

Description

Title of Invention: Textured Surface Ophthalmic Device

Technical Field

The present invention generally relates to a textured surface ophthalmic device. The present invention also relates to a method of preparing the textured surface ophthalmic device.

Background Art

An ophthalmic device, which can include contact lens, is a favourable and effective way of correcting vision that has gained popularity in the recent years. Hence, there is a demand to improve specific aspects of the contact lens function while maintaining essential ability of correcting vision. There are several aspects of the contact lens which include oxygen transport, water content, anti-microbial, anti-ultraviolet and structural colours properties that can be optimized to achieve exceptional results for the benefits of consumers.

Microbial or bacterial contamination is one of the most common aspects that the researchers have been trying to curtail. This is due to the fact that contact lenses are often exposed to microorganisms which can cause eye infections after the infected lenses are worn. This is especially so if the users do not disinfect the contact lenses daily with the prescribed care regimen. Therefore, there is a demand to produce contact lens with the appropriate anti-microbial property. Some contact lens that have been developed to enhance the anti-microbial or anti-bacterial property include contact lens that contains an inorganic anti-microbial agent being dispersed in the lens material, contact lens with an anti-bacterial ceramic containing at least one metal wherein the metal was mixed with the lens material by a kneading process or contact lens that is made from water-soluble anti-bacterial polymer.

Extended periods of exposure to ultraviolet radiation (200 to 400 nm) are known to be harmful to the cornea and result in several ocular pathologies. For this reason, it is imperative to provide adequate ocular protection against ultraviolet radiation. In this regard, researchers have been trying to reduce the exposure to ultraviolet radiation by developing alternative contact lens products that contain anti-UV property. In fact, most of the contact lenses contain an ultraviolet radiation absorbing agent that is covalently bonded to the lens material but with varying agents such as halotriazine-derivatives, 3,3',4,4'-benzophenonetetracarboxylic dianhydride, hydroxyethylmethacrylate (HEMA) and the derivatives.

Coloured contact lenses have become trendy fashion accessories in the recent years. In fact, coloured contact lenses would be more desirable if the lenses are able to provide the essential functions and yet look sufficiently trendy. Some conventional methods to generate coloured contact lens include coloured pigments, colloid photonic crystals, nanowire arrays and polycarbonates (PC) which have certain limitations such as lower resolution and the size of unit cells of the non-plasmonic nanostructures. Thus, there is a subtle demand for

coloured contact lenses that are well-equipped with the essential functions as mentioned above, which will exhibit selective transmission or reflection of visible light.

Accordingly, there is a need to provide alternative ophthalmic device that overcomes, or at least ameliorates, one or more of the disadvantages described above. There is also a need to provide a method of preparing a textured surface ophthalmic device that ameliorates one or more disadvantages mentioned above.

Summary

There is provided a textured surface ophthalmic device comprising a polymeric material having a micro or nano-sized textured surface, wherein said polymeric material is configured for insertion into an eye of a human.

According to a first aspect, there is provided a textured surface ophthalmic device comprising a polymeric material having a micro or nano-sized textured surface, wherein said polymeric material is configured for insertion into an eye of a human, and wherein said textured surface ophthalmic device comprises at least one amorphous metal/metal oxide layer deposited thereon.

There is provided a method of preparing a textured surface ophthalmic device comprising a) heating the polymeric material precursor to a molten state and injecting the polymeric material precursor into a patterned mold under pressure; b) providing a complementary negative textured surface on said polymeric material precursor from said patterned mold; and c) removing said textured surface polymeric material from the mold to cool to form said ophthalmic device.

According to another aspect, the present disclosure refers to a method of preparing a textured surface ophthalmic device comprising a) heating the polymeric material precursor to a molten state and injecting the polymeric material precursor into a patterned mold under pressure; b) providing a complementary negative textured surface on said polymeric material precursor from said patterned mold; c) removing said textured surface polymeric material from the mold to cool to form said ophthalmic device; and d) depositing at least one amorphous metal/metal oxide layer on said textured surface ophthalmic device.

Definitions

The following words and terms used herein shall have the meaning indicated:

The term "ophthalmic device" as used herein includes a wide range of design types and applications such as contact lenses, intraocular lenses, ocular inserts, ocular bandages, corneal implants and retinal implants.

The word "substantially" does not exclude "completely" e.g. a composition which is "substantially free" from Y may be completely free from Y. Where necessary, the word "substantially" may be omitted from the definition of the invention.

Unless specified otherwise, the terms "comprising" and "comprise", and grammatical variants thereof, are intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, unrecited elements.

As used herein, the term "about", in the context of concentrations of components of the formulations, typically means $\pm 5\%$ of the stated value, more typically $\pm 4\%$ of the stated value, more typically $\pm 3\%$ of the stated value, more typically, $\pm 2\%$ of the stated value, even more typically $\pm 1\%$ of the stated value, and even more typically $\pm 0.5\%$ of the stated value.

