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(54) Title: STACKED INTEGRATED COMPONENT MEDIA INSERT FOR AN OPHTHALMIC DEVICE

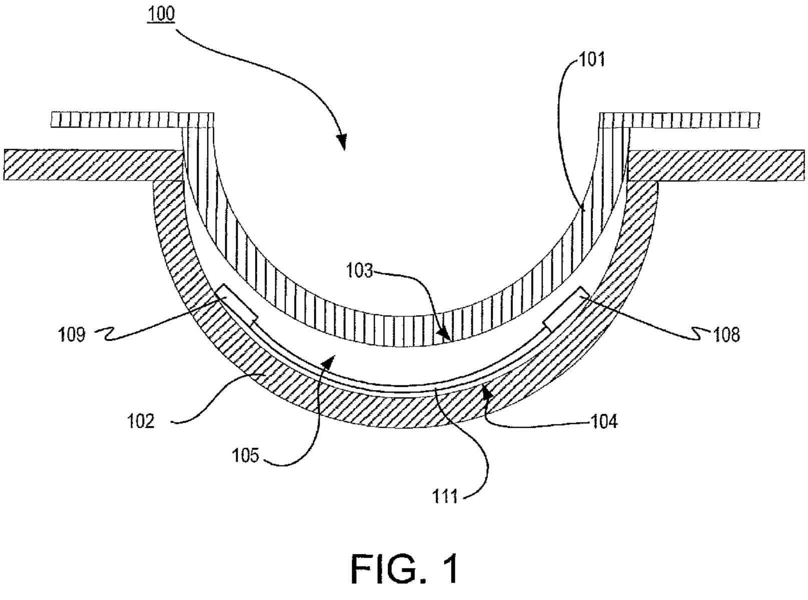

FIG. 1

(57) Abstract: A method for forming a stacked integrated component layer insert and a stacked integrated component layer insert is described. The component layer insert comprises substrate layers with functionality. The substrate layers are assembled to form electrical interconnections between the substrate layers creating a stacked feature. The stacked feature is encapsulated with a material for bonding within the body of a molded ophthalmic lens.

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STACKED INTEGRATED COMPONENT MEDIA INSERT FOR AN OPHTHALMIC DEVICE

This invention relates to a method of forming a stacked integrated component media insert for an ophthalmic lens and a stacked integrated component media insert for an ophthalmic lens.

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, can 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 can provide a vision corrective function. A pigment incorporated into the lens can provide a cosmetic enhancement. An active agent incorporated into a lens can provide a therapeutic functionality. Such physical characteristics are accomplished without the lens entering into an energized state.

More recently, it has been theorized that active components may be incorporated into a contact lens. Some components can include semiconductor devices. Some examples have shown semiconductor devices embedded in a contact lens placed upon animal eyes. However, such devices lack a free standing energizing mechanism. Although wires may be run from a lens to a battery to power such semiconductor devices, and it has been theorized that the devices may be wirelessly powered, no mechanism for such wireless power has been available.

It is desirable therefore to have additional methods and apparatus conducive to the formation of ophthalmic lenses that are energized to an extent suitable for providing one or more of functionality into an ophthalmic lens and a controlled change in optical characteristic of an ophthalmic lens or other biomedical device.

SUMMARY

According to an aspect of the present invention there is provided a method of forming a stacked integrated component media insert for an ophthalmic lens. The method comprising: forming substrate layers with functionality; assembling the substrate layers; forming electrical interconnections between substrate layers;

encapsulating the stacked feature with a material for bonding within the body of a molded ophthalmic lens.

The substrate layers may be assembled into one of a circular annular shape or a portion of an annular shape.

The stacked functional layers may be adhered to insulating layers forming a stacked feature.

A second stacked integrated component layer may be shaped into at least a portion of a circular annulus with an external radius that is smaller than that of the first layer.

One or more layers may comprise a metallic feature surface.

Solder film may be placed upon the surface of the one or more layers comprising a metallic feature.

The method may comprise arranging a battery on the stacked integrated component media insert, wherein the battery is chargeable via one or more of radio frequency and magnetic inductance.

The method may comprise arranging a thin film battery on the stacked integrated component media insert and altering the surface of the battery to define the appearance of the battery.

The substrate layers may be flexible.

According to further aspect, there is provide a method comprising the steps of forming a stacked integrated component media insert and bonding the media insert in an ophthalmic lens.

According to a further aspect there is provided a stacked integrated component layer insert. The insert comprising: substrate layers with functionality; wherein the substrate layers are assembled to form electrical interconnections between the substrate layers creating a stacked feature; wherein the stacked feature is encapsulated with a material for bonding within the body of a molded ophthalmic lens.

The substrate layers may be assembled into one of a circular annular shape or a portion of an annular shape.

The stacked functional layers may be adhered to insulating layers forming a stacked feature.

The stacked integrated component layer insert may comprise a second stacked integrated component layer is shaped into at least a portion of a circular annulus with an external radius that is smaller than that of the first layer.

One or more layers may comprise a metallic feature surface.

The stacked integrated component layer insert may comprise solder film placed upon the surface of the one or more layers comprising a metallic feature.

The stacked integrated component layer insert may comprise a battery, wherein the battery is configured to be chargeable via one or more of radio frequency and magnetic inductance.

The stacked integrated component layer insert may comprise a thin film battery, wherein the surface of the battery is configured to define a predetermined appearance.

The substrate layers may be flexible.

According to a further aspect there is provided an ophthalmic lens comprising a stacked integrated component layer insert bonded therein.

A media insert is described herein that can be energized and incorporated into an ophthalmic device, such as, for example a contact lens or a punctal plug. In addition, methods and apparatus for forming an ophthalmic lens, with an energized media insert are presented. In some illustrative examples, the media in an energized state 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, a semiconductor device and an active or passive electronic device. Some examples can also include a cast molded silicone hydrogel contact lens with a rigid or formable energized insert contained within the ophthalmic lens in a biocompatible fashion.

An ophthalmic lens with an energized media portion, an apparatus for forming an ophthalmic lens with an energized media portion and methods for the manufacturing the same are described herein. An energy source can be deposited onto a media insert and the insert can 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 media 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 are formed via the control of actinic radiation to which the reactive monomer mixture is exposed.

DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a mold assembly apparatus according to an embodiment of the present invention.

FIG. 2A-2D illustrates various media inserts which can be placed within an ophthalmic lens according to an embodiment of the invention.

FIG. 3 illustrates an apparatus for placing an Energy Source within an ophthalmic lens mold part.

Fig. 4 illustrates method steps according to an embodiment of the present invention.

Fig. 5 illustrates method steps according to some additional aspect of the present invention.

Fig. 6 illustrates a processor that may be used to implement the method according to an embodiment of the present invention.

Fig. 7 illustrates a depiction of an exemplary media insert.

Fig. 8 illustrates a cross section of an exemplary media insert.

Fig. 9 illustrates a cross section of a Stacked Integrated Component Device with energization of stacked integrated component media inserts according to an embodiment of the invention.

Fig. 10 illustrates a stacked integrated component media insert within an exemplary Ophthalmic Lens.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a method of forming a media insert and media insert for an ophthalmic lens. . In addition, the media insert may be incorporated into the ophthalmic lens.

An energized lens 100 may be formed with an embedded Media Insert and an Energy Source, such as an electrochemical cell or battery as the storage means for the energy and optionally, encapsulation and isolation of the materials comprising the Energy Source from an environment into which an ophthalmic lens is placed.

In some illustrative examples, a Media Insert also includes a pattern of circuitry, components and Energy Sources. The Media Insert locating the pattern of circuitry, components and Energy Sources may be included around a periphery of an optic zone through which a wearer of a lens would see, while alternatively a pattern of circuitry, components and Energy Sources are included which are small enough to not adversely affect the sight of a contact lens wearer and therefore the Media Insert can locate them within, or exterior to, an optical zone.

In general, a Media Insert 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.

In some illustrative examples, an Energy Source is placed in electrical communication with a component which can be activated on command and draws electrical current from the Energy Source included within the ophthalmic lens. A component can include for example, a semiconductor device, an active or passive electrical device or an electrically activated machine, including for example: Microelectromechanical systems (MEMS), nanoelectromechanical systems (NEMS), or micromachines. Subsequent to placing the Energy Source and component, a Reactive Mixture can be shaped by the mold part and polymerized to form 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:

Component: as used herein refers to a device capable of drawing electrical current from an Energy Source to perform one or more of a change of logical state or physical state.

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 capable of supplying Energy or placing a biomedical 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.

Lens: refers to any ophthalmic device that resides in or on the eye. These devices can provide optical correction or may be cosmetic. 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. Preferred lenses are soft contact lenses, made from silicone elastomers or hydrogels.

Lens forming mixture or “Reactive Mixture” or “RMM”(reactive monomer mixture): as used herein refers to a monomer or prepolymer material which can be cured and crosslinked or crosslinked to form an ophthalmic lens. Lens forming mixtures may include 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.

Lens Forming Surface: refers to a surface that is used to mold a lens. Any such surface can have an optical quality surface finish, which indicates that it is sufficiently smooth and formed so that a lens surface fashioned by the polymerization of a lens forming material in contact with the molding surface is optically acceptable. Further, the lens forming surface 103-104 can have a geometry that is necessary to impart to the lens surface the desired optical characteristics, including without limitation, spherical, aspherical and cylinder power, wave front aberration correction, corneal topography correction and the like as well as any combinations thereof.

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.

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 support 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 can be removed with mild agitation or pushed off with a swab.

"Stacked Integrated Component Devices" as used herein and sometimes referred to as "SIC-Devices", refers to the product of packaging technologies that can assemble thin layers of substrates, which may contain electrical and electromechanical devices, into operative integrated devices by means of stacking at least a portion of each layer upon each other. The layers may comprise component devices of various types, materials, shapes, and sizes. Furthermore, the layers may be made of various device production technologies to fit and assume various contours as it may be desired.

<u>Molds</u>

Referring now to Fig. 1, a diagram of a mold device 100 for an ophthalmic lens is illustrated with a Media Insert 111. As used herein, the terms a mold device 100 includes a plastic formed to shape a cavity 105 into which a lens forming mixture can be dispensed such that upon reaction or cure of the lens forming mixture, an ophthalmic lens of a desired shape is produced. The molds and mold assemblies 100 of this invention are made up of more than one "mold parts" or "mold pieces" 101-102. The mold parts 101-102 can be brought together such that a cavity 105 is formed between the mold parts 101-102 in which a lens can be formed. This combination of mold parts 101-102 is preferably temporary. Upon formation of the lens, the mold parts 101-102 can again be separated for removal of the lens.

At least one mold part 101-102 has at least a portion of its surface 103-104 in contact with the lens forming mixture such that upon reaction or cure of the lens forming mixture that surface 103-104 provides a desired shape and form to the portion of the lens with which it is in contact. The same is true of at least one other mold part 101-102.

Thus, for example, a mold device 100 is formed from two parts 101-102, a female concave piece (front piece) 102 and a male convex piece (back piece) 101 with a cavity formed between them. The portion of the concave surface 104 which makes contact with lens forming mixture has the curvature of the front curve of an ophthalmic lens to be produced in the mold device 100 and is sufficiently smooth and formed such that the surface of an ophthalmic lens formed by polymerization of the lens forming mixture which is in contact with the concave surface 104 is optically acceptable.

