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(54) **LIGHT MODULE ASSEMBLY HAVING REDUCED MOISTURE INGRESS AND METHOD FOR MANUFACTURING THE SAME**

LICHTMODULANORDNUNG MIT REDUZIERTEM FEUCHTIGKEITSEINGANG UND VERFAHREN ZUR HERSTELLUNG DAVON

ENSEMBLE MODULE DE LUMIÈRE AYANT UNE ENTRÉE D'HUMIDITÉ RÉDUITE ET SON PROCÉDÉ DE FABRICATION

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Description

FIELD

[0001] Embodiments of the subject matter disclosed herein relate to light module assemblies, such as devices that generate light.

BACKGROUND

[0002] Light module assemblies include devices that emit light. One example of such assemblies includes light emitting diode (LED) modules. These types of modules can include one or more LEDs, a circuit board to supply power to the LEDs, and one or more lenses to redistribute or adjust the light emitted by the LEDs in space and/or to protect the LEDs from the external environment.

[0003] In some circumstances, these modules may be used in locations that expose the modules to environmental conditions. These environmental conditions can include moisture, such as water from rain, snow, sleet, condensation, or the like. Because the LEDs are electric devices, exposure of the LEDs and/or circuit boards to moisture can damage and/or destroy the module. For example, moisture can pass between seals between components of the modules and/or damage these seals. The moisture can reach underneath the lenses where the electrical components of the modules are located. If sufficient moisture reaches the LEDs and/or circuit boards, the LED modules may no longer be capable of generating light.

[0004] Some known LED modules include seals between lenses of the modules and other components of the modules. These seals located on or in interfaces between different components of the modules, and are intended to prevent ingress of moisture into the interiors of the modules. But, the seals may not be able to prevent all moisture from passing between the interfaces. Once the moisture is inside the module and between the interfaces, the moisture may pass along the interface and reach the electric components of the modules.

US2011/157891A1 discloses a light module including one or more LEDs coupled to a circuit board, a lens disposed over at least one LED, and an adhesive layer disposed between each LED and the lens.

BRIEF DESCRIPTION

[0005] In one embodiment, a light module assembly includes a lens, a circuit board, and an overmold body. The lens includes one or more pooling structures formed by transversely oriented exterior surfaces of the lens. The circuit board is coupled to the lens and has one or more light-generating devices disposed on the circuit board. The overmold body is coupled to the lens to form an interface between the lens and the overmold body. The interface between the lens and the overmold body includes or defines a moisture ingress path into the circuit

board. The one or more pooling structures prevent passage of moisture along the moisture ingress path past the one or more pooling structures to the circuit board.

[0006] In the invention, as disclosed in claim 1, another light module assembly includes a circuit board, a lens, and an overmold body. The circuit board includes opposite first and second sides with one or more light-generating devices disposed on the first side of the circuit board. The first and second sides are separated by opposite first and second ends of the circuit board. The lens is coupled with the circuit board such that the one or more light-generating devices are between the lens and the circuit board. The lens includes arms that extend around the first and second ends the circuit board and project past the circuit board in a direction that is opposite of a light-emanating direction of the light-generating devices. The arms include one or more pooling structures. The overmold body is coupled to the lens to form an interface between the lens and the overmold body. The interface forms a moisture ingress path into the circuit board from outside of the overmold body and the lens. The one or more pooling structures in the arms collect moisture passing along the moisture ingress path and prevent passage of the moisture along the moisture ingress path past the one or more pooling structures to the circuit board.

[0007] In the invention, as disclosed in claim 7, a method includes forming a lens of a light module assembly to include arms forming one or more pooling structures and coupling the lens with a circuit board having opposite first and second sides with one or more light-generating devices disposed on the first side of the circuit board. The first and second sides are separated by opposite first and second ends of the circuit board. The lens is coupled with the circuit board such that the one or more light-generating devices are between the lens and the circuit board and such that the arms of the lens extend around the first and second ends the circuit board and project past the circuit board in a direction that is opposite of a light-emanating direction of the light-generating devices. The method also includes forming an overmold body on the lens to form an interface between the lens and the overmold body. The interface forms a moisture ingress path into the circuit board from outside of the overmold body and the lens. The one or more pooling structures in the arms collect moisture passing along the moisture ingress path and prevent passage of the moisture along the moisture ingress path past the one or more pooling structures to the circuit board.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The subject matter described herein will be better understood from reading the following description of non-limiting embodiments, with reference to the attached drawings, wherein below:

Figure 1 illustrates a perspective view of a light module assembly according to one embodiment;

Figure 2 illustrates a cross-sectional view of the light module assembly along line 2-2 shown in Figure 1;

Figure 3 illustrates another cross-sectional view of the light module assembly along line 3-3 shown in Figure 1;

Figure 4 illustrates a cross-sectional view of one portion of arms of the lens shown in Figure 2 according to one embodiment;

Figure 5 illustrates a cross-sectional view of another portion of the arms of the lens according to one embodiment; and

Figure 6 is a flowchart of one embodiment of a method for manufacturing a light module assembly.

DETAILED DESCRIPTION

[0009] Embodiments described herein relate to light module assemblies and methods of manufacturing the same. The light module assemblies prevent ingress of moisture to locations where electric components of the assemblies are located and, as a result, have greater ingress protection (IP) ratings that some known LED modules. The light module assemblies include uniquely shaped components, such as lenses, having a moisture pooling structure in the outer shapes of the components. This structure is shaped such that, when the lenses are coupled with other components, such as an overmold body, the interface between the lens and the overmold body can be shaped to significantly reduce or eliminate ingress of moisture into the assemblies sufficiently far to reach or damage electric components of the assemblies.

[0010] Figure 1 illustrates a perspective view of a light module assembly 100 according to one embodiment. The assembly 100 includes an overmold body 102, which also may be referred to as an outer housing, outer body, or the like. The overmold body 102 is coupled with a light-transmissive lens 104. Between the lens 104 and the overmold body 102 are one or more light-generating devices 106 (such as LEDs or another type of electric device that generates light) and one or more circuit boards (not shown in Figure 1). While three light-generating devices 106 are shown in the illustrated embodiment, alternatively, the assembly 100 may include a different number of light-generating devices 106, such as a single device 106, two devices 106, or more than three devices 106. The overmold body 102 and/or lens 104 can be formed from a variety of materials. For example, the overmold body 102 can be formed from poly(vinyl chloride), or PVC, or another type of polymer. The lens 104 can be formed from acrylic or another type of polymer or other material that permits at least some light generated by the light-generating devices 106 to pass therethrough and emanate from the lens 104. One or more power supplies 108 (e.g., cables, conductive buses, wires, or the like) extend

into the overmold body 102 and/or lens 104 to conductively couple the printed circuit board with one or more sources of electric current, such as an electric outlet, a battery, or the like.

[0011] Figure 2 illustrates a cross-sectional view of the light module assembly 100 along line 2-2 shown in Figure 1. The cross-sectional view of the light module assembly 100 shown in Figure 2 may be referred to as the X-section of the assembly 100. Figure 3 illustrates another cross-sectional view of the light module assembly 100 along line 3-3 shown in Figure 1. The cross-sectional view of the light module assembly 100 shown in Figure 3 may be referred to as the Y-section of the assembly 100.

[0012] A circuit board 200 is disposed between the lens 104 and the overmold body 102. The light-generating devices 106 are conductively coupled with the circuit board 200. The circuit board 200 may be sandwiched between the lens 104 and the overmold body 102 such that one side 202 (e.g., an upper or light-emitting side) of the circuit board 200 is in direct physical contact with the lens 104 with no intermediate components or materials between the circuit board 200 and the lens 104 and such that an opposite side 204 (e.g., a lower side) of the circuit board 200 is in direct physical contact with the overmold body 102 with no intermediate components or materials between the circuit board 200 and the overmold body 102. Alternatively, one or more other components or materials may be between the lens 104 and the circuit board 200 and/or between the overmold body 102 and the circuit board 200, such as adhesives, sealants, or the like.

