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(54) **Lighting device, luminaire and manufacturing method**

(57) Disclosed is a lighting device (1) having a tubular body (10) and a plurality of solid state lighting elements (14) mounted inside said tubular body, wherein the lighting device further comprises an optical film (20) enveloping said tubular body, wherein at least a portion (22, 24) of said optical film is adapted to redirect the luminous output of said solid state lighting elements. A luminaire including such a lighting device and a method of manufacturing such a lighting device are also disclosed.

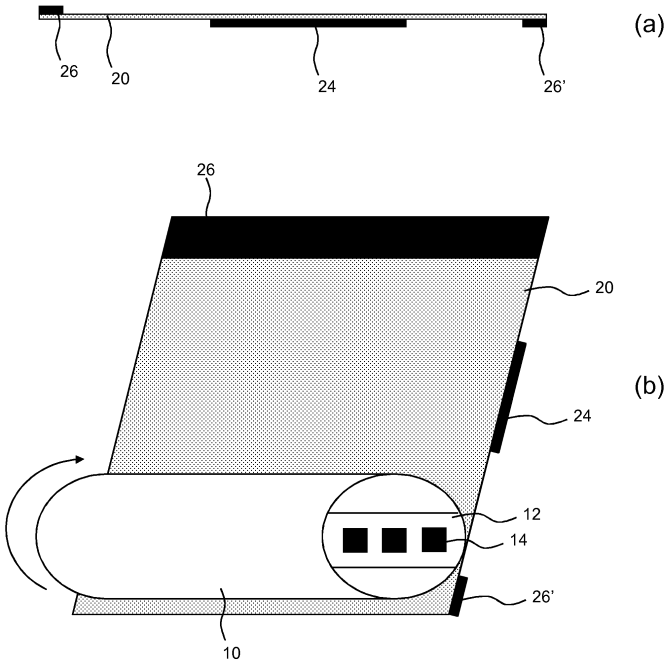

FIG. 6

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Description

FIELD OF THE INVENTION

[0001] The present invention is related to a lighting device having a tubular body and a plurality of solid state lighting elements mounted inside said tubular body.

[0002] The present invention is further related to a luminaire including such a lighting device.

[0003] The present invention is yet further related to a method of manufacturing such a lighting device.

BACKGROUND OF THE INVENTION

[0004] In order to meet a growing demand for energy and at the same time kerb greenhouse gas emissions, there is a clear trend towards the replacement of traditional energy-inefficient light bulbs such as incandescent or fluorescent light bulbs with more energy efficient replacements. Indeed, in many jurisdictions the production and retailing of incandescent light bulbs has been outlawed, thus forcing consumers to buy energy-efficient alternatives, e.g. when replacing incandescent light bulbs.

[0005] A particular promising alternative is provided by solid state lighting (SSL) devices, which can produce a unit luminous output at a fraction of the energy cost of incandescent light bulbs. An example of such a SSL element is a light emitting diode.

[0006] A drawback of SSL element-based lighting devices is that the compatibility with incandescent light-based device fittings, e.g. luminaires, is not perfect, which hampers the market penetration of the SSL element-based lighting devices. Cost is another concern; SSL element-based lighting devices are significantly more expensive than their traditional counterparts, such that there is an existing need to reduce the cost of such devices. This is a far from trivial task as SSL-based lighting devices typically require several additional optical components to shape the luminous output of the SSL elements such that it mimics or improves the appearance and/or luminous distribution of its traditional counterparts.

[0007] In addition, where the lighting devices include housings made of shattering materials, e.g. glass or hard polymers, a risk of injury upon breakage of the housing exists, which may furthermore expose live SSL elements. At least the injury risk has been recognized in US 6,452,325 B2, which discloses a fluorescent lamp having a glass envelope and a polymeric coating over the lamp envelope so that it intimately embraces substantially all of the external contours of the lamp, including its glass envelope and end-ferrules, thereby increasing the hoop strength of the glass envelope. However, this adds another component to the lighting device design, which further increases cost and hampers market penetration, in particular for SSL element-based lighting devices.