The front mold piece 102 may also have an annular flange integral with and surrounding circular circumferential edge and extends from it in a plane normal to the axis and extending from the flange (not shown).

A lens forming surface can include a surface 103-104 with an optical quality surface finish, which indicates that it is sufficiently smooth and formed so that a lens surface fashioned by the polymerization of a lens forming material in contact with the molding surface is optically acceptable. Further, , the lens forming surface 103-104 may have a geometry that is necessary to impart to the lens surface the desired optical characteristics, including without limitation, spherical, aspherical and cylinder power, wave front aberration correction, corneal topography correction and the like as well as any combinations thereof.

At 111, a Media Insert is illustrated onto which an Energy Source 109 and a Component 108 are mounted. The Media Insert 111 may be any receiving material onto which an Energy Source 109 may be placed, may also include circuit paths, components and other aspects useful to place the Energy Source109 in electrical communication with the Component 108 and enable the Component to draw an electrical current from the Energy Source 109.

The Media Insert 111 may include a flexible substrate. Additional examples can include a Media Insert 111 that is rigid, such as a silicon wafer. A rigid insert may include an optical zone providing an optical property (such as those utilized for vision correction) and a non-optical zone portion. An Energy Source can be placed on one or both of the optic zone and non-optic zone of the insert. Still other examples can include an annular insert, either rigid or formable or some shape which circumvents an optic zone through which a user sees.

Other examples include a Media Insert 111 formed of a clear coat of a material which be incorporated into a lens when the lens is formed. The clear coat can include for example a pigment as described below, a monomer or other biocompatible material.

An Energy Source 109 may be placed onto Media Insert 111 prior to placement of the Media Insert 111 into a mold portion used to form a lens. The Media Insert 111 may also include one or more components which will receive an electrical charge via the Energy Source 109.

A lens with a Media Insert 111 can include a rigid center soft skirt design in which a central rigid optical element is in direct contact with the atmosphere and the corneal surface on respective an anterior and posterior surfaces, wherein the soft skirt of lens material (typically a hydrogel material) is attached to a periphery of the rigid optical element and the rigid optical element also acts as a Media Insert providing energy and functionality to the resulting ophthalmic lens.

Some examples include a Media Insert 111 that is a rigid lens insert fully encapsulated within a hydrogel matrix. A Media Insert 111 which is a rigid lens insert may be manufactured, for example using microinjection molding technology. For example, a poly(4-methylpent-1-ene copolymer resin with a diameter of between about 6mm to 10mm and a front surface radius of between about 6 mm and 10mm and a rear surface radius of between about 6 mm and 10 mm and a center thickness of between about 0.050mm and 0.5 mm, may be included. An insert with a diameter of about 8.9 mm and a front surface radius of about 7.9 mm and a rear surface radius of about 7.8 mm and a center thickness of about 0.100 mm and an edge profile of about 0.050

radius may be included. A micromolding machine may include the Microsystem 50 five-ton system offered by Battenfield Inc.

The Media Insert can be placed in a mold part 101-102 utilized to form an ophthalmic lens.

Mold part 101-102 material can include, for example: a polyolefin of one or more of: polypropylene, polystyrene, polyethylene, polymethyl methacrylate, and modified polyolefins. Other molds can include a ceramic or metallic material.

Other mold materials that may be combined with one or more additives to form an ophthalmic lens mold include, for example, Zieglar-Natta polypropylene resins (sometimes referred to as znPP); a clarified random copolymers for clean molding as per FDA regulation 21 CFR (c) 3.2; a random copolymer (znPP) with ethylene group.

Still further, the molds may contain polymers such as polypropylene, polyethylene, polystyrene, polymethyl methacrylate, modified polyolefins containing an alicyclic moiety in the main chain and cyclic polyolefins. This blend can be used on either or both mold halves, where it is preferred that this blend is used on the back curve and the front curve consists of the alicyclic co-polymers.

In some preferred methods of making molds 100, injection molding is utilized according to known techniques, however, methods can also include molds fashioned by other techniques including, for example: lathing, diamond turning, or laser cutting.

Typically, lenses are formed on at least one surface of both mold parts 101-102. However, one surface of a lens may be formed from a mold part 101-102 and another surface of a lens can be formed using a lathing method, or other methods.

Lenses

Referring now to Fig. 2A-2D, exemplary designs of Media Inserts 211-214 are illustrated. Fig. 2A illustrates an annular Media Insert 211. Other Media Inserts may be of various shapes conducive to placement with an ophthalmic lens. Some preferred shapes include shapes with arcuate designs matching a portion of the overall shape of the ophthalmic lens. Fig. 2B illustrates a Media Insert 212 which includes an area of about ½ of an full annular design and also includes an arcuate area which may surround an optic zone of a lens into which the Media Insert 212 is placed. Similarly, Fig. 2C includes a Media insert 213 of about 1/3 of an annular design. Fig. 2D illustrates an annular design 214 with multiple discrete portions 215, 216, 21 of the

Media Insert 214. Discrete portions 215, 216, 21 can be useful to isolate various functions attributed to the individual portions 215, 216, 21. For example, one discrete portion 215, 216, 21 may contain one or more Energy Sources and another discrete portion 215, 216, 21 may include components.

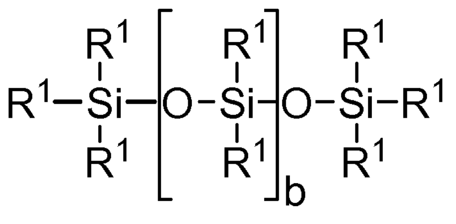
A Media Insert 211-214 may optionally have an optic zone that includes a variable optic powered by an Energy Source located on the Media Insert 211-214. The Media Insert 211-214 can also include circuitry to control the variable optic included in the optic zone 211-214. In this discussion, a variable optic can be considered a component.

An Energy Source can be in electrical communication with a component. The component can include any device which responds to an electrical charge with a change in state, such as, for example: a semiconductor type chip; a passive electrical device; or an optical device such as a crystal lens.

An Energy Source includes, for example: battery or other electrochemical cell; capacitor; ultracapacitor; supercapacitor; or other storage component. A lithium ion battery may be located on a Media Insert 211-214 on the periphery of an ophthalmic lens outside of the optic zone and chargeable via one or more of radio frequency and magnetic inductance into an Energy Source deposited via ink jetting.

A preferred lens type can include a lens that includes a silicone containing component. A "silicone-containing component" is one that contains at least one [-Si-O-] unit in a monomer, macromer or prepolymer. Preferably, the total Si and attached O are present in the silicone-containing component in an amount greater than about 20 weight percent, and more preferably greater than 30 weight percent of the total molecular weight of the silicone-containing component. Useful silicone-containing components preferably comprise polymerizable functional groups such as acrylate, methacrylate, acrylamide, methacrylamide, vinyl, N-vinyl lactam, N-vinylamide, and styryl functional groups.

Suitable silicone containing components include compounds of Formula I



where

R^1 is independently selected from monovalent reactive groups, monovalent alkyl groups, or monovalent aryl groups, any of the foregoing which may further comprise functionality selected from hydroxy, amino, oxa, carboxy, alkyl carboxy, alkoxy, amido, carbamate, carbonate, halogen or combinations thereof; and monovalent siloxane chains comprising 1-100 Si-O repeat units which may further comprise functionality selected from alkyl, hydroxy, amino, oxa, carboxy, alkyl carboxy, alkoxy, amido, carbamate, halogen or combinations thereof;

where b = 0 to 500, where it is understood that when b is other than 0, b is a distribution having a mode equal to a stated value; wherein at least one R^1 comprises a monovalent reactive group, and in some examples between one and 3 R^1 comprise monovalent reactive groups.

As used herein "monovalent reactive groups" are groups that can undergo free radical and/or cationic polymerization. Non-limiting examples of free radical reactive groups include (meth)acrylates, styryls, vinyls, vinyl ethers, C_{1-6}alkyl(meth)acrylates, (meth)acrylamides, C_{1-6}alkyl(meth)acrylamides, N-vinyllactams, N-vinylamides, C_{2-12}alkenyls, C_{2-12}alkenylphenyls, C_{2-12}alkenylnaphthyls, C_{2-6}alkenylphenylC_{1-6}alkyls, O-vinylcarbamates and O-vinylcarbonates. Non-limiting examples of cationic reactive groups include vinyl ethers or epoxide groups and mixtures thereof. In one embodiment the free radical reactive groups comprises (meth)acrylate, acryloxy, (meth)acrylamide, and mixtures thereof.

Suitable monovalent alkyl and aryl groups include unsubstituted monovalent C_1 to C_{16}alkyl groups, C_6-C_{14} aryl groups, such as substituted and unsubstituted methyl, ethyl, propyl, butyl, 2-hydroxypropyl, propoxypropyl, polyethyleneoxypropyl, combinations thereof and the like.

In one example b is zero, one R^1 is a monovalent reactive group, and at least 3 R^1 are selected from monovalent alkyl groups having one to 16 carbon atoms, and in another example from monovalent alkyl groups having one to 6 carbon atoms. Non-limiting examples of silicone components include 2-methyl-,2-hydroxy-3-[3-[1,3,3,3-tetramethyl-1-[(trimethylsilyl)oxy]disiloxanyl]propoxy]propyl ester ("SiGMA"),
2-hydroxy-3-methacryloxypropyloxypropyl-tris(trimethylsiloxy)silane,
3-methacryloxypropyltris(trimethylsiloxy)silane ("TRIS"),
3-methacryloxypropylbis(trimethylsiloxy)methylsilane and

3-methacryloxypropylpentamethyl disiloxane.

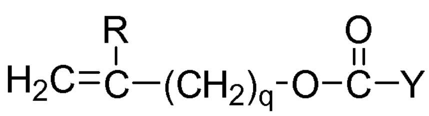
In another example, b is 2 to 20, 3 to 15 or 3 to 10; at least one terminal R^1 comprises a monovalent reactive group and the remaining R^1 are selected from monovalent alkyl groups having 1 to 16 carbon atoms, and in another example from monovalent alkyl groups having 1 to 6 carbon atoms. In yet another example, b is 3 to 15, one terminal R^1 comprises a monovalent reactive group, the other terminal R^1 comprises a monovalent alkyl group having 1 to 6 carbon atoms and the remaining R^1 comprise monovalent alkyl group having 1 to 3 carbon atoms. Non-limiting examples of silicone components include (mono-(2-hydroxy-3-methacryloxypropyl)-propyl ether terminated polydimethylsiloxane (400-1000 MW)) ("OH-mPDMS"), monomethacryloxypropyl terminated mono-n-butyl terminated polydimethylsiloxanes (800-1000 MW), (“mPDMS”).

In another example b is 5 to 400 or from 10 to 300, both terminal R^1 comprise monovalent reactive groups and the remaining R^1 are independently selected from monovalent alkyl groups having 1 to 18 carbon atoms which may have ether linkages between carbon atoms and may further comprise halogen.

