Referring now to Fig. 4, an exemplary embodiment of an insert 455 with both a non-optic zone region and an optic zone region 465 is illustrated in a top down view. Some such embodiments may include elements that support battery-type energization elements, such as electrodes 475, 480, 485, 490 upon which the battery chemicals may be placed and encapsulated.

For example, a series combination of two alkaline cell pairs may be included around the periphery and electrically connected through an interconnecting element 466. These elements may be located in the non-optic zone region since the materials may absorb or scatter light. The non-optic zone region may also have electronic components, including circuit elements, which may be encapsulated within the insert body and connected to the energization elements 462. There may be other connections and electrodes that are made to the circuit element in various exemplary embodiments.

Free Form Methods of producing insert-containing ophthalmic lenses

Referring to Figs. 5A-5F, exemplary processing steps to form an ophthalmic lens containing an insert by use of aspects of voxel-based lithography free form methods are illustrated. In this exemplary embodiment, a specialized well 511 may be formed at step 510. The specialized well 511 may be formed through a variety of processes, including, thermoforming, molding, or three-dimensional printing. The specialized well 511 may include protruding support features 512, which may allow for the holding and placement of an insert piece that may be encapsulated within the ophthalmic lens. Other exemplary embodiments may include additional features 512 across the mold surface, but at least three protrusions 512, two of which are illustrated, may be useful to establish a hold position for the insert piece.

At step 520, the insert piece may be placed upon the protruding support features 512. In some exemplary embodiments, the support features 512 may be relatively sharp features that are designed to mate with features that are preformed into the insert body to allow for a preferred orientation. When the piece is in its designated location, the reservoir may be filled with reactive media as shown at step 530. In some alternative exemplary embodiments, mating may not be necessary, and the support features 512 may function as an alignment mechanism, wherein the support features 512 may allow for

CLAIMS

1. A method of forming an ophthalmic lens with an insert, the method comprising:

placing a forming optic in contact with a first reactive monomer mixture, wherein the forming optic comprises a forming surface with dimensions and curvature consistent with a back curve of an ophthalmic lens;

forming a first lens precursor by exposing the first reactive monomer mixture to actinic radiation, wherein the actinic radiation is configured to control polymerization on a voxel by voxel basis over the forming surface;

removing the forming optic and the lens precursor from contact with the first reactive monomer mixture, wherein the lens precursor comprises a first surface portion in contact with the forming optic, wherein the first surface portion comprises an optical quality surface, a second surface portion, the second surface portion comprising non-fluent polymerized material, and a third surface portion comprising non-voxel fluent partially polymerized material separate from the first reactive monomer mixture, wherein the third surface portion is located on a distal end of the lens precursor from the forming surface;

placing an insert proximate to the third surface portion, wherein the placing defines the location of the insert within the ophthalmic lens;

positioning the first lens precursor and the insert, wherein the positioning allows for the fluent partially polymerized material to flow onto at least a portion of the insert;

forming the ophthalmic lens by exposing the fluent partially polymerized material to actinic radiation; and

releasing the ophthalmic lens from the forming optic.

2. The method of Claim 1, wherein the fluent reactive monomer mixture is configured to promote adhesion between the insert and the first lens precursor.

3. The method of Claim 1, wherein the forming optic comprises a concave surface, wherein the first surface comprises a convex portion of the ophthalmic lens.

4. The method of Claim 1, wherein the forming optic comprises a convex surface, wherein the first surface comprises a concave portion of the ophthalmic lens.

5. The method of Claim 1, further comprising the method steps of:

placing the lens precursor and the insert in contact with a second reactive monomer mixture, wherein the reactive monomer mixture is capable of engulfing the insert into the first lens precursor;

forming a second lens precursor, wherein the second lens precursor comprises the first lens precursor and the insert, by exposing, in a path through the forming optic, the second reactive monomer mixture to the actinic radiation, wherein the second lens precursor comprises non-fluent polymerized material; and

removing the forming optic and second ophthalmic lens precursor from contact with the reactive monomer mixture.