[0013] A light-emanating or light-emitting direction of the assembly 100 is a direction oriented upward in the perspective of Figure 2. This is the direction in which light generated by the light-generating devices 106 and emanating from the lens 104 is primarily oriented, even though some of the light may emanate from the lens 104 in other directions. In one embodiment, the light-emanating or light-emitting direction is oriented upward in the perspective of Figure 2 in an orientation that is perpendicular to the top side 202 of the circuit board 200.

[0014] The circuit board 200 also extends between opposite ends 206, 208, with each end 206, 208 extending vertically (in the perspective of Figure 2) from one side 202 of the circuit board 200 to the opposite side 204 of the circuit board 200. Another end 210 of the circuit board 200 extends between the sides 202, 204 and the ends 206, 208, as shown in Figure 2. An end 300 of the circuit board 200 shown in Figure 3 may be opposite of the end 210 and also may extend vertically between the sides 202, 204 and the ends 206, 208. As a result, the circuit board 200 may have six surfaces, including the sides 202, 204 and the ends 206, 208, 210, 300. Alternatively, the circuit board 200 may have another shape and/or different number of sides and/or ends. The lens 104 may extend between the ends 206, 208, 210, and/or 300 and the circuit board 200 such that the ends 206, 208, 210, and/or 300 do not directly abut the overmold body 102.

Optionally, the ends 206, 208, 210, 300 of the circuit board 200 may be spaced apart from the lens 104 such that gaps are disposed between one or more of the ends 206, 208, 210, and/or 300 and the lens 104.

[0015] In the illustrated embodiment, the lens 104 is a single, continuous body and the overmold body 102 is a single, continuous body. For example, the lens 104 may be formed from a single body and not formed from two or more separate bodies that are adhered together, fused together, melted together, welded together, or otherwise combined. Similarly, the overmold body 102 may be formed from a single body and not formed from two or more separate bodies that are adhered together, fused together, melted together, welded together, or otherwise combined. Alternatively, the lens 104 may be formed from two or more separate bodies that are adhered together, fused together, melted together, welded together, or otherwise combined, and/or the overmold body 102 may be formed from two or more separate bodies that are adhered together, fused together, melted together, welded together, or otherwise combined.

[0016] The lens 104 forms a body having projecting portions 210 that extend in a first direction (e.g., upward in the perspective of Figures 2 and 3) away from the circuit board 200 and projecting arms 212 that extend in an opposite, second direction (e.g., downward in the perspective of Figures 2 and 3). The arms 212 may continuously extend along the ends 206, 208, 210, 300 of the circuit board 200 to form a collar around the circuit board 200. For example, the arms 212 of the lens 104 can form an upside down bowl in the perspective of Figures 2 and 3 into which the circuit board 200 and light-generating devices 106 are placed into.

[0017] The overmold body 102 can be formed over the lens 104 and the circuit board 200. For example, after placing the circuit board 200 into contact with the lens 104, the material or materials used to form the overmold body 102 may be deposited onto, flow onto, or otherwise come into contact with the lens 104 and the circuit board 200 and then cure or otherwise solidify to form the overmold body 102. With respect to the perspective of Figures 2 and 3, the overmold body 102 can extend beneath the circuit board 200, beneath the arms 212, around and to the outer sides of the arms 212, and above portions of the arms 212. Alternatively, the overmold body 102 may have another shape.

[0018] The overmold body 102 and the lens 104 form an interface 214 between the body 102 and lens 104. This interface 214 can represent locations where the body 102 directly abuts the lens 104. Alternatively, one or more sealing materials, adhesives, or the like, may be located within the interface 214. Because the overmold body 102 extends around the arms 212 of the lens 104 in the illustrated embodiment, the interface 214 similarly extends around the arms 212 (e.g., above, below, and along opposite sides of the arms 212) in the illustrated embodiment. For example and with respect to the perspectives of Figures 2 and 3, the interface 214 can extend

downward from the circuit board 200, generally outward, generally upward, generally inward, and then upward. The term "generally" is used to indicate that the interface 214 may include one or more turns or bends but largely extend in the direction indicated.

[0019] The interface 214 can define a moisture ingress path 216 of the assembly 100. For example, moisture may enter into the assembly 100 along the interface 214. The shape of the interface 214, however, can reduce or prevent the moisture from reaching the circuit board 200 and/or light-generating devices 106. For example, the shape of the interface 214 can significantly reduce the amount of moisture that is able to enter into the assembly 100 on a top side of the interface 214 (in the perspective of Figures 2 and 3), pass between the lens 104 and the overmold body 102 in the interface 214 and around the arms 212 of the lens 104, and then pass upward between the lens 104 and the overmold body 102 into the space where the circuit board 200 and light-generating devices 106 are located.

[0020] The shapes of the interface 214 and path 216 are defined by the shape of the arms 212 of the lens 104, and can include one or more pooling structures 218, 220. As described below, the pooling structures 218, 220 prevent or reduce the amount of moisture that enters into the assembly 100 from outside of the overmold body 102 and the lens 104 and that passes along the moisture ingress path 216 into the assembly 100. The moisture can collect or be pooled in the pooling structures 218, 220 to thereby prevent further passage of the moisture into the assembly 100. Optionally, the transverse surfaces of the lens 104 that form the pooling structures 218, 220 can make it more difficult for the moisture to pass along the ingress path 216 by requiring an increased force and/or an increased amount of moisture to pass through the pooling structures 218, 220.

[0021] While only two pooling structures 218, 220 are shown for each arm 212 of the lens 104, optionally, a smaller or larger number of pooling structures may be provided. As shown in Figures 2 and 3, the arms 212 may have different shapes along different ends 206, 208, 210, 300 of the circuit board 200. For example, the arms 212 may define a portion of the interface 214 having a single pooling structure 218 along the ends 210, 300 of the circuit board 200, but may define a portion of the interface 214 having multiple pooling structures 218, 220 along the ends 206, 208 of the circuit board 200. Alternatively, the arms 214 of the lens 104 may define different pooling structures 218, 220 and/or a different number of pooling structures 218, 220 along one or more ends 206, 208, 210, 300 of the circuit board 200.

[0022] Figure 4 illustrates a cross-sectional view of one portion of the arms 212 of the lens 104 according to one embodiment. The overmold body 102 is not shown in Figure 4. The arm 212 shown in Figure 4 is the portion of the arm 212 along the end 300 of the circuit board 200, but alternatively may represent another portion of the arm 212. The arm 212 shown in Figure 4 includes the pooling

structure 218, which can restrict or prevent ingress of moisture by increasing the length of the path 216 defined by the interface 214 between the lens 104 and the overmold body 102. Increasing the length of this path 216 can extend the distance that moisture must travel to reach the electric components of the assembly 100 (e.g., the circuit board 200 and/or light-generating devices 106).

[0023] The pooling structure 218 includes bends or turns 400 (e.g., bends 400A, 400B) that are formed by interfaces between transversely oriented exterior surfaces 402, 404 of the lens 104. The exterior surface 402 may be referred to as a horizontal surface because the surface 402 is oriented more toward a horizontal plane than a vertical plane in the perspective of Figure 4. The exterior surfaces 404 may be referred to as vertical surfaces because the surfaces 404 are oriented more toward a vertical plane than a horizontal plane in the perspective of Figure 4. Prior to forming the overmold body 102, the exterior surfaces 402, 404 and bends 400 in the pooling structure 218 form a channel or moat extending along the end 310 of the circuit board 200. The surfaces 402, 404 and bends 400 in the portion of the arm 212 that extends along the opposite end 208 of the circuit board 200 similarly may form another channel or moat extending along the end 208 of the circuit board 200.