In one example, where a silicone hydrogel lens is desired, the lens will be made from a reactive mixture comprising at least about 20 and preferably between about 20 and 70%wt silicone containing components based on total weight of reactive monomer components from which the polymer is made.

In another example, one to four R^1 comprises a vinyl carbonate or carbamate of the formula:

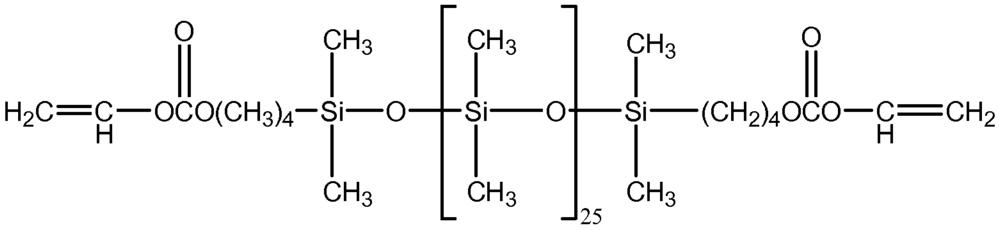
Formula II



wherein: Y denotes O-, S- or NH-;

R denotes, hydrogen or methyl; d is 1, 2, 3 or 4; and q is 0 or 1.

The silicone-containing vinyl carbonate or vinyl carbamate monomers specifically include: 1,3-bis[4-(vinyloxycarbonyloxy)but-1-yl]tetramethyl-disiloxane; 3-(vinyloxycarbonylthio) propyl-[tris (trimethylsiloxy)silane]; 3-[tris(trimethylsiloxy)silyl] propyl allyl carbamate; 3-[tris(trimethylsiloxy)silyl] propyl vinyl carbamate; trimethylsilylethyl vinyl carbonate; trimethylsilylmethyl vinyl carbonate, and



Where biomedical devices with modulus below about 200 are desired, only one R^1 shall comprise a monovalent reactive group and no more than two of the remaining R^1 groups will comprise monovalent siloxane groups.

Another class of silicone-containing components includes polyurethane macromers of the following formulae:

Formulae IV-VI

$(*D*A*D*G)_a$ $*D*D*E^1$;

$E(*D*G*D*A)_a$ $*D*G*D*E^1$ or;

$E(*D*A*D*G)_a$ $*D*A*D*E^1$

wherein:

D denotes an alkyl diradical, an alkyl cycloalkyl diradical, a cycloalkyl diradical, an aryl diradical or an alkylaryl diradical having 6 to 30 carbon atoms,

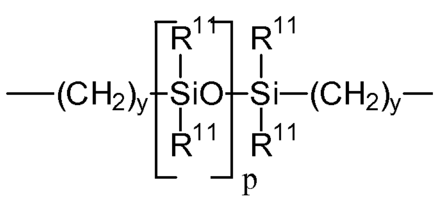
G denotes an alkyl diradical, a cycloalkyl diradical, an alkyl cycloalkyl diradical, an aryl diradical or an alkylaryl diradical having 1 to 40 carbon atoms and which may contain ether, thio or amine linkages in the main chain;

* denotes a urethane or ureido linkage;

$_a$ is at least 1;

A denotes a divalent polymeric radical of formula:

Formula VII



R^{11} independently denotes an alkyl or fluoro-substituted alkyl group having 1 to10 carbon atoms which may contain ether linkages between carbon atoms; y is at least 1;

and p provides a moiety weight of 400 to 10,000; each of E and E^1 independently denotes a polymerizable unsaturated organic radical represented by formula:

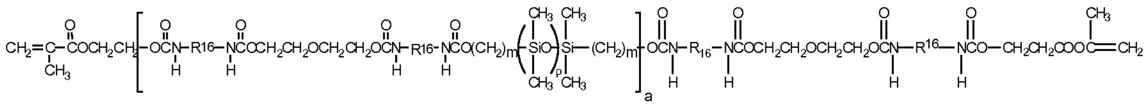
Formula VIII

$$R^{13}CH{=}\overset{\overset{\displaystyle R^{12}}{|}}{C}{-}(CH_2)_w{-}(X)_x{-}(Z)_z{-}(Ar)_y{-}R^{14}{-}$$

wherein: R^{12} is hydrogen or methyl; R^{13} is hydrogen, an alkyl radical having 1 to 6 carbon atoms, or a —CO—Y—R^{15} radical wherein Y is —O—,Y—S— or —NH—; R^{14} is a divalent radical having 1 to 12 carbon atoms; X denotes —CO— or —OCO—; Z denotes —O— or —NH—; Ar denotes an aromatic radical having 6 to 30 carbon atoms; w is 0 to 6; x is 0 or 1; y is 0 or 1; and z is 0 or 1.

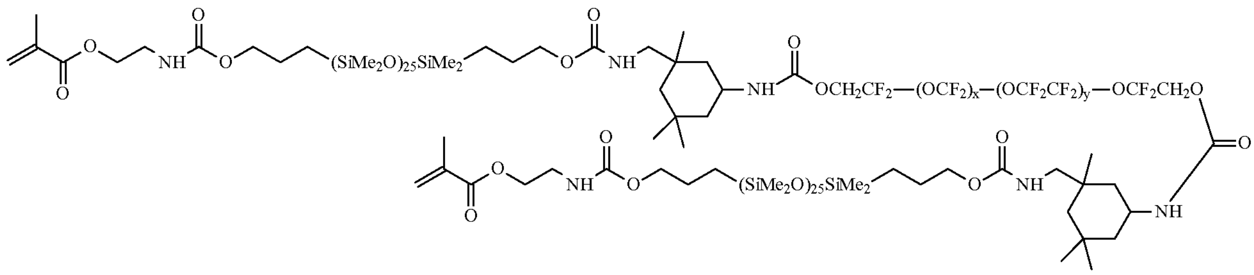
A preferred silicone-containing component is a polyurethane macromer represented by the following formula:

Formula IX



wherein R^{16} is a diradical of a diisocyanate after removal of the isocyanate group, such as the diradical of isophorone diisocyanate. Another suitable silicone containing macromer is compound of formula X (in which x + y is a number in the range of 10 to 30) formed by the reaction of fluoroether, hydroxy-terminated polydimethylsiloxane, isophorone diisocyanate and isocyanatoethylmethacrylate.

Formula X



Other silicone containing components suitable for use in this invention include macromers containing polysiloxane, polyalkylene ether, diisocyanate, polyfluorinated hydrocarbon, polyfluorinated ether and polysaccharide groups; polysiloxanes with a polar fluorinated graft or side group having a hydrogen atom attached to a terminal difluoro-substituted carbon atom; hydrophilic siloxanyl methacrylates containing ether and siloxanyl linkanges and crosslinkable monomers containing polyether and polysiloxanyl groups. Any of the foregoing polysiloxanes can also be used as the silicone containing component in this invention.

Processes

The following method steps are provided as examples of processes that may be implemented according to some aspects of the present invention. It should be understood that the order in which the method steps are presented is not meant to be limiting and other orders may be used to implement the invention. In addition, not all of the steps are required to implement the present invention and additional steps may be included in various examples of the present invention.

Referring now to Fig. 4, a flowchart illustrates steps that may be used to implement the present invention, at 401 an Energy Source is placed on to a Media Insert. The Media Insert may or may not also contain one or more components.

At 402, a reactive monomer mix can be deposited into a first mold part.

At 403, the Media Insert is placed into a cavity formed by the first mold part. The Media Insert 111 may be placed in the mold part 101-102 via mechanical placement. Mechanical placement can include, for example, a robot or other automation, such as those known in the industry to place surface mount components. Human placement of a Media Insert 111 is also within the scope of the present invention. Accordingly, any mechanical placement effective to place a Media Insert 111 with an Energy Source 109 within a cast mold part such that the polymerization of a Reactive Mixture 110 contained by the mold part will include the Energy Source 109 in a resultant ophthalmic lens.

A processor device, MEMS, NEMS or other component may also be mounted on the Media Insert and be in electrical communication with the Energy Source.

At 404, the first mold part can be placed proximate to the second mold part to form a lens forming cavity with at least some of the reactive monomer mix and the Energy Source in the cavity. At 405, the reactive monomer mix within the cavity can be polymerized. Polymerization can be accomplished for example via exposure to one or both of actinic radiation and heat. At 406, the lens is removed from the mold parts.

Although invention may be used to provide hard or soft contact lenses made of any known lens material, or material suitable for manufacturing such lenses, preferably, the lenses of the invention 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 of the invention 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 again to Fig 4, at 402, a reactive mixture is placed between a first mold part and a second mold part and at 403, the Media Insert is positioned in contact with the reactive mixture. At 404, the first mold part is placed proximate to a second mold part to form a lens cavity with the reactive monomer mix and the media in the lens cavity.

At 405, the reactive mixture is polymerized, such as for example via exposure to one or both of actinic radiation and heat. At 406, an ophthalmic device incorporating the Media Insert and Energy Source is removed from the mold parts used to form the ophthalmic device.

Referring now to Fig. 5, in another aspect of the present invention, a Media Insert incorporated into an ophthalmic device can be powered via an incorporated Energy Source. At 501, a Media Insert is placed within an ophthalmic lens, as discussed above. At 502, the Media Insert is placed in electrical communication with a component incorporated into the Media Insert or otherwise included in the ophthalmic lens 105. Electrical communication can be accomplished, for example, via circuitry incorporated into the Media Insert or via pathways ink jetted or otherwise formed directly upon lens material.

At 503, energy is directed to a component incorporated into the ophthalmic lens. The energy can be directed, for example, via electrical circuitry capable of conducting the electrical charge. At 504 the component performs some action based upon the energy directed to the component. The action can include a mechanical action affecting the lens or some action processing information including one or more of: receiving, transmitting, storing and manipulating information. Examples will include the information being processed and stored as digital values.

At 505, information may be transmitted from a component incorporated into the lens.

Apparatus

Referring now to Fig. 3, automated apparatus 310 is illustrated with one or Media Insert 314 transfer interfaces 311. As illustrated, multiple mold parts, each with an associated Media Insert 314 are contained on a pallet 313 and presented to a media transfer interfaces 311. Examples may include a single interface individually placing Media Inserts 314, or multiple interfaces (not shown) simultaneously placing Media Inserts 314 in multiple mold parts, and in some examples, in each mold.

Another aspect includes an apparatus to support the Media Insert 314 while the body of the ophthalmic lens is molded around these components. The Energy Source may be affixed to holding points in a lens mold (not illustrated). The holding points may be affixed with polymerized material of the same type that will be formed into the lens body.

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

The processors 610 are 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: automation used in the placement of a media with an Energy Source into the ophthalmic lens mold part and the transfer of digital data to and from a component mounted on the media and placed within an ophthalmic lens mold part or to control a component incorporated into the ophthalmic lens.

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 (*e.g.*, magnetic tape and hard disk drives), 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 a software program 640, and thereby operates in accordance with the present invention. For example, the processor 610 may receive information descriptive of Media Insert placement, component placement, and the like. The storage device 630 can also store ophthalmic related data in one or more databases 650 and 660. The database may include customized Media Insert designs, metrology data, and specific control sequences for controlling energy to and from a Media Insert.

