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(54) **DIFFUSER FOR LED LIGHT SOURCES**

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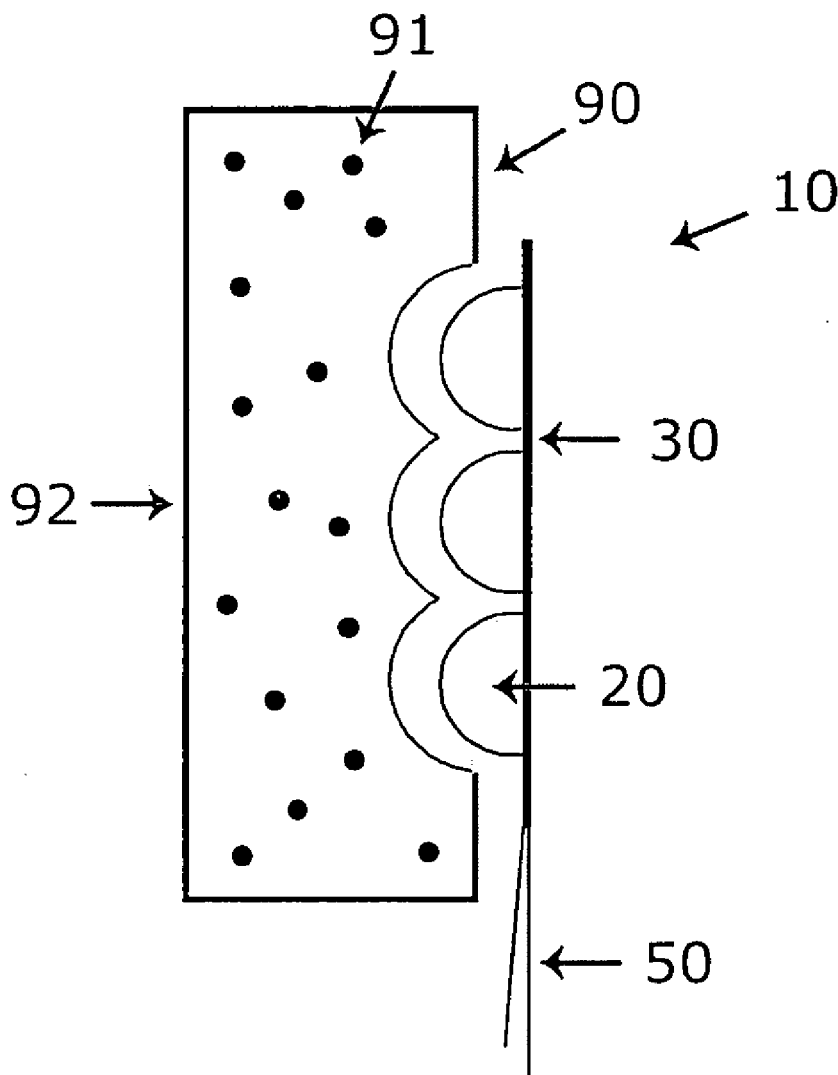
(57) **ABSTRACT**

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An LED light source is described. The light source includes an LED and a diffuser. The LED emits a light having a dominant wavelength. The diffuser includes a filler material, which includes particles. The mean diameter of the particles is at least as large as the dominant wavelength of the light emitted by the LED. The particles are configured to scatter the light emitted by the LED.

**Related U.S. Application Data**

(63) Continuation of application No. 12/739,944, filed on Aug. 24, 2010, now Pat. No. 8,415,695, filed as application No. PCT/US2008/011984 on Oct. 21, 2008.