[0024] The pooling structure 218 can be spatially characterized by a height dimension 406 and a width dimension 408, as shown in Figure 4. The height dimension 406 can represent a depth of the channel or moat formed in the arm 212, and can be measured along a vertical direction (in the perspective of Figure 4) from the horizontal surface 402 of the pooling structure 218 to the top of the vertical surface 404 that is farther from the circuit board 200 or light-generating devices 106 than the other vertical surface 404 in the pooling structure 218. The width dimension 408 can represent a width of the channel or moat formed in the arm 212, and can be measured along a horizontal direction (in the perspective of Figure 4) from one vertical surface 404 to another vertical surface 404 of the pooling structure 218.

[0025] The height dimension 406 and/or the vertical dimension 408 of the pooling structure 218 can be altered based on limitations on the overall size of the assembly 100. In one embodiment, a ratio of the width dimension 408 to the height dimension 406 (e.g., a width-to-height ratio) is 1.25 or a ratio of the height dimension 406 to the width dimension 408 (e.g., a height-to-width ratio) is 0.8. Alternatively, another value may be used. For example, the width-to-height ratio may be less than 1.25 or greater than 1.25. As another example, the height-to-width ratio may be less than 0.8 or greater than 0.8. In one embodiment, the width dimension 408 is 0.5 millimeters and the height dimension 406 is 0.4 millimeters, but, alternatively, other dimensions may be used.

[0026] In one aspect, using a width-to-height ratio of 1.25 or a height-to-width ratio of 0.8 results in an unexpected decrease in the amount of moisture that is able

to travel through the interface 214, through the pooling structure 218, around the arm 218, and into the interior of the assembly 100 to reach the electric components relative to other light module assemblies having the same or similar overall outer dimensions, but without the pooling structure 218. For example, with smaller or larger ratios, more moisture may be able to reach the interior of the assembly 100. The pooling structure 218 causes an unexpected increase in the force required to move the moisture through the path 216 along the interface 214 to the interior of the assembly 100 relative to lenses that do not include such pooling structures.

[0027] The pooling structure 218 optionally may assist in keeping the lens 104 coupled to the overmold body 102. For example, the channel or moat defined by the pooling structure 218 can increase the force needed to separate the overmold body 102 from the lens 104. The lens 104 may have a profile roughness parameter (R_a) that is no greater than 0.8 or another value. This roughness can assist in keeping the lens 104 and overmold body 102 coupled with each other.

[0028] Figure 5 illustrates a cross-sectional view of another portion of the arms 212 of the lens 104 according to one embodiment. The arm 212 shown in Figure 5 represents the portion of the arm 212 along the end 208 of the circuit board 200, but alternatively may represent another portion of the arm 212. The arm 212 shown in Figure 5 includes the pooling structure 218 and the pooling structure 220. In addition to the pooling structure 218, the pooling structure 220 can restrict or prevent ingress of moisture by increasing the length of the path 216 defined by the interface 214 between the lens 104 and the overmold body 102.

[0029] Similar to the pooling structure 218, the pooling structure 220 includes bends or turns 400 that are formed by interfaces between transversely oriented exterior surfaces 402, 404 of the lens 104. Similar to the pooling structure 218, the pooling structure 220 forms a channel or moat extending along a bottom side of the arm 212. In contrast to the pooling structure 218, the pooling structure 220 may face in a downward or opposite direction. For example, the horizontal surface 402 of the pooling structure 218 may face upward, or in a light-emitting direction of the assembly 100, while the horizontal surface 402 of the pooling structure 220 may face downward, or in a direction that is opposite of the light-emitting direction of the assembly 100.

[0030] The pooling structure 220 also can be spatially characterized by the height dimension 406 and the width dimension 408 shown in Figure 4. The pooling structure 220 may have the same or different dimensions 406 and/or 408 as the pooling structure 218, or the same or different height-to-width ratio or width-to-height ratio as the pooling structure 218. The pooling structure 220 optionally may assist in keeping the lens 104 coupled to the overmold body 102. For example, the channel or moat defined by the pooling structure 220 can increase the force needed to separate the overmold body 102 from

the lens 104.

[0031] The pooling structures 218, 220 can increase the distance that moisture needs to travel to reach the interior electric components of the assembly 100 from outside of the assembly 100. The pooling structures 218, 220 can significantly reduce the amount of moisture ingress, without significantly increasing the overall size or outer dimensions of the assembly 100. For example, the bends 400 and surfaces 402, 404 forming the pooling structures 218, 220 can significantly increase the locations for moisture to be located without entering into the electric components of the assembly 100, without requiring a significantly larger lens 104.

[0032] In one aspect, the IP rating of the assembly 100 can be increased due to the presence of one or more of the pooling structures 218, 220. For example, for a similar light module assembly that does not include the pooling structures 218 and/or the pooling structures 220 in the lens 104, the assembly may have an IP rating of IP66. With the addition of the pooling structures 218 and/or the pooling structures 220 to the lens 104, however, the IP rating of the assembly 100 may increase, such as to a rating of IP 68.

[0033] Additionally or alternatively, forming the lens 104 to include the pooling structures 218, 220 can reduce or eliminate the need for additional sealing bodies or other bodies placed over the lens 104 and/or overmold body 102 to reduce moisture ingress. Because the pooling structures 218, 220 reduce the ingress of moisture to a large degree, additional sealants or other bodies may not need to be placed over or inside the interface 214 to prevent moisture ingress into the areas of the assembly 100 where the electric components (e.g., the circuit board 200 and the light-generating devices 106) are located.

[0034] Figure 6 is a flowchart of one embodiment of a method 600 for manufacturing a light module assembly. The method 600 may be used to provide the light module assembly 100 shown and described herein. At 602, a lens is formed. This lens may have pooling structures built into the lens. For example, the lens 104 may be formed with one or more arms 212 having the pooling structures 218 and/or 220 formed in the arms. As described above, these pooling structures can assist in preventing ingress of moisture into the interior spaces of the light module assembly where the electric components are located. The lens may be formed by heating acrylic or other polymer material and placing the heated material in a mold that defines the shape of the lens. Alternatively, the lens may be cut from a solid block of material. Optionally, another technique may be used for forming the lens.

[0035] At 604, a circuit board having one or more light-generating devices is coupled with the lens. For example, the circuit board 200 having the light-generating devices 106 can be disposed within the inverted bowl formed by the arms 212 of the lens 104. At 606, an overmold body is formed onto at least part of the lens and optionally the circuit board. For example, the overmold body 102 can

be formed onto the lower portions of the lens 104 (which includes the pooling structures 218, 220). The formation of the overmold body 102 onto the lens 104 can create the interface 214 that defines the moisture ingress path 216. As described above, however, the pooling structures 218, 220 can significantly reduce, if not eliminate, the ingress of moisture into the interior spaces of the assembly 100 along the interface 214.

[0036] In one embodiment, a light module assembly includes a lens, a circuit board, and an overmold body. The lens includes one or more pooling structures formed by transversely oriented exterior surfaces of the lens. The circuit board is coupled to the lens and has one or more light-generating devices disposed on the circuit board. The overmold body is coupled to the lens to form an interface between the lens and the overmold body. The interface between the lens and the overmold body includes or defines a moisture ingress path into the circuit board. The one or more pooling structures prevent passage of moisture along the moisture ingress path past the one or more pooling structures to the circuit board.

[0037] In one aspect, the one or more pooling structures of the lens include plural opposing first exterior surfaces of the lens and a second exterior surface that extends between the opposing first exterior surfaces.

[0038] In one aspect, the opposing first exterior surfaces of the lens are vertically oriented surfaces and the second exterior surface is a horizontally oriented surface.