6. The method of Claim 1, wherein the insert comprises a media insert, wherein the media insert comprises:

a power source;

an energizable element in electrical communication with the first processor and the power source, wherein the energizable element is configured to provide a functionality to the ophthalmic lens;

a first processor in electrical communication with the power source, wherein the processor comprises a first executable software, wherein the first executable software is configured to control the energizable element based on the set of programming parameters; and

conductive traces configured to allow electrical communication between the processor and the power source.

7. The method of Claim 5, wherein the placing the first lens precursor and the insert in contact with a second reactive monomer mixture comprises placing the lens precursor and the insert in proximity to a spraying mechanism, wherein the

spraying mechanism is configured to cause the second reactive monomer mixture to engulf the first lens precursor and insert.

8. The method of Claim 5, wherein the placing of the first lens precursor and the insert in contact with a second reactive monomer mixture comprises placing the first lens precursor and the insert in a bath of second reactive monomer mixture.

9. The method of Claim 6, wherein the energizable element further comprises a variable optic portion configured to provide a plurality of optic powers.

10. The method of Claim 9, wherein the variable optic portion comprises a liquid meniscus.

11. The method of Claim 9, wherein the variable optic portion comprises a liquid crystal.

12. A method of forming an ophthalmic lens, the method comprising:

placing the insert proximate to a specialized well, wherein the specialized well is configured to contain a reactive monomer mixture, and wherein after placement the insert is supported upon tabs that comprise the specialized well;

placing a forming optic proximate to the insert, wherein the forming optic comprises a forming surface with dimensions and curvature consistent with a back curve of an ophthalmic lens;

adding the reactive monomer mixture to the specialized well in a quantity sufficient to contact the forming surface and at least partially engulf the insert;

forming a lens precursor by exposing the reactive monomer mixture to actinic radiation through the forming optic, wherein the actinic radiation is configured to control polymerization on a voxel by voxel basis over the forming surface, and wherein the lens precursor comprises a first surface portion in contact with the forming optic, wherein the first surface portion comprises an optical quality surface, a second surface portion, wherein the second surface portion comprising non-fluent polymerized material, and a third surface portion comprising non-voxel fluent partially polymerized material separate from the first

reactive monomer mixture, wherein the third surface portion is located on a distal end of the lens precursor from the forming surface;

removing the forming optic, the insert, and the lens precursor from contact with the reactive monomer mixture, wherein the lens precursor comprises non-fluent polymerized material capable of securing the insert to the lens precursor;

forming the ophthalmic lens with the insert by exposing the fluent partially polymerized material to actinic radiation; and

removing the ophthalmic lens from the forming optic.

13. The method of Claim 12, wherein the forming optic comprises a concave surface, wherein the first surface comprises a convex portion of the ophthalmic lens.

14. The method of Claim 12, wherein the forming optic comprises a convex surface, wherein the first surface comprises a concave portion of the ophthalmic lens.

15. The method of Claim 12, wherein the insert is located between the second surface and the third surface.

16. The method of Claim 12, wherein the specialized well further comprises a plurality of holding features configured to stabilize a position of the insert within the specialized well.

17. The method of Claim 16, wherein the processing relating to the plurality of holding features creates depressions on the distal surface of the lens precursor, and the method further comprises the method steps of:

filling the depressions on the surface of the lens precursor by placing the ophthalmic lens precursor in contact with the reactive monomer mixture after separating the lens precursor from the holding features of the specialized well; and

creating a smooth surface of an ophthalmic lens by allowing the reactive monomer mixture to flow across the lens precursor surface and into the depressions and then exposing the reactive monomer mixture to a second actinic radiation.

18. A method of forming an ophthalmic lens, the method comprising:

placing a forming optic in contact with a reactive monomer mixture, wherein the forming optic comprises a forming surface with dimensions and curvature consistent with an ophthalmic lens;

forming a lens precursor form by exposing the reactive monomer mixture to actinic radiation, wherein the actinic radiation is configured to control polymerization on a voxel by voxel basis over the forming surface;

removing the forming optic and the lens precursor from contact with the bath of reactive monomer mixture, wherein the lens precursor comprises and a first surface portion in contact with the forming optic, wherein the first surface portion comprises an optical quality surface, a second surface portion, the second surface portion comprising non-fluent polymerized material, and a third surface portion comprising non-voxel fluent partially polymerized material separate from the first reactive monomer mixture, wherein the third surface portion is located on a distal end of the lens precursor from the forming surface;

releasing the first lens precursor from the forming optic into a holding fixture;

placing an insert proximate to the first surface, the second surface, or the third surface, wherein the placing allows for a region to be formed that may at least partially surround the insert with reactive monomer mixture during processing;

immersing the insert within a bath of the reactive monomer mixture, wherein the immersing occurs while the insert is in contact with the lens precursor in the holding fixture;

forming an ophthalmic lens with insert by exposing the reactive monomer mixture to actinic radiation; and

removing the ophthalmic lens from the bath.

