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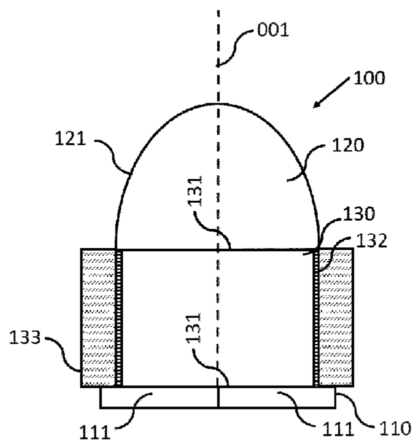
(54) **Title:** AN OPTICAL DIRECTIONAL DETECTOR



(a)

Figure 1

(57) Abstract: An optical detector (100) for receiving incoming optical signals from a plurality of directions is provided. The optical detector (100) comprises a sensor (110) having a plurality of sensor segments (111) and a first optical component (120) for forming an image of the incoming optical signals on the plurality of sensor segments (111). The optical detector (100) further comprises a second optical component (130) between the sensor (110) and the first optical component (120). Furthermore, the second optical component (130) is in optical contact (131) with the first optical component (120) and with the sensor (110). Also, the second optical component (130) has a cylindrical shape with a circumferential inner surface (132) and a circumferential outer surface (133). The circumferential inner surface (132) is light reflective and the circumferential outer surface is opaque (133).

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An optical directional detector

FIELD OF THE INVENTION

The invention generally relates to an optical detector that is arranged to receive incoming optical signals from a plurality of directions. Particularly, but not exclusively, this invention is concerned with an optical wireless communication receiver.

BACKGROUND OF THE INVENTION

In recent years, optical wireless communication has seen rapid growth in terms of research and commercial activities. High speed, high bandwidth, immunity to electromagnetic interference and security are attractive features that are driving these activities. Briefly, this is an area of communication in which modulated visible, infrared, or ultraviolet modulated light is used to transmit optical signals. This optical signal transmitting component is called the access point, that is connected to the information network. In a generic scenario, multiple access points are set up on the ceiling to cover the area of interest as much as possible. Each of the access points may be incorporated in a ceiling luminaire. At the receiving side, there is an optical detector that is arranged to receive these transmitted optical signals and establish a communication link with one of these access points.

Commonly, an optical detector is based on a light sensor provided with an optical element to collect light and to concentrate the collected light on the receiving surface of the light sensor. WO2009153697A1 discloses an optical detector made direction sensitive by using a light sensor with multiple segments. The optical detector further includes an optical conductor for conducting a light beam from the reception point to a particular light sensor segment. Each light sensor segment is associated with an acceptance interval that defines the angle of incidence which a light beam must have to reach the light sensor segment.

SUMMARY OF THE INVENTION

The arrangements for the optical detector suggested in the prior art result in a relatively large footprint for the optical detector in order to capture and concentrate light from a wide viewing angle. The light concentration process is typically characterized by the concentration ratio. The term concentration ratio refers to the factor by which the incident light energy flux is optically enhanced on the receiving surface. Maintaining a high concentration ratio with the arrangement proposed in the prior art limits down scaling the optical detector, especially when the optical conductor is made from trivial optical materials such as glass and polymer.

In addition, the inventors have also realized that an optical detector that has approximate direction selectivity can be beneficial. The optical wireless communication space generally constitutes multiple access points that are set up in defined stationary locations. Instead, an optical detector can be at an arbitrary location based on the user's movement and positioning. Hence, it can be beneficial if the optical detector could image the access points on the ceiling on detector/sensor segments and determine the approximate direction of the incident optical signals. As a result, significant energy efficiency can be achieved as a communication link is made between the optical detector and a single closest access point.

Therefore, the object of the present invention is to provide an optical detector that is capable of energy-efficient operation while keeping the optical detector compact with high concentration ratio for satisfactory signal quality.

The object is achieved by providing a detector having the features as defined in the independent claim. Preferred embodiments are defined in the dependent claims.

According to a first aspect of the invention, there is provided an optical detector for receiving incoming optical signals from a plurality of directions, wherein the optical detector comprises: a sensor having a plurality of sensor segments, and a first optical component for forming an image of the incoming optical signals on the plurality of sensor segments. The optical detector further comprises a second optical component between the sensor and the first optical component, wherein the second optical component is in optical contact with the first optical component and with the sensor, wherein the second optical component has a cylindrical shape with a circumferential inner surface and a circumferential outer surface, and wherein the circumferential inner surface is light reflective and the circumferential outer surface is opaque.

The sensor comprises a plurality of sensor segments that substantially are photodetectors of relatively small size, wherein each sensor segment can detect light waves independently of each other. By “independently of each other” is here meant that each segment may detect light waves and generate a signal based on the photons that are only incident on that segment. Thus, each segment may generate a signal distinguishable from all other segments.

The first optical component is for forming an image of the access points that are emitting the incoming optical signals. In other words, the first optical component is an image-forming optical component. In the context of the invention, an image-forming optical component is a converging optical component to produce a real image on the plurality of sensor segments. Suitable examples of an image-forming optical component include, but are not limited to, plano-convex lenses and cylindrical lenses with a semi-hemispherical or semi-ellipsoidal light receiving surface that allows a wide field of view.

The produced image of the access points on the plurality of sensor segments can be used to determine the direction of the access points. The sensor segments can be radially arranged, two-dimensionally arranged or linearly (one-dimensionally) arranged photodetectors.

An arrangement made with an image-forming optical component and a set of sensor segments can be substantially large if the goal is to produce an image from a wide field of view. Furthermore, achieving a high concentration ratio can be challenging as well.

