



US009091399B2

(12) **United States Patent**  
**Farmer**

(10) **Patent No.:** **US 9,091,399 B2**  
(45) **Date of Patent:** **Jul. 28, 2015**

(54) **DRIVER-FREE LIGHT-EMITTING DEVICE**

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 302 days.

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(21) Appl. No.: **13/228,247**

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(22) Filed: **Sep. 8, 2011**

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(65) **Prior Publication Data**

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**Related U.S. Application Data**

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(60) Provisional application No. 61/412,723, filed on Nov. 11, 2010.

(Continued)

(51) **Int. Cl.**  
**F21S 4/00** (2006.01)  
**F21K 99/00** (2010.01)

*Primary Examiner* — Ismael Negron

(52) **U.S. Cl.**  
CPC ..... **F21K 9/30** (2013.01)

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(58) **Field of Classification Search**  
USPC ..... 362/650, 241, 243, 245, 247, 249.02,  
362/249.06, 249.14, 294, 373; 315/187,  
315/185 R, 185 S, 192  
See application file for complete search history.

(57) **ABSTRACT**

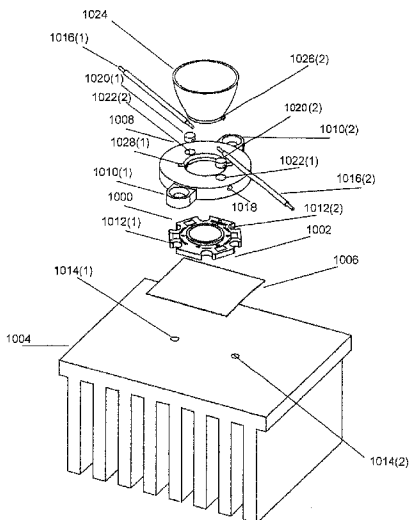
A light source includes a plurality of solid state light emitters arranged in first and second light emitter groups, a printed circuit board for supporting the solid state light emitters, a thermally conductive mounting fixture, and a heat sink. The mounting fixture secures the light emitters and the circuit board to the heat sink. A reflector might also be supported by the mounting fixture. The light emitter within each light emitter group are connected in series, with the first light emitter group connected in parallel to the second light emitter group, but with reverse polarity, such that the light source is configured to be powered directly from an AC source.

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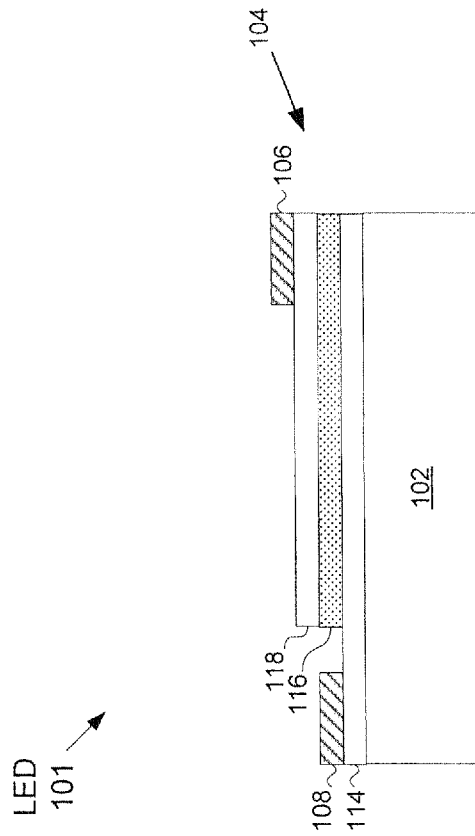