Referring to Fig. 7, a top down depiction of a Media Insert 700 is shown. In this depiction, an Energy Source 710 is shown in a periphery portion 711 of the Media Insert 700. The Energy Source 710 may include, for example, a thin film, rechargeable lithium ion battery. The Energy Source 710 may be connected to contact points 714 to allow for interconnection. Wires may be wire bound to the contact points 714 and connect the Energy Source 710 to a photoelectric cell 715 which may be used to reenergize the battery Energy Source 710. Additional wires may connect the Energy Source 710 to a flexible circuit interconnect via wire bonded contact.

The Media Insert 700 may include a flexible substrate. This flexible substrate may be formed into a shape approximating a typical lens form in a similar manner previously discussed. However to add additional flexibility, the Media Insert 700 may include additional shape features such as radial cuts along its length. Various electronic components 712 such as integrated circuits, discrete components, passive components and such devices may also be included.

An optic zone 713 is also illustrated. The optic zone may be optically passive with no optical change, or it may have a predetermined optical characteristic, such as a predefined optical correction. Still other examples lenses include an optical zone with a variable optic component that may be varied on command.

Referring now to Fig. 8, a cross sectional of a Media Insert 800 is illustrated. The Media Insert 800 can include an optic zone 830 as discussed above and also one or more periphery portions 810-820. The media insert and components may be placed within the periphery portions 810-820.

In some examples there may be manners of affecting the ophthalmic lens' appearance. Aesthetics of the thin film microbattery surface may be altered in various manners which demonstrate a particular appearance when embedded in the electroactive contact lens or shaped hydrogel article. For example, the thin film microbattery may be produced with aesthetically pleasing patterned and/or colored packaging materials which could serve to either give a muted appearance of the thin film microbattery or alternatively provide iris-like colored patterns, solid and/or mixed color patterns, reflective designs, iridescent designs, metallic designs, or potentially any other artistic design or pattern. In other examples, the thin film battery may be partially obscured by other components within the lens, for example a photovoltaic chip mounted to the battery anterior surface, or alternatively placement of the battery behind all or a portion of a flexible circuit. Furthermore, the thin film battery may be strategically located such that either the upper or lower eyelid partially or wholly obscures the visibility of the battery. It may be apparent to one skilled in the art that there are numerous examples relating to the appearance of an energized ophthalmic device and the methods to define them.

There may be numerous examples relating to the method of forming an energized ophthalmic device of the various types that have been described. In one set of examples, described herein may include assembling subcomponents of a particular energized ophthalmic lens in separate steps. The "off-line" assembly of advantageously shaped thin film microbatteries, flexible circuits, interconnects, microelectronic components, and/or other electroactive components in conjunction with a biocompatible, inert, conformal coating to provide an all-inclusive, embeddable singular package that can be simply incorporated into standard contact lens manufacturing processes. Flexible circuits may include those fabricated from copper clad polyimide film or other similar substrates. Conformal coatings may include, but are not limited to, parylene (grades N, C, D, HT, and any combinations thereof), poly(p-xylylene), dielectric coatings, silicone conformal coatings, or any other advantageous biocompatible coatings.

Some examples of the present invention may be methods that are directed toward the geometric design of thin film microbatteries in geometries amenable to the embedment within and/or encapsulation by ophthalmic lens materials. Other examples may involve methods that incorporate thin film microbatteries in various materials such as, but not limited to, hydrogels, silicone hydrogels, rigid gas-permeable “RGP” contact lens materials, silicones, thermoplastic polymers, thermoplastic elastomers, thermosetting polymers, conformal dielectric/insulating coatings, and hermetic barrier coatings.

Other examples may involve methods for the strategic placement of an Energy Source within an ophthalmic lens geometry. Specifically, the Energy Source may be an opaque article. Since the Energy Source may not obstruct the transmission of light through the ophthalmic lens, methods of design may ensure that the central 5-8 mm of the contact lens may not be obstructed by any opaque portions of the Energy Source. It may be apparent to one skilled in the art that there may be many different embodiments relating to the design of various Energy Sources to interact favorably with the optically relevant portions of the ophthalmic lens.

The mass and density of the Energy Source may facilitate designs such that said Energy Source may also function either alone or in conjunction with other lens stabilization zones designed into the body of the ophthalmic lens to rotationally stabilize the lens while on eye. Such examples could be advantageous for a number of applications including, but not limited to, correction of astigmatism, improved on-eye comfort, or consistent/controlled location of other components within the energized ophthalmic lens.

In addition, the Energy Source may be placed a certain distance from the outer edge of the contact lens to enable advantageous design of the contact lens edge profile in order to provide good comfort while minimizing occurrence of adverse events. Examples of such adverse events to be avoided may include superior epithelial arcuate lesions or giant papillary conjunctivitis.

By way of non-limiting example, a cathode, electrolyte and anode features of embedded electrochemical cells may be formed by printed appropriate inks in shapes to define such cathode, electrolyte and anode regions. It may be apparent that batteries thus formed could include both single use cells, based for example on manganese oxide and zinc chemistries, and rechargeable thin batteries based on lithium chemistry similar to the above mentioned thin film battery chemistry. It may be apparent to one skilled in the arts that a variety of different examples of the various features and methods of forming energized ophthalmic lenses may involve the use of printing techniques.

In addition, energy harvesters may be included and placed in electrical communication in a fashion which enables the energy harvesters to charge one or more Energy Sources. Energy harvesters can include, for example: photovoltaic energy cells, thermoelectric cells or piezoelectric cells. Harvesters have a positive aspect in that they can absorb energy from the environment and then can provide electrical energy without an external wired connection. Harvesters may comprise an energy source in an energized ophthalmic lens. However, the energy harvester may be combined with other sources that can store energy in an electrical form.

Other types of Energy Source include the use of capacitor type devices. It may be apparent, that capacitors may provide an energy density solution that is higher than energy harvesters but less than that of batteries.

Capacitors are a type of Energy Source that stores energy in an electrical form and therefore, may be one of the Energy Sources that can be combined with energy harvesters to create a wireless Energy Source that is capable of storage of energy. Generally capacitors have an advantage over batteries in that they have higher power density, in general, than batteries. There are many different types of capacitors ranging from standard electrical thin film capacitors, Mylar capacitors, electrolytic capacitors and relative newer and more advanced technologies of high-density nanoscale capacitors or supercapacitors.

Additionally, Energy Sources including electrochemical cells or batteries may define a relatively desirable operational point. Batteries have numerous advantageous characteristics. For example, batteries store energy in a form that is directly converted to electrical energy. Some batteries may be rechargeable or Re-energizable and therefore, represent another category of Energy Source that may be coupled to energy harvesters. Batteries generally are capable of relatively high energy density, and the energy batteries store can perform functions with relatively higher energy requirements as compared with other miniaturized Energy Sources. In addition, the batteries can be assembled into forms that are flexible. For applications requiring high power capabilities, it may be apparent to one skilled in the art that a Battery may also be coupled to Capacitors. There may be numerous embodiments that comprise a battery at least as part of an Energy Source in an energized ophthalmic lens.

A fuel cell may be included as an Energy Source. Fuel cells generate electricity by consuming a chemical fuel source which then generates electricity and byproducts including heat energy. Fuel cell Energy Sources may be possible using biologically available materials as the fuel source.

There are many different types of batteries which may be included in energized ophthalmic lenses. For example, single use batteries may be formed from various cathode and anode materials. By way of non-limiting examples these materials may include one or more of: Zinc, carbon, Silver, Manganese, Cobalt, Lithium and Silicon. Still other examples may derive from the use of batteries that are rechargeable. Such batteries may in turn be made of one or more of: Lithium Ion technology; Silver Technology; Magnesium technology; Niobium technology or other current providing material. It may be apparent to one skilled in the art that various current battery technologies for single use or rechargeable battery systems may comprise the Energy Source of an energized ophthalmic lens.

The physical and dimensional constraints of a contact lens environment may be conducive to thin film batteries. Thin film batteries may occupy the small volume of space consistent with human ophthalmic examples. Furthermore, they may be formed upon a substrate that is flexible allowing for the body of both the ophthalmic lens and included battery with substrate to have freedom to flex.

In the case of thin film batteries, examples may include single charge and rechargeable forms. Rechargeable batteries afford the ability of extended usable product lifetime and, therefore, higher energy consumption rates. Much development activity has focused on the technology to produce electrically energized ophthalmic lenses with rechargeable thin film batteries; however, the invention is not limited to this subclass.

Rechargeable thin film batteries are commercially available, for example, Oak Ridge National Laboratory has produced various forms since the early 1990s. Current commercial producers of such batteries include Excellatron Solid State, LLC (Atlanta, GA), Infinite Power Solutions (Littleton, CO), and Cymbet Corporation, (Elk River, MN). The technology is currently dominated by uses that include flat thin film batteries. Use of such batteries may comprise forming the thin film battery into a three dimensional shape, for example with a spherical radius of curvature. Numerous shapes and forms of such a three dimensional battery are within the scope of the invention.

Stacked Integrated Component Media Inserts

The thin film batteries and/or the energized electronic elements may be included into the media insert in the form of stacked integrated components. Proceeding to Fig. 9, item 900, an illustration of a cross section of this type is provided in a non-limiting example. The media insert may include numerous layers of different types which are encapsulated into forms consistent with the ophthalmic environment that they will occupy. These inserts with stacked integrated component layers may assume the entire insert shapes as depicted in the various exemplary shapes in Fig 2A, 2B, 2C and 2D. Alternatively in some cases, the media insert may assume these shapes whereas the stacked integrated component may occupy just a portion of the volume within the entire shape.

Continuing with the example of item 900, a stacked integrated component media insert may assume numerous functional aspects. As shown in Fig. 9, the thin film batteries, may comprise one or more of the layers that are stacked upon each other, in this case layers 906 and 907 may represent the battery layers, with multiple components in the layers. One such battery component may be found as item 940. As can be seen in nearly all of the layers, there may be interconnections that are made between two layers that are stacked upon each other. In the state of the art there may be numerous manners to make these interconnections, however as demonstrated by items 930 and 931, the interconnection may be made through solder ball interconnections between the layers 907 and 908. In some cases only these connections may be required, however in other cases the solder balls may contact other interconnection elements, as for example with through layer vias. In the component in layer 907 which has interconnections 930 and 931, there may be a through substrate via in the body of the thin film battery component that passes electrical connection from one side of the component to another side. Some of these thru substrate components may then, on the alternative side of the substrate, make another interlayer connection to a layer above the component, as may be the case for component 940.

In other layers of the Stacked Integrated Component media insert, a layer dedicated to interconnection of various components in the interconnect layers may be found, as for example layer 905. This layer may contain vias and routing lines that pass signals from various components to others. For example, 905 may provide the various battery elements connections to a power management unit that may be present in the technology layer components of layer 904. As well the interconnection layer may make connections between components in the technology layer and also components outside the technology layer; as may exist for example in the Integrated Passive Device component shown as item 920. There may be numerous manners that routing of electrical signals may be supported by the presence of dedicated interconnect layers.