These issues can be solved by employing a second optical component between the first optical component (such as an imaging lens) and the sensor segments, wherein the second optical component has a reflective inner circumferential surface. The optical signals coming from wide viewing angles are then reflected by the reflective inner circumferential surface and folded towards the sensor segments. This approach allows the implementation of a compact optical detector with a high concentration ratio without substantially increasing the size of the detector. The circumference of the second optical component can be circular or polygonal.

For the purpose of the invention, the image quality is not paramount as long as the signal has an intensity that is sufficiently higher than the background noise. Then the highest signal detected will indicate the direction of optical signals coming from the closest access point.

By increasing the number of sensor segments, the resolution of direction detection can be increased. However, the image quality such as the spread of the image over the segments may limit the implementation of the number of sensor segments.

A further advantage provided by the optical detector according to the first aspect of the invention is that it allows continuous imaging of the access points on the ceiling to improve hand-over execution between access points for a moving user. In certain conditions, it is possible that a plurality of sensor segments may have sufficient optical signal intensities for setting up multiple communication links between a plurality of access points. Therefore, this unit optical detector may also allow multi-channel communication thereby increasing the bandwidth of communication.

The optical detector may further comprise a third optical component between the second optical component and the sensor, wherein the third optical component is an optical concentrator having a plurality of concentrator segments that are optically isolated from each other by means of one or more optical isolators, wherein the plurality of sensor segments and the plurality of concentrator segments consists of equal numbers, and wherein each concentrator segment is arranged to concentrate radiation energy onto a unique sensor segment.

This has the advantage that the image formed by the first optical component and the second optical component can be concentrated towards individual sensor segments by the third optical component. This third optical component also allows the image formed on the entry plane of the component to be optically isolated and prevents interaction between other sensor segments as each concentrator segment is arranged to concentrate radiation energy onto a unique sensor segment, for example, because the optical isolators align with the borders of the sensor segments. This will help increase the signal to noise ratio for better detection capability as the optical cross-talks are minimized.

The first optical component has an optical axis, and the first optical component may be arranged to receive optical signals at an acceptance angle up to at least 50 degrees from the optical axis.

In the context of the invention, the maximum acceptance angle is the maximum incidence angle from the optical axis of the first optical component at which incoming optical signals can be captured. A large acceptance angle is desired to ensure a sufficient field of view such that most of the access points can be images by the optical detector. An acceptance angle up to at least 50 degrees may be sufficient.

The third optical component of the optical detector may be a compound parabolic concentrator, a total internal reflecting concentrator or a cone concentrator.

Well known optical concentrators with various geometries can be used. One such concentrator has to be assembled in such a way that the segmented components will make up a unit concentrator itself once put together. Alternatively, a unit optical concentrator can be considered that corresponds to a unique sensor segment. In this case, an equal number of such unit optical concentrators can be assembled onto the sensor segments. The borders between these optical concentrators or separation between these optical concentrators can constitute the optical isolators.

The first optical component, the second optical component and, if present, the third optical component of the optical detector may be made of the same material.

The optical components of the optical detector being made of a single optical material has the advantage that a homogeneous optical medium is formed wherein the optical signal can propagate forward without back reflection at interfaces.

The first optical component, the second optical component and, if present, the third optical component of the optical detector may be made of a material having a refractive index in a range from 1.4 to 1.7.

This has the advantage that the optical detector may be realized with a compact form factor and a high concentration ratio with commonly used low-cost optical materials such as glass, PMMA, polycarbonate, and silicone. These optical materials typically have a refractive index in a range from 1.4 to 1.7.

The first optical component, the second optical component and the third optical component of the optical detector may be made of a material having a refractive index greater than 1.7.

One way to reduce the size of the optical detector for use in portable and mobile devices by using optical materials with a relatively high refractive index. This is because increasing the refractive index of the optical components may improve the concentration ratio.

The first optical component, the second optical component and, if present, the third optical component of the optical detector may be interconnected by means of an optical adhesive.

The optical components can be fabricated individually as separate elements. Then, they can be glued together utilizing an optical adhesive to form one single, robust and mechanically stable optical body.

The first optical component, the second optical component and, if present, the third optical component of the optical detector may be monolithically formed.

It is beneficial in terms of production to fabricate the optical components monolithically, for example by means of additive or subtractive manufacturing techniques such as injection molding, transfer molding and 3D printing.

The optical isolators of the third optical component of the optical detector may be air gaps or air cavities.

The optical isolators can be air gaps or air cavities having a width or thickness larger than a few times the wavelength of the light used. For example, the air gaps or air cavities may have a width of at least 5 micrometers, or at least 10 micrometers, or at least 100 micrometers. These optical isolators may be conceived by slicing the third optical component by means of laser ablation.

The circumferential inner surface of the second optical component may be provided with a first metal layer or with a dielectric mirror layer.

The circumferential inner surface of the second optical component is preferably completely reflective so that the optical signals are folded on the sensor segments without any loss due to partial transmission and/or absorption.

The circumferential outer surface of the second optical component may be provided with a second metal layer or a light absorbing layer.

To optimize the signal quality, light should preferably only enter the optical detector via the first optical component. An opaque circumferential outer surface will limit the entry of stray light and/or unwanted light into the optical detector, thereby providing a higher signal quality.

The second optical component of the optical detector may be in optical contact with the sensor by means of an optical adhesive.

Optical components may be connected to the sensor via optical adhesives to form one single, robust and mechanically stable optical detector.

