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(54) **A compact lighting module**

(57) A lighting module includes:
- a printed circuit board (12) carrying a light source (10), such as e.g. a LED light source, as well as related drive circuitry,
- a cup-shaped reflector (14) having a proximal end and a distal end, the proximal end coupled to the printed circuit board (12), so that light from the light source (10) is directed from the proximal end to the distal end of the

reflector (14), wherein the reflector (14) is provided with heat dissipation formations (16), and
- a cover (18) transparent to the light emitted from the light source (10) capable of including optical functions, the cover (18) coupled to the distal end of the reflector (14).

The printed circuit board (12) and the reflector (14) are coupled via a quick-release coupling to permit easy replacement of the light source.

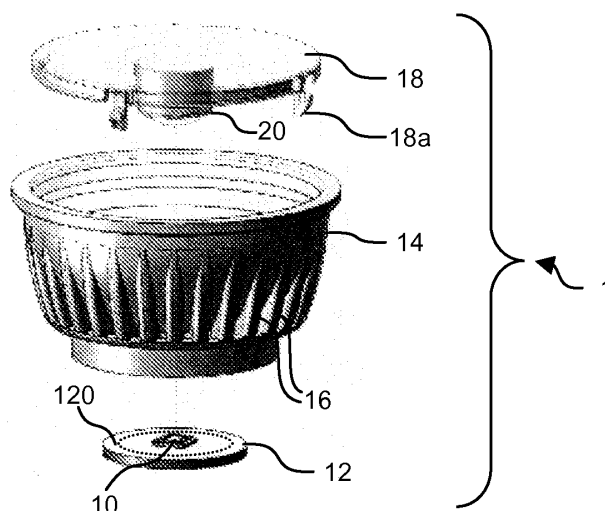


Fig. 1

Description

Field of the invention

[0001] This disclosure relates to lighting modules.

[0002] More specifically, this disclosure relates to compact lighting modules such as e.g. LED lighting modules.

Description of the related art

[0003] Light Emitting Diodes or, briefly, LEDs are increasingly used as light sources, especially in the form of so-called high-flux LEDs.

[0004] Current LED lighting modules are comprised of several components: the LED light source, an optical system (in turn including one or more components), the driver electronics and wires, a cover, a housing, one or more heat sinks.

[0005] Developing such modules involves striking a balance between various contrasting requirements. In fact, production process complexity and costs grow with an increasing number of components involved. In terms of performance, optical efficiency usually decreases as the number of surfaces to be traversed by the optical rays increases. Thermal dissipation (which is important for obtaining efficiency and a long lifetime) may be limited by heat having to flow through a high number of components before being dissipated. Also, dissipation efficiency depends on mutual thermal coupling of those components and additional heat sink elements may be coupled with the LED light source, which is the major source of heat. For instance, additional heat sinks may be mounted on the housing, where the heat arrives after traversing all the components in the path from the source and the thermal couplings therebetween. The International Protection (IP) degree, when required, may strongly depend on the number of slits or interfaces, that is the number of components in the LED module.

[0006] Different approaches can be resorted to in an attempt to overcome the limitations considered in the foregoing e.g. by accepting a reduction in performance to the advantage of lower cost and increased compactness or, conversely, by accepting higher costs and complexity to achieve a higher performance level.

[0007] Also, the inventors have noted that another possible critical aspect of current LED lighting modules lies in that once the light source reaches the end of its useful life (usually due to LED aging) a good part of the rest of the module (such as the optical system, the electronic driver and wires, cover, housing, heat sink) is still working properly. Consequently, substituting the whole LED module gives rise to unnecessary costs and also has an adverse effect on the environment.

[0008] This disadvantage may be palliated by achieving a longer lifetime of the LED source via e.g. a reduction in the operating temperature obtained by achieving a better thermal behaviour and higher heat dissipation. In any case, the improvements achieved in that way are still far

from permitting the LED lifetime to be extended to the point of reaching the lifetime of the other components in the module.

5 Object and summary of the invention

[0009] Despite the efforts witnessed in the prior art, the need is still felt for arrangements which:

- 10 - provide a high performance level without unduly penalising compactness and cost requirements, and
- avoid having to substitute the whole module when in fact only the light source need to be replaced.

15 **[0010]** The object of the invention is to provide such an improved arrangement.

[0011] According to the invention, that object is achieved by means of a lighting module, such as, e.g., a LED module, having the features set forth in the claims that follow.

