

INSPECTION OF DEFECTS IN A CONTACT LENS

TECHNICAL FIELD

[001] The embodiments herein relate to clear and printed contact lenses, and more particularly but not exclusively to, technique for inspecting printed contact lens.

BACKGROUND

[002] Contact lenses of various types are being manufactured and used for correcting vision, cosmetic purposes and therapeutic purposes, among others. Such contact lenses may be broadly classified as being printed contact lens or clear contact lens.

[003] Contact lens being an object that is worn on the eyes, which is known to be a sensitive organ, has to be manufactured such that it meets the stringent technical specification. To ensure that the contact lenses meet the strict quality requirements of the consumer, they are inspected at various stages of their manufacture.

[004] Traditionally, a contact lens after being molded is inspected for defects, using bright-field illumination. FIG. 1 illustrates an image 100 of a clear contact lens, which is taken using bright-field illumination. In the figure, the bright area is the contact lens, and the black dots 102 are bubble or other types of defects that are present in the clear contact lens. While the bright field illumination is well suited for inspecting clear contact lens, such a technique may not be best suited for inspecting printed contact lens. A printed contact lens has an iris print, and when such lenses are illuminated using bright-field illumination, the image of the printed contact lens will include black area corresponding to the iris print and black dots corresponding to bubble or other types of defects. Such an image may not be suited for identifying the defects because the black dots corresponding to the bubble defects may get camouflaged in the black area corresponding to the iris print. Alternatively, if only dark-field illumination is used for inspecting

the printed contact lens, the image of the printed contact lens will include bright area corresponding to the iris print and bright dots corresponding to bubble or other types of defects. Such an image may not be suited for identifying the defects because the bright dots corresponding to the bubble or other similar type of defects may get camouflaged in the bright area corresponding to the iris print. Hence, there is a need in the industry for a system that can reliably identify the defects in a printed contact lens.

[005] Further, in the traditional techniques, during the process of capturing images for defect detection, systems require one of the molds (male or female) in the mold assembly to be removed to provide access to the inspection system for illuminating the contact lens to perform defect inspection. When the molds are disengaged, there is a possibility of defects being introduced during the disengagement process. Further, when defects are found in the contact lens, it will be difficult to determine if the defects were created during the molding process or during the disengagement process. Hence, there is a need in the industry to understand the process related defects at the point of their creation, so that appropriate measures can be taken to address the problem.

SUMMARY

[006] In view of the foregoing, an embodiment herein provides a method for inspecting clear and printed contact lenses. The method includes illuminating the contact lens using bright field illumination and dark field illumination simultaneously, when the contact lens is disposed in a cavity between a male mold and a female mold. Further, image of the contact lens is captured using light emerging from the contact lens and entering the imaging optical system. The image is then processed for identifying existence of defects in the contact lens. The defects are identified by processing the image corresponding to the dark defects that are in a first portion of dynamic range of brightness and bright defects that are in a second portion of the dynamic range of

brightness. The dark defects are contamination in the case of clear lens, and in case of printed contact lens, the dark defects are contamination and print smear. The bright defects are bubble and similar defects in clear as well as printed contact lens.

[007] Embodiments further disclose a system for inspecting a contact lens. The system includes an illumination system, an imaging optical system, at least one camera and a data processing system. The illumination system is configured to illuminate the contact lens using bright field illumination and dark field illumination simultaneously, when the contact lens is inside a cavity between a male mold and a female mold. Further, the imaging optical system is configured to receive the light emerging from the contact lens. Further, a camera is configured to capture the image of the contact lens using the light entering the imaging optical system. Further, a data processing system is configured to process the image captured by the camera for identifying existence of one or more defects in the contact lens. The dark defects are identified by processing the image in a first portion of dynamic range of brightness and bright defects are identified by processing the image in a second portion of the dynamic range of brightness.

[008] These and other aspects of the embodiments herein will be better appreciated and understood when considered in conjunction with the following description and the accompanying drawings.

BRIEF DESCRIPTION OF THE FIGURES

[009] The embodiments herein will be better understood from the following detailed description with reference to the drawings, in which:

[0010] FIG. 1 illustrates an image 100 of a clear contact lens captured using bright-field illumination.