Throughout this disclosure, certain embodiments may be disclosed in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4,

from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

Certain embodiments may also be described broadly and generically herein. Each of the narrower species and subgeneric groupings falling within the generic disclosure also form part of the disclosure. This includes the generic description of the embodiments with a proviso or negative limitation removing any subject matter from the genus, regardless of whether or not the excised material is specifically recited herein.

Detailed Disclosure of Embodiments

Exemplary, non-limiting embodiments of a textured surface ophthalmic device shall now be disclosed.

The micro or nano-sized textured surface features may be formed on a hierarchical array. For instance, one or more of the specific regions of a polymeric material may comprise an array of micro-sized structures that are integrally formed on said polymeric material, each micro-sized feature in turn being imprinted with nano-sized surface features on its surface thereon. The textured surface features may be hierarchical structures.

The hierarchical structures may refer to surface topological structures that are imprinted sequentially, usually in increasingly smaller dimensions. In the context of the present invention, a hierarchical structure may refer to the embossing of nano-sized features on the surface of existing micro-sized structures formed by an earlier imprinting step. The micro-sized structures may be integrally formed on the polymeric material. Each micro-sized feature may comprise a planar surface that extends from the surface of the polymeric material. Such planar surfaces may refer to a distal end of a cone, a cylinder, or a polygonal (e.g., square, hexagonal) structure extending from the base of the polymeric material. The nano-sized features may be imprinted or embossed on such a planar surface to thereby form hierarchical structures. Advantageously, it is been demonstrated herein that the provision of hierarchical structures may provide low reflectivity concurrently with UV-resistance, e.g., by selectively causing low transmittance (high reflectivity) of electromagnetic radiation in the UV-A (wavelength: 320 to 400 nm) and/or UV-B spectrum (wavelength: 290 to 320 nm). The textured polymeric material may express, independently, UV-A and/or UV-B transmittance in the range of 0 to about 60%, 0 to about 10%, 0 to about 20%, 0 to about 30%, 0 to about 40%, 0 to 50%, about 10 to about 60%, about 10 to about 50%, about 10 to about 40%, about 10 to about 30%, about 10 to about 20%, about 20 to about 60%, about 20 to about 50%, about 20 to about 40%, about 20 to about 30%, about 30 to about 60%, about 30 to about 50%, about 30 to about 40%, about 40 to about 60%, about 40 to about 50%, or about 50% to about 60%.

The amorphous oxide layer may comprise an oxide of a metal selected from titanium, zinc, aluminium, cobalt or composites thereof. The metal oxide layer may comprise a composite oxide e.g., iron-doped titanium dioxide composition (Fe/TiO_2), zinc-cobalt composite ($\text{ZnO / Co}_3\text{O}_4$). The amorphous oxide layer is a TiO_2 layer. Advantageously, the TiO_2 particles may provide anti-UV effects when coated on the polymeric material.

The amorphous metal oxide layer may be substantially evenly distributed across the entire or part of the surface of the polymeric material.

The amorphous metal oxide layer may be deposited by a chemical vapour deposition process (CVD), which may be undertaken at conditions that would not deform the polymeric material or adversely affect the topological features imprinted thereon. The amorphous metal oxide layer may be deposited by an Atomic Layer Deposition (ALD) process. Advantageously, the ALD process may afford precise control over the thickness and uniformity of the topological features. The ALD may be performed at considerably mild temperatures in the range of about 15 °C to about 100 °C, about 20 °C to about 100 °C, about 25 °C to about 100 °C, about 30 °C to about 100 °C, about 40 °C to about 100 °C, about 50 °C to about 100 °C, about 60 to about 100 °C, about 15 °C to about 90 °C, about 20 °C to about 90 °C, about 25 °C to about 90 °C, about 30 °C to about 90 °C, about 40 °C to about 90 °C, about 50 °C to about 90 °C, about 60 °C to about 90 °C, about 15 °C to about 80 °C, about 20 °C to about 80 °C, about 25 °C to about 80 °C, about 30 °C to about 80 °C, about 40 °C to about 80 °C, about 50 °C to about 80 °C, about 60 °C to about 80 °C, about 15 °C to about 70 °C, about 20 °C to about 70 °C, about 25 °C to about 70 °C, about 30 °C to about 70 °C, about 40 °C to about 70 °C, about 50 °C to about 70 °C, about 60 °C to about 70 °C, about 70 °C to about 100 °C, about 70 °C to about 90 °C, or about 70 °C to about 80 °C. The ALD may be performed at ambient or room temperature.

The amorphous metal layer may comprise of a metal selected from gold or silver.