In the optical detector according to the first aspect, the second optical component is in optical contact with the first optical component and with the sensor. The term “optical contact” generally refers to a juxtaposition of two surfaces with a separation small compared to the wavelength of light so that interference fringes are not observable. In the context of the present invention, two components are said to be in optical contact with each other if light rays can travel from one component to the other without being perturbed. Two components can be in direct or indirect optical contact with each other, the latter referring to the situation wherein there is an intermediate component between the two components, such as a further optical component or an optical adhesive. When an optical adhesive is used to bring two components in optical contact with each other, the refractive index of the optical adhesive may be in between the refractive indices of the two components that are brought in optical contact with each other. On the other hand, direct optical contact can be established between two optical components when they are arranged to have direct physical contact. A suitable example can be surface adhesion by means of weak Van Der

Waals interactions. The first optical component of the optical detector may have a receiving surface that is provided with a first anti-reflection layer.

A carefully chosen anti-reflection layer on the receiving surface that matches the application wavelength or bandwidth may significantly improve the amount of light captured by the optical detector.

The sensor segments of the optical detector may be provided with a second anti-reflection layer.

Sensor segments of a photodetector are often based on silicon, which has a relatively high refractive index (n=3.6). Therefore, such segments may be highly reflective. To reduce the reflection from the sensor segments and to ensure maximum absorption of the optical signal, anti-reflection coatings may be applied on the light receiving surface of the sensor segments.

According to a second aspect of the invention, there is provided a device comprising the optical detector and a data transfer interface. The optical detector may be communicatively connected to the data transfer interface. The optical detector may be part of a device that is provided with a commonly used data transfer interface. The device can be a mobile or a portable device and the data transfer interface such as popularly used USB type connectivity (e.g. USB stick or dongle) which can be connected to a computer. Therefore, the optical signals detected by the optical detector can be transferred and utilized as desired by the user.

It is noted that the invention relates to all possible combinations of features recited in the claims. Other objectives, features, and advantages of the present inventive concept will appear from the following detailed disclosure, from the attached claims as well as from the drawings. A feature described in relation to one of the aspects may also be incorporated in the other aspect, and the advantage of the feature is applicable to all aspects in which it is incorporated.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, and in which:

Figures 1(a) and 1(b) show an optical detector in a cross-sectional view and top view, respectively;

Figure 2 shows a schematic drawing of the operating principle of the invention;

Figures 3(a) and 3(b) show cross-sectional views of optical detectors with different geometries for the third optical component;

Figure 4(a) and 4(b) show perspective views of the third optical component along with the sensor segments;

Figure 5 shows the operating principle of the invention with the third optical component; and

Figures 6(a) to 6(c) show a top view of an optical detector with a third optical component and a sensor.

As illustrated in the figures, the sizes of layers and regions are exaggerated for illustrative purposes and, thus, are provided to illustrate the general structures of embodiments of the present invention. Like reference numerals refer to like elements throughout.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which currently preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided for thoroughness and completeness, and fully convey the scope of the invention to the skilled person.

Figure 1(a) schematically shows a cross-sectional view of an optical detector 100. The optical detector 100 comprises a sensor 110 which is essentially a photodetector to detect the image of the incoming optical signals and it comprises a plurality of segments 111. The image is produced by an imaging lens 120. The imaging lens 120 is an example of a first optical component 120 to concentrate optical signals with an acceptance angle of at least up to 50 degrees from the optical axis 001. The imaging lens 120 is a semi-hemispherical lens with a convex light receiving surface 121. Alternatively, the imaging lens may be a semi-ellipsoidal lens with a semi-major and semi-minor axis or a cylindrical lens. Between the sensor 110 and the first optical component 120, there is a second optical component 130. The second optical component 130 is in optical contact 131 with the first optical component 120 and with the sensor 110. Therefore, light entering the first optical component 120 will be able to freely propagate towards the sensor 110 via the second optical component 130. The second optical component 130 has a circumferential inner surface 132 and a circumferential outer surface 133. The circumferential inner surface 132 is light reflective to contain the light within the optical detector 100. Thin layers of metal or multilayer thin-films forming a dielectric mirror layer can effectively represent this reflective circumferential inner surface 132. On the other hand, the circumferential outer surface 133 is opaque such that no stray light gets in the optical detector 100. Thick layers of metal, opaque plastic materials, or black paint can effectively represent this opaque circumferential outer surface 133.

Figure 1(b) shows a top view of the optical detector 100. From this perspective, the second optical component 130 is presented to have a cylindrical geometry with a circular circumference. Alternatively, the second optical component may also have a geometry that has a polygonal circumference.

The sensor 110 has four segments 111 that are radially distributed. The number of segments can be increased for higher resolution of detectability, although this may be limited by the quality of the image produced by the first optical component 120 and second optical component 130. While a radial array of sensor segments will facilitate direction detection with high confidence, linear arrays of sensor segments 111 may also be used for the simplicity of implementation. Linear arrays are expected to result in significantly lower power dissipations on system level, while simplifying the addressability and track-and-trace algorithms in case of sweeping or segment-wise activated beams.

The principle of the invention is presented using the schematic image in Figure 2. Here, the optical detector 100 is exhibited in a scenario wherein two light sources acting as information access points 002 and 003, respectively. This scenario represents a situation where multiple access points are available on the ceiling with defined height and distinct spacing in between. The first access point 002 emits optical signal 102 that is incident on the optical detector 100 from one direction, while the second access point 003 emits optical signal 103 that is incident on the optical detector 100 from another direction. The optical detector 100 is placed between these access points 002 and 003 such that a wide angles of incidence from these access points 002 and 003 are obtained. The optical signals 102 and 103 impinging on receiving surface 121 of the first optical component 120 are refracted and guided towards the circumferential inner surface 132 of the second optical component 130. Since the circumferential inner surface 132 is light reflective, the image of the optical signals from access points 002 and 003 are formed on different sensor segments 111. Thereby, the directions of the access points 002 and 003 are known. In this scenario, it is beneficial to know the direction of the nearest access point which can be determined from the relative intensity difference between these two optical signals.