19. The method of Claim 18, wherein the forming optic comprises a concave surface, wherein the first surface comprises a convex portion of the ophthalmic lens.

20. The method of Claim 18, wherein the forming optic comprises a convex surface, wherein the first surface comprises a concave portion of the ophthalmic lens.

21. The method of Claim 18, wherein one or both the second surface and the third surface comprises a surface aberration configured to accept the insert.

22. The method of Claim 18, further comprising the method steps of:

placing a second forming optic in proximity to the insert in the bath of reactive monomer mixture, wherein the forming optic comprises an optical quality forming surface in contact with the reactive monomer mixture; and

forming a second lens precursor by exposing the bath reactive monomer mixture to actinic radiation, wherein the actinic radiation is configured to control polymerization on a voxel by voxel basis over the forming surface, wherein the second lens precursor comprises a first surface portion in contact with the forming optic, wherein the first surface portion comprises an optical quality surface, a second surface portion, the second surface portion comprising non-fluent polymerized material, and a third surface portion comprising non-voxel fluent partially polymerized material separate from the first reactive monomer mixture, wherein the third surface portion is located on a distal end of the lens precursor from the forming surface.

23. The method of Claim 22, wherein the second forming optic comprises a curvature opposite to the first forming optic.

24. A method of forming an ophthalmic lens, the method comprising:

placing a forming optic in contact with a reactive monomer mixture, wherein the forming optic comprises a forming surface with dimensions and curvature consistent with a front curve of an ophthalmic lens;

forming a lens precursor form by exposing the reactive monomer mixture to actinic radiation, wherein the actinic radiation is configured to control polymerization on a voxel by voxel basis over the forming surface;

removing the forming optic and the lens precursor from contact with the reactive monomer mixture, wherein the lens precursor comprises a first surface

portion in contact with the forming optic, wherein the first surface portion comprises an optical quality surface, a second surface portion, the second surface portion comprising non-fluent polymerized material and located on the distal end of the forming surface, and a third surface portion comprising non-voxel fluent partially polymerized material separate from the reactive monomer mixture, wherein the third surface portion is located on a distal end of the lens precursor from the forming surface;

releasing the lens precursor from the forming optic, wherein the releasing places the lens precursor proximate to a front curve mold, wherein a surface portion of the lens precursor comprising a convex surface is in contact with the front curve mold;

placing an insert proximate to the second surface portion formed by the releasing, wherein the placement allows for at least a partial encapsulation of the insert within an ophthalmic lens;

depositing the reactive monomer mixture on a back curve portion of the insert;

placing a back curve mold proximate to the front curve mold, wherein the placement causes the reactive monomer mixture to engulf the insert and after further processing to encapsulate the insert into the lens precursor;

forming the ophthalmic lens by exposing the reactive monomer mixture to the actinic radiation, wherein the ophthalmic lens comprises the lens precursor and the insert; and

releasing the ophthalmic lens from the front curve mold and the back curve mold.

25. The method of Claim 24, wherein the forming optic comprises a concave surface, wherein the first surface comprises a convex portion of the ophthalmic lens.

26. The method of Claim 24, wherein the forming optic comprises a convex surface, wherein the first surface comprises a concave portion of the ophthalmic lens.

27. The method of Claim 24, wherein an injection molding mechanism is configured to deposit the reactive monomer mixture on the back curve portion of the insert.

28. The method of Claim 24, wherein the releasing comprises the steps of:

separating the front curve mold from the back curve mold, wherein the ophthalmic lens remains affixed to either the front curve mold or the back curve mold; and

placing the ophthalmic lens and the affixed front curve mold or the affixed back curve mold in a solution configured to dissolve the affixed front curve mold or the affixed back curve mold.