There are two features identified as technology layers, items 904 and 902. These features represent a diversity of technology options that may be included in media inserts. One of the layers may include CMOS, BiCMOS, Bipolar, or memory based technologies whereas the other layer may include a different technology. Alternatively, the two layers may represent different technology families within a same overall family; as for example layer 902 may include electronic elements produced using a 0.5 micron CMOS technology and layer 904 may include elements produced using a 20 nanometer CMOS technology. It may be apparent that many other combinations of various electronic technology types would be consistent within the art described herein.

Additional interconnection layers similar to layer 905 may be present. The additional layer may be another full layer of interconnection as depicted in item 903. Alternatively, the additional layer may be a portion of a stacked layer as shown in item 910. In some cases these additional elements may provide electrical interconnection, in others there may be structural interconnection performed by the presence of the layer. Both structural and electronic interconnection may be included between the various layers.

The media insert may include locations for electrical interconnections to components outside the insert as has been described previously. In other examples, however the media insert may also include interconnection to external components in a wireless manner. In such cases, the use of antennas may provide exemplary manners of wireless communication. A layer may exist, as shown as item 901, where such an exemplary antenna may be supported in the layer. In many cases, such an antenna layer may be located on the top or bottom of the stacked integrated component device within the media insert. As shown in item 908, it is possible for such a layer on the top or bottom to also not include an antenna for wireless communication and therefore act as a supporting substrate upon which the stacked device is produced.

In some of the examples discussed herein, the battery elements may be included as elements in at least one of the stacked layers themselves. It may be noted as well that other embodiments may be possible where the battery elements are located externally to the stacked integrated component layers. Still further a separate battery or other energization component may also exist within the media insert, or alternatively these separate energization components may also be located externally to the media insert.

Proceeding to Fig. 10, item 1000, a stacked integrated component media insert, item 1040, within an ophthalmic lens, item 1030, is depicted. The boundary of the media insert material is depicted by the feature labeled 1040. Within the bounds of the media insert, in this example, is located stacked integrated component layers depicted as item 1010. In some examples of this type, external to the media insert but within the ophthalmic lens, 1030, an electro active lens may be represented as item 1020. The control signals for the components within the lens may originate from a wireless signal as discussed earlier. And, the stacked component layers within the media insert may receive this wireless signal and in some cases adjust an electrical signal that is routed on wires that run externally to the media insert, 1040, connecting to the electroactive lens 1020. It may be apparent that there may be many alternatives to using and connecting a media insert which contains stacked integrated components within an ophthalmic lens and that may include stacked integrated components in devices other than ophthalmic lenses as well including in a non-limiting sense, energized biomedical devices of various kinds.

Various examples and aspects of the present invention are described below.

A method of forming a stacked integrated component media insert for an ophthalmic lens is provided. The method comprising: forming substrate layers with functionality; assembling the substrate layers; forming electrical interconnections between substrate layers; encapsulating the stacked feature with materials that may be bonded within the body of a molded ophthalmic lens.

One of the layers of the stacked integrated component media insert may comprise a solid state energy source.

The stacked integrated component media insert may comprise an annular shape.

The stacked integrated component media insert may comprise an arcuate shape.

The method may additionally comprise the step of placing a variable focus lens in proximity to the stacked integrated component media insert.

The variable focus lens may be fixed to the stacked integrated component media insert.

At least a portion of one or more of the layers may comprise an adhesive film.

Two or more layers may be adhered to one another through the adhesive film in at least a portion of one or more of the layers.

The stacked layers may be encapsulated with one or more materials that may be bonded within the body of an ophthalmic lens.

The one or more materials for encapsulation may comprise a polysilicone based polymer.

A layer may comprise a semiconductor substrate with electronic circuitry in proximity to its first surface.

The method may additionally comprise a layer with one or more substrate with layers for an electrochemical energizing component.

At least one layer within the stacked integrated component media insert may comprise a semiconductor layer with electronic circuitry capable to control electric current flow from the electrochemical cells.

The method may additionally comprise an electroactive lens component within the ophthalmic device.

The electronic circuitry may be electrically connected to the electroactive lens component within the ophthalmic device.

The layers may comprise one or more metallic layers which function as an antenna.

The substrate layers may be assembled into one of a circular annular shape or a portion of an annular shape.

The stacked functional layers may be adhered to insulating layers forming a stacked feature.

The integrated component layer insert may comprise one or more layers shaped into at least a portion of a circular annulus.

One or more layers may be electrically connected to a second layer with at least one solder ball located between them.

One or more layers may be electrically connected to a second layer with at least wire bond between a contact pad located between them.

A second stacked integrated component layer may be shaped into at least a portion of a circular annulus with an external radius that is smaller than that of the first layer.

One or more layers may comprise a metallic feature surface.

A solder film may be placed upon the surface of the one or more layers comprising a metallic feature.

A Stacked Integrated Component Layer Insert is provided. The Stacked Integrated Component Layer Insert comprising: substrate layers with functionality; wherein the substrate layers are assembled to form electrical interconnections between the substrate layers creating a stacked feature; wherein the stacked feature is encapsulated with materials that may be bonded within the body of a molded ophthalmic lens.

One of the layers of the stacked integrated component layer or media insert may comprise a solid state energy source.

The stacked integrated component layer or media insert may comprise an annular shape.

The stacked integrated component layer or media insert may comprise an arcuate shape.

The Stacked Integrated Component Layer Insert may additionally comprise placing a variable focus lens in proximity to the stacked integrated component layer or media insert.

The variable focus lens is fixed to the stacked integrated component layer or media insert.

At least a portion of one or more of the layers may comprise an adhesive film.

Two or more layers may be adhered to one another through the adhesive film in at least a portion of one or more of the layers.

The stacked layers may be encapsulated with one or more materials that may be bonded within the body of an ophthalmic lens.

One or more materials for encapsulation may comprise a polysilicone based polymer.

A layer may comprise a semiconductor substrate with electronic circuitry in proximity to its first surface.

The Stacked Integrated Component Layer Insert may additionally comprise a layer with one or more substrate with layers for an electrochemical energizing component.

At least one layer within the stacked integrated component layer or media insert may comprise a semiconductor layer with electronic circuitry capable to control electric current flow from the electrochemical cells.

The Stacked Integrated Component Layer Insert may additionally comprise an electroactive lens component within the ophthalmic device.

The electronic circuitry is electrically connected to the electroactive lens component within the ophthalmic device.

The layers may comprise one or more metallic layers which function as an antenna.

The substrate layers may be assembled into one of a circular annular shape or a portion of an annular shape.

The stacked functional layers may be adhered to insulating layers forming a stacked feature.

The integrated component layer insert may comprise one or more layers shaped into at least a portion of a circular annulus.

One or more layers may be electrically connected to a second layer with at least one solder ball located between them.

One or more layers may be electrically connected to a second layer with at least wire bond between a contact pad located between them.

A second stacked integrated component layer may be shaped into at least a portion of a circular annulus with an external radius that is smaller than that of the first layer.

One or more layers may comprise a metallic feature surface.

A solder film may be placed upon the surface of the one or more layers comprising a metallic feature.

An apparatus for manufacturing a stacked integrated component media insert is described. The apparatus comprising: a rigid protruding surface in a generally conical shape; shelves along the edges of the protruding surface operant to support the placement of thin layers upon the exposed surface of the shelves; and alignment features along the aximuth of the conical shaped protruding surface.

At least a portion of the surface of the protruding surface may have been coated with a non adherent surface film.

The non-adherent surface film may be a Teflon formulation.

The apparatus may additionally comprise automation for handling to place layered pieces upon the protruding surface.

The apparatus may additionally comprise: a processor for controlling the automation; a digital storage device comprising software, executable upon demand, said software operative with the processor to place the functionalized layer insert into a mold part.

The processor may be capable of receiving programmed command sets from a network in logical connection with said processor.

<u>Conclusion</u>

As described above and as further defined by the claims below, there is provided methods of forming Media Inserts, media inserts and apparatus for performing such methods, as well as ophthalmic lenses formed with the Media Inserts.

CLAIMS

1. A method of forming a stacked integrated component media insert for an ophthalmic lens, the method comprising:

forming substrate layers with functionality;

assembling the substrate layers;

forming electrical interconnections between substrate layers; and

encapsulating the stacked feature with a material for bonding within the body of a molded ophthalmic lens.

2. The method of Claim 1, wherein the substrate layers are assembled into one of a circular annular shape or a portion of an annular shape.

3. The method of Claim 1 or 2, wherein the stacked functional layers are adhered to insulating layers forming a stacked feature.

4. The method of any preceding claim, wherein a second stacked integrated component layer is shaped into at least a portion of a circular annulus with an external radius that is smaller than that of the first layer.

5. The method of any preceding claim, wherein one or more layers comprise a metallic feature surface.

6. The method of Claim 5, wherein solder film is placed upon the surface of the one or more layers comprising a metallic feature.

7. The method of any preceding claim, comprising arranging a battery on the stacked integrated component media insert, wherein the battery is chargeable via one or more of radio frequency and magnetic inductance.

8. The method of any preceding claim, comprising arranging a thin film battery on the stacked integrated component media insert and altering the surface of the battery to define the appearance of the battery.

9. The method of any preceding claim, wherein the substrate layers are flexible.

10. A method comprising the steps of forming a stacked integrated component media insert according to any one of Claims 1 to 9 and bonding the media insert in an ophthalmic lens.

11. A stacked integrated component layer insert comprising:

substrate layers with functionality; wherein the substrate layers are assembled to form electrical interconnections between the substrate layers creating a stacked feature;

wherein the stacked feature is encapsulated with a material for bonding within the body of a molded ophthalmic lens.

12. The stacked integrated component layer insert of Claim 11, wherein the substrate layers are assembled into one of a circular annular shape or a portion of an annular shape.

13. The stacked integrated component layer insert of Claim 11 or 12, wherein the stacked functional layers are adhered to insulating layers forming a stacked feature.

14. The stacked integrated component layer insert of any one Claims 11, 12 or 13, wherein a second stacked integrated component layer is shaped into at least a portion of a circular annulus with an external radius that is smaller than that of the first layer.

15. The stacked integrated component layer insert of any one of Claims 11, 12 or 13, wherein one or more layers comprise a metallic feature surface.

16. The stacked integrated component layer Insert of Claim 15, wherein solder film is placed upon the surface of the one or more layers comprising a metallic feature.

17. The stacked integrated component layer insert of any one of Claims 11, 12, 13 14, 15 or 16, comprising a battery, wherein the battery is configured to be chargeable via one or more of radio frequency and magnetic inductance.

18. The stacked integrated component layer insert of any one of Claims 11, 12, 13 14, 15 16 or 17, comprising a thin film battery, wherein the surface of the battery is configured to define a predetermined appearance.

19. The stacked integrated component layer insert of any one of Claims 11, 12, 13 14, 15, 16, 17 or 18, wherein the substrate layers are flexible.

20. An ophthalmic lens comprising a stacked integrated component layer insert according to any one of Claims 11 to 19 bonded therein.

