part and the second mold part. The first mold part is positioned proximate to the second mold part thereby forming a lens cavity with the energized substrate insert and at least some of the reactive monomer mix in the lens cavity; the reactive monomer mix is exposed to actinic radiation to form an ophthalmic lens. Lenses may be formed via the control of actinic radiation to which the reactive monomer mixture is exposed.

DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a block diagram of some embodiments of a power source layer.

FIG. 2 illustrates some exemplary embodiments of form factor for a wire based power source.

FIG. 3 illustrates a three dimensional representation of an insert formed of stacked functional layers which is incorporated within an ophthalmic lens mold part.

Fig. 4 illustrates a cross sectional representation of an ophthalmic lens mold part with an insert.

Fig. 5 demonstrates an exemplary embodiment of an insert comprising multiple stacked functional layers upon a supporting and aligning structure.

Fig. 6 illustrates different shapes and embodiments of the components used for forming layers in a stacked functional layer insert.

DETAILED DESCRIPTION OF THE INVENTION

The present invention includes a substrate insert device formed through the stacking of multiple functionalized layers. Additionally the present invention includes methods and apparatus for manufacturing an ophthalmic lens with such a stacked functionalized layer substrate as an insert in the formed lens. In addition, some

embodiments of the present invention include an ophthalmic lens with a stacked functionalized layer substrate insert incorporated into the ophthalmic lens.

In the following sections detailed descriptions of embodiments of the invention will be given. The description of both preferred and alternative embodiments 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 said exemplary embodiments do not limit the scope of the underlying invention.

GLOSSARY

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

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

Energy: as used herein refers to the capacity of a physical system to do work. Many uses within this invention may relate to the said capacity being able to perform electrical actions in doing work.

Energy Source: as used herein refers to device or layer which is capable of supplying Energy or placing a logical or electrical device in an Energized state.

Energy Harvesters: as used herein refers to device capable of extracting energy from the environment and convert it to electrical energy.

Functionalized: as used herein refers to making a layer or device able to perform a function including for example, energization, activation, or control.

Lens: refers to any ophthalmic device that resides in or on the eye. These devices may provide optical correction or may be cosmetic. For example, the term lens may 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. In some embodiments, the preferred lenses of the invention are soft contact lenses are made from silicone elastomers or hydrogels, which include but are not limited to silicone hydrogels, and fluorohydrogels.

Lens forming mixture or "Reactive Mixture" or "RMM" (reactive monomer mixture): as used herein refers to a monomer or prepolymer material which may be cured and crosslinked or crosslinked to form an ophthalmic lens. Various embodiments may include lens forming mixtures with one or more additives such as: UV blockers, tints, photoinitiators or catalysts, and other additives one might desire in an ophthalmic lenses such as, contact or intraocular lenses.

Lithium Ion Cell: 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.

Substrate insert: as used herein refers to a formable or rigid substrate capable of supporting an Energy Source within an ophthalmic lens. In some embodiments, the Substrate insert also supports one or more components.

Mold: refers to a rigid or semi-rigid object that may be used to form lenses from uncured formulations. Some preferred molds include two mold parts forming a front curve mold part and a back curve mold part.

Optical Zone: as used herein refers to an area of an ophthalmic lens through 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 within this invention may relate to the capability of being restored with the ability to flow electrical current at a certain rate for a certain, reestablished time period.

Reenergize or Recharge: To restore to a state with higher capacity to do work. Many uses within this invention may relate to restoring a device to the capability to flow electrical current at a certain rate for a certain, reestablished time period.

Released from a mold: means that a lens is either completely separated from the mold, or is only loosely attached so that it may be removed with mild agitation or pushed off with a swab.

Stacked: as used herein means to place at least two component layers in proximity to each other such that at least a portion of one surface of one of the layers contacts a first surface of a second layer. In some embodiments, a film, whether for

adhesion or other functions may reside between the two layers that are in contact with each other through said film.