SUMMARY OF THE INVENTION

[0008] The present invention seeks to provide a more cost-effective lighting device having a tubular body and a plurality of solid state lighting elements mounted inside said tubular body.

[0009] The present invention further seeks to provide a luminaire comprising such a more cost-effective lighting device.

[0010] The present invention yet further seeks to provide a method of manufacturing such a more cost-effective lighting device.

[0011] According to an aspect, there is provided a lighting device having a tubular body and a plurality of solid state lighting elements mounted inside said tubular body, wherein the lighting device further comprises an optical film enveloping said tubular body, wherein at least a portion of said optical film is adapted to redirect the luminous output of said solid state lighting elements.

[0012] The present invention is based on the insight that at least some of the beam shaping optical elements required to shape the luminous output of the SSL elements in order for the luminous output of the lighting device to become more aesthetically pleasing, e.g. more similar to the luminous output of traditional tubular lighting devices such as fluorescent tubes, or to improve such luminous output, may be integrated in the film surrounding the tubular body. This has the added advantage that the shatter proofing of the tubular lighting device may be achieved without increasing the number of components of the lighting device, thus providing a cost-effective SSL-element based tubular lighting device.

[0013] This is particularly relevant if the tubular body is made of glass, as in such an embodiment the shatter proofing of the lighting device is particularly desirable.

[0014] In an embodiment, said portion is adapted to diffuse at least part of the luminous output of said solid state lighting elements.

[0015] In an alternative embodiment, said portion is adapted to reflect at least part of the luminous output of said solid state lighting elements.

[0016] In a particularly advantageous embodiment, the optical film comprises a laminated section extending along the length of the tubular body, said laminated section comprising a further film portion adapted to manipulate the luminous output of said solid state lighting elements. In this embodiment, the optical film may implement a plurality of different optical functions, which further reduces the number of components of the lighting device.

[0017] The further film portion may be adapted to redirect the luminous output of said solid state lighting elements. For instance, the further film portion may be a reflective film portion arranged such that at least a part of the luminous output of said solid state lighting elements is reflected by the reflective film portion.

[0018] The optical film may comprise an overlapping section on said tubular body, said overlapping section comprising an adhesive on the respective surfaces of the

overlapping section that face each other. This allows for a simply assembly of the optical film on the tubular body. The adhesive may for instance be an adhesive tape.

[0019] In the lighting device, the at least one solid state lighting element may be a light emitting diode (LED) such as an organic or inorganic LED.

[0020] According to another aspect, there is provided a luminaire comprising the lighting device according to embodiments of the present invention. Such a luminaire may for instance be a holder of the lighting device or an apparatus into which the lighting device is integrated.

[0021] According to yet another aspect, there is provided a method of manufacturing a tubular lighting device, the method comprising providing a tubular body; mounting a plurality of solid state lighting elements inside said tubular body; and enveloping said tubular body with an optical film adapted to redirect the luminous output of said solid state lighting elements. This method therefore provides a cost-effective way of manufacturing SSL element-based tubular lighting device by using an optical film that provides shatter proofing as well as optical functionality as previously explained.

[0022] In an embodiment, the optical film has a first end portion comprising a first surface carrying a first adhesive and a second end portion opposite the first end portion, said second end portion comprising a second surface carrying a second adhesive, and wherein the step of enveloping the tubular body with the optical film comprises forming an overlapping section in the optical film, wherein in said overlapping section the first adhesive contacts the second adhesive. This provides a straightforward manner of securing the optical film on the tubular body.

[0023] In an embodiment, the method further comprises laminating a further film portion adapted to manipulate the luminous output of said solid state lighting elements onto the optical film prior to enveloping said tubular body with the optical film. This has the advantage that the optical film can provide a plurality of optical functions, thereby further improving the cost-effectiveness of the manufacturing method.