FIG. 1

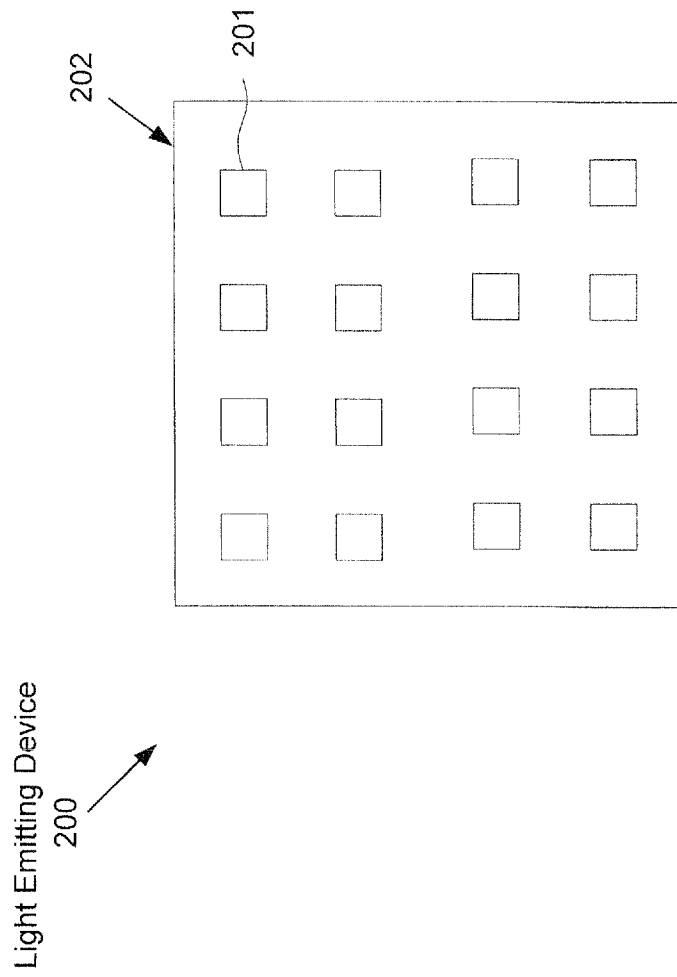


FIG. 2

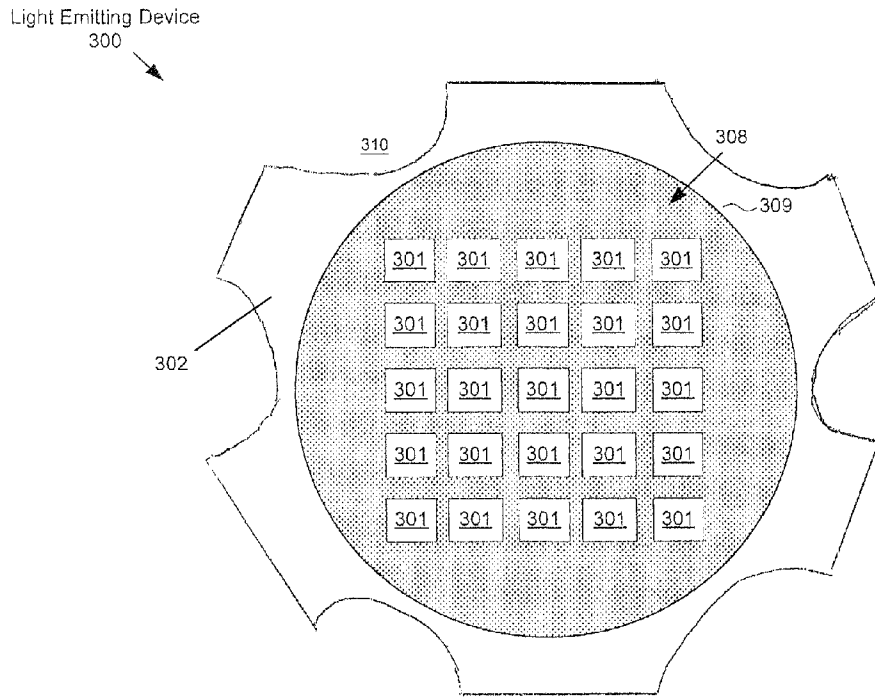