Description

Powered Layers

Referring now to Fig. 1, in some embodiments, one or more layers of a functionalized stack of substrates may include a thin film electrical power source 100. The thin electrical power source may be viewed essentially as a battery on a substrate.

A thin film battery (sometimes referred to as a TFB) may be structured on a suitable substrate, such as silicon, using known deposition processes. Deposition may include, for example, sputter deposition and may be used to deposit various materials using one or more of masking and material removal techniques.

A wide variety of different materials have been studied and are possible. In some applications, such as for example, die stack and an ophthalmic device; a preferable substrate includes one that is able to withstand 800 deg. C without chemical change. In another aspect, a preferable substrate may be insulating. Optionally, the substrate may have vias that interconnect current collectors from a top side of the device to a bottom side.

A TFB according to the present invention will preferably be enclosed in a packaging to prevent ingress of one or more of: oxygen, moisture other gasses or liquids. Preferred embodiments may therefore include packaging in one or more layers wherein the packaging may include one or more of an insulative (e.g. parylene) and impermeable layer (e.g. metals, aluminum, titanium, etc.) . Layers may be applied by deposition over a TFB device.

Preferably interconnects remain accessible to electrical communication outside the package. In some embodiments, electrical communication may include a conductive path. In other embodiments, electrical communication may include a wireless transport of energy, such as via a radio frequency or light wavelength.

Other methods include applying organic materials (e.g. epoxy) in conjunction with pre-shaped impermeable materials (e.g. the next layer of the die stack, or a precision formed /cut glass , alumina, or silicon cover layer.

Wire Formed Power Source

Referring now to Fig. 2A, an exemplary design of some embodiments of a power source which includes a battery formed about a conductive wire. Preferably the battery will include a high aspect ratio wire battery.

In some embodiments, a fine gauge copper wire may be used as a support. Various battery component layers may be built up using batch or continuous wire coating processes. In this manner, a very high volumetric efficiency (> 60 %) of active battery materials can be achieved in a convenient form factor that is flexible. In some embodiments, a thin wire may be utilized to form small batteries, such as, for example, a battery in a range measured by Milliamp hours. Voltage capacities may be targeted to be approximately 1.5 volts, direct current. Larger batteries and higher voltages may also be scaled and are within the scope of the present invention.

Typically, a wire formed battery provides a significant improvement (~40x or more) over an incumbent thin film 6-pack.

Referring now to Fig. 2B, a method is illustrated for forming some embodiments of a wire based battery. A copper wire of high purity such as those available from commercial source, such as McMaster Carr Corp. may be used coated with one or more layers.

In some embodiments, a zinc anode coating may be formulated from zinc metal powder, polymer binders, solvents, and additives. The coating may be applied and immediately dried. Multiple passes of the same coating may be used to achieve the desired thickness.

A separator coating may be formulated from non-conductive filler particles, polymer binders, solvents, and additives. Application method may be the same.

A silver oxide cathode coating may be formulated from Ag2O powder, graphite, polymer binders, solvents, and additives. Application method may be the same.

The wire battery may be coated with current collector (e.g. carbon conductive adhesive, silver conductive adhesive, or the like).

Electrolyte (potassium hydroxide solution with additives) may be applied to the finished battery to complete construction.

The cell should remain "open" (i.e. non-hermetic) so as to allow any evolved gases to safely leave. Silicone or fluoropolymer coatings may be used to protect the battery from mechanical damage, and to contain liquid electrolyte within.

The battery may have an open circuit voltage of ~ 1.5 V or greater.

Referring now to Fig. 3 a three dimensional representation is illustrated of some embodiments of a fully formed ophthalmic lens using a stacked layer substrate insert of the time in item 210 is demonstrated as item 300. The representation shows a partial cut out from the ophthalmic lens to realize the different layers present inside the device. Item 320 shows the body material in cross section of the encapsulating layers of the substrate insert. This item surrounds the entire periphery of the ophthalmic lens. It may be clear to one skilled in the arts that the actual insert may comprise a full annular ring or other shapes that still may reside within the constraints of the size of a typical ophthalmic lens.

