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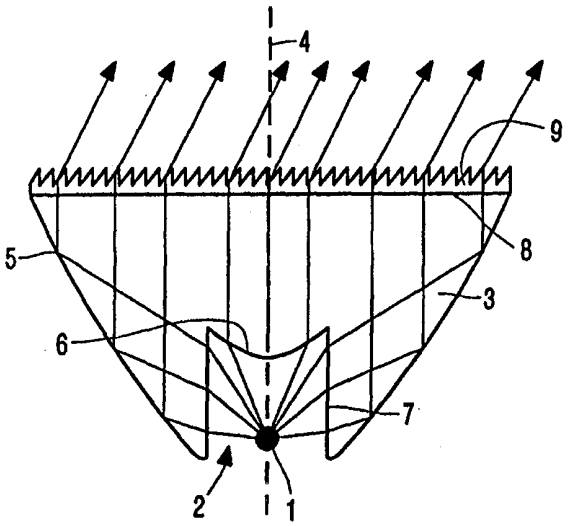

(57) Abstract

A LED module comprising a LED and a rotationally symmetrical, bowl–shaped collimator lens. Said lens comprises a hole for accommodating the LED. The lens also includes a flat surface through which light from the LED passes. The normal to this emergent surface is substantially parallel to the axis of symmetry of the lens. Said surface comprises a sawtooth–like structure for bending the outgoing light. LED modules of this type can deflect the outgoing light through a certain angle relative to the axis of symmetry of the lens. These modules are relatively cheap and compact.

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LED module and luminaire.

The invention relates to a LED module comprising a LED (light-emitting diode) and a rotationally symmetrical, bowl-shaped collimator lens which is provided with a recess in which the LED is situated, and which collimator lens is also provided with a flat surface from which light generated by the LED emerges, the normal to the surface extending substantially parallel to the axis of symmetry of the lens. The invention also relates to a luminaire provided with a number of said LED modules.

A LED module of the type mentioned in the opening paragraph is known per se. For example in the English-language abstract of Japanese patent application JP 61-147.585, a description is given of such a LED module. This LED module comprises a LED which is secured onto a substrate and which is positioned in the recess of a bowl-shaped collimator lens. This lens is rotationally symmetrical in shape and has an associated axis of symmetry. The position of the LED and the shape of the lens are attuned to each other in such a manner that a large part of the light generated by the LED is converted via refraction and reflection into a parallel light beam which leaves the lens via a flat surface. The lens and the substrate are secured in a metal housing.

The known LED module has an important drawback. The emerging light leaves the lens in a direction which is substantially parallel to the axis of symmetry of the lens. Under certain conditions it is desirable for the parallel beam to leave the lens at a certain angle, viewed relative to the axis of symmetry. This angle must be at least 20°.

It is an object of the invention to obviate said drawback. The invention more particularly aims at providing a LED module of the above-mentioned type, in which the light emerges at a specific angle relative to the axis of symmetry of the lens. The proposed LED module should additionally be compact. Besides, said LED module must have a simple structure and its manufacture must be inexpensive.

These and other objects of the invention are achieved by a LED module comprising a LED (light-emitting diode) and a rotationally symmetrical, bowl-shaped collimator lens which is provided with a recess in which the LED is situated and which collimator lens is also provided with a flat surface from which light generated by the LED emerges, the normal to the surface extending substantially parallel to the axis of symmetry of

the lens, which LED module in accordance with the invention is characterized in that the surface is provided with a sawtooth-like structure for deflecting the emerging light.

The invention is based on the recognition that such a sawtooth-like structure offers a good solution to the deflection of the parallel beam leaving the lens. Since the maximum dimensions of the teeth are very small (below 1 mm), such a sawtooth-like structure can be provided in a relatively thin layer (thickness below 1 mm). By virtue thereof, also the maximum dimensions of the LED module remain limited. In comparison to alternative solutions in which a separate prism is arranged in front of the emergent face of the lens, or the lens is bevelled, the present solution offers compact, inexpensive LED modules which can be readily manufactured. This applies in particular if deflection angles of 20° and more must be obtained.

A preferred embodiment of the invented LED module is characterized in that the sawtooth-like structure is provided in a separate foil, which is secured to the surface of the collimator lens. Such foils are commercially available, for example from 3M. The thickness of these foils is below 1 mm. The foils can be readily secured to the flat surface of the lens, preferably by means of an adhesive.

Another preferred embodiment of the invented LED module is characterized in that the sawtooth-like structure is pressed into the surface of the collimator lens. In practice, a template whose pressing surface is provided with the negative of this structure will be used to press-in such a sawtooth-like structure. In principle, it is possible to use collimator lenses of mouldable glass for this purpose. In practice, however, it is more convenient to provide such a structure in collimator lenses of a thermoplastic synthetic resin while they are subjected to heat. These lenses can be obtained by means of injection molding. Very good results are achieved using lenses of polycarbonate.