[0039] In one aspect, a width dimension of the one or more pooling structures is larger than a height dimension of the one or more pooling structures.

[0040] In one aspect, the one or more pooling structures of the lens include one or more channels extending around the circuit board.

[0041] In one aspect, the overmold body extends into the one or more channels in the lens.

[0042] In one aspect, a depth of the one or more channels is smaller than a width dimension of the one or more channels.

[0043] In one aspect, the one or more pooling structures of the lens include an upwardly facing pooling structure and a downwardly facing pooling structure. The upwardly facing pooling structure includes a first horizontally oriented surface facing in a first direction and opposing first vertically oriented surfaces on opposite sides of the first horizontally oriented surface. The downwardly facing pooling structure includes a second horizontally oriented surface facing in a second direction that is opposite of the first direction and opposing second vertically oriented surfaces on opposite sides of the second horizontally oriented surface.

[0044] In another embodiment, another light module assembly includes a circuit board, a lens, and an overmold body. The circuit board includes opposite first and second sides with one or more light-generating devices disposed on the first side of the circuit board. The first and second sides are separated by opposite first and second ends of the circuit board. The lens is coupled with

the circuit board such that the one or more light-generating devices are between the lens and the circuit board. The lens includes arms that extend around the first and second ends the circuit board and project past the circuit board in a direction that is opposite of a light-emanating direction of the light-generating devices. The arms include one or more pooling structures. The overmold body is coupled to the lens to form an interface between the lens and the overmold body. The interface forms a moisture ingress path into the circuit board from outside of the overmold body and the lens. The one or more pooling structures in the arms collect moisture passing along the moisture ingress path and prevent passage of the moisture along the moisture ingress path past the one or more pooling structures to the circuit board.

[0045] In one aspect, the one or more pooling structures of the lens include plural opposing first exterior surfaces of the lens and a second exterior surface that extends between the opposing first exterior surfaces.

[0046] In one aspect, the opposing first exterior surfaces of the lens are vertically oriented surfaces and the second exterior surface is a horizontally oriented surface.

[0047] In one aspect, a width dimension of the one or more pooling structures is larger than a height dimension of the one or more pooling structures.

[0048] In one aspect, the one or more pooling structures of the lens include one or more channels extending around the circuit board.

[0049] In one aspect, the overmold body extends into the one or more channels in the lens.

[0050] In one aspect, a depth of the one or more channels is smaller than a width dimension of the one or more channels.

[0051] In one aspect, the one or more pooling structures of the lens include an upwardly facing pooling structure and a downwardly facing pooling structure. The upwardly facing pooling structure includes a first horizontally oriented surface facing in the light-emanating direction and opposing first vertically oriented surfaces on opposite sides of the first horizontally oriented surface. The downwardly facing pooling structure includes a second horizontally oriented surface facing in a second direction that is opposite of the light-emanating direction and opposing second vertically oriented surfaces on opposite sides of the second horizontally oriented surface.

[0052] In another embodiment, a method includes forming a lens of a light module assembly to include arms forming one or more pooling structures and coupling the lens with a circuit board having opposite first and second sides with one or more light-generating devices disposed on the first side of the circuit board. The first and second sides are separated by opposite first and second ends of the circuit board. The lens is coupled with the circuit board such that the one or more light-generating devices are between the lens and the circuit board and such that the arms of the lens extend around the first and second ends the circuit board and project past the circuit board in a direction that is opposite of a light-emanating direc-

tion of the light-generating devices. The method also includes forming an overmold body on the lens to form an interface between the lens and the overmold body. The interface forms a moisture ingress path into the circuit board from outside of the overmold body and the lens. The one or more pooling structures in the arms collect moisture passing along the moisture ingress path and prevent passage of the moisture along the moisture ingress path past the one or more pooling structures to the circuit board.

[0053] In one aspect, the lens is formed such that the one or more pooling structures include plural opposing first exterior surfaces of the lens and a second exterior surface that extends between the opposing first exterior surfaces.

[0054] In one aspect, the lens is formed such that the opposing first exterior surfaces of the lens are vertically oriented surfaces and the second exterior surface is a horizontally oriented surface.

[0055] In one aspect, the lens is formed such that a width dimension of the one or more pooling structures is larger than a height dimension of the one or more pooling structures.

[0056] The foregoing description of certain embodiments of the inventive subject matter will be better understood when read in conjunction with the appended drawings. The various embodiments are not limited to the arrangements and instrumentality shown in the drawings. The above description is illustrative and not restrictive. For example, the above-described embodiments (and/or aspects thereof) may be used in combination with each other. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the inventive subject matter without departing from its scope. While the dimensions and types of materials described herein are intended to define the parameters of the inventive subject matter, they are by no means limiting and are exemplary embodiments. Other embodiments may be apparent to one of ordinary skill in the art upon reviewing the above description. The scope of the inventive subject matter should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.

[0057] In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects. Further, the limitations of the following claims are not written in means-plus-function format and are not intended to be interpreted based on 35 U.S.C. § 112(f), unless and until such claim limitations expressly use the phrase "means for" followed by a statement of function void of further structure. And, as used herein, an element or step recited in the singular and proceeded with the word "a" or "an" should be understood as not excluding plural of said elements or steps, unless such exclusion

is explicitly stated. Furthermore, references to "one embodiment" of the inventive subject matter are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. Moreover, unless explicitly stated to the contrary, embodiments "comprising," "including," or "having" an element or a plurality of elements having a particular property may include additional such elements not having that property.

[0058] This written description uses examples to disclose several embodiments of the inventive subject matter and also to enable a person of ordinary skill in the art to practice the embodiments of the inventive subject matter, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the inventive subject matter is defined by the claims, and may include other examples that occur to those of ordinary skill in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

Claims

1. A light module assembly comprising:

a circuit board (200) having opposite first and second sides with one or more light-generating devices (106) disposed on the first side of the circuit board (200), the first and second sides separated by opposite first and second ends of the circuit board (200);

a lens (104) coupled with the circuit board (200) such that the one or more light-generating devices (106) are between the lens (104) and the circuit board (200), the lens (104) including arms (212) that project past the circuit board (200) in a direction that is opposite of a light-emanating direction of the light-generating devices (106), the arms (212) including one or more pooling structures (218, 220); **characterized in that** the arms (212) of the lens (104) extend around the first and second ends of the circuit board (200), and **in that** 104

an overmold body (102) is coupled to the lens (104) to form an interface between the lens (104) and the overmold body (102), the interface forming a moisture ingress path (216) into the circuit board (200) from outside of the overmold body (102) and the lens (104), wherein the one or more pooling structures (218, 220) in the arms (212) collect moisture passing along the moisture ingress path (216) and prevent passage of the moisture along the moisture ingress path (216) past the one or more pooling structures

(218, 220) to the circuit board (200).

2. The light module assembly of claim 1, wherein the one or more pooling structures (218, 220) of the lens (104) include plural opposing first exterior surfaces of the lens (104) and a second exterior surface that extends between the opposing first exterior surfaces.

3. The light module assembly of claim 2, wherein the opposing first exterior surfaces of the lens (104) are vertically oriented surfaces and the second exterior surface is a horizontally oriented surface, or wherein a width dimension of the one or more pooling structures (218, 220) is larger than a height dimension of the one or more pooling structures (218, 220).

4. The light module assembly of claim 1, wherein the one or more pooling structures (218, 220) of the lens (104) include one or more channels extending around the circuit board (200).

5. The light module assembly of claim 4, wherein the overmold body (102) extends into the one or more channels in the lens (104), or wherein a depth of the one or more channels is smaller than a width dimension of the one or more channels.