Items 330, 331 and 332 are meant to illustrate three of numerous layers that may be found in a substrate insert formed as a stack of functional layers. In some embodiments, a single layer may include one or more of: active and passive components and portions with structural, electrical or physical properties conducive to a particular purpose.

In some embodiments, a layer 330 may include an energization source, such as, for example, one or more of: a battery, a capacitor and a receiver within the layer 330. Item 331 then, in a non limiting exemplary sense may comprise microcircuitry in a layer that detects actuation signals for the ophthalmic lens. In some embodiments, a power regulation layer 332, may be included that is capable of receiving power from external sources, charges the battery layer 330 and controls the use of battery power from layer 330 when the lens is not in a charging environment. The power regulation may also control signals to an exemplary active lens, demonstrated as item 310 in the center annular cutout of the substrate insert.

An energized lens with an embedded Substrate insert may include an Energy Source, such as an electrochemical cell or battery as the storage means for the energy and in some embodiments, encapsulation and isolation of the materials comprising the Energy Source from an environment into which an ophthalmic lens is placed.

In some embodiments, a Substrate insert also includes a pattern of circuitry, components and Energy Sources. Various embodiments may include the Substrate insert locating the pattern of circuitry, components and Energy Sources around a periphery of an optic zone through which a wearer of a lens would see, while other embodiments may include a pattern of circuitry, components and Energy Sources which are small enough to not adversely affect the sight of a contact lens wearer and therefore the Substrate insert may locate them within, or exterior to, an optical zone.

In general, according to these embodiments previously described, a Substrate insert 111 is embodied within an ophthalmic lens via automation which places an Energy Source a desired location relative to a mold part used to fashion the lens.

Fig. 4 illustrates a closer view of some embodiments of a stacked functional layer insert 400 seen in cross section. Within the body of the ophthalmic lens 410 is embedded the functionalized layer insert 420 which surrounds and connects to an active lens component 450, in some embodiments. It may be clear to one skilled in the arts, that this example shows but one of numerous embodiments of embedded function that may be placed within an ophthalmic lens.

Within the stacked layer portion of the insert are demonstrated numerous layers. In some embodiments the layers may comprise multiple semiconductor based layers. For example, item 440, the bottom layer in the stack, may be a thinned silicon layer upon which circuits have been defined for various functions. Another thinned silicon layer may be found in the stack as item 441. In a non-limiting example, such a layer may have the function of energization of the device. These silicon layers will in some embodiments be electrically isolated from each other through an intervening insulator layer show as item 450. The portions of the surface layers of items 440, 450 and 441 that overlap each other may be adhered to each other through the use of a thin film of adhesive. It may be obvious to one skilled in the arts that numerous adhesives may have the desired characteristics to adhere and passivate the thin silicon layers to the insulator, as in an exemplary sense an epoxy might.

A multiple stacked layer may include additional layers 442, which in an non limiting example may include a thinned silicon layer with circuitry capable of activating and controlling an active lens component. As mentioned before, when the stacked layers need to be electrically isolated from each other, stacked insulator layers

may be included between the electrically active layer and in this example item 451 may represent this insulator layer comprising part of the stacked layer insert. In some of the examples described herein, reference has been made to layers formed from thin layers of silicon. The general art may be extended to different embodiments where the material definitions of the thin stacked layers include, in a non limiting sense, other semiconductors, metals or composite layers. And the function of the thin layers may include electrical circuitry, but also may include other functions like signal reception, energy handling and storage and energy reception to mention a few examples. In embodiments with different material types, the choice of different adhesives, encapsulants and other materials which interact with the stacked layers may be required. In an example embodiment, a thin layer of epoxy may adhere three silicon layers shown as 440, 441 and 442 with two silicon oxide layers 450 and 451.