Yet another preferred embodiment of the invented LED module is characterized in that the sawtooth-like structure in the surface of the collimator lens is obtained by means of a replica technique. In this technique, a solution of thermally curable or UV-curable material is provided on the flat surface of the known lens. Subsequently, a template whose active surface is provided with the negative of the intended sawtooth-like structure is pressed into this liquid, whereafter the liquid is cured by exposure to heat or to UV radiation. Subsequently, the template is removed. This method also enables the entire lens to be manufactured in a single step. It has been found that particularly (methyl) methacrylate compounds are very suitable for manufacturing the intended collimator lenses.

The invention also relates to a luminaire comprising a box-like housing which accommodates a number of LED modules, each module including a LED and a collimator lens, said lens being provided with a flat surface from which light generated by the LED emerges. This luminaire is characterized in that the surface is provided with a sawtooth-like structure for deflecting the emerging light. Such luminaires are compact and can be readily and inexpensively manufactured.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

In the drawings:

Fig. 1 is a diagrammatic, sectional view of an embodiment of a known LED module,

Fig. 2 is a diagrammatic, sectional view of a first embodiment of the LED module in accordance with the invention,

Fig. 3 is a diagrammatic, sectional view of a second embodiment of the LED module in accordance with the invention,

Fig. 4 is a diagrammatic, sectional view of a luminaire in accordance with the invention.

It is noted that in the Figures like reference numerals refer to like parts. It is also noted that the drawings are not to scale.

Fig. 1 is a diagrammatic, sectional view of the essential parts of a LED module in accordance with the state of the art. This module comprises a LED (1) (indicated by means of a dot) which is positioned in a recess (2) of a rotationally symmetrical, bowl-shaped collimator lens (3). The axis of rotation of lens (3) is indicated by means of an interrupted line (4). The shape of the curved outside surfaces (5) and (6) of the lens approximates to a certain degree to the shape of the outside surface of the body of revolution of a parabole. The LED is positioned in the focus of this approximate parabole. The surfaces (7) and (8) are predominantly cylindrical and flat, respectively. For clarity, the parts of the LED module keeping the lens and the LED fixed relative to each other are not shown.

Fig. 1 also diagrammatically shows (by means of arrows) the optical path of a substantial part of the light generated by the LED (1). This is converted by the lens (3) into a

parallel beam, either via deflection onto the lens surface (6) or via deflection onto the lens surface (7) and total reflection at the lens surface (5). The emerging parallel light beam extends substantially parallel to the axis of symmetry (4) of the lens.

Fig. 2 is a schematic, sectional view of a LED module in accordance with the invention. This LED module comprises the essential parts of the LED module shown in Fig. 1. The collimator lens (3) of the module additionally includes a sawtooth-like structure (9) which is glued in the form of a separate foil (a so-called "image directing film", make 3M) onto surface (8) of the collimator lens by means of Dymax 625 (make Dymax). It has been found that by means of this LED module a 30• deflection of the light beam relative to the normal to the surface (8) can be achieved. In the present case, the lens was made of polymethyl methacrylate (PMMA).

Fig. 3 shows another LED module in accordance with the invention. This module too comprises the essential parts of the module shown in Fig. 1. The collimator lens of the module additionally comprises a sawtooth-like structure which is provided by means of a replica technique. In the present case, the lens is made from polymethyl methacrylate. This lens enables a 40°-deflection of the light beam relative to the axis of symmetry (4) to be achieved.

Fig. 4 schematically shows a luminaire in accordance with the invention. Fig. 4-a is a plan view of said luminaire. Fig. 4-b is a cross-sectional view taken on the lines IV-IV. The luminaire comprises a box-like housing (11) accommodating 25 LED modules (12). These modules each include a LED (13) and a collimator lens (14). Each of these lenses has an axis of symmetry (15) which extend in mutually parallel directions.

The emergent face of each lens is provided with a sawtooth-like structure (16) for deflecting the emerging light generated by the relevant LED (13). In the present case, this structure (16) consists of a glued foil (see above) in which a sawtooth-like structure is provided.

The individual foils of each of the collimator lenses of the luminaire may be oriented in such a way that the deflected beams are directed parallel to each other. It is alternatively possible, however, to orient the individual foils in such a manner that another, desirable illumination pattern is formed. It is also possible to use sawtooth-like structures with different deflection angle for the different LED modules, as schematically shown in Fig. 4. It is also possible to use different types of LEDs, so that a desired color and/or intensity pattern can be obtained.