6. The light module assembly of claim 1, wherein the one or more pooling structures (218) of the lens (104) include an upwardly facing pooling structure and a downwardly facing pooling structure, the upwardly facing pooling structure including a first horizontally oriented surface facing in the light-emanating direction and opposing first vertically oriented surfaces on opposite sides of the first horizontally oriented surface, the downwardly facing pooling structure including a second horizontally oriented surface facing in a second direction that is opposite of the light-emanating direction and opposing second vertically oriented surfaces on opposite sides of the second horizontally oriented surface.

7. A method comprising:

forming a lens (104) of a light module assembly to include arms (212) forming one or more pooling structures (218);

coupling the lens (104) with a circuit board (200) having opposite first and second sides with one or more light-generating devices (106) disposed on the first side of the circuit board (200), the first and second sides separated by opposite first and second ends of the circuit board (200), the lens (104) coupled with the circuit board (200) such that the one or more light-generating devices (106) are between the lens (104) and the circuit board (200) and such that the arms

(212) of the lens (104) project past the circuit board (200) in a direction that is opposite of a light-emanating direction of the light-generating devices (106); **characterized in that** the arms (212) of the lens (104) extend around the first and second ends of the circuit board (200), and **in that**

the method comprises: forming an overmold body (102) on the lens to form an interface between the lens (104) and the overmold body (102), the interface forming a moisture ingress path (216) into the circuit board (200) from outside of the overmold body (102) and the lens (104), wherein the one or more pooling structures (218, 220) in the arms (212) collect moisture passing along the moisture ingress path (216) and prevent passage of the moisture along the moisture ingress path (216) past the one or more pooling structures (218, 220) to the circuit board (200).

8. The method of claim 7, wherein the lens is formed such that the one or more pooling structures (218, 220) include plural opposing first exterior surfaces of the lens (104) and a second exterior surface that extends between the opposing first exterior surfaces.
9. The method of claim 8, wherein the lens (104) is formed such that the opposing first exterior surfaces of the lens (104) are vertically oriented surfaces and the second exterior surface is a horizontally oriented surface, or wherein the lens (104) is formed such that a width dimension of the one or more pooling structures (218, 220) is larger than a height dimension of the one or more pooling structures (218, 220).

Patentansprüche

1. Lichtmodulanordnung umfassend:

eine Leiterplatte (200) mit gegenüberliegenden ersten und zweiten Seiten mit einer oder mehreren auf der ersten Seite der Leiterplatte (200) angeordneten lichterzeugenden Vorrichtungen (106), wobei die ersten und zweiten Seiten durch gegenüberliegende erste und zweite Enden der Leiterplatte (200) getrennt sind; eine Linse (104), die mit der Leiterplatte (200) gekoppelt ist, so dass die eine oder mehreren lichterzeugenden Vorrichtungen (106) zwischen der Linse (104) und der Leiterplatte (200) liegen, wobei die Linse (104) Arme (212) aufweist, die an der Leiterplatte (200) vorbei in eine Richtung ragen, die entgegengesetzt zu einer Lichtausstrahlrichtung der lichterzeugenden Vorrichtungen (106) ist, wobei die Arme (212)

eine oder mehrere Pooling-Strukturen (218, 220) aufweisen; **dadurch gekennzeichnet, dass** sich die Arme (212) der Linse (104) um die ersten und zweiten Enden der Leiterplatte (200) herum erstrecken, und dass ein Umspritzkörper (102) mit der Linse (104) gekoppelt ist, um eine Schnittstelle zwischen der Linse (104) und dem Umspritzkörper (102) zu bilden, wobei die Schnittstelle einen Feuchtigkeitseintrittspfad (216) in die Leiterplatte (200) von außerhalb des Umspritzkörpers (102) und der Linse (104) bildet, wobei die eine oder mehreren Pooling-Strukturen (218, 220) in den Armen (212) Feuchtigkeit sammeln, die sich entlang des Feuchtigkeitseintrittspfades (216) bewegt, und den Durchgang der Feuchtigkeit entlang des Feuchtigkeitseintrittspfades (216) an der einen oder den mehreren Pooling-Strukturen (218, 220) vorbei zu der Leiterplatte (200) verhindern.

2. Lichtmodulanordnung nach Anspruch 1, wobei die eine oder mehreren Pooling-Strukturen (218, 220) der Linse (104) mehrere gegenüberliegende erste Außenflächen der Linse (104) und eine zweite Außenfläche, die sich zwischen den gegenüberliegenden ersten Außenflächen erstreckt, aufweisen.
3. Lichtmodulanordnung nach Anspruch 2, wobei die gegenüberliegenden ersten Außenflächen der Linse (104) vertikal orientierte Flächen sind und die zweite Außenfläche eine horizontal orientierte Fläche ist, oder wobei eine Breitenabmessung der einen oder mehreren Pooling-Strukturen (218, 220) größer als eine Höhenabmessung der einen oder mehreren Pooling-Strukturen (218, 220) ist.
4. Lichtmodulanordnung nach Anspruch 1, wobei die eine oder mehreren Pooling-Strukturen (218, 220) der Linse (104) einen oder mehrere Kanäle, die sich um die Leiterplatte (200) herum erstrecken, aufweisen.
5. Lichtmodulanordnung nach Anspruch 4, wobei sich der Umspritzkörper (102) in den einen oder die mehreren Kanäle in der Linse (104) hinein erstreckt, oder wobei eine Tiefe des einen oder der mehreren Kanäle geringer als eine Breitenabmessung des einen oder der mehreren Kanäle ist.
6. Lichtmodulanordnung nach Anspruch 1, wobei die eine oder mehreren Pooling-Strukturen (218) der Linse (104) eine nach oben weisende Pooling-Struktur und eine nach unten weisende Pooling-Struktur aufweisen, wobei die nach oben weisende Pooling-Struktur eine erste horizontal orientierte Fläche, die in die Lichtausstrahlrichtung weist, und gegenüberliegende erste vertikal orientierte Flächen auf gegenüberliegenden Seiten der ersten horizontal orientier-

ten Fläche aufweist, wobei die nach unten weisende Pooling-Struktur eine zweite horizontal orientierte Fläche, die in eine zweite Richtung weist, die zu der Lichtausstrahlrichtung entgegengesetzt ist, und gegenüberliegende zweite vertikal orientierte Flächen auf gegenüberliegenden Seiten der zweiten horizontal orientierten Fläche aufweist.

7. Verfahren umfassend:

Bilden einer Linse (104) einer Lichtmodulanordnung, um Arme (212) aufzuweisen, die eine oder mehrere Pooling-Strukturen (218) bilden;
Koppeln der Linse (104) mit einer Leiterplatte (200) mit gegenüberliegenden ersten und zweiten Seiten mit einer oder mehreren auf der ersten Seite der Leiterplatte (200) angeordneten lichterzeugenden Vorrichtungen (106), wobei die ersten und zweiten Seiten durch gegenüberliegende erste und zweite Enden der Leiterplatte (200) getrennt sind, wobei die Linse (104) mit der Leiterplatte (200) gekoppelt ist, so dass die eine oder mehreren lichterzeugenden Vorrichtungen (106) zwischen der Linse (104) und der Leiterplatte (200) liegen, und so dass die Arme (212) der Linse (104) an der Leiterplatte (200) vorbei in eine Richtung ragen, die entgegengesetzt zu einer Lichtausstrahlrichtung der lichterzeugenden Vorrichtungen (106) ist; **dadurch gekennzeichnet, dass** sich die Arme (212) der Linse (104) um die ersten und zweiten Enden der Leiterplatte (200) herum erstrecken, und dass das Verfahren umfasst: Bilden eines Umspritzkörpers (102) auf der Linse (104), um eine Schnittstelle zwischen der Linse (104) und dem Umspritzkörper (102) zu bilden, wobei die Schnittstelle einen Feuchtigkeitseintrittspfad (216) in die Leiterplatte (200) von außerhalb des Umspritzkörpers (102) und der Linse (104) bildet, wobei die eine oder mehreren Pooling-Strukturen (218, 220) in den Armen (212) Feuchtigkeit sammeln, die sich entlang des Feuchtigkeitseintrittspfades (216) bewegt, und einen Durchgang der Feuchtigkeit entlang des Feuchtigkeitseintrittspfades (216) an der einen oder den mehreren Pooling-Strukturen (218, 220) vorbei zu der Leiterplatte (200) verhindern.