As mentioned in some of the examples the thinned stacked layer may comprise circuits formed into silicon layers. There may be numerous manners to fabricate such layers, however, standard and state of the art semiconductor processing equipment may form electronic circuits on silicon wafers using generic processing steps. After the circuits are formed into the appropriate locations on the silicon wafers, wafer processing equipment may be used to thin the wafers from hundreds of microns thick to thicknesses of 50 microns or less. After thinning the silicon circuits may be cut or "diced" from the wafer into the appropriate shapes for the ophthalmic lens or other application. In later section, different exemplary shapes of the stacked layer invention disclosed herein are shown in Fig. 6. These will be discussed in detail later; however, the "dicing" operation may use various technical options to cut out thin layers with curved, circular, annular, rectilinear and other more complicated shapes.

When the stacked layers perform a function relating to electrical current flow, in some embodiments, there may be a need to provide electrical contact between the stacked layers. In the general field of semiconductor packaging this electrical connection between stacked layers has generic solutions comprising wire bonding, solder bumping and wire deposition processes. Some embodiments of wire deposition may use printing process where electrically conductive inks are printed between two connection pads. In other embodiments, wires may be physically defined by an energy source, like for example a laser, interacting with a gaseous, liquid or solid chemical

intermediate resulting in an electrical connection where the energy source irradiates. Still further interconnection definition embodiments may derive from photolithographic processing before or after metal films are deposited by various means.

In the invention herein, if one or more of the layers needs to communicate electrical signals outside itself, it may have a metal contact pad that is not covered with passivating and insulating layers. In many embodiments these pads would be located on the periphery of the layer where subsequent stacked layers do not cover the region. In an example of this type of embodiment, in Fig. 4 interconnect wires 430 and 431 are demonstrated as electrically connecting peripheral regions of layers 440, 441 and 442. It may be apparent to one skilled in the art that numerous layouts or designs of where the electrical connection pads are located and the manner of electrically connecting various pads together. Furthermore, it may be apparent that different circuit designs may derive from the choice of which electrical connect pads are connected and to which other pads they are connected. Still further, the function of the wire interconnection between pads may be different in different embodiments including the functions of electrical signal connection, electrical signal reception from external sources, electrical power connection and mechanical stabilization to mention a few examples.

In a previous discussion, it was presented that non semiconductor layers may comprise one or more of the stacked layers in the inventive art. It may be apparent that there could be a great diversity of applications which may derive from nonsemiconductor layers. In some embodiments, the layers may define energizing sources like batteries. This type of layer in some cases may have a semiconductor acting as the supporting substrate for the chemical layers, or in other embodiments may have metallic or insulating substrates. Other layers may derive from layers which are primarily metallic in nature. These layers may define antennas, thermal conductive paths, or other functions. There may be numerous combinations of semiconducting and non semiconducting layers that comprise useful application within the spirit of the inventive art herein.

In some embodiments where electrical connection is made between stacked layers the electrical connection will need to be sealed after connection is defined.

There are numerous methods that may be consistent with the art herein. For example, the epoxy or other adherent materials used to hold the various stacked layers together could be reapplied to the regions with electrical interconnect. Additionally, passivation films may, in some embodiments, be deposited across the entire device to encapsulate the regions that were used for interconnection. It may be apparent to one skilled in the art that numerous encapsulating and sealing schemes may be useful within this art to protect, strengthen and seal the stacked layer device and its interconnections and interconnection regions.

Assembling Stacked Functionalized Layer Inserts

Proceeding to Fig. 5, item 500, a close up view of an exemplary apparatus to assemble stacked functionalized layer inserts is demonstrated. In the example, a stacking technique where the stacked layers do not align on either side of the layer is shown. Items 440, 441 and 442 again may be silicon layers. On the right side of the Fig. it may be seen that the right side edge of the items 440, 441 and 442 do not align with each other, as they may in alternative embodiments. Such a stacking methodology may allow the insert to assume a three dimensional shape similar to that of the general profile of an ophthalmic lens. In some embodiments as well, such a stacking technique may allow for the layers to be made from the largest surface area as possible. In layers that are functional for energy storage and circuitry such surface area maximization may be important.