29. The method of Claim 24, wherein the releasing comprises the step of

placing the front curve mold, the back curve mold, and the ophthalmic lens in a solution configured to dissolve the front curve mold and the back curve mold.

30. The method of Claim 28, wherein the solution comprises an aqueous solution capable of hydrating the ophthalmic lens.

31. The method of Claim 29, wherein the solution comprises an aqueous solution capable of hydrating the ophthalmic lens.

32. A ophthalmic lens device comprising:

an insert; and

a soft lens portion comprising voxels of polymerized material, wherein the soft lens portion is in contact with at least a portion of the insert.

Referring now to Fig. 4, an exemplary embodiment of an insert 455 with both a non-optic zone region and an optic zone region 465 is illustrated in a top down view. Some such embodiments may include elements that support battery-type energization elements, such as electrodes 475, 480, 485, 490 upon which the battery chemicals may be placed and encapsulated.

For example, a series combination of two alkaline cell pairs may be included around the periphery and electrically connected through an interconnecting element 466. These elements may be located in the non-optic zone region since the materials may absorb or scatter light. The non-optic zone region may also have electronic components, including circuit elements, which may be encapsulated within the insert body and connected to the energization elements 462. There may be other connections and electrodes that are made to the circuit element in various exemplary embodiments.

Free Form Methods of producing insert-containing ophthalmic lenses

Referring to Figs. 5A-5F, exemplary processing steps to form an ophthalmic lens containing an insert by use of aspects of voxel-based lithography free form methods are illustrated. In this exemplary embodiment, a specialized well 511 may be formed at step 510. The specialized well 511 may be formed through a variety of processes, including, thermoforming, molding, or three-dimensional printing. The specialized well 511 includes protruding support features 512, which may allow for the holding and placement of an insert piece that may be encapsulated within the ophthalmic lens. Other exemplary embodiments may include additional features 512 across the mold surface, but at least three protrusions 512, two of which are illustrated, may be useful to establish a hold position for the insert piece.

At step 520, the insert piece may be placed upon the protruding support features 512. In some exemplary embodiments, the support features 512 may be relatively sharp features that are designed to mate with features that are preformed into the insert body to allow for a preferred orientation. When the piece is in its designated location, the reservoir may be filled with reactive media as shown at step 530. In some alternative exemplary embodiments, mating may not be necessary, and the support features 512 may function as an alignment mechanism, wherein the support features 512 may allow for

CLAIMS

1. A method of forming an ophthalmic lens with an insert, the method comprising:

placing a forming optic in contact with a first reactive monomer mixture, wherein the forming optic comprises a forming surface with dimensions and curvature consistent with a back curve of an ophthalmic lens;

forming a first lens precursor by exposing the first reactive monomer mixture to actinic radiation, wherein the actinic radiation is configured to control polymerization on a voxel by voxel basis over the forming surface;

removing the forming optic and the lens precursor from contact with the first reactive monomer mixture, wherein the lens precursor comprises a first surface portion in contact with the forming optic, wherein the first surface portion comprises an optical quality surface, a second surface portion, the second surface portion comprising non-fluent polymerized material, and a third surface portion comprising non-voxel fluent partially polymerized material separate from the first reactive monomer mixture, wherein the third surface portion is located on a distal end of the lens precursor from the forming surface;

placing an insert proximate to the third surface portion, wherein the insert comprises a media insert, wherein the media insert comprises:

a power source;

an energizable element in electrical communication with the first processor and the power source, wherein the energizable element is configured to provide a functionality to the ophthalmic lens;

a first processor in electrical communication with the power source, wherein the processor comprises a first executable software, wherein the first executable software is configured to control the energizable element based on the set of programming parameters; and

conductive traces configured to allow electrical communication between the processor and the power source; and

wherein the placing of the insert defines the location of the insert within the ophthalmic lens;

positioning the first lens precursor and the insert, wherein the positioning allows for the fluent partially polymerized material to flow onto at least a portion of the insert;

forming the ophthalmic lens by exposing the fluent partially polymerized material to actinic radiation; and

releasing the ophthalmic lens from the forming optic.