The amorphous metal layer may be deposited in a form of physical vapour deposition (PVD) process, which may be undertaken at conditions that would not deform the polymeric material or adversely affect the topological features imprinted thereon. The amorphous metal layer may be deposited by an electron beam evaporation process. The electron beam evaporation process system may be in a deposition chamber that must be evacuated to a pressure in the range of about 5×10^{-3} to about 8×10^{-5} Torr, about 5×10^{-3} to about 6×10^{-3} Torr, about 5×10^{-3} to about 7×10^{-3} Torr, about 6×10^{-3} to about 8×10^{-3} Torr or 7×10^{-3} to about 8×10^{-3} Torr to allow passage of electrons from the electron gun to the ingot comprising the metal. The generated electron beam may be accelerated to a high kinetic energy and directed towards the evaporation material which is the metal. Upon striking the evaporation material, the electrons will lose their energy very rapidly. The kinetic energy of the electrons is converted into other forms of energy through interactions with the evaporation material. The thermal energy that is produced heats up the evaporation material causing it to melt or sublime. Once temperature and vacuum level are sufficiently high, vapour will result from the melt or solid. The resulting vapour may then be used to coat on the polymeric material. A high deposition rate may be achievable in the range of about 0.1 $\mu\text{m}/\text{min}$ to 10 $\mu\text{m}/\text{min}$, at an appropriate low temperature that has very high material utilization efficiency.

The textured surface ophthalmic device/ocular lens may be substantially optically transparent.

Exemplary, non-limiting embodiments of a method of preparing a textured surface ophthalmic device comprising a) heating the polymeric material precursor to a molten state and injecting the polymeric material precursor into a patterned mold under pressure; b) providing a complementary negative textured surface on said polymeric material precursor

from said patterned mold; and c) removing said textured surface polymeric material from the mold to cool to form said ophthalmic device will now be disclosed.

The method comprises the steps of a) heating the polymeric material precursor to a molten state and injecting the polymeric material precursor into a patterned mold under pressure; b) providing a complementary negative textured surface on said polymeric material precursor from said patterned mold; and c) removing said textured surface polymeric material from the mold to cool to form said ophthalmic device

Industrial Applicability

The ophthalmic device may be used as a coloured contact lens comprising structural colours. The ophthalmic device may be used as a contact lens that reduces exposure to UV radiation. The ophthalmic device may be used as a contact lens to prevent microbial or bacteria contamination. The ophthalmic device may be used as a contact lens for correcting vision.

The method of preparing a textured surface ophthalmic device may combine nanoinjection molding process, nanoimprinting technologies and depositing technologies to provide ophthalmic devices with a combination of desirable properties. The method may be used for small-scale production or for large-scale production. The deposition process may provide ophthalmic devices having reduced microbial or bacteria contamination. The deposition process may provide ophthalmic devices having reduced UV transmission. The deposition process may provide ophthalmic devices having selective transmission or reflection of visible light, resulting in high resolution structural colours.

It will be apparent that various other modifications and adaptations of the invention will be apparent to the person skilled in the art after reading the foregoing disclosure without departing from the spirit and scope of the invention and it is intended that all such modifications and adaptations come within the scope of the appended claims.

Claims

1. A textured surface ophthalmic device comprising
a polymeric material having a micro or nano-sized textured surface, wherein said polymeric material is configured for insertion into an eye of a human, and

wherein said textured surface ophthalmic device comprises at least one amorphous metal/metal oxide layer deposited thereon.
2. The textured surface ophthalmic device according to claim 1, wherein said textured surface ophthalmic device is integrally formed with the polymeric material.
3. The textured surface ophthalmic device according to claim 1, wherein said amorphous oxide layer comprises an oxide of a metal selected from titanium, cobalt, zinc, aluminum and composites thereof.
4. The textured surface ophthalmic device according to claim 1, wherein said amorphous metal layer comprises of a metal selected from gold or silver.
5. The textured surface ophthalmic device according to claim 1, wherein said amorphous oxide layer is deposited by atomic layer deposition.
6. The textured surface ophthalmic device according to claim 1, wherein said amorphous metal layer is deposited by electron beam evaporation.
7. The textured surface ophthalmic device according to claim 1, wherein said amorphous oxide layer comprises amorphous titanium dioxide.
8. The textured surface ophthalmic device according to any one of the preceding claims, wherein said textured surface ophthalmic device is substantially optically transparent.
9. The textured surface ophthalmic device according to any one of the preceding claims, wherein said textured surface comprises hierarchical structures.
10. A method of preparing a textured surface ophthalmic device comprising
 - a) heating the polymeric material precursor to a molten state and injecting the polymeric material precursor into a patterned mold under pressure;
 - b) providing a complementary negative textured surface on said polymeric material precursor from said patterned mold;
 - c) removing said textured surface polymeric material from the mold to cool to form said ophthalmic device; and
 - d) depositing at least one amorphous metal/metal oxide layer on said textured surface ophthalmic device.
11. The method of preparing a textured surface ophthalmic device according to claim 10, wherein said amorphous metal oxide layer comprises an oxide of a metal selected from titanium, cobalt, zinc, aluminum and composites thereof.

12. The method of preparing a textured surface ophthalmic device according to claim 10, wherein said amorphous metal layer comprises of a metal selected from gold or silver.