In general many of the features of the previously described stacked inserts may be observed in Fig. 5 including stacked functional layers 440, 441 and 442; stacked insulating layers 450 and 451; and interconnections 430 and 431. Additionally a supporting jig, item 510, may be observed to support the stacked functionalized layer insert as it is being assembled. It may be apparent that the surface profile of item 510 may assume a large number of shapes which will change the three dimensional shape of inserts made thereon.

In general, a jig 510 may be provided with a predetermined shape. It may be coated with different layers, item 520, for a number of purposes. In a non limiting exemplary sense, the coating may first comprise a polymer layer that will allow easy incorporation of an insert into the base material of an ophthalmic lens, and may even be formed from a polysilicone material in some embodiments. An epoxy coating may

then be deposited upon the polysilicone coating to adhere the bottom thin functional layer 440 to the coating 520. The bottom surface of a next insulating layer 450 may then be coated with a similar epoxy coating and then placed into its appropriate location upon the jig. It may be clear that the jig may in some embodiments have the function of aligning the correct placement of the stacked layers relative to each other as the device is assembled. In repetitious fashion, the rest of the insert may then be assembled, the interconnections defined and then the insert encapsulated. In some embodiments, the encapsulated insert may then be coated from the top with a polysilicone coating. In some embodiments that use a polysilicone coating for item 520, the assembled insert may be dissociated from the jig 510 by hydration of the polysilicone coating.

The jig 510 may be formed from numerous materials. In some embodiments, the jig may be formed and made of similar materials that are used to make molding pieces in the manufacture of standard contact lenses. Such a use could support the flexible formation of various jig types for different insert shapes and designs. In other embodiments the jig may be formed from materials that either in their own right or with special coatings will not adhere to the chemical mixtures used to adhere the different layers to each other. It may be apparent that numerous options may exist for the configuration of such a jig.

Another aspect of the jig demonstrated as item 510 is the fact that its shape physically supports the layers upon it. In some embodiments the interconnection between the layers may be formed by wirebonding connection. In the process of wirebonding significant force is applied the wire to ensure it forms a good bond. Structural support of the layers during such bonding could be important and could be performed by the supporting jig 510.

Still another function of the jig demonstrated as item 510 is that the jig may have alignment features on it that allow for the alignment of pieces of the functionalized layers to be aligned both relative to each other linearly and radially along the surfaces. In some embodiments, the jig may allow the alignment of azimutal angle of the functional layers relative to each other around a center point. Regardless of the ultimate shape of the insert produced it may be apparent that the assembly jib

may be useful in insuring that the pieces of the insert are properly aligned for their function and correct interconnection.

Proceeding to Fig. 6, a more generalized discussion of shapes of stacked layer inserts may be had. In a subset of the generality of shapes consistent with the art, some sample variation in shape is shown. For example, item 610 shows a top view of a stacked insert which has been formed from essentially circular layer pieces. In some embodiments, the region shown with cross hatching 611 may be an annular region where layer material has been removed. However, in other embodiments, it may be apparent that the pieces of the stacked layers used form the insert could be disks without an annular region. Although, such a non annular insert shape may be of limited utility in an ophthalmic application the spirit of the inventive art herein is not intended to be limited by the presence of an internal annulus.

Item 620 may in some embodiments demonstrate different embodiments of a stacked functional layer insert. As shown in item 621, in some embodiments the layer pieces may be discrete not only in the stacking direction but also around the azimuthal direction perpendicular to the stacking direction. In some embodiments, semicircular pieces may be used to form the insert. It may be apparent that in shapes that have an annular region, which partial shapes could be useful to reduce the amount of material that would need to be "diced" or cut out after the layer material is formed into its function.