[0024] The further film portion may be a reflective film portion, wherein the step of enveloping said tubular body with the optical film comprises aligning the further film portion with said solid state elements such that at least a part of the luminous output of said solid state lighting elements is reflected by the reflective film portion. Such a reflective film portion may for instance be used as a redirection element for redirecting the luminous output of the SSL elements towards a target area to be illuminated, e.g. a work surface or the like, thereby creating a more focussed luminous output compared to traditional fluorescent tubular lighting devices that typically produce a 360° luminous output distribution.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Embodiments of the invention are described in more detail and by way of non-limiting examples with reference to the accompanying drawings, wherein:

Fig. 1 schematically depicts a cross-section of a lighting device according to an embodiment of the present invention;

Fig. 2 schematically depicts a cross-section of a lighting device according to another embodiment of the present invention;

Fig. 3 schematically depicts a cross-section of a lighting device according to yet another embodiment of the present invention;

Fig. 4 schematically depicts a cross-section of a lighting device according to yet another embodiment of the present invention;

Fig. 5 schematically depicts a cross-section of a lighting device according to yet another embodiment of the present invention; and

Fig. 6 schematically depicts a method of manufacturing a lighting device according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0026] It should be understood that the Figures are merely schematic and are not drawn to scale. It should also be understood that the same reference numerals are used throughout the Figures to indicate the same or similar parts.

[0027] In the context of the present invention, the term 'redirect' is used in relation to optical films to describe optical effects that prevent light from simply travelling through such optical films. It therefore is intended to exclude optical films that modify the optical path of light through the film by virtue of the refractive index of the film only. Instead, such redirection of light is intended to cover optical films that assist in reducing the angle of luminous distribution of the lighting device and/or prevent an observer from directly observing the luminous surfaces of the SSL elements inside the tubular body of the lighting device.

[0028] FIG. 1 schematically depicts a cross-section of a lighting device according to an embodiment of the present invention. The lighting device comprises a tubular body 10, which may be made of any suitable material, e.g. glass or a suitable polymer such as polycarbonate or PMMA and may be transparent or translucent, e.g. clouded, to allow light to exit the lighting device. The tubular body 10 has an inner volume in which a carrier 12 is fitted. The carrier 10 carries a plurality of SSL elements 14, which for instance may be mounted on a circuit board (not shown). Alternatively, each SSL element 14 may be mounted individually on the carrier 12. The SSL elements in the lighting device may be LEDs, e.g. organic or inorganic LEDs. The carrier 12 preferably acts as a heat sink for the SSL elements 14. In an embodiment, the carrier 12 is made of a material having good heat conductive properties, e.g. a metal. Aluminium is particularly pre-

ferred. In embodiments where such a heat sink functionality is not required, the carrier 12 may also be chosen from materials lacking such heat conductive properties. Generally speaking, the carrier 12 may be selected from any suitable material. The carrier 12 may be secured in the tubular body 10 in any suitable manner, e.g. using an adhesive or adhesive tape 16.

[0029] The lighting device further comprises an optical film 20 enveloping the tubular body 10. Such an optical film 20 is typically a polymer film, e.g. a PET film. The optical film 20 at least comprises a portion that redirects the luminous output of the SSL elements 14. In FIG. 1, the entire optical film 20 acts as a diffuser such that the luminous surfaces of the SSL elements 14 cannot be directly observed by an observer when the lighting device is in use. The optical film 20 further provides shatter protection such that upon breaking the tubular body 10 the fragments of the broken tubular body 10 are contained by the optical film 20, thereby preventing persons from becoming exposed to these fragments or indeed from direct exposure to live parts of the lighting device, such as live SSL elements 14 and/or their driver circuits.

[0030] It is not necessary that the entire optical film 20 implements a desired optical function. This is demonstrated in FIG. 2, in which the optical film 20 comprises a laminated section including a further film portion 22 extending over the full length of the tubular body 10. In FIG. 2, the optical film 20 is a transparent film with the further film portion 22 acting as a diffuser for at least a part of the luminous output of the SSL elements 14.