CLAIMS:

1. A LED module comprising a LED (light-emitting diode) and a rotationally symmetrical, bowl-shaped collimator lens which is provided with a recess in which the LED is situated, and which collimator lens is also provided with a flat surface from which light generated by the LED emerges, the normal to the surface extending substantially parallel to the axis of symmetry of the lens, characterized in that the surface is provided with a sawtooth-like structure for deflecting the emerging light.

2. A LED module as claimed in claim 1, characterized in that the sawtooth-like structure is provided in a separate foil, which is secured to the surface of the collimator lens.

3. A LED module as claimed in claim 1, characterized in that the sawtooth-like structure is pressed into the surface of the collimator lens.

4. A LED module as claimed in claim 1, characterized in that the sawtooth-like structure in the surface of the collimator lens is obtained by means of a replica technique.

5. A luminaire comprising a box-like housing which accommodates a number of LED modules, each module including a LED and a collimator lens, said lens being provided with a flat surface from which light generated by the LED emerges, characterized in that the surface is provided with a sawtooth-like structure for deflecting the emerging light.

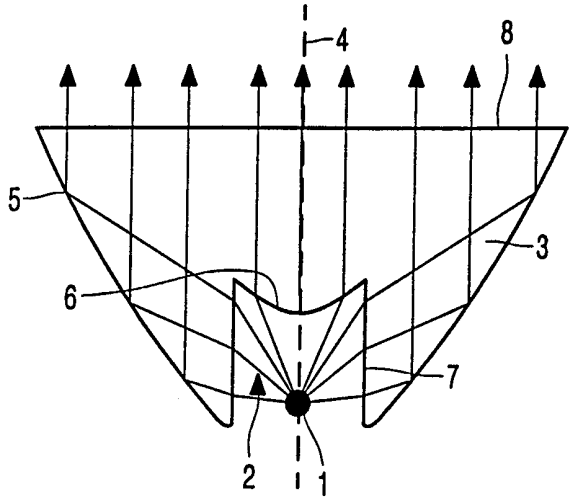

FIG. 1

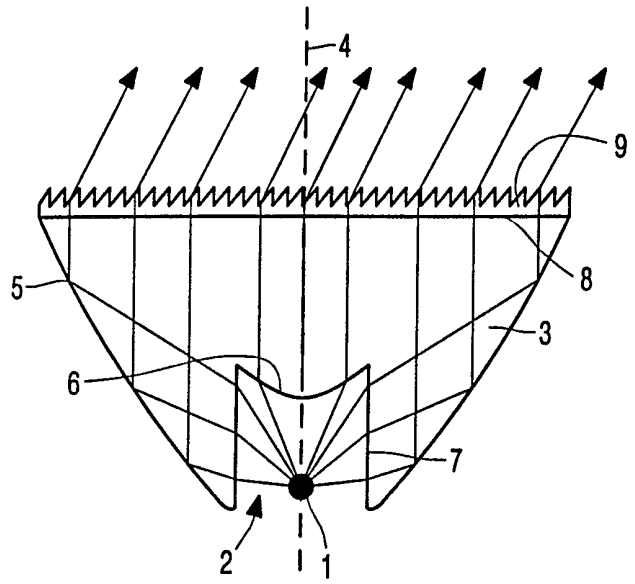

FIG. 2

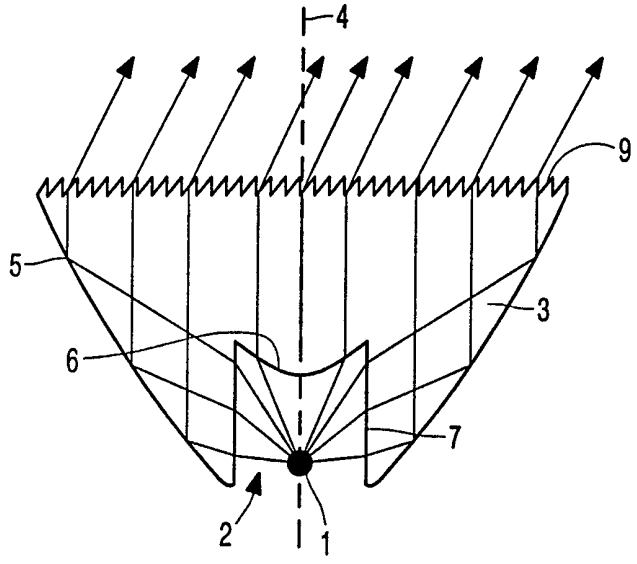

FIG. 3

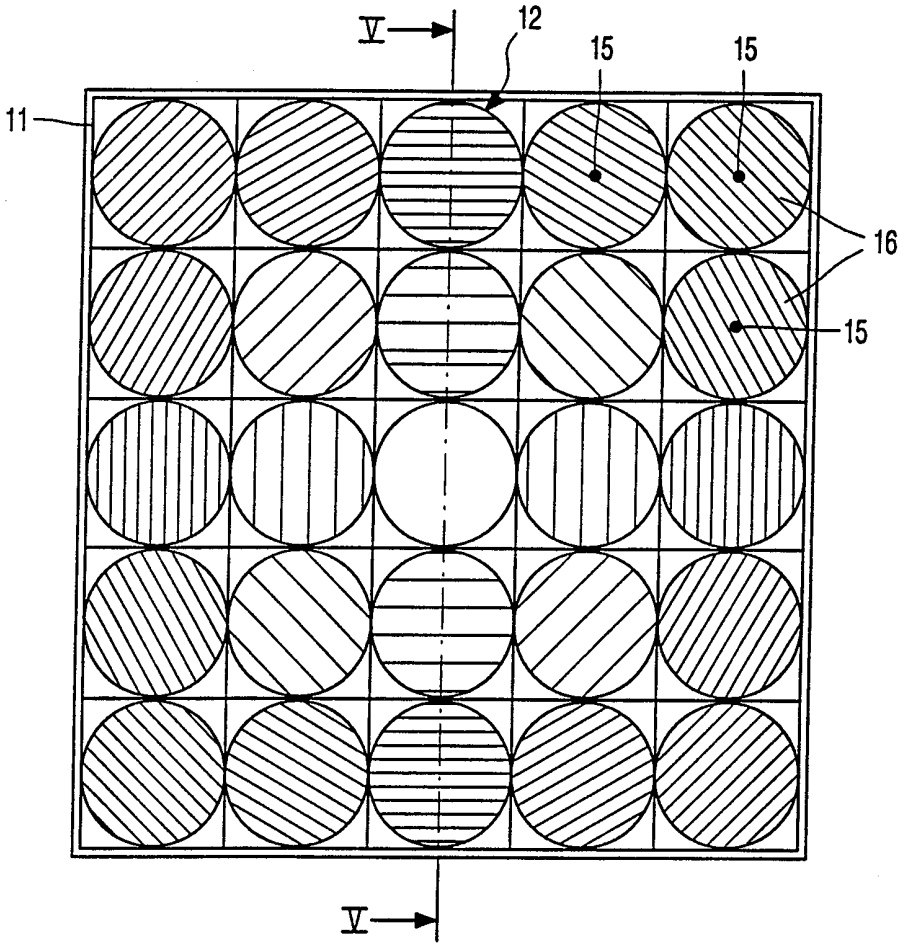

FIG. 4

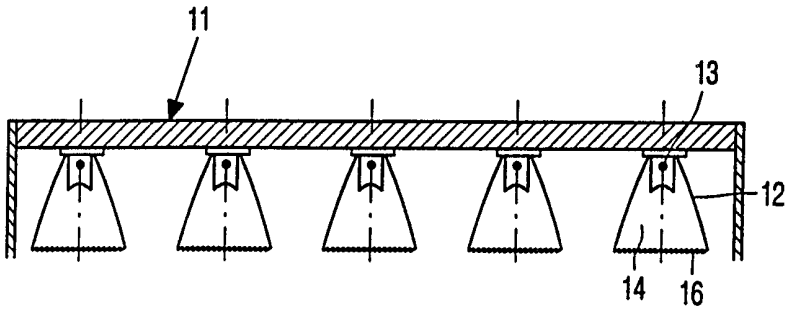

FIG. 5

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/EP 99/07456

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01L33/00

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)
IPC 7 H01L

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 practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 195 07 234 A (FER FAHRZEUGELEKTRIK GMBH) 5 September 1996 (1996-09-05)	1
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A	column 4, line 54 -column 5, line 35	2

Y	WO 98 33007 A (KONINKL PHILIPS ELECTRONICS NV ;PHILIPS NORDEN AB (SE)) 30 July 1998 (1998-07-30) page 9, line 18-29; figures 5-7	5

A	EP 0 798 788 A (ROLLS ROYCE POWER ENG ;BROWN JOHN HERBERT (GB)) 1 October 1997 (1997-10-01) column 3, line 24 -column 4, line 34	1,2,5

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

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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	PATENT ABSTRACTS OF JAPAN vol. 011, no. 051 (E-480), 17 February 1987 (1987-02-17) & JP 61 214485 A (STANLEY ELECTRIC CO LTD), 24 September 1986 (1986-09-24) abstract	1

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