[0012] The claims are an integral part of the disclosure of the invention as provided herein.

[0013] In an embodiment, a lighting module includes:

- 25 - a printed circuit board having mounted thereon a light source as well as related drive circuitry,
- a cup-shaped reflector having a proximal end and a distal end, said proximal end coupled to said printed circuit board, whereby light from said light source is directed from said proximal end towards said distal end of the reflector, wherein said reflector is provided with heat dissipation formations, and
- 30 - a cover transparent to the light emitted from said light source and capable of integrating optical functions like collimating, broadening or mixing optical rays passing through, said cover coupled to said distal end of said reflector.

35 **[0014]** In an embodiment, the arrangement described herein includes only three components, thus achieving the following advantages:

- 40 - maximum limitation in the number of components;
- a minimum number of thermal couplings, with consequent optimisation of heat dissipation;
- 45 - upgrade of the degree of IP protection is facilitated due to the minimum number of "slits" to be taken care of.

50 **[0015]** In an embodiment, the module can thus be regarded as comprised of two sub-systems, namely:

- a first sub-system, having a longer lifetime, including the long-lasting components such as the optical system, the cover, the housing and the heat sink (e.g. a reflector/heat sink plus an associated cover);
- 55 - a second, shorter-lived, sub-system, including essentially the light source (e.g. a printed circuit board

having mounted thereon a LED light source as well as related drive circuitry).

[0016] Connection between the two sub-systems is made accessible to permit replacing the shorter-lived components without adversely affecting the structure, characteristics and behaviour of the rest of the module.

[0017] Various embodiments of the arrangement disclosed achieve notable advantages, such as:

- the cost of components is reduced,
- production costs are similarly reduced due to a simplification of process complexity in view of the lower number of components to be assembled and preference given to mechanical interfaces in the assembly process,
- optical efficiency of the module is increased by reducing the number of optical surfaces/interfaces traversed by the optical radiation,
- higher efficiency and longer lifetime are obtained due to the better thermal behaviour achieved with an efficient heat flow through a reduced number of components and thermal couplings; even higher efficiency and longer lifetime can be achieved by using an additional heat-sink leading to higher extraction of heat from the LED module,
- the LED module can be easily insulated, thus achieving a high IP protection degree thanks to minimum number of components and the reduced number of "slits" between components to be insulated (via mechanical coupling/application of insulators).

Brief description of the annexed representations

[0018] The invention will now be described, by way of example only, with reference to the enclosed representations, wherein:

- Figure 1 is an exploded prospective view of a lighting module, and
- Figure 2 is a diametral sectional view across the module of figure 1.

Detailed description of embodiments

[0019] In the following description, numerous specific details are given to provide a thorough understanding of embodiments. The embodiments can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the embodiments.

[0020] Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, the appearances of the phrases "in one

embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0021] The headings provided herein are for convenience only and do not interpret the scope or meaning of the embodiments.

[0022] In figure 1, reference 1 denotes as whole a compact LED module including (a single or multiple) LED lighting source 10 and comprised of just three basic components, namely:

- a Printed Circuit Board (PCB) 12 carrying the LED source 10,
- a reflector module 14 externally provided with fins 16 to act as a combined heat sink/reflector, and
- a cover 18.

[0023] In an embodiment, the PCB 12 is a metal-core PCB carrying, in addition to the LED lighting source 10, an electronic driver with associated power supply wires as well as the light source wire bonding connected with the driver.

[0024] In an embodiment, those elements are confined to the central portion of the side of the PCB 12 intended to face the reflector 14, thus forming an outer annular "free" area 120 adapted to face and abut against a corresponding inner annular "free" area 140 (see figure 2) at the end of the reflector 14 facing the PCB 12.

[0025] In the exemplary embodiment illustrated, the reflector 14 is a cup-shaped, approximately frusto-conical, hollow body of a heat conductive material (e.g. metal or plastics charges with heat conductive particles) having

- a narrow "proximal" end for receiving the light source 10 carried by the PCB 12; and
- a large "distal" end whose mouth portion is closed by the cover 18.

[0026] In an embodiment, the PCB 12 and the proximal end of the reflector 14 jointly define a self-screwing, snap-in or analogous arrangement (e.g. mechanical interference coupling) to permit mechanical fixing and thermal coupling of the PCB 12 to the reflector 14.

[0027] Any type of a quick release coupling can be used for that purpose, so that even an unskilled person can easily assemble, de-assemble and re-assemble the coupling of the PCB 12 with the reflector 14.