[0031] It can be seen that light produced by the SSL elements 14 under shallow angles may exit the tubular body 10 through the transparent part of the optical film 20 only. This typically does not cause glare issues when the lighting device is mounted in a luminaire such that the further film portion 22 faces an observer, such that the further film portion 22 prevents the observer from directly observing the luminous surfaces of the SSL elements 14 inside the tubular body 10.

[0032] FIG. 3 schematically depicts a cross-section of a lighting device according to yet another embodiment of the present invention, wherein the tubular body 10 is enveloped by an optical film 20 comprising a laminated section in which the diffusing further film portion 22 in FIG. 2 is replaced by a reflective film portion 24. The optical film 20 may be a transparent film defining a light exit window of the lighting device outside the laminated section. The reflective film portion 24 may be used to reduce the angle of distribution of the luminous output of the lighting device, i.e. to produce a more focussed luminous output such that a higher luminous flux per unit area of the light exit window of the lighting device is achieved. This may for instance be used to increase the luminous intensity directed to a target area such as a work surface or the like above which the lighting device is mounted.

[0033] In FIG. 3, the reflective film portion 24 is positioned on the tubular body 10 such that the luminous surfaces of the SSL elements 14 face the reflective film portion 24 by way of non-limiting example. It is for instance equally feasible to mount the carrier 12 including the SSL elements 14 such that the carrier 12 is placed over the reflective film portion 24. This is shown in FIG. 4. FIG. 5 schematically depicts a cross-section of a lighting device according to yet another embodiment of the present invention. The embodiment shown in FIG. 5 is the same as the embodiment shown in FIG. 3 apart from the fact that the optical film 20 is a diffusing film rather than a transparent film. This has the advantage that the optical film combines two optical functions, i.e. diffusion and reflection, which obviates the need for separate diffusers and reflectors in or on the tubular body 10. Again, it should be understood that it is equally feasible to mount the carrier 12 including the SSL elements 14 such that the carrier 12 is placed over the reflective film portion 24 as shown in FIG. 4.

[0034] At this point it is noted that although the optical functionality of the optical film 20 has been limited to reflection and diffusion, alternative or additional functions, e.g. colour adjustment, partial absorption and so on, may also be contemplated without departing from the teachings of the present invention.

[0035] At this point, it is further noted that in the above embodiments, the further film portion is shown external to the optical film 20 by way of non-limiting example only. It is of course equally feasible to mount the optical film 20 onto the tubular body 10 such that the further film portion 22 or 24 is located in between the tubular body 10 and the optical film 20. Other suitable mounting arrangements may be contemplated.

[0036] It should further be understood that the optical film 20 may comprise a plurality of laminated sections, i.e. comprises a plurality of further film portions in different regions of the optical film 20, which may be individually arranged relative to the glass tube 10 in any suitable manner, e.g. in between the optical film 20 and the glass tube 10 or external to the optical film 20 such that the optical film 20 is located in between the glass tube 10 and the further film portion as is shown in FIG. 1-5. Different further film portions may provide different optical functionality, e.g. the optical film 20 may carry reflective as well as diffusive further film portions.

[0037] In the aforementioned embodiments, the diffusive and reflective optical film portions may be made from any suitable polymer material, e.g. PET, which can be made diffusive or reflective by secondary processing steps, as is well-known per se.

[0038] A non-limiting example embodiment of a method of manufacturing a lighting device is schematically depicted in FIG. 6. In step (a), an optical film 20 is provided, which in certain embodiments may comprise a laminated section including a further film portion 24, e.g. a reflective film portion on a diffusing or transparent optical film 20. The film portion 24 may be laminated onto the optical film 20 in any suitable manner, e.g. using an adhesive or using electrostatic interactions between the

film portion 24 and the optical film 20 to keep the film portion 24 in its intended location. The optical film 20 may for instance be manufactured by roll to roll lamination. In certain other embodiments, the further film portion 24 may be omitted such that the optical film 20 alone implements the desired optical function, e.g. diffusion.