8. Verfahren nach Anspruch 7, wobei die Linse derart gebildet ist, dass die eine oder mehreren Pooling-Strukturen (218, 220) mehrere gegenüberliegende erste Außenflächen der Linse (104) und eine zweite Außenfläche, die sich zwischen den gegenüberliegenden ersten Außenflächen erstreckt, aufweisen.

9. Verfahren nach Anspruch 8, wobei die Linse (104) derart gebildet ist, dass die gegenüberliegenden ersten Außenflächen der Linse (104) vertikal orientierte

Flächen sind, und die zweite Außenfläche eine horizontal orientierte Fläche ist, oder wobei die Linse (104) derart gebildet ist, dass eine Breitenabmessung der einen oder mehreren Pooling-Strukturen (218, 220) größer als eine Höhenabmessung der einen oder mehreren Pooling-Strukturen (218, 220) ist.

10 Revendications

1. Ensemble de module d'éclairage comprenant :

une carte de circuit imprimé (200) ayant des premier et second côtés opposés avec un ou plusieurs dispositifs de génération de lumière (106) disposés sur le premier côté de la carte de circuit imprimé (200), les premier et second côtés étant séparés par des première et seconde extrémités opposées de la carte de circuit imprimé (200) ; une lentille (104) couplée à la carte de circuit imprimé (200) de sorte que les un ou plusieurs dispositifs de génération de lumière (106) soient entre la lentille (104) et la carte de circuit imprimé (200), la lentille (104) incluant des bras (212) qui dépassent de la carte de circuit imprimé (200) dans une direction qui est opposée à une direction d'émanation de lumière des dispositifs de génération de lumière (106), les bras (212) incluant une ou plusieurs structures de mise en commun (218, 220) ; **caractérisé en ce que** les bras (212) de la lentille (104) s'étendent autour des première et seconde extrémités de la carte de circuit imprimé (200), et **en ce que** un corps surmoulé (102) est couplé à la lentille (104) pour former une interface entre la lentille (104) et le corps surmoulé (102), l'interface formant un chemin d'infiltration d'humidité (216) dans la carte de circuit imprimé (200) depuis l'extérieur du corps surmoulé (102) et de la lentille (104), dans lequel les une ou plusieurs structures de mise en commun (218, 220) dans les bras (212) recueillent l'humidité passant le long du chemin d'infiltration d'humidité (216) et empêchent un passage de l'humidité le long du chemin d'infiltration d'humidité (216) au-delà des une ou plusieurs structures de mise en commun (218, 220) vers la carte de circuit imprimé (200).

2. Ensemble de module d'éclairage selon la revendication 1, dans lequel les une ou plusieurs structures de mise en commun (218, 220) de la lentille (104) incluent plusieurs premières surfaces extérieures opposées de la lentille (104) et une seconde surface extérieure qui s'étend entre les premières surfaces extérieures opposées.

3. Ensemble de module d'éclairage selon la revendication 1, dans lequel les une ou plusieurs structures de mise en commun (218, 220) de la lentille (104) incluent une première surface extérieure opposée de la lentille (104) et une seconde surface extérieure qui s'étend entre les premières surfaces extérieures opposées.

- cation 2, dans lequel les premières surfaces extérieures opposées de la lentille (104) sont des surfaces orientées verticalement et la seconde surface extérieure est une surface orientée horizontalement, ou dans lequel une dimension de largeur des une ou plusieurs structures de mise en commun (218, 220) est plus grande qu'une dimension de hauteur des une ou plusieurs structures de mise en commun (218, 220).
4. Ensemble de module d'éclairage selon la revendication 1, dans lequel les une ou plusieurs structures de mise en commun (218, 220) de la lentille (104) incluent un ou plusieurs canaux s'étendant autour de la carte de circuit imprimé (200).
5. Ensemble de module d'éclairage selon la revendication 4, dans lequel le corps surmoulé (102) s'étend dans les un ou plusieurs canaux dans la lentille (102), ou dans lequel une profondeur des un ou plusieurs canaux est plus petite qu'une dimension de largeur des un ou plusieurs canaux.
6. Ensemble de module d'éclairage selon la revendication 1, dans lequel les une ou plusieurs structures de mise en commun (218) de la lentille (104) incluent une structure de mise en commun en regard vers le haut et une structure de mise en commun en regard vers le bas, la structure de mise en commun en regard vers le haut incluant une première surface orientée horizontalement en regard de la direction d'émanation de lumière et des premières surfaces orientées verticalement opposées sur des côtés opposés de la première surface orientée horizontalement, la structure de mise en commun en regard vers le bas incluant une seconde surface orientée horizontalement en regard dans une seconde direction qui est opposée à la direction d'émanation de lumière et des secondes surfaces orientées verticalement opposées sur des côtés opposés de la seconde surface orientée horizontalement.
7. Procédé comprenant :
- la formation d'une lentille (104) d'un ensemble de module d'éclairage pour inclure des bras (212) formant une ou plusieurs structures de mise en commun (218) ;
 - le couplage de la lentille (104) à une carte de circuit imprimé (200) ayant des premier et second côtés opposés avec un ou plusieurs dispositifs de génération de lumière (106) disposés sur le premier côté de la carte de circuit imprimé (200), les premier et second côtés étant séparés par des première et seconde extrémités opposées de la carte de circuit imprimé (200), la lentille (104) étant couplée à la carte de circuit imprimé (200) de sorte que les un ou plusieurs dispositifs de génération de lumière (106) soient entre la lentille (104) et la carte de circuit imprimé (200) et de sorte que les bras (212) de la lentille (104) dépassent de la carte de circuit imprimé (200) dans une direction qui est opposée à une direction d'émanation de lumière des dispositifs de génération de lumière (106) ; **caractérisé en ce que**
 - les bras (212) de la lentille (104) s'étendent autour des première et seconde extrémités de la carte de circuit imprimé (200), et **en ce que** le procédé comprend : la formation d'un corps surmoulé (102) sur la lentille (104) pour former une interface entre la lentille (104) et le corps surmoulé (102), l'interface formant un chemin d'infiltration d'humidité (216) dans la carte de circuit imprimé (200) depuis l'extérieur du corps surmoulé (102) et de la lentille (104), dans lequel les une ou plusieurs structures de mise en commun (218, 220) dans les bras (212) recueillent l'humidité passant le long du chemin d'infiltration d'humidité (216) et empêchent un passage de l'humidité le long du chemin d'infiltration d'humidité (216) au-delà des une ou plusieurs structures de mise en commun (218, 220) vers la carte de circuit imprimé (200).
8. Procédé selon la revendication 7, dans lequel la lentille est formée de sorte que les une ou plusieurs structures de mise en commun (218, 220) incluent plusieurs premières surfaces extérieures opposées de la lentille (104) et une seconde surface extérieure qui s'étend entre les premières surfaces extérieures opposées.
9. Procédé selon la revendication 8, dans lequel la lentille (104) est formée de sorte que les premières surfaces extérieures opposées de la lentille (104) soient des surfaces orientées verticalement et la seconde surface extérieure soit une surface orientée horizontalement, ou dans lequel la lentille (104) est formée de sorte qu'une dimension de largeur des une ou plusieurs structures de mise en commun (218, 220) soit plus grande qu'une dimension de hauteur des une ou plusieurs structures de mise en commun (218, 220).