The optical detector 100 can also find an access point immediately on top or in closer proximity. In that case, the image of the optical signals originating from that access point will directly form on the sensor segments 111 via the first optical component 120. The signal intensity can be higher compared to the scenario presented in Figure 2. Therefore, the need to determine the direction of an alternative access point with higher intensity is not needed.

The reflective circumferential inner surface 132 allows incoming optical signals from different directions and wide viewing angles to be contained within the optical detector 100. Hence, it allows the implementation of a compact device with a small footprint. The relative intensity difference between these two optical signals will also allow the determination of the nearest information access point.

In the optical detector 100 as shown in Figure 3, a third optical component 140 is included between the second optical component 130 and the sensor 110. The third optical component 140 is an optical concentrator that is also in optical contact 131 with the second optical component 130 and with the sensor 110. In Figure 3(a), the third optical component 140 is a compound parabolic concentrator. In Figure 3(b), the third optical component 140 is a total internal reflecting concentrator or a cone concentrator. This component also has a plurality of concentrator segments 141 that are equal in numbers as the sensor segments 111. These concentrator segments 141 are optically isolated from each other by optical isolators 142. The optical isolators 142 are air gaps or air cavities having a thickness larger than a few times the wavelength of the optical signals. For example, they may have a width of at least 5 micrometers, or at least 10 micrometers, or at least 100 micrometers. These optical isolators 142 can be conceived by slicing the third optical component 140 by means of laser ablation. The optical isolators 142 are aligned with the borders of the sensor segments 111, so that each concentrator segment 141 is arranged to concentrate radiation energy onto a unique sensor segment 111.

The third optical component 140 has a light entry plane 004 and a light exit plane 005. In Figure 3, the second optical component 130 is in optical contact with the sensor segments 111 via the third optical component 140. Figure 4(a) shows a perspective view of the third optical component 140 along with the sensor segments 111.

In Figure 4(b), a perspective view of the third optical component 140 in an alternative embodiment is shown along with the sensor segments 111.

The third optical component 140 shown in Figure 4(b) essentially consists of an arrangement of optical concentrators. Each of these optical concentrators can be considered to represent a separate concentrator segment, wherein the arrangement as a whole represents the third optical component 140. In this case, the separation between the optical concentrators or the borders of the optical concentrators represent the optical isolators 142.

The operating principle of the invention in case a third optical component 140 is included in the optical detector 100 is presented using the schematic images in Figure 5.

The image of the optical signals originating from 002 and 003 which previously formed on the sensor segments 111 in Figure 2, is now formed on the light entry plane 004 of the third optical component 140. The first optical component 120 may have an image plane that substantially coincides with the light entry plane 004 of the concentrator segments 141. The image plane does not need to exactly coincide with the light entry plane 004, as it may be located somewhat above or below the light entry plane 004 to make the optical detector 100 less critical for alignment. The image of the optical signals corresponding to their access points from various directions is separated by the concentrator segments 141 into a number of images depending on the number of the concentrator segments 141 and propagated toward the sensor segments 111. Therefore, the images of the optical signals from access points 002 and 003 are formed on different sensor segments 111. Thereby, the directions of the optical signal sources are known. The nearest direction of the source optical signal can be determined from the intensity of the images as well. The images of the optical signals are isolated and concentrated towards the respective sensor segments 111. This way, more light is captured by the sensor segments 111, optical cross-talks between the segments are minimized and therefore the resolution of direction detection can be improved.

In Figures 6(a) to 6(c), top views of the third optical component 140 on the sensor 110 are shown. As mentioned earlier, optical concentrators with various geometries can be used as the third optical component 140.

In Figure 6(a), the third optical component 140 is a concentrator with a circular light entry circumference 143 and a circular light exit circumference 144. Because the radiation should be concentrated towards the sensor 110, the circular light entry circumference 143 is larger compared to the circular light exit circumference 144. Because of this, the inner circumference 145 of the third optical component can be seen from the top. The optical isolators 142 are aligned with the borders of the sensor segments 111. Alternatively, the concentrator can have a polygonal, such as a square or rectangular light entry surface 143 and a correspondingly shaped light exit surface 144, as shown in Figure 4(b). When the third optical component 140 has a square or rectangular circumference, the optical isolators 142 can be also realized diagonally. In that case, the sensor 110 has to be rotated 45 degrees to align the sensor segments 111 borders as shown in Figure 4(c). It is also possible to have a square or rectangular light entry circumference and a circularly shaped light exit circumference and vice versa.

The first optical component 120, the second optical component 130 and the third optical component 140 can be made from one single optical material. It is possible to realize these optical components with traditional and economic optical materials such as glass and polymer composites that have refractive indices in a range from 1.4 and 1.7. Even so, the embodiments are not limited to these materials only, as materials with refractive indices higher than 1.7 may be used to further reduce the footprint of the optical detector 100. Some commercially available optical material with a high refractive index would be S-LAH79 (n_D = 2.00, Ohara corporation) and N-LASF44 (n_D = 1.8, Schott AG).

Additive and subtractive manufacturing techniques such as 3D printing, injection molding, or transfer molding can be used to realize a monolithically formed single optical body that includes the first optical component 120, the second optical component 130, and the third optical component 140.

On the other hand, individual optical components can be glued to form the optical contacts 131. Silicone resin or other refractive index matching optical adhesives can be used. For the purpose of refractive index matching, high refractive index adhesives can be obtained from NTT Advanced Technology Corporation. An alternative for using adhesives can be waferbonding in which two flat and clean surfaces are put together to provide adhesion between the surfaces by means of Van der Waals interactions. Similarly, the second optical component 130 or the third optical component is connected with the sensor 110.