2. The method of Claim 1, wherein the fluent reactive monomer mixture is configured to promote adhesion between the insert and the first lens precursor.

3. The method of Claim 1, further comprising the method steps of:

placing the lens precursor and the insert in contact with a second reactive monomer mixture, wherein the reactive monomer mixture is capable of engulfing the insert into the first lens precursor;

forming a second lens precursor, wherein the second lens precursor comprises the first lens precursor and the insert, by exposing, in a path through the forming optic, the second reactive monomer mixture to the actinic radiation, wherein the second lens precursor comprises non-fluent polymerized material; and

removing the forming optic and second ophthalmic lens precursor from contact with the reactive monomer mixture.

4. The method of Claim 3, wherein the placing the first lens precursor and the insert in contact with a second reactive monomer mixture comprises placing the lens precursor and the insert in proximity to a spraying mechanism, wherein the spraying mechanism is configured to cause the second reactive monomer mixture to engulf the first lens precursor and insert.

5. The method of Claim 3, wherein the placing of the first lens precursor and the insert in contact with a second reactive monomer mixture comprises placing the first lens precursor and the insert in a bath of second reactive monomer mixture.

6. The method of Claim 1, wherein the energizable element further comprises a variable

optic portion configured to provide a plurality of optic powers.

7. The method of Claim 6, wherein the variable optic portion comprises a liquid meniscus.

8. The method of Claim 6, wherein the variable optic portion comprises a liquid crystal.

9. A method of forming an ophthalmic lens, the method comprising:

placing the insert proximate to a specialized well, wherein the specialized well is configured to contain a reactive monomer mixture, and wherein after placement the insert is supported upon tabs that comprise the specialized well;

placing a forming optic proximate to the insert, wherein the forming optic comprises a forming surface with dimensions and curvature consistent with a back curve of an ophthalmic lens;

adding the reactive monomer mixture to the specialized well in a quantity sufficient to contact the forming surface and at least partially engulf the insert;

forming a lens precursor by exposing the reactive monomer mixture to actinic radiation through the forming optic, wherein the actinic radiation is configured to control polymerization on a voxel by voxel basis over the forming surface, and wherein the lens precursor comprises a first surface portion in contact with the forming optic, wherein the first surface portion comprises an optical quality surface, a second surface portion, wherein the second surface portion comprising non-fluent polymerized material, and a third surface portion comprising non-voxel fluent partially polymerized material separate from the first reactive monomer mixture, wherein the third surface portion is located on a distal end of the lens precursor from the forming surface;

removing the forming optic, the insert, and the lens precursor from contact with the reactive monomer mixture, polymerized material around the periphery of the insert is capable of securing the insert to the lens precursor, wherein the lens precursor comprises non-fluent polymerized material capable of securing the insert to the lens precursor;

forming the ophthalmic lens with the insert by exposing the fluent partially polymerized material to actinic radiation; and

removing the ophthalmic lens from the forming optic.

10. The method of Claim 9, wherein the insert is located between the second surface and the third surface.

11. The method of Claim 9, wherein the specialized well further comprises a plurality of holding features configured to stabilize a position of the insert within the specialized well.

12. The method of Claim 11, wherein the processing relating to the plurality of holding features creates depressions on the distal surface of the lens precursor, and the method further comprises the method steps of:

filling the depressions on the surface of the lens precursor by placing the ophthalmic lens precursor in contact with the reactive monomer mixture after separating the lens precursor from the holding features of the specialized well; and

creating a smooth surface of an ophthalmic lens by allowing the reactive monomer mixture to flow across the lens precursor surface and into the depressions and then exposing the reactive monomer mixture to a second actinic radiation.