[0028] In an embodiment, the PCB 12 carries a similar fixing arrangement to permit an additional heat sink (not explicitly shown in the drawing) to be mechanically fixed and thermally coupled to the PCB 12.

[0029] The heat sink/reflector 14 provides for dissipation of the heat coming from the LED source 10 and the electronic drive circuitry associated therewith. This occurs primarily via the external surface of the reflector 14 which is provided with fins 16 and/or similar heat dissi-

pating formations.

[0030] In the exemplary embodiment illustrated, the reflector 14 is at least slightly dome-shaped and the fins 16 are in the form of arch-shaped ribs extending in a longitudinal direction to the reflector 14. The waved surface defined by the fins 16 is beneficial to improve dissipation. Various embodiments may comprise different configurations of waved external surface in addition to or as an alternative to the ribs or fins as shown in the figures.

[0031] The cover 18 includes a disk-shaped body of a transparent material (e.g. plastics or other material fulfilling the desired functions) capable of integrating optical functions like collimating, broadening or mixing optical rays passing through. The cover 18 has the purpose of providing mechanical protection of the light source 10 against dust, undesired contact and also electrical protection both for the light source and the electronic driver circuit associated therewith.

[0032] Self-screwing and snap-in formations for mechanical collection with the reflector 14 may be provided as desired. Similarly, connections for additional heat-sink elements may be provided. In the exemplary embodiment shown, the cover 18 includes formations such as snap-in tongue-like formations 18a adapted to extend towards and into the reflector 14 to permit, e.g. a snap-in "plugging" the cover 18 into the mouth portion of the reflector 16.

[0033] In the embodiment illustrated, a single metal-core PCB 12 is used to mount both the LED source 10 and the associated drive circuitry.

[0034] In those embodiments where the light source 10 is high-flux LED module, so that thermal behaviour may become a critical aspect, a metal-core PCB with good thermal dissipation provides a better behaviour in comparison to other arrangements adapted for mounting a LED source.

[0035] Good thermal dissipation between the metal core PCB 12 and the heat sink/reflector 14 is achieved thanks to the thermal coupling of the mutually exposed annular surfaces 120, 140.

[0036] In an embodiment, a heat conductive material such as a thermal paste or a thin graphite layer interposed therebetween provides further improved thermal coupling.

[0037] In an embodiment, the mutually abutting surfaces 120, 140 are radially external and radially internal surfaces of the printed circuit board 12 and the reflector 14, respectively.

[0038] The arrangement described herein allows to achieve a high degree of insulation, together with good mechanical coupling due to the presence of only two "slits", namely:

- the connection interface between the PCB 12 and the proximal end of the reflector 14, and
- the connection interface between the distal end (mouth portion) of the reflector 14 and the cover 18.

[0039] Connection between the various elements aims at ensuring both thermal coupling and also reliable mechanical connection.

[0040] Thermal coupling achieves good thermal behaviour of the whole system, while ensuring that this thermal behaviour is not adversely affected even if e.g. the LED source 10 is replaced by an unskilled user.

[0041] For the same reason, mutual coupling and blocking is made very simple to permit an easy replacement of the LED source 10. Such mutual blocking can involve both screws and mechanical interference.

[0042] Coupling of the reflector 14 and the cover 18 (which usually do not need to be disassembled when the light source 10 is replaced) is arranged in such a way to be particularly robust and stable. An additional feature for the LED module could be the possibility of substituting also the cover 18 in case of short lifetime (use of cheap short-lasting plastic material) or for providing differentiated optical performance (e.g. interchangeable covers with different view angles).

[0043] The connection between the PCB 12 and the reflector 14 also ensures that these elements can be easily disassembled and re-assembled to permit the replacement of the LED source 10.

[0044] This approach takes into account a notional partition of the elements comprising the module 1 in view of their different lifetimes and the different rates of evolution of their related technology and standards.

[0045] The connection interface between the PCB 12 and the reflector 14 may adopt any known quick-release coupling (self-screwing and snap-in formations being exemplary of such couplings) thus making it easy, even for an unskilled person, to remove from the module a PCB 12 carrying a LED source 10 which has completed its useful life-cycle and replace it with a PCB 12 carrying a "new" LED source 10.