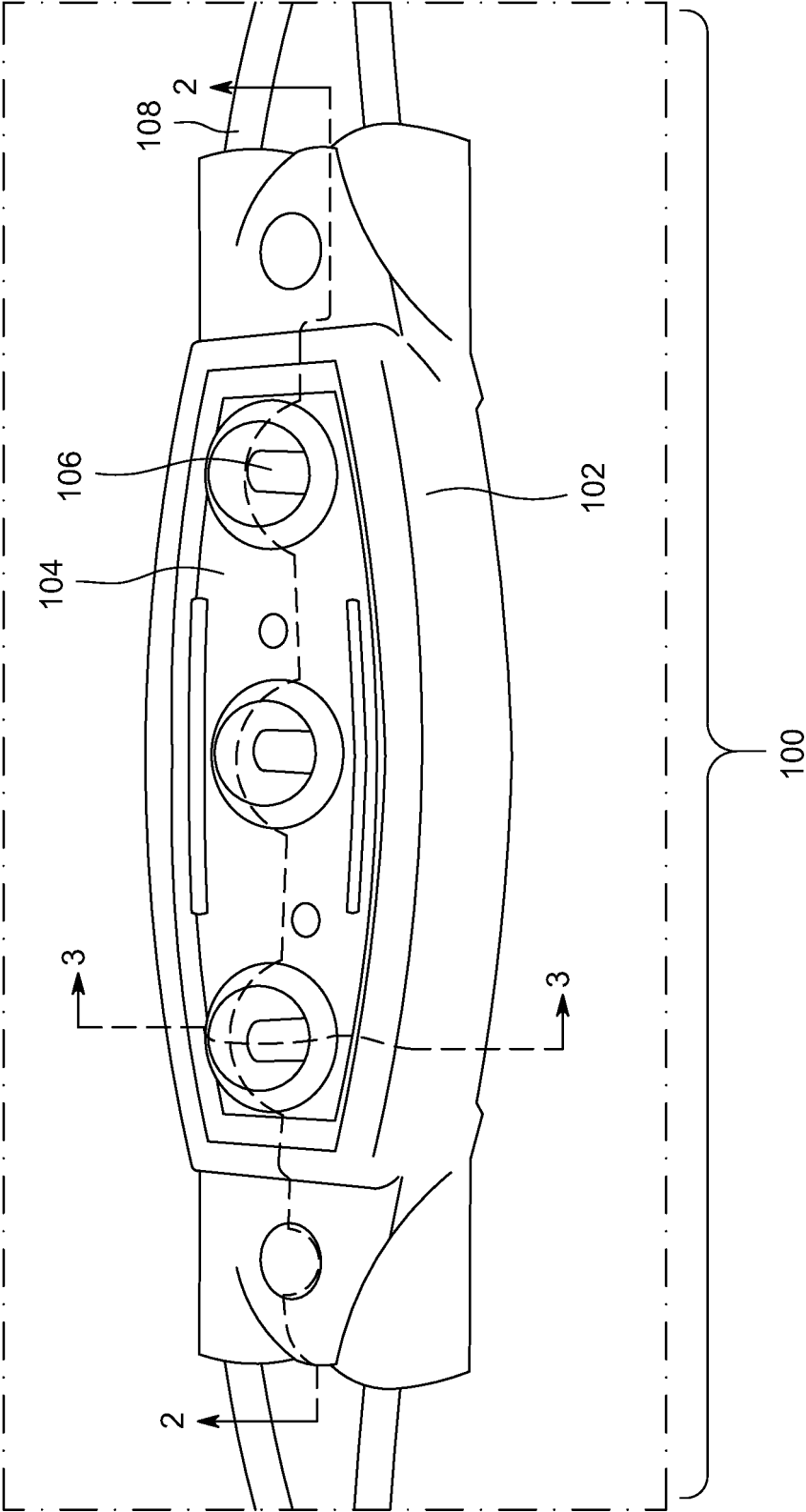


FIG. 1

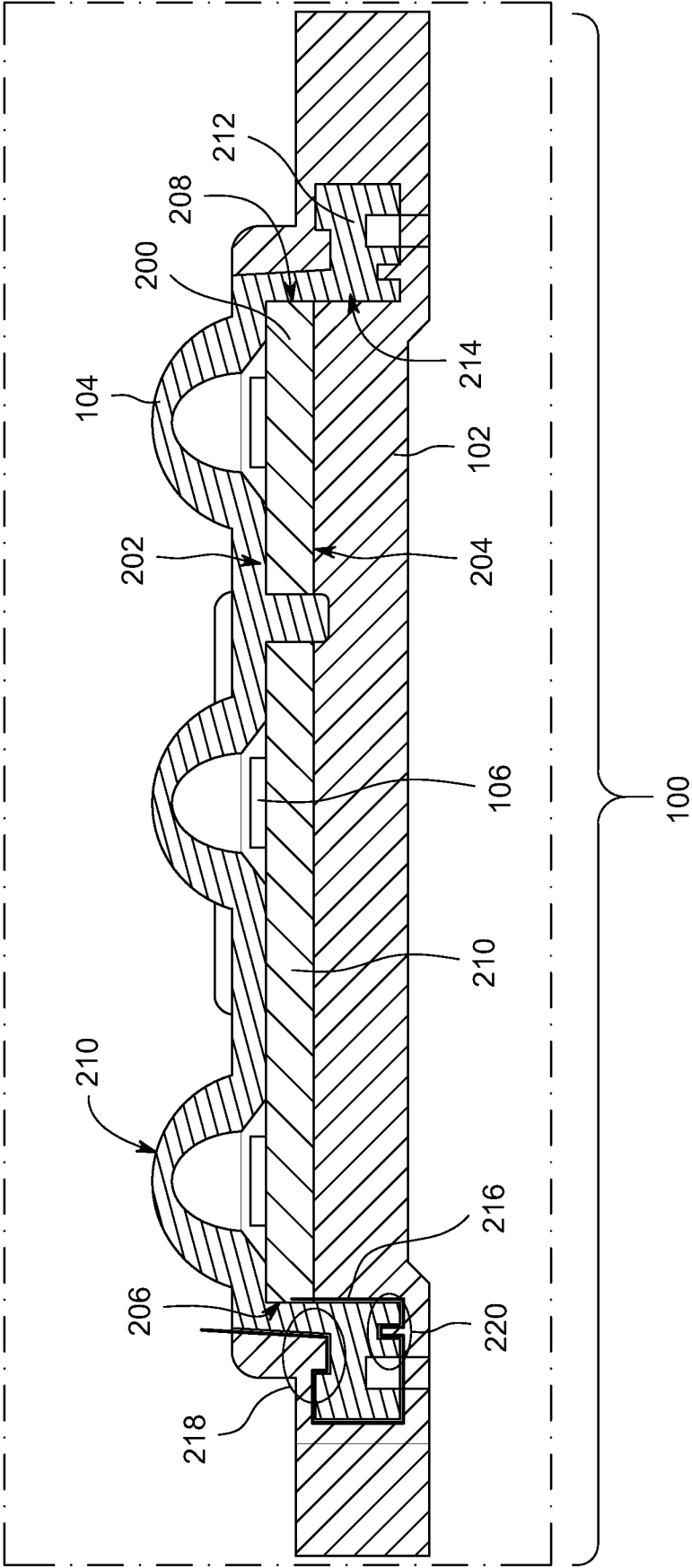


FIG. 2

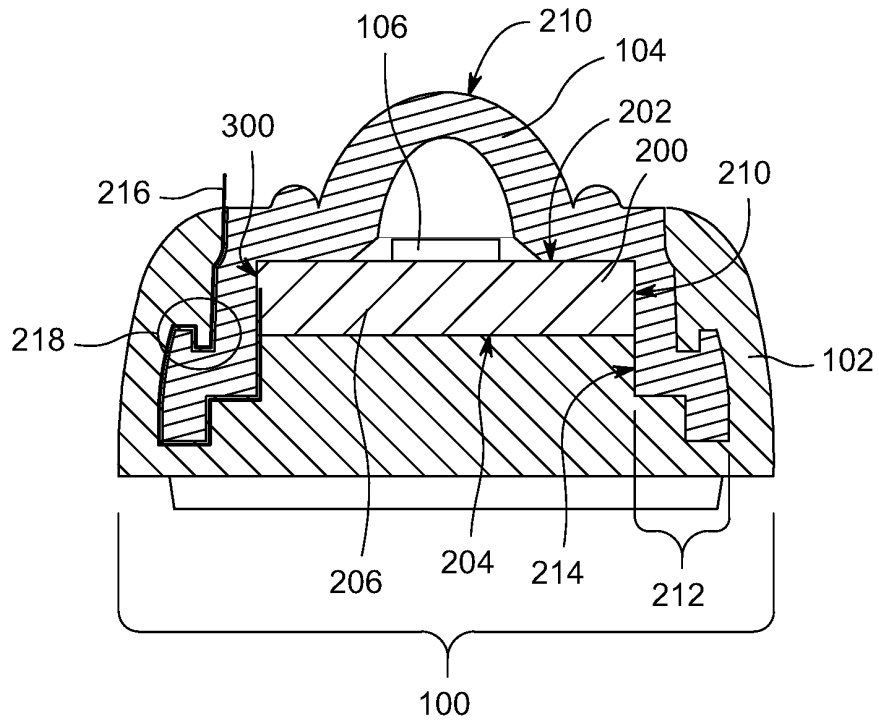


FIG. 3

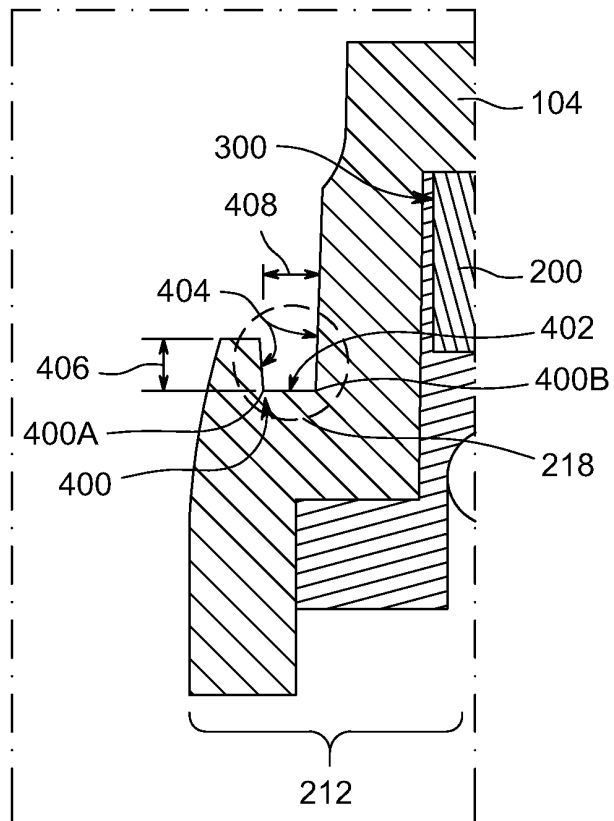


FIG. 4