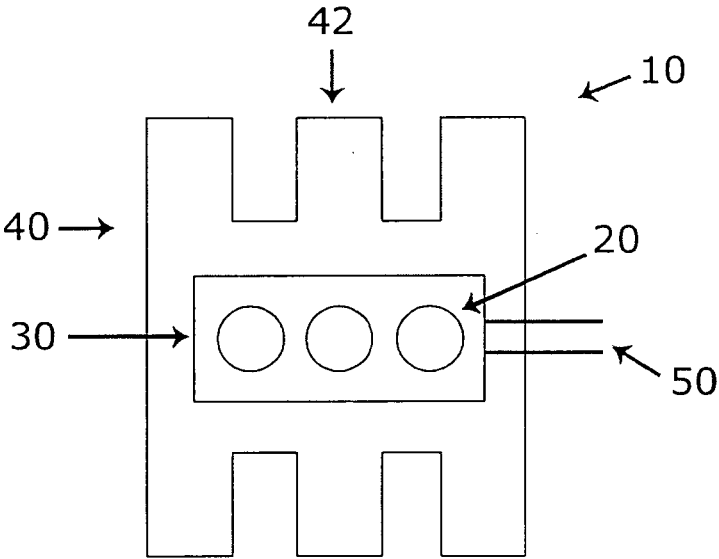


Fig. 1

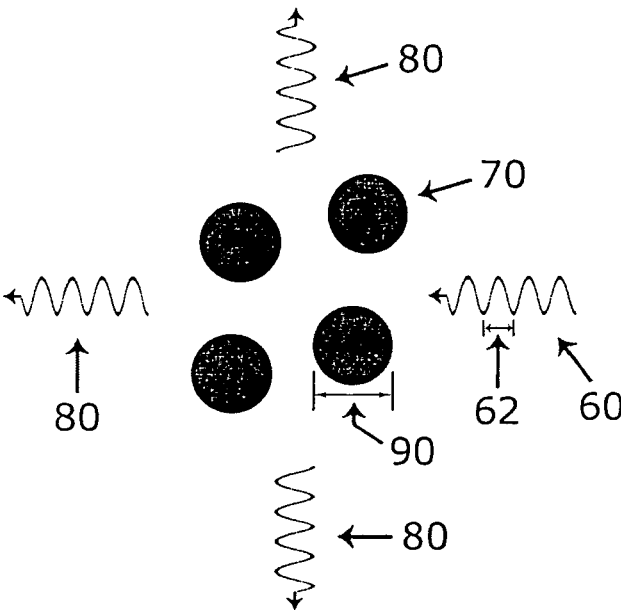


Fig. 2

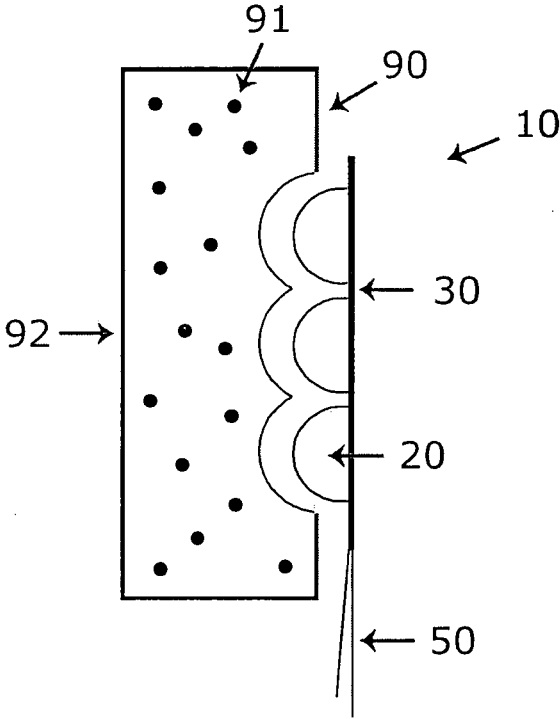


Fig. 3

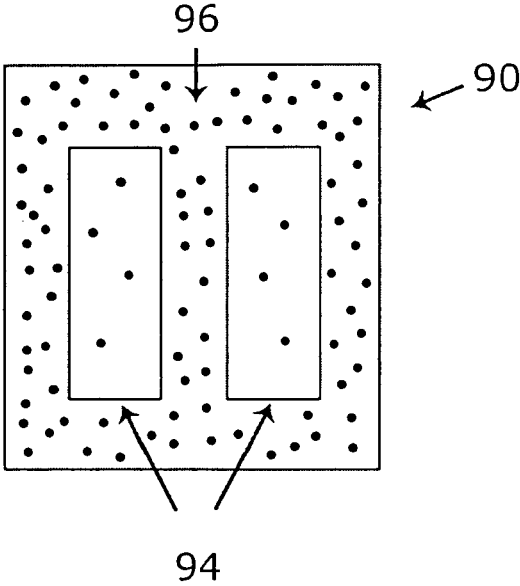


Fig. 4

## DIFFUSER FOR LED LIGHT SOURCES

### FIELD OF THE INVENTION

[0001] The present invention relates to providing uniformly dispersed light from a light emitting diode (LED) source and to the efficient removal of the heat generated by the LEDs, and more particularly, to the uniform dispersion of the light generated by LEDs in a light source without substantial light loss, in order to provide a uniform illumination surface, and to permit the LEDs to be run at higher power.