[0039] The optical film 20 further comprises a first end portion comprising a first surface carrying a first adhesive 26 and a second end portion opposite the first end portion, wherein the second end portion comprises a second surface carrying a second adhesive 26'. Alternatively, the second adhesive 26' may be omitted. Instead of an adhesive, adhesive tape may also be used.

[0040] The method subsequently proceeds to step (b), in which the tubular body 10 is enveloped with the optical film 20, for instance by forming an overlapping section in the optical film 20 wherein the opposite ends of the optical film 20 are adhered to each other by the first adhesive 26 and optionally by the second adhesive 26' as previously explained. In case of the presence of a laminated section on the optical film 20, the further film portion 24 may be located in between the optical film 20 and the tubular body 10 or may alternatively be located at the external surface of the optical film 20, as shown in step (b).

[0041] The aforementioned embodiment of the manufacturing method of the lighting device is shown by way of non-limiting example only, and several alternative embodiments may be contemplated. For instance, instead of using one or more adhesives 26, 26' on the optical film 20, the tubular body 10 may be at least partially covered by an adhesive for securing the optical film 20 on the tubular body 20. Other alternatives will be immediately apparent to the skilled person.

[0042] It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" does not exclude the presence of elements or steps other than those listed in a claim. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The invention can be implemented by means of hardware comprising several distinct elements. In the device claim enumerating several means, several of these means can be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

Claims

1. A lighting device (1) having a tubular body (10) and a plurality of solid state lighting elements (14) mounted inside said tubular body, wherein the lighting device further comprises an optical film (20) enveloping said tubular body, wherein at least a portion (22, 24) of said optical film is adapted to redirect the luminous output of said solid state lighting elements.

2. The lighting device (1) of claim 1, wherein the tubular body (10) is made of glass.

3. The lighting device (1) of claim 1 or 2, wherein said portion (22) is adapted to diffuse at least part of the luminous output of said solid state lighting elements (14).

4. The lighting device (1) of claim 1 or 2, wherein said portion (24) is adapted to reflect at least part of the luminous output of said solid state lighting elements (14).

5. The lighting device (1) of any of claims 1-3, wherein the optical film (20) comprises a laminated section extending along the length of the tubular body, said laminated section comprising a further film portion (24) adapted to manipulate the luminous output of said solid state lighting elements (14).

6. The lighting device (1) of claim 5, wherein the further film portion (24) is adapted to redirect the luminous output of said solid state lighting elements (14).

7. The lighting device (1) of claim 6, wherein the further film portion (24) is a reflective film portion arranged such that at least a part of the luminous output of said solid state lighting elements (14) is reflected by the reflective film portion.

8. The lighting device (1) of any of claims 1-7, wherein the optical film (20) comprises an overlapping section on said tubular body (10), said overlapping section comprising an adhesive (26, 26') on the respective surfaces of the overlapping section that face each other.

9. The lighting device (1) of claim 8, wherein the adhesive (26, 26') is an adhesive tape.

10. The lighting device (1) of any of claims 1-9, wherein the at least one solid state lighting element (14) is a light emitting diode.

11. A luminaire comprising the lighting device (1) of any of claims 1-10.

12. A method of manufacturing a tubular lighting device, the method comprising:

providing a tubular body (10);
mounting a plurality of solid state lighting ele-

ments (14) inside said tubular body; and
enveloping said tubular body with an optical film (20) adapted to redirect the luminous output of said solid state lighting elements.

13. The method of claim 12, wherein the optical film (20) has a first end portion comprising a first surface carrying a first adhesive (26) and a second end portion opposite the first end portion, said second end portion comprising a second surface carrying a second adhesive (26'), and wherein the step of enveloping the tubular body (10) with the optical film comprises forming an overlapping section in the optical film, wherein in said overlapping section the first adhesive contacts the second adhesive.