13. A method of forming an ophthalmic lens, the method comprising:

placing a forming optic in contact with a reactive monomer mixture, wherein the forming optic comprises a forming surface with dimensions and curvature consistent with an ophthalmic lens;

forming a lens precursor form by exposing the reactive monomer mixture to actinic radiation, wherein the actinic radiation is configured to control polymerization on a voxel by voxel basis over the forming surface;

removing the forming optic and the lens precursor from contact with the bath of reactive monomer mixture, wherein the lens precursor comprises ~~and~~ a first surface portion in contact with the forming optic, wherein the first surface portion comprises an optical quality surface, a second surface portion, the second surface portion comprising non-fluent polymerized material, and a third surface portion comprising non-voxel fluent

partially polymerized material separate from the first reactive monomer mixture, wherein the third surface portion is located on a distal end of the lens precursor from the forming surface;

releasing the first lens precursor from the forming optic into a holding fixture;

placing an insert proximate to the first surface, the second surface, or the third surface, wherein the placing allows for a region to be formed that may at least partially surround the insert with reactive monomer mixture during processing;

immersing the insert within a bath of the reactive monomer mixture, wherein the immersing occurs while the insert is in contact with the lens precursor in the holding fixture;

forming an ophthalmic lens with insert by exposing the reactive monomer mixture to actinic radiation;

removing the ophthalmic lens from the bath;

placing a second forming optic in proximity to the insert in the bath of reactive monomer mixture, wherein the forming optic comprises an optical quality forming surface in contact with the reactive monomer mixture; and

forming a second lens precursor by exposing the bath reactive monomer mixture to actinic radiation, wherein the actinic radiation is configured to control polymerization on a voxel by voxel basis over the forming surface, wherein the second lens precursor comprises a first surface portion in contact with the forming optic, wherein the first surface portion comprises an optical quality surface, a second surface portion, the second surface portion comprising non-fluent polymerized material, and a third surface portion comprising non-voxel fluent partially polymerized material separate from the first reactive monomer mixture, wherein the third surface portion is located on a distal end of the lens precursor from the forming surface.

14. A method of forming an ophthalmic lens, the method comprising:

placing a forming optic in contact with a reactive monomer mixture, wherein the forming optic comprises a forming surface with dimensions and curvature consistent with a front curve of an ophthalmic lens;

forming a lens precursor form containing an encapsulation pocket by exposing the

reactive monomer mixture to actinic radiation, wherein the actinic radiation is configured to control polymerization on a voxel by voxel basis over the forming surface;

removing the forming optic and the lens precursor from contact with the reactive monomer mixture, wherein the lens precursor comprises a first surface portion in contact with the forming optic, wherein the first surface portion comprises an optical quality surface, a second surface portion, the second surface portion comprising non-fluent polymerized material and located on the distal end of the forming surface, and a third surface portion comprising non-voxel fluent partially polymerized material separate from the reactive monomer mixture, wherein the third surface portion is located on a distal end of the lens precursor from the forming surface;

releasing the lens precursor from the forming optic, wherein the releasing places the lens precursor proximate to a front curve mold, wherein a surface portion of the lens precursor comprising a convex surface is in contact with the front curve mold;

placing an insert into the encapsulation pocket proximate to the second surface portion formed by the releasing, wherein the placement allows for at least a partial encapsulation of the insert within an ophthalmic lens;

depositing the reactive monomer mixture on a back curve portion of the insert;

placing a back curve mold proximate to the front curve mold, wherein the placement causes the reactive monomer mixture to engulf the insert and after further processing to encapsulate the insert into the lens precursor;

forming the ophthalmic lens by exposing the reactive monomer mixture to the actinic radiation, wherein the ophthalmic lens comprises the lens precursor and the insert; and

releasing the ophthalmic lens from the front curve mold and the back curve mold; wherein the releasing of the ophthalmic lens comprises the steps of:

separating the front curve mold from the back curve mold, wherein the ophthalmic lens remains affixed to either the front curve mold or the back curve mold; and

placing the ophthalmic lens and the affixed front curve mold or the affixed back curve mold in a solution configured to dissolve the affixed front curve mold or the affixed back curve mold.

15. The method of Claim 14, wherein an injection molding mechanism is configured to deposit the reactive monomer mixture on the back curve portion of the insert.

16. The method of Claim 14, wherein the releasing of the ophthalmic lens comprises the step of:

placing the front curve mold, the back curve mold, and the ophthalmic lens in a solution configured to dissolve the front curve mold and the back curve mold.

17. The method of Claim 16, wherein the solution comprises an aqueous solution capable of hydrating the ophthalmic lens.

18. The method of Claim 16, wherein the solution comprises an aqueous solution capable of hydrating the ophthalmic lens.