### BACKGROUND OF THE INVENTION

[0002] An LED consists of a semiconductor junction, which emits light due to a current flowing through the junction. A white LED is typically made by using a blue or ultraviolet LED die, and adding a plastic coat to it, the coat containing a phosphor. The phosphor is used to convert the blue or ultraviolet light emitted by the LED die to a spectrum of light that more or less closely resembles white light or blackbody radiation.

[0003] At first sight, it would seem that white LEDs should make an excellent replacement for the traditional lighting sources. At equal power, they give far more light output than do incandescent bulbs, or, what is the same thing, they use much less power for equal light; and their operational life is orders of magnitude larger, namely, 10-100 thousand hours vs. 1-2 thousand hours. Similarly, their ultimate efficiency is higher than that of fluorescent tubes, and their lifetime is also substantially longer than that of fluorescent tubes.

[0004] However, LEDs have a number of drawbacks that have prevented them, so far, from being widely adopted as traditional lighting sources. One of these is that LEDs are discrete sources of light. They produce intense light within the beam of their output, but dim light outside of that beam. Using multiple LEDs does not fully alleviate this problem, as there are then interference patterns in the light.

[0005] In the past, LEDs have had diffusers added to their shells or bodies to spread out the light from the LED as a solution to the point light source problem. Another method has been to roughen the surface of the LED package. Neither of these methods accomplishes uniform light distribution for an LED light source, and may lower luminous efficiency. Methods of accomplishing approximate angular uniformity may also involve partially absorptive processes, further lowering luminous efficacy.

[0006] Another drawback with LEDs is that although LEDs require substantially less power for a given light output than do incandescent bulbs, it still takes many watts to generate adequate light for illumination. An LED, being a semiconductor, is nearly a point source of heat, and cannot be allowed to get hotter than a range of approximately 85-150° C. The LED thus has a substantial heat problem.

[0007] One possible solution to this heat problem is to use a large metallic heat sink, attached to the LEDs. This heat sink would then extend out away from the bulb, removing the heat from the LEDs. However, this solution is undesirable, because the heat sink may make it difficult for the light source to fit in to the desired form factor.

### SUMMARY OF THE INVENTION

[0008] This invention has the object of developing a diffuser for LEDs, such that the above-described primary problems are effectively solved. It aims at providing a diffuser that

may be attached to an LED light source, the diffuser uniformly distributing the light over the surface of the light source with very little light loss, and also providing a large surface area for heat dissipation. The apparatus includes a sealed panel, preferentially formed of a plastic such as polycarbonate, and a filler material, preferentially formed of a fluid, plastic or gel. The fluid, gel or plastic is designed to either contain, or itself form, a system of Mie scatterers. Additionally, the fluid, gel or plastic is designed to be, or to contain, material that efficiently removes heat from the LEDs and conveys it to a suitable surface for removal.

[0009] In accordance with one embodiment, the sealed panel has a rectangular cross-section. The fluid, gel or plastic fills the panel to approximately 70-99%, or as suitable to provide room for thermal expansion. The panel may be built as an integral part of the LED light source assembly, or may be an add-on attached by any of several well-known methods.

[0010] In accordance with another embodiment, the fluid, gel or plastic may be distributed in the sealed panel with a non-uniform spatial distribution. This may be used to generate light that is more intense in one direction than another.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

[0012] FIG. 1 is a view of a present state-of-the-art LED light source showing the reason for its directionality of light output.

[0013] FIG. 2 is a cross-sectional view of light emitted from an LED having Mie scattering from supra-wavelength particles.

[0014] FIG. 3 is a cross-sectional view of an LED light source showing the diffuser mounted in front of the LEDs.