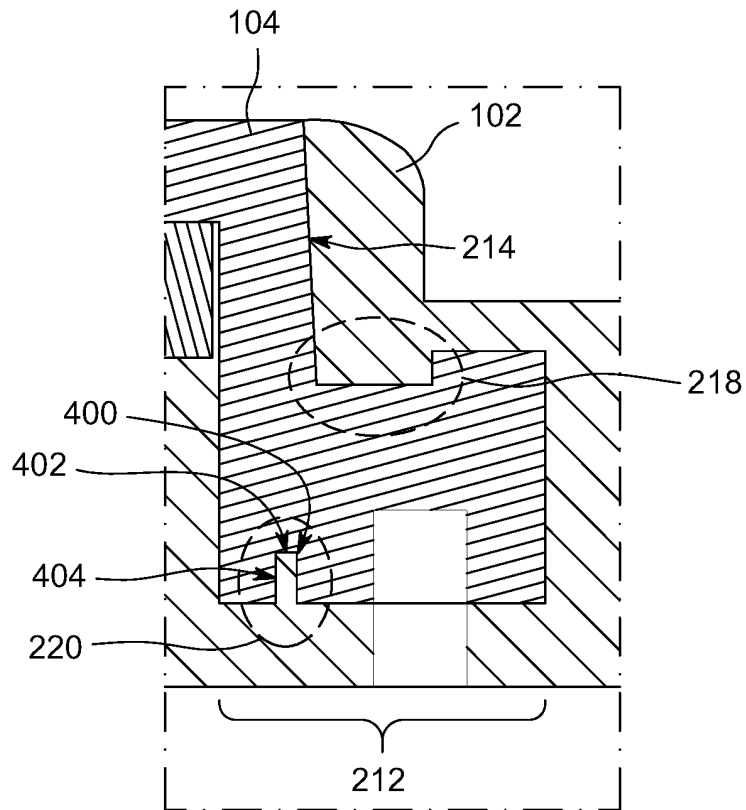


FIG. 5

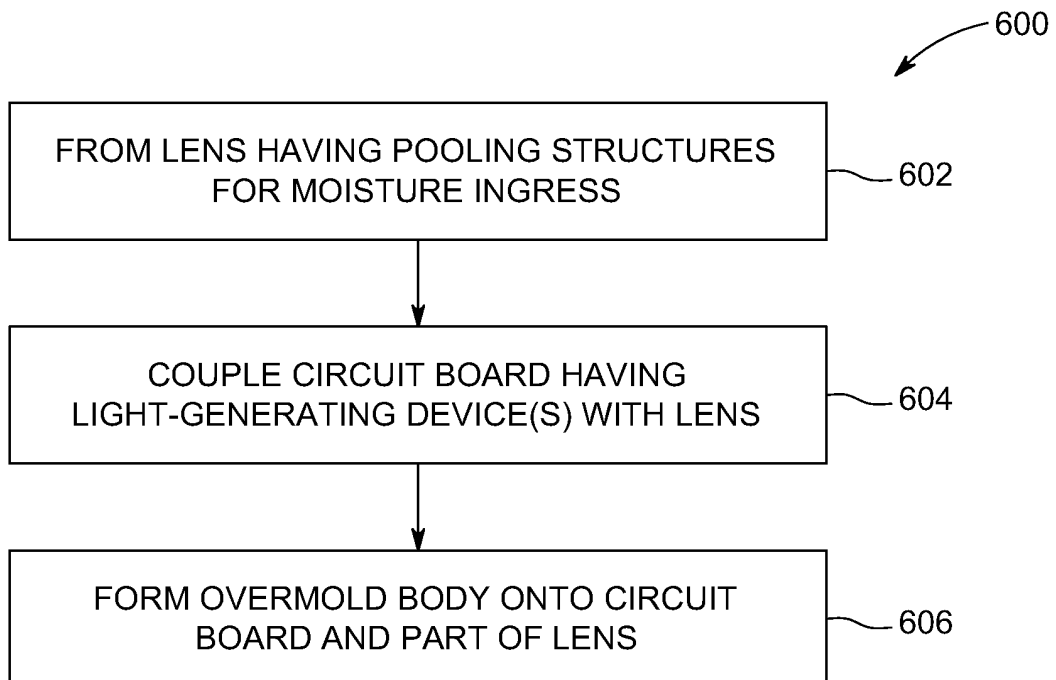


FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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