OPHTHALMIC DEVICE WITH THIN FILM NANOCRYSTAL INTEGRATED CIRCUITS

FIELD OF USE

This invention describes methods and apparatus operant to form a device wherein thin film nanocrystal transistors and integrated circuit devices are defined upon Ophthalmic Device insert components. In some embodiments, the methods and apparatus to form Thin Film Nanocrystal Integrated Circuit devices within Ophthalmic Devices relate to said formation upon surfaces that occur on substrates that have three-dimensional shapes. In some embodiments, a field of use for the methods and apparatus may include Ophthalmic Devices, which incorporate energization elements, inserts and Thin Film Nanocrystal Integrated Circuit devices.

BACKGROUND

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

More recently, active components have been incorporated into a contact lens. Some components may include semiconductor devices. Some examples have shown semiconductor devices embedded in a contact lens placed upon animal eyes. It has also been described how the active components may be energized and activated in numerous manners within the lens structure itself. The topology and size of the space defined by the lens structure creates a novel and challenging environment for the

The invention claimed is:

1. An ophthalmic device comprising:

a first media insert comprising an active optical device, a first thin film nanocrystal transistor, a first energization element and a first conductive trace, wherein the first thin film nanocrystal transistor comprises an n-type nanocrystal layer, wherein the first energization element is proximate to the first conductive trace so that the first energization element is in electrical communication with the first thin film nanocrystal transistor, wherein the active optical device comprises a liquid meniscus lens element having two immiscible fluids forming a meniscus therebetween, wherein the active optical device is in electrical communication with the first energization element and the first thin film nanocrystal transistor, and wherein the active optical device is configured to change the focal characteristics of the ophthalmic device upon application of an electrical charge to change the shape of the meniscus; and

a hydrogel material surrounding or encapsulating the first media insert.

2. The ophthalmic device of claim **1**, wherein the first thin film nanocrystal transistor comprises a p-type nanocrystal layer.

3. The ophthalmic device of claim **1**, wherein the first conductive trace comprises a transparent electrode.

4. The ophthalmic device of claim **1**, wherein the first energization element comprises a plurality of electrochemical cells, wherein the electrochemical cells are in connection at least in part in a series.

5. The ophthalmic device of claim **1**, wherein the first media insert further comprises an activation element in electrical communication with the active optical device.

6. The ophthalmic device of claim **1**, wherein the n-type nanocrystal layer comprises cadmium selenide nanocrystals.

7. The ophthalmic device of claim **1**, wherein the first media insert further comprises a second thin film transistor comprising a second nanocrystal layer, wherein the second thin film transistor is in electrical communication with the first energization element.

8. The ophthalmic device of claim **2**, wherein the p-type nanocrystal layer comprises copper selenide.

9. The ophthalmic device of claim **3**, wherein the transparent electrode comprises indium tin oxide.

10. The ophthalmic device of claim **5**, wherein the activation element comprises a pressure sensitive switch.

11. The ophthalmic device of claim **7**, wherein the second thin film transistor comprises a p-type nanocrystal layer.

12. The ophthalmic device of claim **11**, wherein the p-type nanocrystal layer of the second thin film transistor comprises copper selenide.

13. The ophthalmic device of claim **7**, additionally comprising a

second media insert comprising:

a second energization element;

a second conductive trace; and

a third thin film transistor comprising an organic semiconductor layer, wherein the second conductive trace is capable of placing the second energization element in electrical communication with the third thin film transistor.

14. The ophthalmic device of claim **13**, wherein the third thin film transistor comprises an n-type nanocrystal layer.

15. The ophthalmic device of claim **14**, wherein the n-type nanocrystal layer comprises cadmium selenide nanocrystals.

16. The ophthalmic device of claim **13**, additionally comprising a fourth thin film transistor, wherein the fourth thin film transistor comprises a p-type organic semiconductor layer.