[0011] FIG. 2 illustrates a mold assembly 200, in accordance with an embodiment;

[0012] FIG. 3 illustrates a system 300 for inspecting clear or printed contact lenses inside a mold, in accordance with an embodiment;

[0013] FIG. 4 illustrates the path of the light from the illumination system to the clear or printed contact lens, in accordance with an embodiment; and

[0014] FIG. 5 illustrates an image 500 of a printed contact lens 210, in accordance with an embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0015] The embodiments herein and the various features and advantageous details thereof are explained more fully with reference to the non-limiting embodiments that are illustrated in the accompanying drawings and detailed in the following description. Descriptions of well-known components and processing techniques are omitted so as to not unnecessarily obscure the embodiments herein. The examples used herein are intended merely to facilitate an understanding of ways in which the embodiments herein may be practiced and to further enable those of skill in the art to practice the embodiments herein. Accordingly, the examples should not be construed as limiting the scope of the embodiments herein.

[0016] The embodiments herein disclose a method and system for inspecting clear and printed contact lenses. Referring now to the drawings, and more particularly to FIGS. 2 through 5, where similar reference characters denote corresponding features consistently throughout the figures, there are shown embodiments. It may be noted that embodiments of the invention are described taking contact lens as an example. However, a person skilled in the art, in light of this patent specification, may make modifications, which are within the scope of the claims, to enable inspection of other transparent objects.

SYSTEM DESCRIPTION

[0017] FIG. 3 illustrates a system 300 for inspecting clear or printed contact lenses, in accordance with an embodiment. System 300 comprises an illumination system 302, an imaging optical system 304, camera 306 and a Data Processing System (DPS) 308. The system enables inspection of a contact lens 210 that is disposed in a mold assembly 200.

MOLD ASSEMBLY

[0018] FIG. 2 illustrates a mold assembly 200, in accordance with an embodiment. The mold assembly 200 includes a male mold 202 and a female mold 204. A portion of each of the molds corresponding to the cavity between the male mold 202 and female mold 204 is transparent. The male mold 202 is coupled with a case 212, and the female mold 204 is coupled with a case 214. Further, the male mold 202 has a curved surface 206, and the female mold 204 has a curved surface 208, such that, when the mold assembly 200 is in engaging position, as shown in FIG. 2, the curved surfaces 206 and 208 define a cavity corresponding to the shape of the contact lens 210 to be molded. The contact lens 210 is manufactured by molding contact lens material in the cavity. Further, the mold assembly 200 can assume a disengaging position (not shown in the figure), enabling retrieval of the molded contact lens 210.

ILLUMINATION SYSTEM

[0019] The illumination system 302 (FIG. 3) is configured to illuminate the contact lens 210, which is disposed between the male mold 202 and female mold 204 of the mold assembly 200. The illumination system 302 illuminates the contact lens 210 by providing bright field illumination and dark field illumination simultaneously. In an embodiment, the illumination system 302 includes two parts. The first part of the illumination system is configured to provide direct light rays 402 (illustrated in FIG. 4) to illuminate the contact lens using bright field illumination. The second part of the illumination system 302 is a ring-type light head that directs

light rays, which may be referred to as angular light rays 404 (illustrated in FIG. 4), angularly into the inner surface of the case 214. The angular light rays 404 that are incident on the inner surface of the case 214 are reflected and scattered by the inner surface of the case 214 and falls on the contact lens 210 at low angles to provide dark field illumination.

IMAGING OPTICAL SYSTEM

[0020] The imaging optical system 304 is configured to receive the light emerging from the contact lens 210 as a result of bright field illumination and dark field illumination.

CAMERA

[0021] The camera 306 is configured to use the light entering the imaging optical system to capture images of the contact lens 210. The camera 306 may be a digital camera.

DATA PROCESSING SYSTEM (DPS)

[0022] The DPS 308 is configured to receive data corresponding to the image of the contact lens 210 captured by the camera 306. Further, the DPS 308 processes the image of the contact lens 108 to identify defects in the contact lens 210.

SYSTEM CONFIGURATION

[0023] In an embodiment, as illustrated in FIG. 3 and 4, illumination system 302 is located on a first side of the mold assembly 200, such that, the illumination system 302 is proximate to the female mold 204 as compared to the male mold 202. The illumination system 302 is positioned in such a way that light from the illumination system 302 is directed towards the contact lens 210. While the illumination system 302 is located on the first side of the mold assembly 200, the imaging optical system 304 and the camera 306 are located on the second side of the mold assembly 200. The imaging optical system 304 is located in between the camera 306 and the mold assembly 200.