Furthermore, at least one of (i) the light receiving surface 121 of the first optical component 120 and (ii) the sensor 110 may also contain an anti-reflection coating to ensure optimum light collection.

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. Use of the verb “to comprise” and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article “a” or “an” preceding an element does not exclude the presence of a plurality of such elements.

The mere fact that certain features are recited in mutually different dependent claims does not indicate that a combination of these features cannot be used to advantage. The various aspects discussed above can be combined in order to provide additional advantages. Further, the person skilled in the art will understand that two or more embodiments may be combined.

CLAIMS:

1. An optical detector (100) for receiving incoming optical signals from a plurality of directions, wherein the optical detector (100) comprises:

- a sensor (110) having a plurality of sensor segments (111), and
- a first optical component (120) for forming an image of the incoming optical signals on the plurality of sensor segments (111),

the optical detector (100) further comprises a second optical component (130) between the sensor (110) and the first optical component (120),

wherein the second optical component (130) is in optical contact (131) with the first optical component (120) and with the sensor (110),

wherein the second optical component (130) has a cylindrical shape with a circumferential inner surface (132) and a circumferential outer surface (133), and

wherein the circumferential inner surface (132) is light reflective and the circumferential outer surface is opaque (133).

2. The optical detector (100) according to claim 1, wherein the optical detector further comprises a third optical component (140) between the second optical component (130) and the sensor (110),

wherein the third optical component (140) is an optical concentrator having a plurality of concentrator segments (141) that are optically isolated from each other by means of one or more optical isolators (142),

wherein the plurality of sensor segments (111) and the plurality of concentrator segments (141) consist of equal numbers, and

wherein each concentrator segment (141) is arranged to concentrate radiation energy onto a unique sensor segment (111).

3. The optical detector (100) according to any one of the preceding claims, wherein the first optical component (120) has an optical axis (001), and wherein the first

optical component (120) is arranged to receive optical signals at an acceptance angle up to at least 50 degrees from the optical axis (001).

4. The optical detector (100) according to claim 2, wherein the third optical component (140) is a compound parabolic concentrator, a total internal reflecting concentrator or a cone concentrator.

5. The optical detector (100) according to any one of claims 2 to 4, wherein the first optical component (120), the second optical component (130) and the third optical component (140) are made of the same material.

6. The optical detector (100) according to any one of claims 2 to 5, wherein each of the first optical component (120), the second optical component (130) and the third optical component (140) is made of a material having a refractive index in a range from 1.4 to 1.7.

7. The optical detector (100) according to any one of claims 2 to 5, wherein each of the first optical component (120), the second optical component (130) and the third optical component (140) is made of a material having a refractive index greater than 1.7.

8. The optical detector (100) according to any one of claims 2 to 7, wherein the first optical component (120), the second optical component (130) and the third optical component (140) are interconnected by means of an optical adhesive.

9. The optical detector (100) according to any one of claims 2 to 7, wherein the first optical component (120), the second optical component (130) and the third optical component (140) are monolithically formed.

10. The optical detector (100) according to any one of claims 2 to 9, wherein the optical isolator (142) is an air gap or an air cavity, and wherein the air gap or the air cavity has a width of at least 5 micrometers.

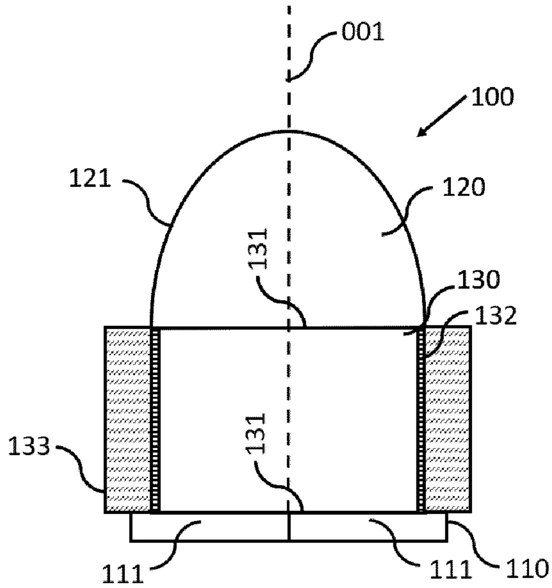
11. The optical detector (100) according to any one of the preceding claims, wherein the circumferential inner surface (132) of the second optical component (130) is provided with a first metal layer or with a dielectric mirror layer.

12. The optical detector (100) according to any one of the preceding claims, wherein the circumferential outer surface (133) of the second optical component (130) is provided with a second metal layer or a light absorbing layer.

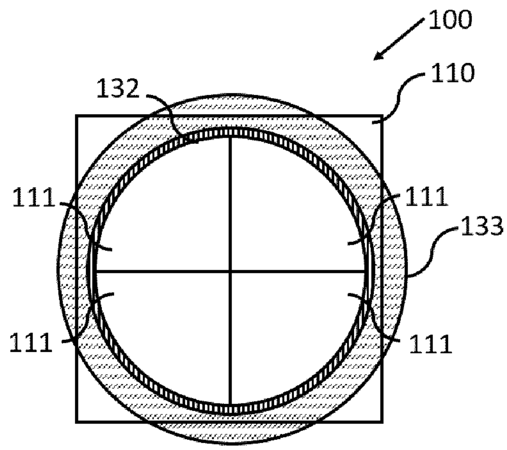
13. The optical detector (100) according to any one of the preceding claims, wherein the second optical component (130) is in optical contact with the sensor (110) by means of an optical adhesive.

14. The optical detector (100) according to any one of the preceding claims, wherein the first optical component (120) has a receiving surface (121) that is provided with a first anti-reflection layer.