FIG. 3A

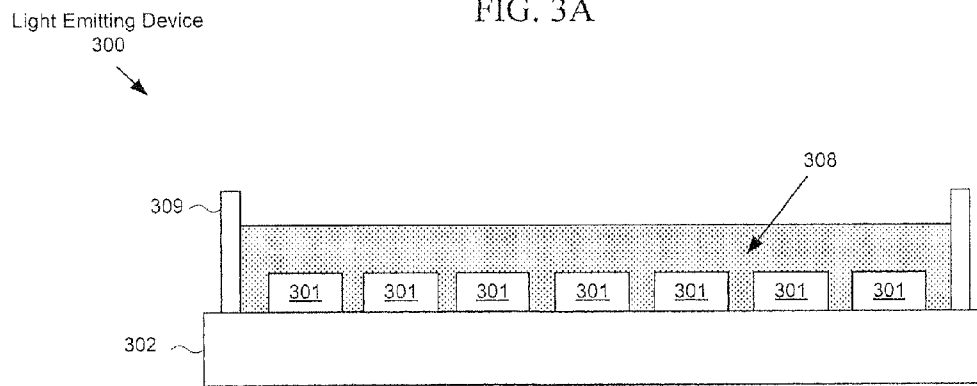


FIG. 3B

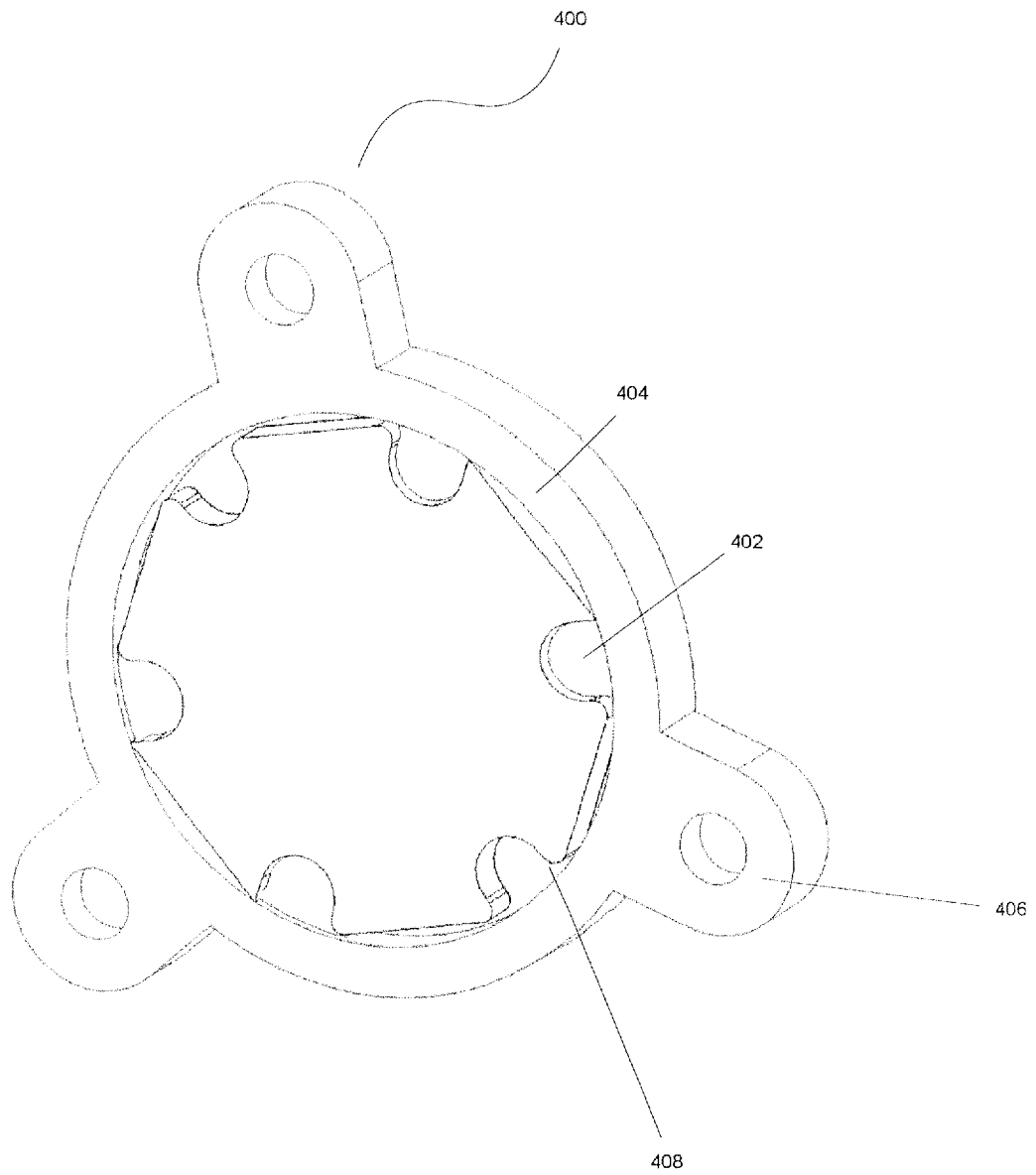


FIG. 4A

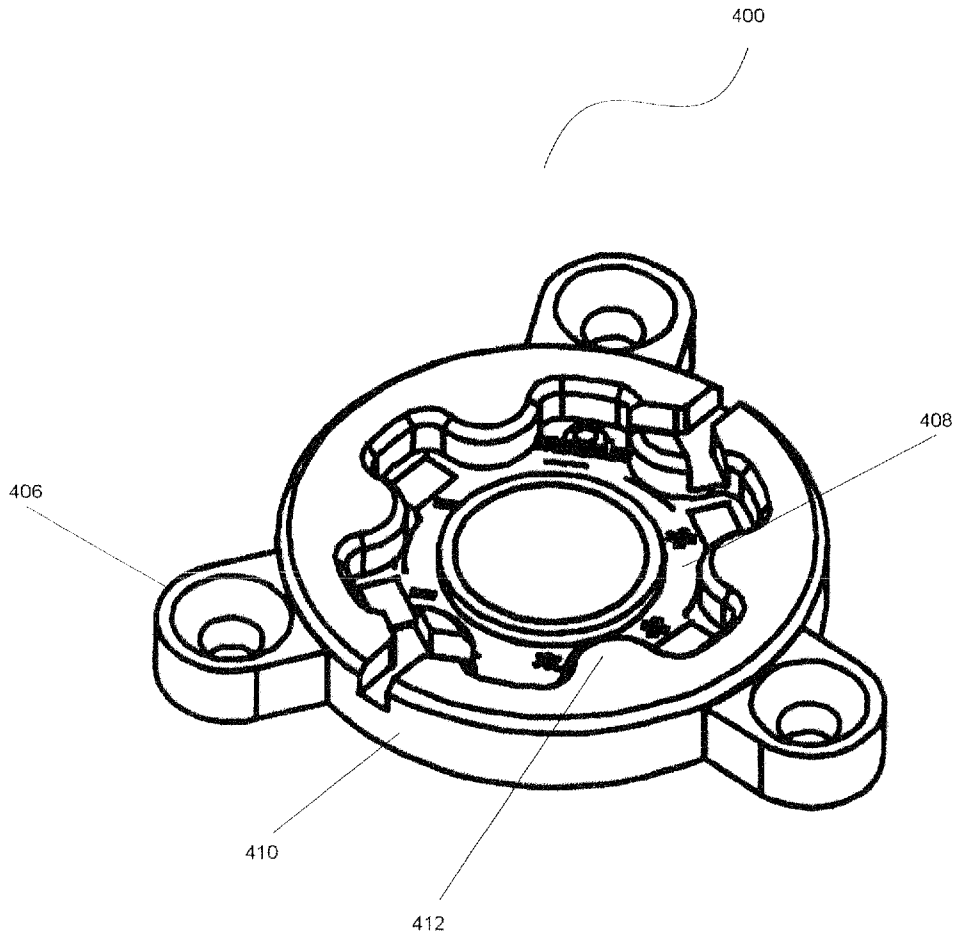