INSPECTING CONTACT LENS

[0024] In an embodiment, clear or printed contact lens 210 is inspected when the mold assembly 200 is in the engaging position, which means, the contact lens 210 is disposed in a cavity between the male mold 202 and female mold 204. While the contact lens 210 is disposed between the molds, the illumination system 302 emits direct light rays 402 and angular light rays 404 that fall on the contact lens 210. FIG. 4 illustrates paths taken by light rays from the illumination system 302, in accordance with an embodiment. Direct light rays 402 providing bright field illumination are emitted by the first portion of the illumination system 302. Angular light rays 404 resulting in dark field illumination are emitted by the second portion (ring-type light head) of the illumination system 302, travel at an angle and fall on the inner surface of the case 214 of the female mold 204. The angular light rays 404 are reflected by the inner surface of the case 214 and fall on the contact lens 210 at low angles, thereby providing dark field illumination. Further, it may be noted that intensity of the direct light rays 402 and the angular light rays 404 may be adjusted so that an image that is desirable for inspecting the contact lens 210 is obtained. Further, the light emerging from the contact lens 210 is captured by the imaging optical system 304. The light received by the imaging optical system 304 is used by the camera 306 to capture at least one image of the contact lens 210.

[0025] FIG. 5 illustrates an image 500 of a printed contact lens 210, in accordance with an embodiment. In the image 500, it may be seen that portions of the image corresponding to clear part of the contact lens, iris print on the contact lens, bubble and other similar defects have significantly different brightness levels. In an embodiment, if the dynamic range of brightness of the image 500 that can be captured by the camera 306 is 255 grayscale levels, then portion of the image corresponding to the iris print has brightness in a first portion of the dynamic range of

brightness, wherein the first portion could be between 0 and 140 grayscale levels, for example. In image 500, print smear 504 that has been encircled can be clearly distinguished. Print smears can be classified as dark defects. Contamination in the case of clear lens and printed contact lens can also be classified as dark defects. Further, the portion of the image corresponding to clear part of the printed contact lens and the bubble defects 502 has brightness in a second portion of the dynamic range of brightness, wherein the second portion could be between 141 and 255 grayscale levels, for example. In image 500, bubble defects 502 that have been encircled can be clearly distinguished. Bubbles and similar defects can be classified as bright defects that appear in clear as well as the printed contact lens. It may be further noted that bright defects such as bubbles and similar defects 502 that are present in the print area are also clearly distinguishable, as seen in the figure. The difference in brightness of the portions of the image corresponding to clear part of the contact lens, iris print on the contact lens, bubbles and other similar defects, enables the DPS 308 to process the image 500 and identify defects.

[0026] The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the claims as described herein.

CLAIMS

What is claimed is:

1. A method for inspecting a contact lens, the method comprising:
 - illuminating the contact lens using bright field illumination and dark field illumination simultaneously;
 - capturing image of the contact lens using light received from the contact lens; and
 - processing the image for identifying existence of one or more defects in the contact lens.
2. The method according to claim 1, wherein illuminating the contact lens comprises, using direct light for providing bright field illumination to the contact lens.
3. The method according to claim 1, wherein illuminating the contact lens comprises, using angular light for providing low angle dark field illumination to the contact lens.
4. The method according to claim 3, wherein illuminating the contact lens using angular light comprises, projecting light angularly into the inner surface of a case of the mold.
5. The method according to claim 1, wherein the inspected contact lens is disposed inside a cavity between a male mold and a female mold.
6. The method according to claim 1, wherein processing the image comprises, identifying dark defects that are in a first portion of dynamic range of brightness and identifying bright defects that are in a second portion of the dynamic range of brightness.
7. A system for inspecting a contact lens the system comprising:
 - an illumination system configured to illuminate the contact lens using bright field illumination and dark field illumination simultaneously;

an imaging optical system for receiving light emerging from the contact lens as a result of simultaneous bright field illumination and dark field illumination;
a camera configured to capture image of the contact lens using the light received by the imaging optical system; and
a data processing system configured to process the image for identifying existence of defects in the contact lens.

8. The system according to claim 7, wherein the illumination system is configured to illuminate the contact lens using direct light for providing bright field illumination to the contact lens.
9. The system according to claim 7, wherein the illumination system is configured to illuminate the contact lens using angular light for providing low angle dark field illumination to the contact lens.
10. The system according to claim 9, wherein the illumination system is configured to project light angularly into the inner surface of a case of the mold for illuminating the contact lens.
11. The system according to claim 7, wherein the inspected contact lens is disposed inside a cavity between a male mold and a female mold.
12. The system according to claim 7, wherein the data processing system is configured to identify dark defects that are in a first portion of dynamic range of brightness and identifying bright defects that are in a second portion of the dynamic range of brightness.
13. The system according to claim 7, wherein the contact lens is clear contact lens or printed contact lens.