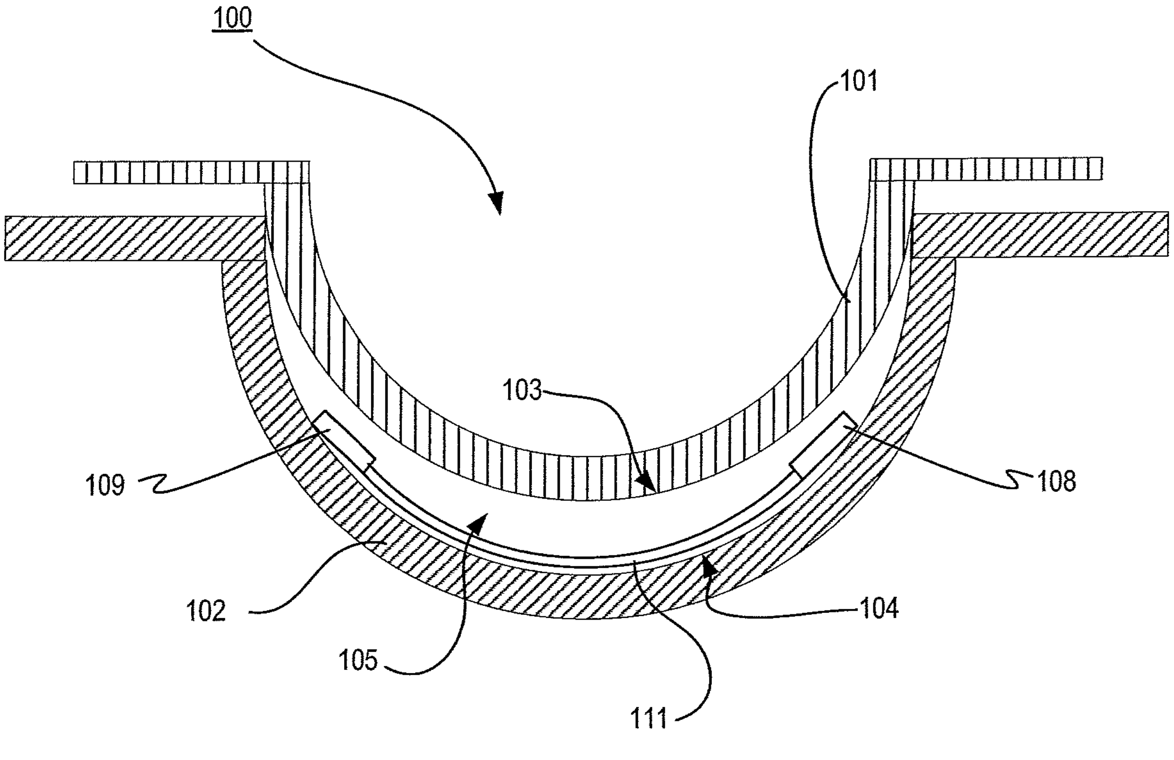


FIG. 1

FIG. 2A

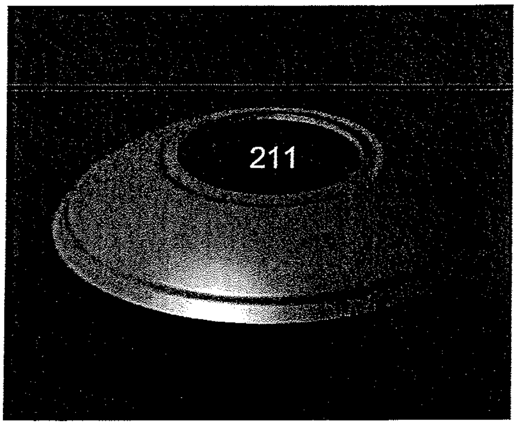
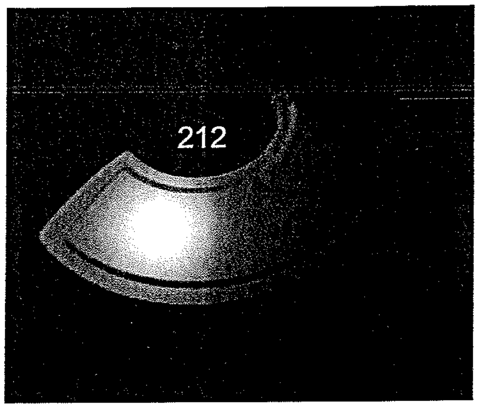