Proceeding further, item 630 demonstrates that non radial, non elliptical and non circular insert shapes could be defined. As shown in item 630, rectilinear shapes may be formed, or as in item 640 other polygonal shapes. In a three dimensional perspective pyramids, cones and other geometrical shapes could result from the different shapes of the individual layer pieces used to form the insert. In a more general sense it may be apparent to one skilled in the arts that a vast diversity of shapes may be formed into shapes and products to make o discuss the more general case of shapes that may be made with the functionality, energization, activation etc…

Conclusion

The present invention, as described above and as further defined by the claims below, provides devices and methods for stacked functional layer inserts and apparatus

for implementing such methods, as well as ophthalmic lenses formed including the stacked layers.

CLAIMS

1. An ophthalmic lens that resides in or on an eye comprising: an electro-active lens component;

an insert comprising a stack of at least three annular-shaped electrically functional layers including at least one thinned silicon layer, wherein at least one of the annular-shaped electrically functional layers comprises an electrical energy source and at least another one of the annular-shaped electrically functional layers comprises an activation component that activates the electro-active lens component; and

a polymeric lens form in which the insert is embedded.

2. The ophthalmic lens of claim 1, wherein: the electrical energy source comprises at least one electrochemical cell.

3. The ophthalmic lens of claim 2, wherein: at least one of the annular-shaped electrically functional layers comprises a semiconductor layer with electronic circuitry to control electric current flow from the at least one electrochemical cell.

4. The ophthalmic lens of claim 3, wherein: the electronic circuitry is electrically connected to the electro-active lens component within the ophthalmic lens.

5. The ophthalmic lens of claim 1, additionally comprising a metallic layer configured to be an antenna.

6. The ophthalmic lens of claim 1, wherein the electrical energy source comprises at least one of a battery, a capacitor and a receiver.

7. The ophthalmic lens of claim 6, wherein the electrical energy source comprises the battery, wherein the battery is a thin film battery.

8. The ophthalmic lens of claim 7, wherein the thin film battery is enclosed in a packaging to prevent ingress of at least one of oxygen and moisture.

9. The ophthalmic lens of claim 8, wherein the stack of at least three annular-shaped electrically functional layers are accessible to electrical communication outside of the packaging.

10. The ophthalmic lens of claim 1, wherein the electrical energy source is a wire battery.

11. The ophthalmic lens of claim 10, wherein the wire battery provides a voltage capacity of at least about 1.5 volts.

12. The ophthalmic lens of claim 1, wherein at least two of the annular-shaped electrically functional layers comprise the electrical energy source and wherein the electrical energy source is a wire battery.

13. The ophthalmic lens of claim 12, wherein the wire battery provides a voltage capacity of at least about 1.5 volts.

14. The ophthalmic lens of claim 10, wherein the wire battery comprises a conductive wire coated with a zinc anode coating, a separator coating and a silver oxide cathode coating.

15. The ophthalmic lens of claim 12, wherein the wire battery comprises a conductive wire coated with a zinc anode coating, a separator coating and a silver oxide cathode coating.

16. The ophthalmic lens of claim 1, wherein another one of the annular-shaped electrically functional layers comprises a power regulation layer.

17. The ophthalmic lens of claim 16, wherein the power regulation layer charges and controls the electrical energy source.

18. The ophthalmic lens of claim 1, wherein at least two of the annular-shaped electrically functional layers partially overlap.

19. The ophthalmic lens of claim 18, wherein the stack of at least three annular-shaped electrically functional layers is configured to reside outside an optic zone of the ophthalmic lens.

20. The ophthalmic lens of claim 18, wherein the stack of at least three annular-shaped electrically functional layers comprises three silicon layers and an epoxy.

21. The ophthalmic lens of claim 20, wherein the stack of at least three annular-shaped electrically functional layers comprises silicon oxide.