15. A device comprising the optical detector (100) according to any one of the preceding claims and a data transfer interface, wherein the optical detector (100) is communicatively connected to the data transfer interface.


001
100
121
120
131
130
132
133
131
111
111
110

(a)


100
132
110
111
111
133
111
111

(b)

Figure 1

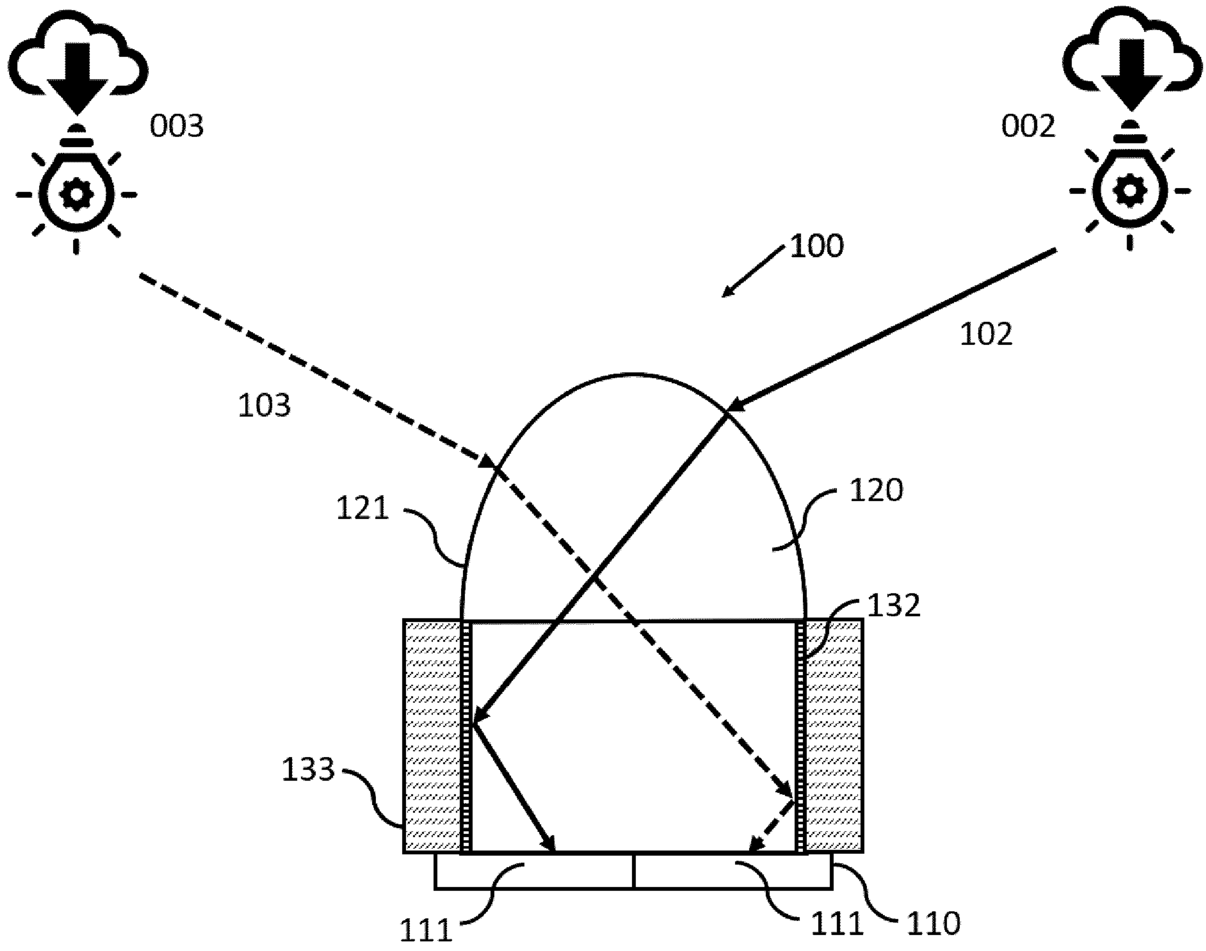
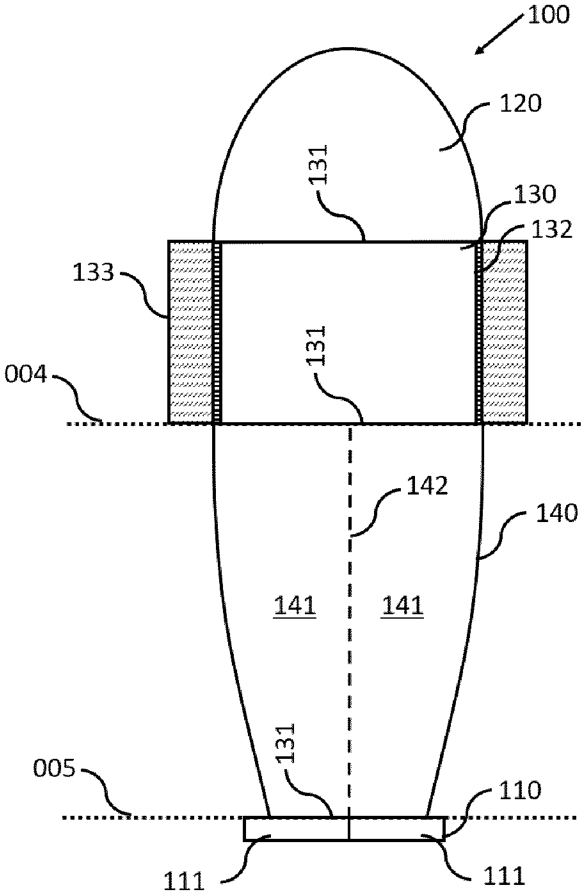