FIG. 2B



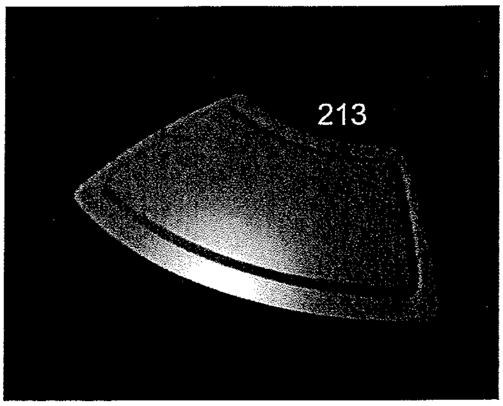


FIG. 2C

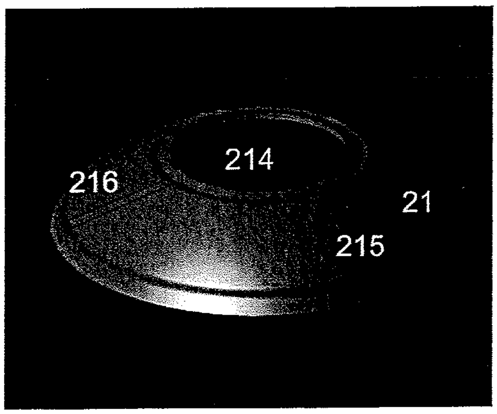


FIG. 2D

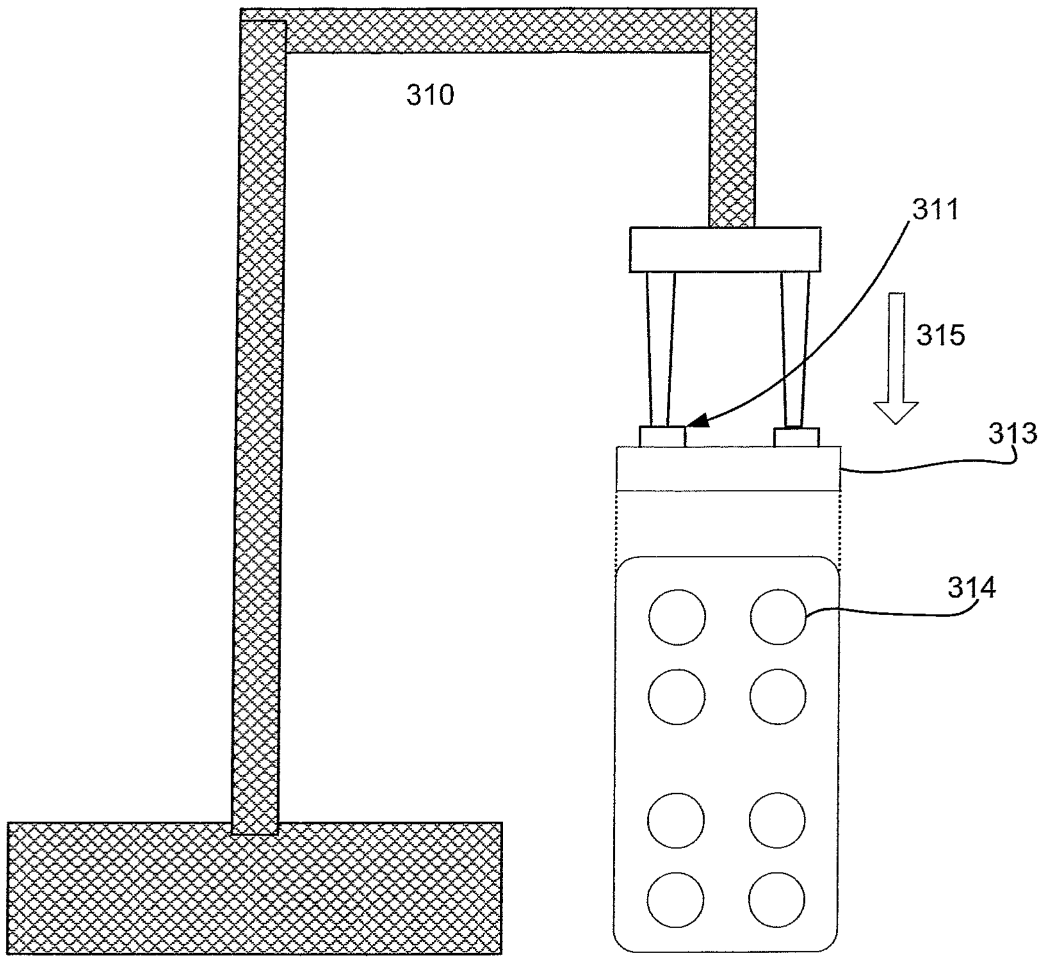


FIG. 3

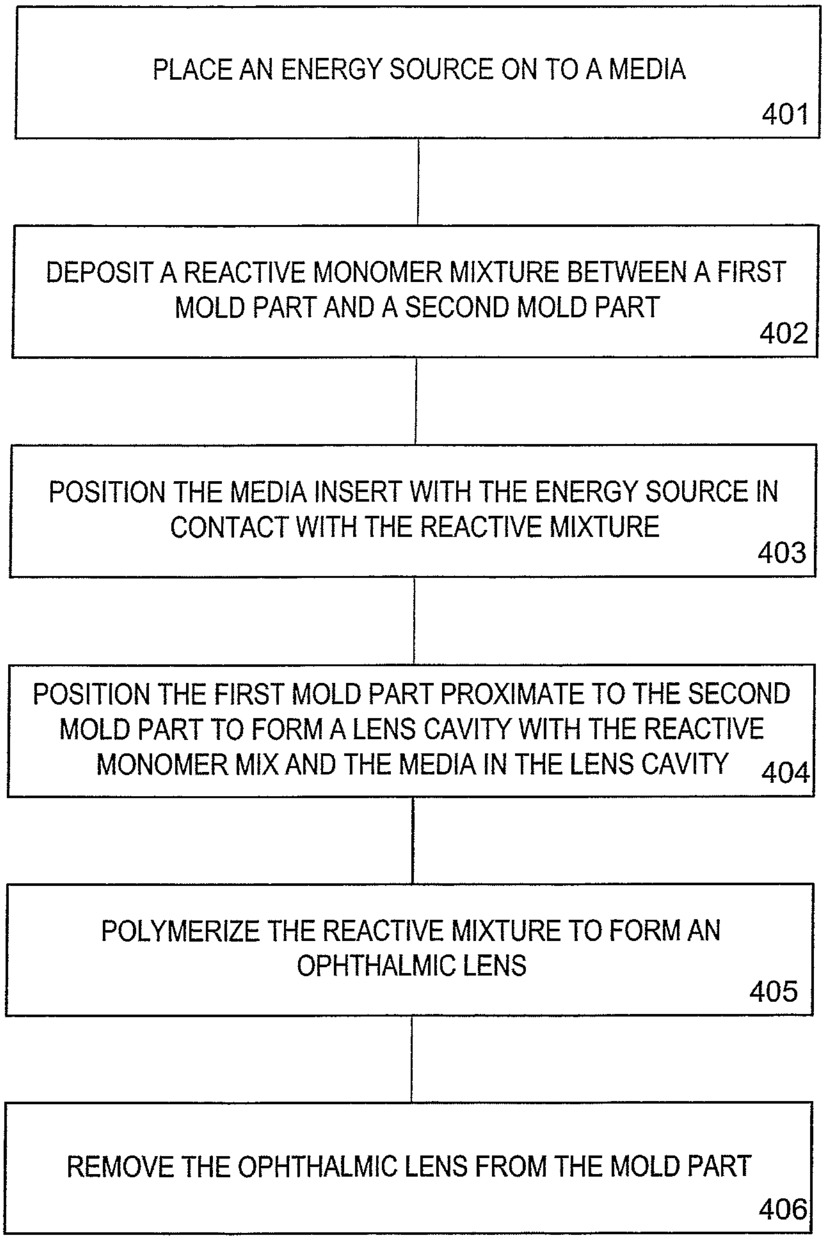

PLACE AN ENERGY SOURCE ON TO A MEDIA
401
DEPOSIT A REACTIVE MONOMER MIXTURE BETWEEN A FIRST MOLD PART AND A SECOND MOLD PART
402
POSITION THE MEDIA INSERT WITH THE ENERGY SOURCE IN CONTACT WITH THE REACTIVE MIXTURE
403
POSITION THE FIRST MOLD PART PROXIMATE TO THE SECOND MOLD PART TO FORM A LENS CAVITY WITH THE REACTIVE MONOMER MIX AND THE MEDIA IN THE LENS CAVITY
404
POLYMERIZE THE REACTIVE MIXTURE TO FORM AN OPHTHALMIC LENS
405
REMOVE THE OPHTHALMIC LENS FROM THE MOLD PART
406

FIG. 4

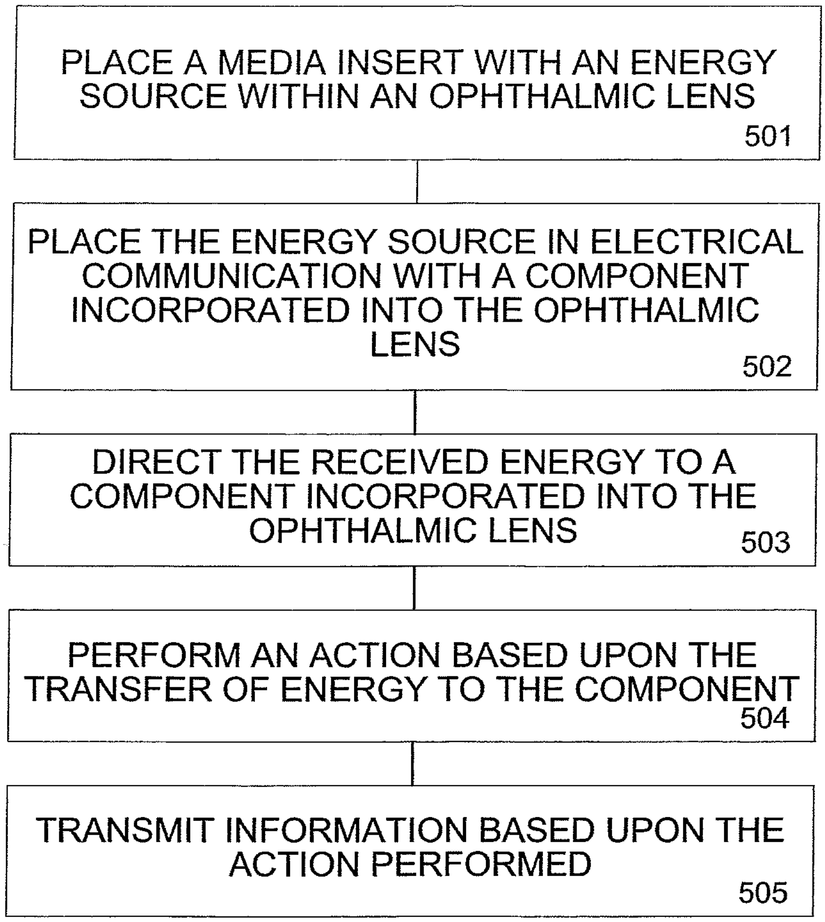

PLACE A MEDIA INSERT WITH AN ENERGY SOURCE WITHIN AN OPHTHALMIC LENS
501
PLACE THE ENERGY SOURCE IN ELECTRICAL COMMUNICATION WITH A COMPONENT INCORPORATED INTO THE OPHTHALMIC LENS
502
DIRECT THE RECEIVED ENERGY TO A COMPONENT INCORPORATED INTO THE OPHTHALMIC LENS
503
PERFORM AN ACTION BASED UPON THE TRANSFER OF ENERGY TO THE COMPONENT
504
TRANSMIT INFORMATION BASED UPON THE ACTION PERFORMED
505