[0015] FIG. 4 is a cross-sectional view of an LED light source showing a diffuser with non-uniform spatial distribution.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the description to refer to the same or like parts.

[0017] According to the design characteristics, a detailed description of the current practice and preferred embodiments is given below.

[0018] FIG. 1 is a view of a present state-of-the-art LED light source 10 showing the reason for its directionality of light output and the construction used for removing heat. As shown in FIG. 1, the LEDs 20 are mounted on a circuit board 30. Since said LEDs are point sources of light, the light emitted from the said LED light source appears concentrated in beams. Said circuit board provides electrical interconnects for the LEDs 20, and may also provide electrical isolation. Wires 50 come from the circuit board to power the LEDs from a power source (not shown). The circuit board 30 is mounted to a heatsink 40, made of a low thermal-resistivity material, whose purpose is to provide a low thermal-resistance path to

the ambient for heat generated by the LEDs 20. In the drawing, heatsink 40 has fins 42 protruding from it, but any shape of heatsink may be used.

[0019] FIG. 2 shows a cross-sectional view of light emitted from an LED having Mie scattering from a plurality of supra-wavelength particles 70 and an equal scattering of each of the wavelengths 80 according to a further embodiment. Typically, the incoming light 60 will include a plurality of wavelength components, including a wavelength 62 based on the light-emitting material used within the LED. For example, in a typical LED emission spectrum, the wavelength 62 emitted from the LED corresponding to the color blue will be approximately 410 to 450 nm. As shown in FIG. 2, the incoming light 60 impinges on a dispersed set or plurality of particles 70 having an effective diameter 90, wherein the effective diameter 90 is greater than a dominant wavelength 62 of light emitted from the LED. The effective diameter 90 of the dispersed particles 70 are preferably a size one to a few times larger than a dominant wavelength 62 of the light emitting source. For example, for an LED producing a blue light, the dispersed set of particles 70 can be alumina trihydrate having a mean diameter of approximately 1.1 microns. It can be appreciated that any suitable particles having an effective diameter 90, which is greater than the dominant wavelength 62 of the emitting light source or LED and creates Mie scattering can be used. It can be appreciated that the particles need not be spherical, or even approximately spherical, and that other shapes can be used such as disk or rod-shaped particles. This creates the condition for Mie scattering of the incoming light 60, wherein each of the incoming wavelengths 62 are scattered into an outgoing wavelength 80. The transmitted light or outgoing wavelengths 80 are thus dispersed in directions relative to the incoming light 60, without significantly affecting the light intensity.

[0020] FIG. 3 is a cross-sectional view of an LED light source 10 showing the diffuser 90 mounted in front of the LEDs. As shown in FIG. 3, the LEDs 20 are mounted on a circuit board 30, and have power wires 50 coming off to their power source, not shown. Placed in front of said LEDs is the diffuser panel 90. Said diffuser panel is shown as being form-fitted to the LEDs 20 and circuit board 30, providing a low-thermal resistance path for the heat both of said LEDs and for the heat of said LEDs being transferred to said circuit board. The heat conducted by the diffuser panel 90 may be transferred to ambient by conduction and radiation from the emitting surface 92. The diffuser panel 90 also spreads out the light from the LEDs 20, producing an approximately uniform light output on the emitting surface 92. It can be appreciated that the diffuser panel 90 need not be rectangular in cross-section, and that other shapes such as disk can be used. It can also be appreciated that the diffuser panel 90 need not have a flat emitting surface, and that other shapes such as hemispherical can be used. It can also be appreciated that the diffuser panel 90 need not be form-fitted to the LEDs 20, but may simply be placed in front of them.

[0021] As shown in FIG. 3, the LED light source 10 includes at least one LED, a panel 90 between the at least one LED 20 and a light emission surface of the light source, and a filler material 91 inside the panel 90 to scatter the light from the at least one LED 20. In accordance with one embodiment, the filler material 91 is a poly(acrylamide) hydrogel having a plurality of particles, which have been lightly coated with inorganic particles, such as calcium carbonate.

[0022] In accordance with another embodiment, the LED light source 10 includes at least one LED 20, a panel between the at least one LED 20 and a light emission surface of the light source 10, and a filler material 91 inside the panel 90 to scatter the light from the at least one LED 20, wherein the filler material 91 contains small Mie cells plus a second different density component. In accordance with an embodiment, the filler material 91 is comprised of a hydrocarbon-based oil, with said second different density component being composed of water and a small amount of a surfactant. It can be appreciated that the filler material 91 is composed of components that are individually each transparent to light.