[0046] The arrangement described herein thus decreases the average cost borne by the customer due the possibility of avoiding the unnecessary replacement of the long lasting components (heat sink/reflector 14 and cover 18). The environmental impact of the LED module is similarly reduced since the long-lasting sub-system can be used for long (notionally indefinitely). Also, the arrangement described herein permits possibly to "upgrade" the LED module 1 by using light sources 10 in line with the technological evolution.

[0047] In an embodiment, the general dome shape of the reflector 14 mirrors the substantially parabolic inner surface of the reflector that provides optical collimation of the light coming from the source 10. To that effect, the internal surface of the reflector is treated (e.g. metallised) in order to be reflective.

[0048] The optical design of the reflector 14 (specifically of the internal surface thereof) aims at ensuring that the light rays from the LED source 10 are properly reflected from the LED source 10 towards the cover 18. The ray directions after reflection are set according to the specific viewing angle of the application and in order

to hit the cover 18 in the outer part. This minimizes undesired overlapping of those rays coming from the reflector with those rays coming directly from the LED source 10. Use of facets at the inner surface of the reflector 14 provides improved colour and image mixing.

[0049] In an embodiment, the cover 18 integrates optical functions not performed by the reflector 14. The cover 18 thus co-operates with the reflector 14 by redirecting the rays coming directly from the LED source 10 (direct rays) while adjusting the direction of the rays coming from the reflector 14 (indirect rays). Such double function is performed at best when the overlapping area of direct and indirect rays is minimized thus increasing the degree of freedom in the optical design of the cover 18.

[0050] Moreover, the cover 18 projects and mixes the light rays in order to achieve the required intensity and colour uniformity of the spot. For intensity and colour mixing, pillow or waved structures may be used.

[0051] In an embodiment, the cover 18 includes a central integrator 20 comprised of a (solid or hollow) hub of a transparent material performing optical collimation and spot shaping functions. The hub 20 can form an integrally moulded part of the cover 18.

[0052] The cross-sectional view of figure 2 refers to an embodiment where the central hub portion 20 protrudes towards the LED source 10 mounted on the PCB 12.

[0053] In an embodiment, the hub portion 20 includes a cylindrical or slightly tapered (e.g. frusto-conical) base portion 20a and a distal portion 20b having a convex end surface exposed to the LED source 10.

[0054] The optical characteristics (shape and/or refraction index of the hub 20) are selected in such a way that a part of the radiation from the LED source 10 and impinging on to the surface of the convex portion 20b of the hub 20 is refracted into the hub 20 and thus collimated toward the requested viewing angle. This is essentially the central part of the beam generated by the LED source 10 (i.e. the direct rays, designated IL in figure 2).

[0055] Conversely, the external portion of the rays impinging on to the surface 20b is reflected from that surface on to the surface of the reflector 14 to adjust the direction of rays coming from the reflector 14 (i.e. the indirect rays, designated OL in figure 2).

[0056] Of course, without prejudice to the underlying principles of the invention, the details and embodiments may vary, even significantly, with respect to what has been described and illustrated by way of example only without departing from the scope of the invention as defined by the annexed claims.

Claims

1. A lighting module, including:

- a printed circuit board (12) having mounted thereon a light source (10),
- a cup-shaped reflector (14) having a proximal

end and a distal end, said proximal end coupled to said printed circuit board (12), whereby light from said light source (10) is directed from said proximal end towards said distal end of the reflector (14), wherein said reflector (14) is provided with heat dissipation formations (16), and
- a cover (18) transparent to the light emitted from said light source (10), said cover (18) coupled to said distal end of said reflector (14).

2. The module of Claim 1, wherein said printed circuit board (12) is a metal-core printed circuit board.

3. The module of either of Claims 1 or 2, wherein said cup-shaped reflector (14) has a narrow proximal end coupled to said printed circuit board (12) and a large distal end having said cover (18) coupled thereto.

4. The module of any of Claims 1 to 3, wherein said printed circuit board (12) and said reflector (14) have mutually abutting surfaces (120, 140) coupled in heat-transmitting relationship.

5. The module of Claim 4, wherein said mutually abutting surfaces (120, 140) have heat conductive material interposed therebetween.

6. The module of either of Claims 4 or 5, wherein said mutually abutting surfaces (120, 140) have annular shapes.

7. The module of any of claims 4 to 6, wherein said mutually abutting surfaces (120, 140) are radially external and radially internal surfaces of said printed circuit board (12) and said reflector (14), respectively.

8. The module of any of the previous claims, wherein said reflector (14) is provided with heat-dissipating formations in the form of wave-like formations such as fins or ribs (16).