FIG. 5

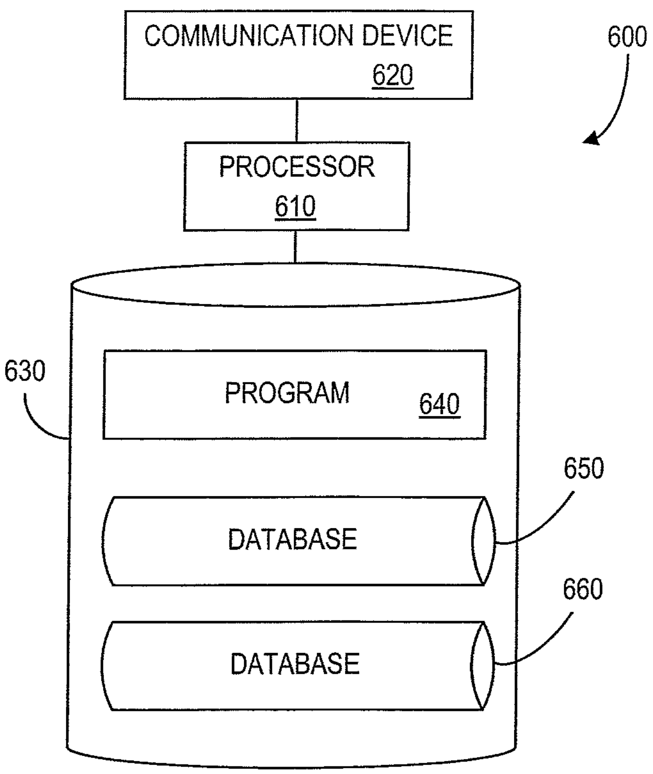

COMMUNICATION DEVICE
620
600
PROCESSOR
610
630
PROGRAM
640
650
DATABASE
660
DATABASE

FIG. 6

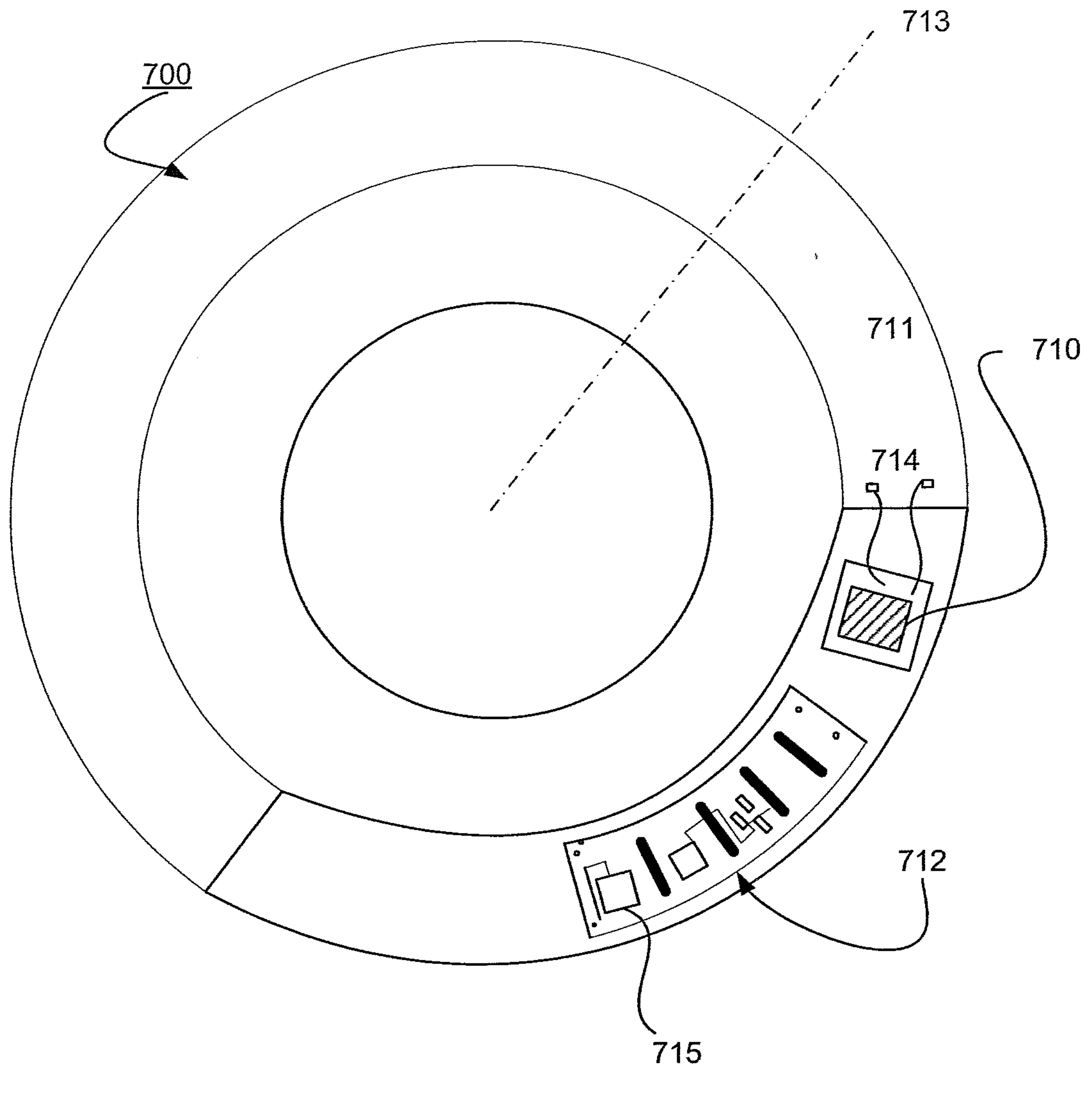


FIG. 7

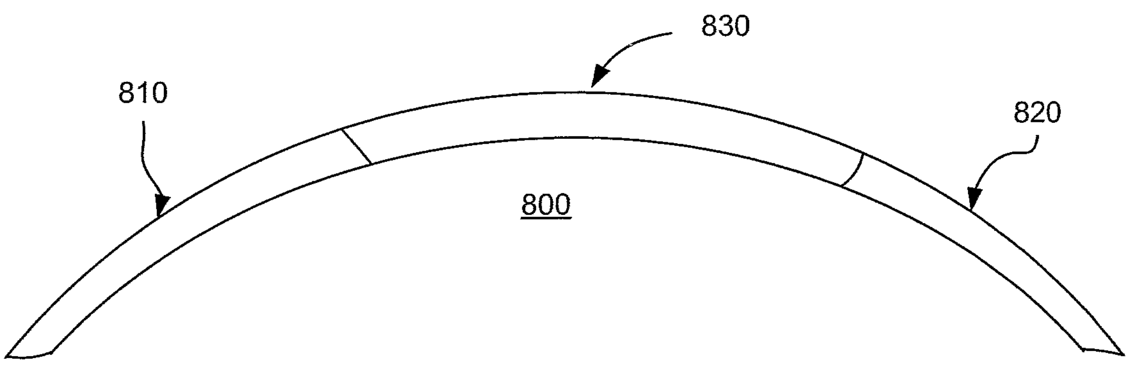


FIG. 8

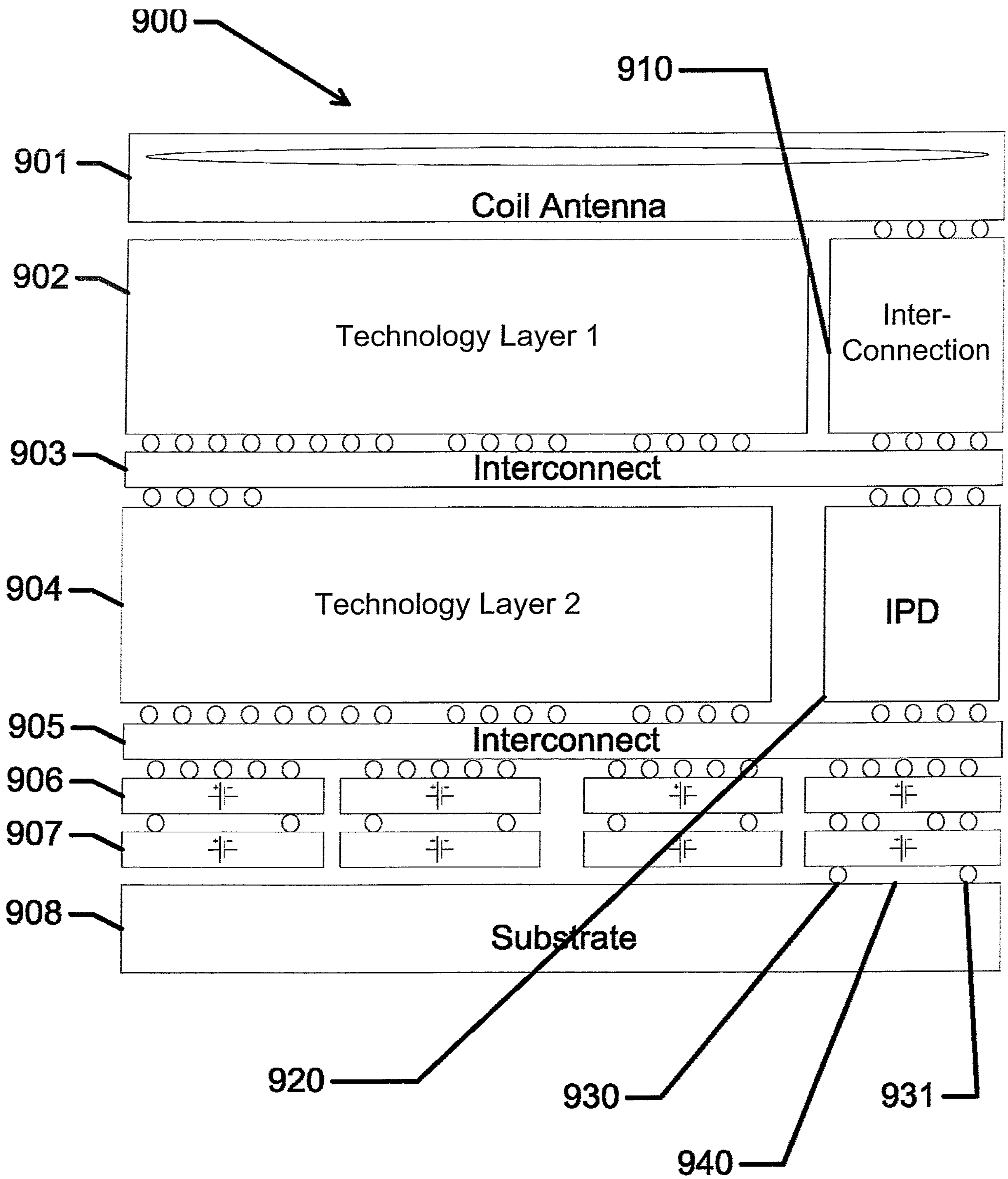

900
910
901
Coil Antenna
902
Technology Layer 1
Inter-
Connection
903
Interconnect
904
Technology Layer 2
IPD
905
Interconnect
906
907
908
Substrate
920
930
931
940

FIG. 9

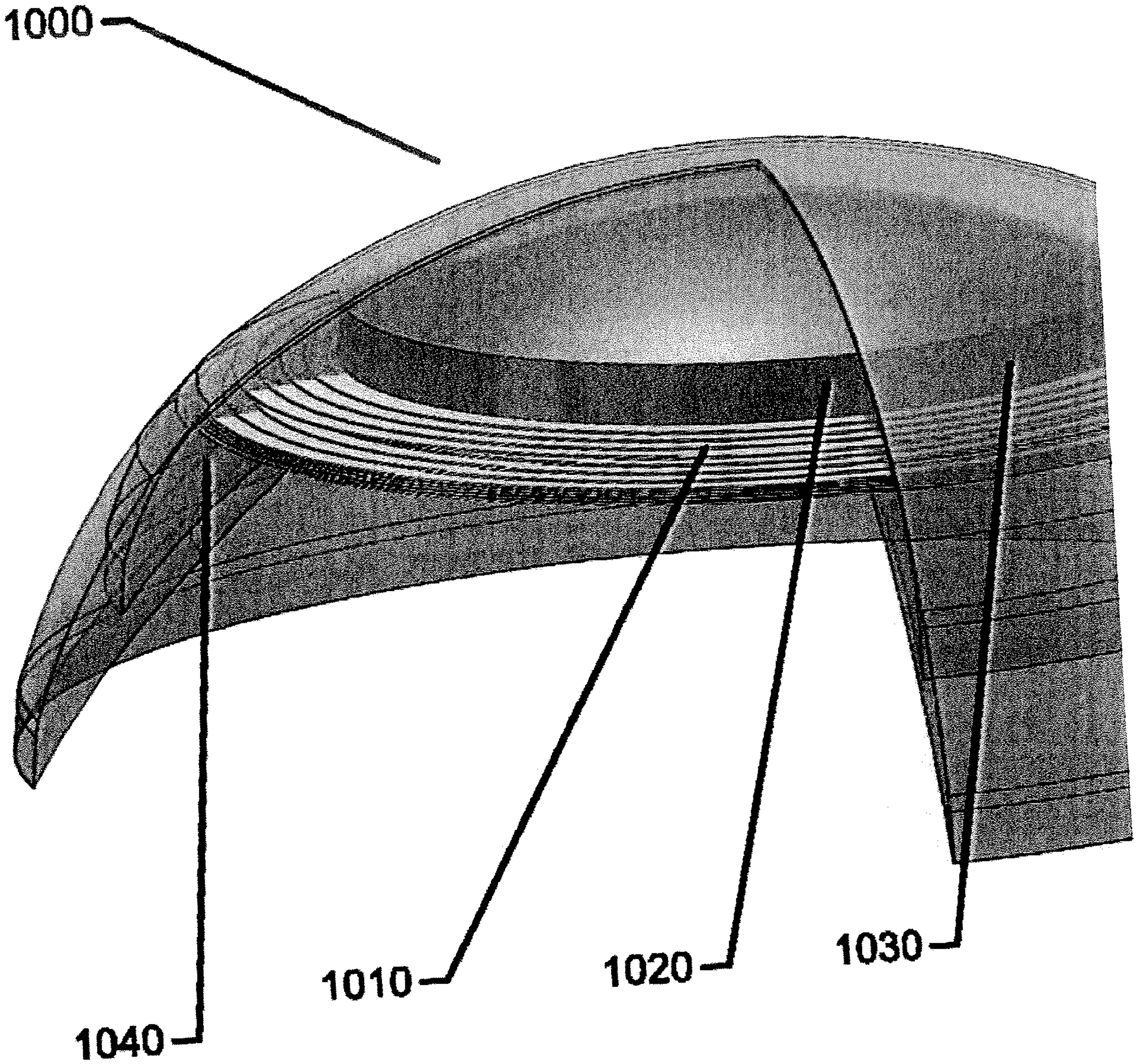


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/023182

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02C7/04 G02C7/08 H01L23/58
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02C H01L B29D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 760 515 A2 (INVISIA LTD [IL]) 7 March 2007 (2007-03-07) paragraph [0030] - paragraph [0060]; figures 1-11	1-20
X	US 2010/072643 A1 (PUGH RANDALL B [US] ET AL) 25 March 2010 (2010-03-25) paragraph [0017] - paragraph [0124]; figures 1-8	1-20
Y	WO 2010/051225 A1 (JOHNSON & JOHNSON VISION CARE [US]; PUGH RANDALL B [US]; OTTS DANIEL B) 6 May 2010 (2010-05-06) page 6, line 4 - page 24, line 13; figures 1-7	1-20

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 April 2013	29/04/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bratfisch, Knut

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/023182

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2010/079724 A1 (PUGH RANDALL B [US] ET AL) 1 April 2010 (2010-04-01) paragraph [0034] - paragraph [0099]; figures 1-8	1-20
Y	WO 2007/050402 A2 (MOTOROLA INC [US]; ADEWOLE HAKEEM B [US]; BRAZIS PAUL W [US]; DYRC GAB) 3 May 2007 (2007-05-03) paragraph [0016] - paragraph [0034]; figures 1-8	1-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2013/023182

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			CA 2737865	A1	25-03-2010
			CN 102159382	A	17-08-2011
			EP 2349698	A1	03-08-2011
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			KR 20110069113	A	22-06-2011
			TW 201024827	A	01-07-2010
			US 2010072643	A1	25-03-2010
			WO 2010033683	A1	25-03-2010
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			CN 102271899	A	07-12-2011
			EP 2349695	A1	03-08-2011
			JP 2012507748	A	29-03-2012
			KR 20110091713	A	12-08-2011
			TW 201029830	A	16-08-2010
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			WO 2010051225	A1	06-05-2010
US 2010079724	A1	01-04-2010	AR 076733	A1	06-07-2011
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			CA 2738865	A1	08-04-2010
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			EP 2328742	A1	08-06-2011
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			KR 20110075001	A	05-07-2011
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			TW 201026490	A	16-07-2010
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			WO 2007050402	A2	03-05-2007