[0023] FIG. 4 is a cross-sectional view of an LED light source, not shown, showing a diffuser 90 with non-uniform spatial distribution. As shown in FIG. 4, the diffuser 90 has two rectangular areas 94 in which the density of the fluid, gel or plastic filler material is lower than in the other areas 96 of said diffuser 90. The lower density filler material areas 94 may be formed with discrete boxes formed within the diffuser 90, or may simply be modulation in the density of the material used. The effect of the lower density filler material areas 94 is to produce light from those areas that is more direct and intense than in the other areas 96 of the diffuser 90. The other areas 96 produce a more diffuse and less intense light. It can be appreciated that the lower density filler material areas 94 need not be rectangular, and may be of other shapes such as circles and annuli. It can also be appreciated that the filler material may be of uniform density, and only the Mie scatterers may be varied in density.

[0024] It will be apparent to those skilled in the art that various modifications and variation can be made to the structure of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention cover modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.

What is claimed is:

1. An LED light source comprising:
  - at least one LED configured to emit a light, wherein the light has a dominant wavelength;
  - a diffuser configured to receive the light emitted by the at least one LED, wherein the diffuser comprises a filler material including particles, and wherein the mean diameter of the particles is at least as large as the dominant wavelength; and
  - wherein the particles are configured to scatter the light emitted by the at least one LED.
2. The LED light source of claim 1, wherein:
  - the diffuser comprises a first area with a first density of the filler material and a second area with a second density of the filler material; and
  - the first density is not the same as the second density.
3. The LED light source of claim 1, wherein:
  - the diffuser comprises a first area with a first density of the particles and a second area with a second density of the particles; and
  - the first density is not the same as the second density.
4. The LED light source of claim 1, wherein the filler material is a fluid.
5. The LED light source of claim 1, wherein the filler material is a gel.
6. The LED light source of claim 1, wherein the filler material is a plastic.

7. The LED light source of claim 1, wherein the particles comprise alumina trihydrate.

8. The LED light source of claim 1, wherein the at least one LED is a blue or ultraviolet LED without a phosphor, and the filler material contains at least one phosphor.

9. The LED light source of claim 1, wherein the filler material is a hydrogel.

10. The LED light source of claim 1, wherein the particles have been coated with inorganic particles.

11. An LED light source comprising:

at least one LED configured to emit a light, wherein the light has a dominant wavelength;

a diffuser configured to receive the light emitted by the at least one LED, wherein the diffuser comprises a poly (acrylamide) hydrogel including particles, and wherein the mean diameter of the particles is at least as large as the dominant wavelength; and

wherein the particles are configured to scatter the light emitted by the at least one LED.

12. The LED light source of claim 11, wherein:

the diffuser comprises a first area with a first density of the particles and a second area with a second density of the particles; and

the first density is not the same as the second density.

13. The LED light source of claim 11, wherein the particles comprise alumina trihydrate.

14. The LED light source of claim 11, wherein the at least one LED is a blue or ultraviolet LED without a phosphor, and the poly(acrylamide) hydrogel contains at least one phosphor.

15. The LED light source of claim 11, wherein the particles have been coated with inorganic particles.

16. An LED light source comprising:

at least one LED configured to emit a light, wherein the light has a dominant wavelength;

a diffuser configured to receive the light emitted by the at least one LED, wherein the diffuser comprises a hydrocarbon-based oil and particles, and wherein the mean diameter of the particles is at least as large as the dominant wavelength; and

wherein the particles are configured to scatter the light emitted by the at least one LED.

17. The LED light source of claim 16, wherein the diffuser further comprises a surfactant.

18. The LED light source of claim 16, wherein:

the diffuser comprises a first area with a first density of the hydrocarbon-based oil and a second area with a second density of the hydrocarbon-based oil; and

the first density is not the same as the second density.

19. The LED light source of claim 16, wherein:

the diffuser comprises a first area with a first density of the particles and a second area with a second density of the particles; and

the first density is not the same as the second density.

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