14. The method of claim 12 or 13, further comprising laminating a further film portion (24) adapted to manipulate the luminous output of said solid state lighting elements onto the optical film (20) prior to enveloping said tubular body (10) with the optical film.

15. The method of claim 14, wherein the further film portion (24) is a reflective film portion, and wherein the step of enveloping said tubular body (10) with the optical film (20) comprises aligning the further film portion with said solid state elements (14) such that at least a part of the luminous output of said solid state lighting elements is reflected by the reflective film portion.

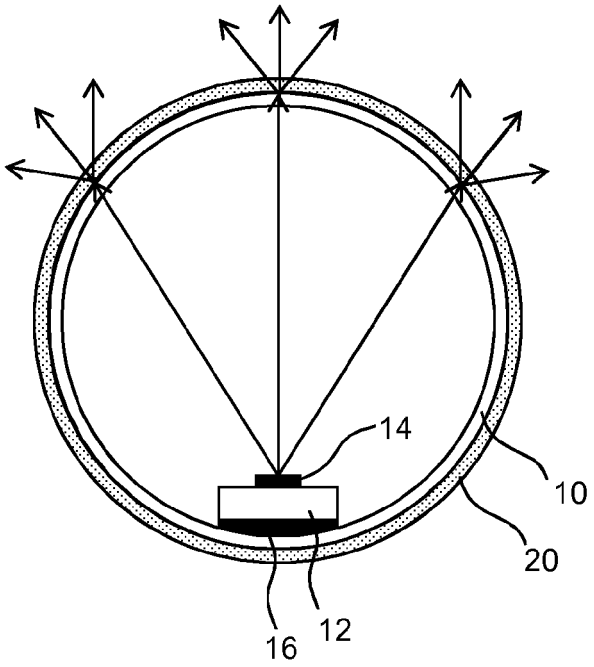

FIG. 1

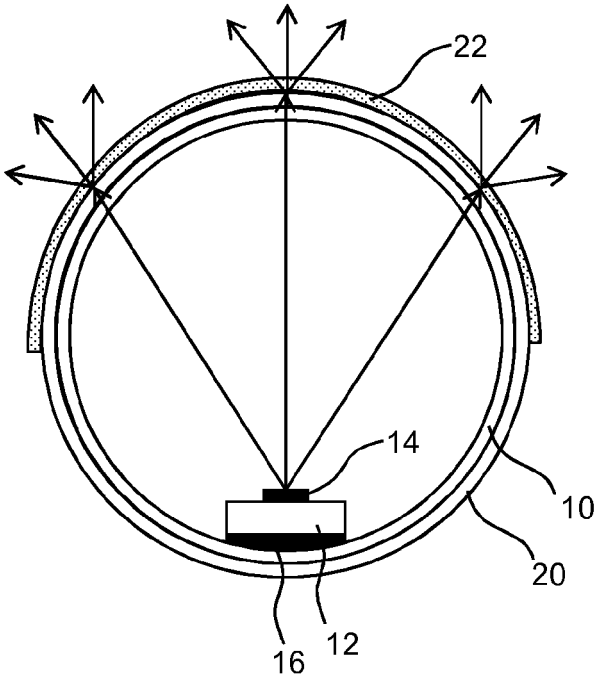

FIG. 2

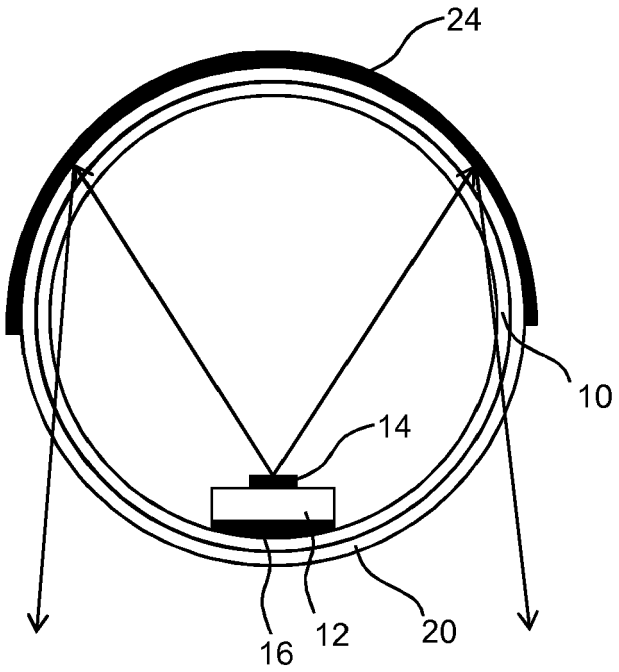

FIG. 3