17. The ophthalmic device of claim **16**, wherein the p-type organic semiconductor layer comprises pentacene.

18. The ophthalmic device of claim **1**, wherein the first media insert has a three-dimensional topography.

19. The ophthalmic device of claim **1**, wherein the first energization element is configured to energize a circuit that includes the first thin film nanocrystal transistor and a second thin film transistor, the first thin film nanocrystal transistor comprising an n-type nanocrystal layer and the second thin film transistor comprising a p-type nanocrystal layer.

20. The ophthalmic device of claim **19**, wherein the circuit is configured to permit the ophthalmic device to turn on and off.

21. The ophthalmic device of claim **1**, wherein the first thin film nanocrystal transistor comprises a gate electrode, a nanocrystal layer, a gate dielectric layer between the gate electrode and the nanocrystal layer, a source electrode in contact with the nanocrystal layer, and a drain electrode in contact with the nanocrystal layer.

22. An ophthalmic device comprising:

a first media insert having a three-dimensional surface, wherein first the media insert comprises at least a first thin film nanocrystal transistor, a first energization element and a first conductive trace, wherein the first thin film nanocrystal transistor comprises a n-type nanocrystal layer, and wherein the first energization element is proximate to the first conductive trace so that it is in electrical communication with the first thin film nanocrystal transistor; and

a hydrogel material surrounding or encapsulating the first media insert.

23. The ophthalmic device of claim **22**, wherein the first thin film nanocrystal transistor comprises a p-type nanocrystal layer.

24. The ophthalmic device of claim **22**, wherein the first conductive trace comprises a transparent electrode.

25. The ophthalmic device of claim **22**, wherein the first energization element comprises a plurality of electrochemical cells, wherein the electrochemical cells are in connection at least in part in a series.

26. The ophthalmic device of claim **22**, wherein the first media insert additionally comprises an active optical device capable of changing the focal characteristics of the ophthalmic device, wherein the active optical device is in electrical communication with the first energization element.

27. The ophthalmic device of claim **26**, wherein the active optical device comprises a liquid meniscus lens element having two immiscible fluids forming a meniscus therebetween, and wherein the active optical device is configured to change the focal characteristics of the ophthalmic device upon application of an electrical charge to change the shape of the meniscus.

28. The ophthalmic device of claim **26**, wherein the first media insert further comprises an activation element in electrical communication with the active optical device.

29. The ophthalmic device of claim **22**, wherein the n-type nanocrystal layer comprises cadmium selenide nanocrystals.

30. The ophthalmic device of claim **22**, wherein the first media insert additionally comprises a second thin film transistor comprising a second nanocrystal layer, wherein the second thin film transistor is in electrical communication with the first energization element.

31. The ophthalmic device of claim **24**, wherein the transparent electrode comprises indium tin oxide.

32. The ophthalmic device of claim **28**, wherein the activation element comprises a pressure sensitive switch.

33. The ophthalmic device of claim **30**, wherein the second thin film transistor comprises a p-type nanocrystal layer.

34. The ophthalmic device of claim **33**, wherein the p-type nanocrystal layer of the second thin film transistor comprises copper selenide.

35. The ophthalmic device of claim **30**, additionally comprising a second media insert comprising:

a second energization element;

a second conductive trace; and

a third thin film transistor comprising an organic semiconductor layer, wherein the second conductive trace is capable of placing the second energization element in electrical communication with the third thin film transistor.

36. The ophthalmic device of claim **35**, wherein the third thin film transistor comprises an n-type nanocrystal layer.

37. The ophthalmic device of claim **36**, wherein the n-type nanocrystal layer comprises cadmium selenide nanocrystals.

38. The ophthalmic device of claim **37**, additionally comprising a fourth thin film transistor, wherein the fourth thin film transistor comprises a p-type organic semiconductor layer.

39. The ophthalmic device of claim **38**, wherein the p-type organic semiconductor layer comprises pentacene.