Figure 2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131
004
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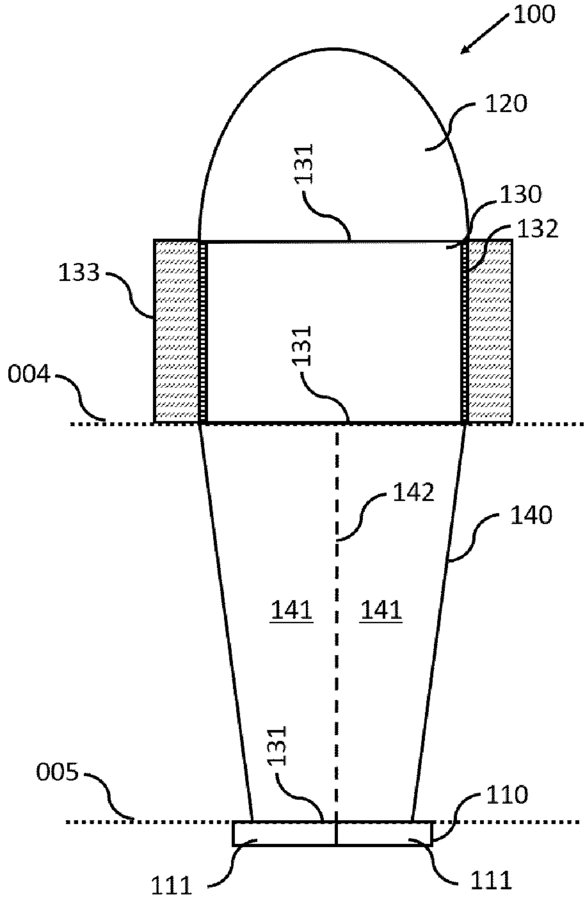
140
141
141
131
005
110
111
111

(a)


100
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131
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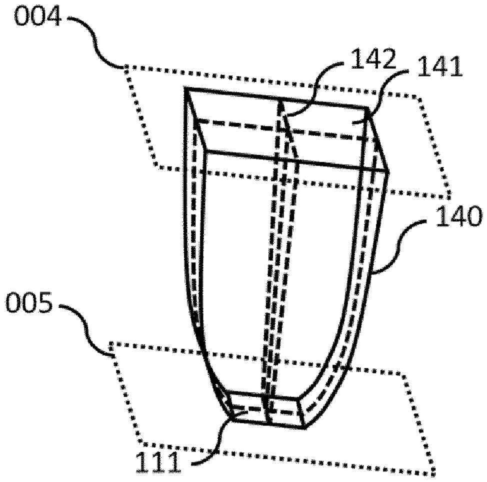
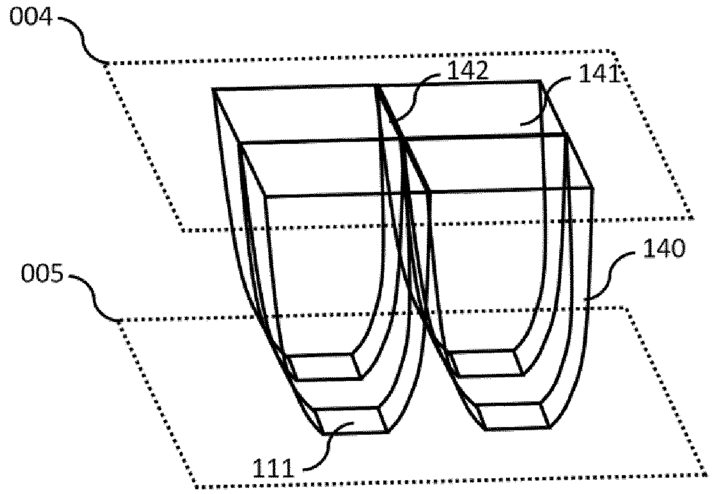
132
133
131
004
142
140
141
141
131
005
110
111
111

(b)

Figure 3



(a)



(b)