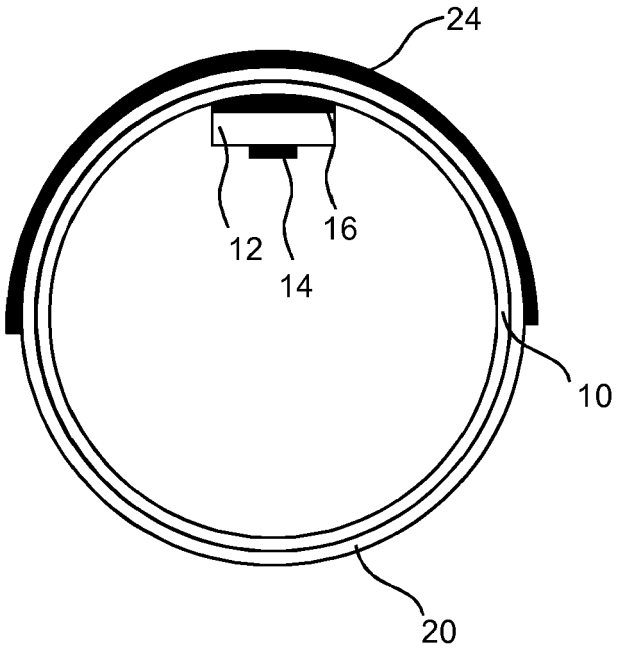

FIG. 4

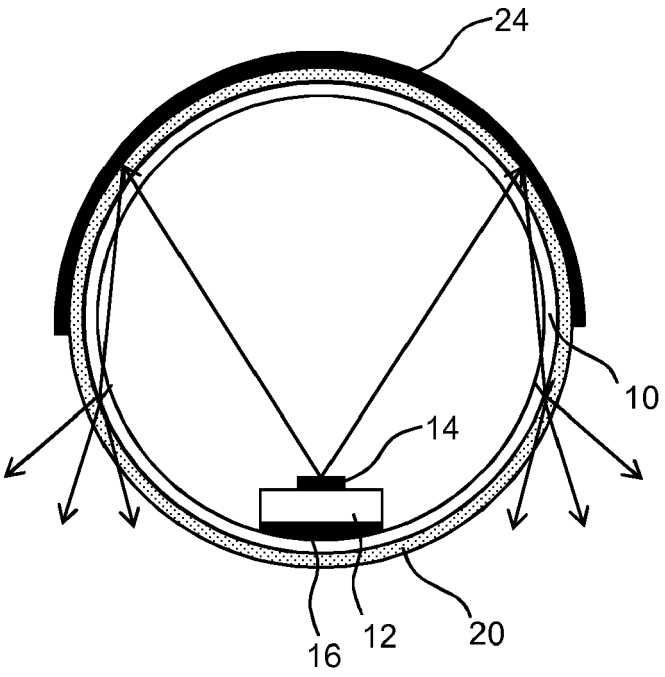

FIG. 5

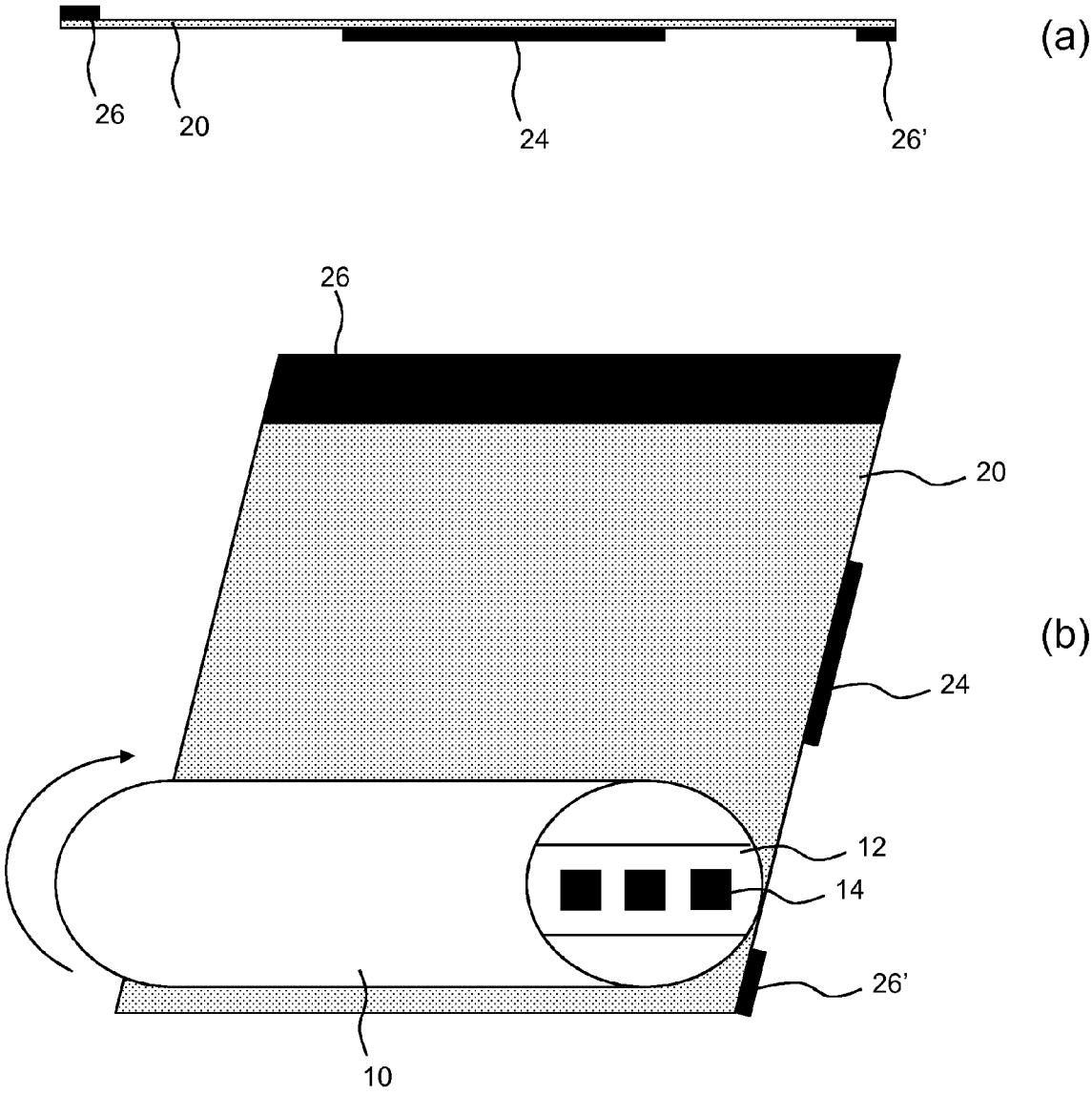

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 13 19 4172

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	3 March 2014	Soto Salvador, Jesús

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
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