9. The module of any of the previous claims, wherein said printed circuit board (12) and said reflector (14) are coupled via a quick-release coupling to permit replacement of said light source (10).

10. The module of any of the previous claims, wherein said cover (14) includes a ray directing formation (20) to co-operate with said reflector (14) in directing light rays from said source (10).

11. The module of Claim 10, wherein said ray directing formation (20) includes a distal surface (20b) conveying within the formation (20) the central portion of the light beam from said light source (10) and reflecting towards said reflector (14) the outer portion of the light beam from said light source (10).

12. The module of either of Claims 10 or 11, wherein said ray directing formation (20) includes an integrator hub (20) protruding from said cover (18) towards said printed circuit board (12). 5
13. The module of Claim 12, wherein said hub (10) has a tapered shape towards said printed circuit board (12).
14. The module of Claim 11, wherein said distal surface (20a) is a convex surface. 10
15. The module of any of the previous claims, wherein said light source is a LED light source (10). 15

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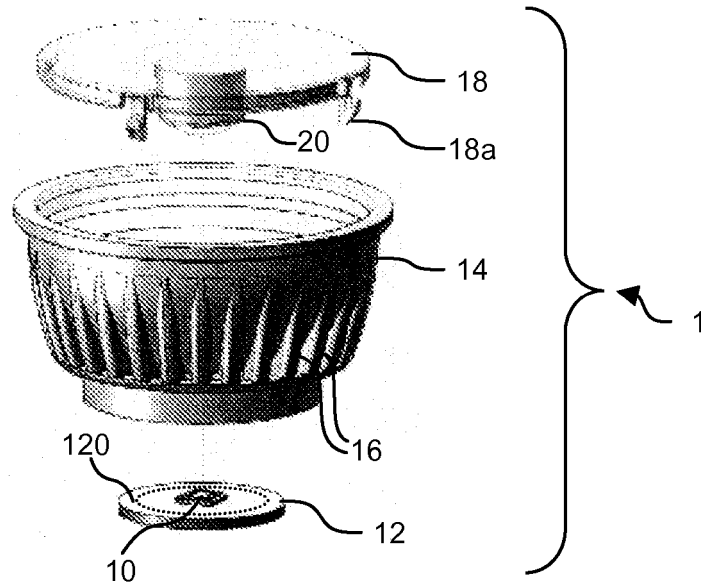


Fig. 1

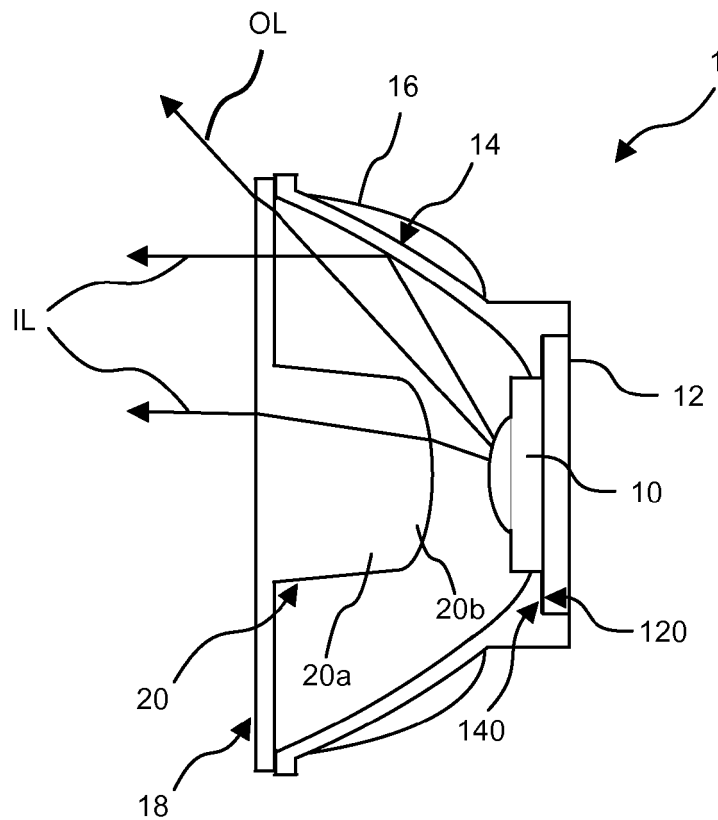


Fig. 2



EUROPEAN SEARCH REPORT

 Application Number
 EP 08 16 6838

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CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)



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<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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