Figure 4

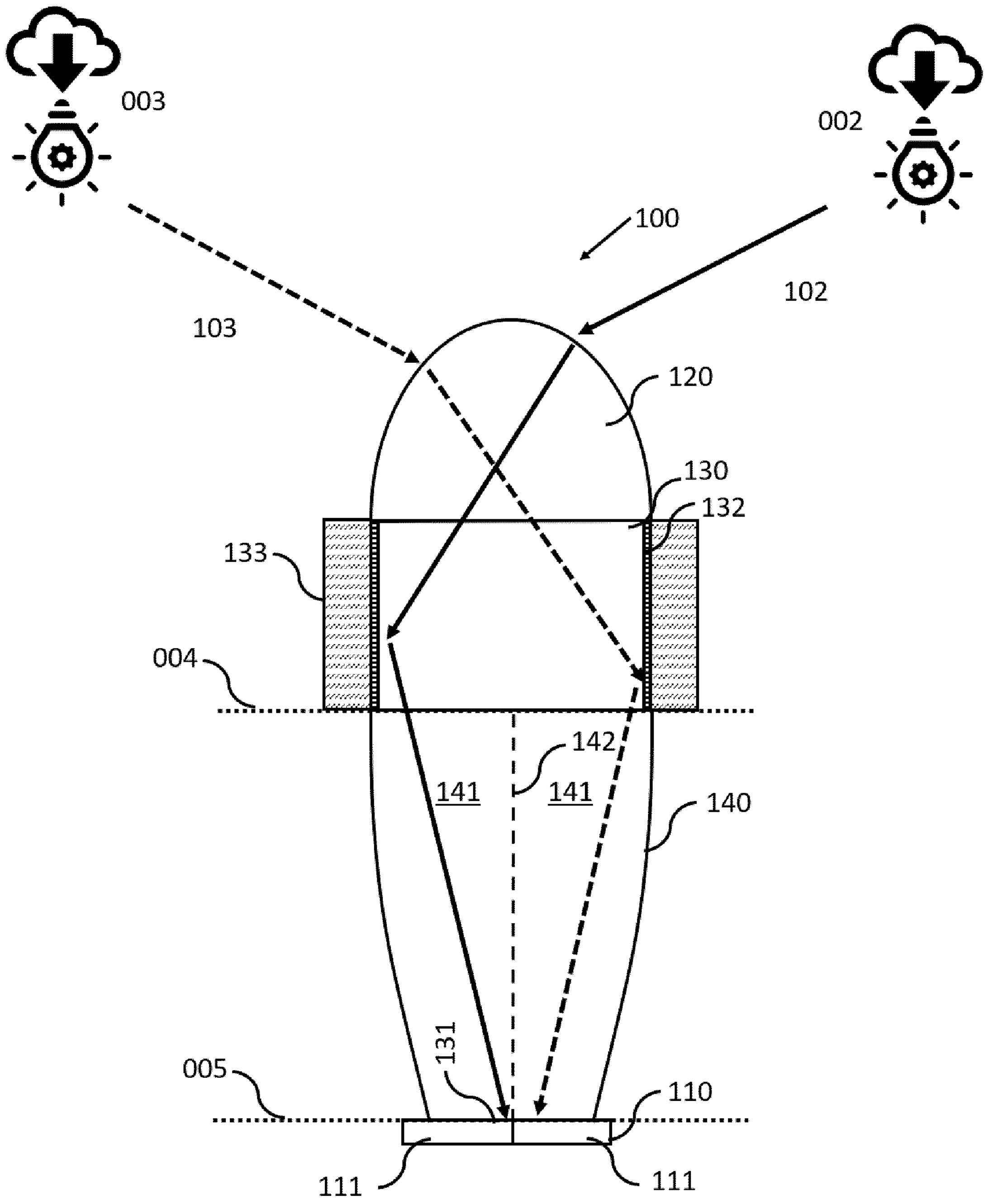
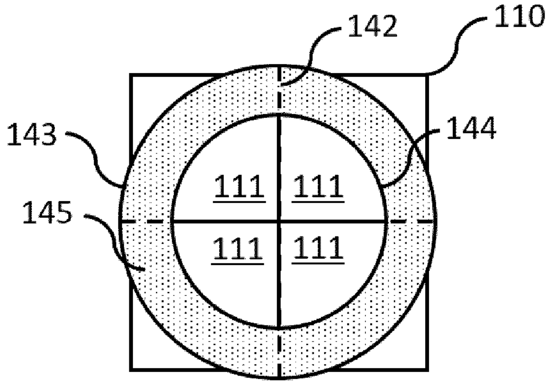
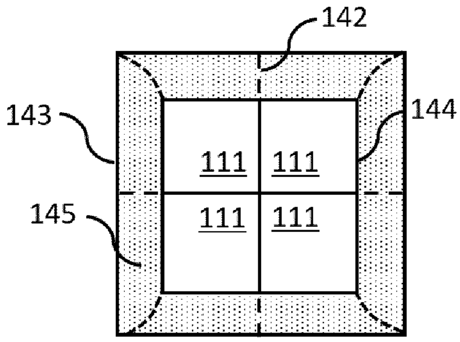

003
002
100
102
103
120
130
132
133
004
142
141
141
140
131
005
110
111
111

Figure 5

(a)


142
110
143
144
111
111
145
111
111

(b)


142
143
144
111
111
145
111
111

(c)

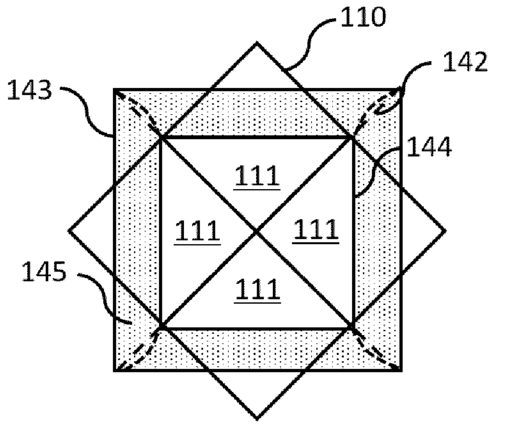

110
143
142
144
111
111
111
145
111

Figure 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2021/060061

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B10/114 G02B19/00 H04B10/67
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2018/213200 A1 (OUSTER INC [US]) 22 November 2018 (2018-11-22) paragraph [0152] - paragraph [0157] figures 22A-I,23A-E,24 paragraphs [0056], [0117], [0132], [191197] -----	1-15
A	US 2007/237490 A1 (REININGER FRANCIS MARK [US]) 11 October 2007 (2007-10-11) paragraph [0039]; figures 1,10 paragraph [0046]; figure 8 figure 4 -----	1-15
A	WO 2010/041249 A1 (ZIRUZ NIHUL LTD [IL]; RUZIAK YARON [IL]) 15 April 2010 (2010-04-15) page 12; figure 5 -----	1-15
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 June 2021	09/07/2021

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Borsier, Celine

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2018/220388 A1 (PURELIFI LTD [GB]) 6 December 2018 (2018-12-06) page 12, line 22 - line 32; figures 10,11 -----	1-15
A	WO 2018/220389 A1 (PURELIFI LTD [GB]) 6 December 2018 (2018-12-06) figures 10,11 -----	1-15

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2021/060061

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		WO 2018220389 A1	06-12-2018