FIG. 4B

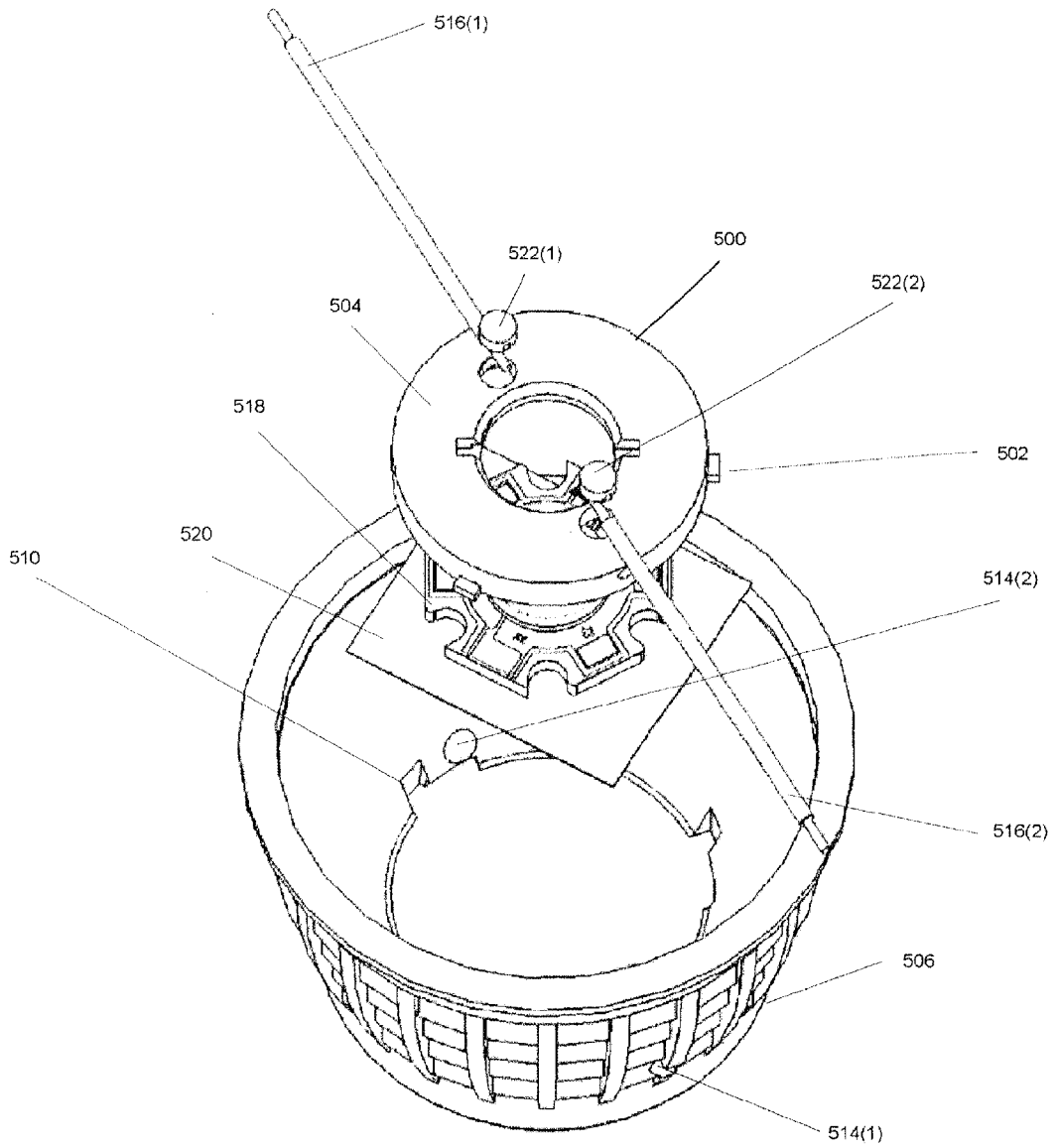


FIG. 5



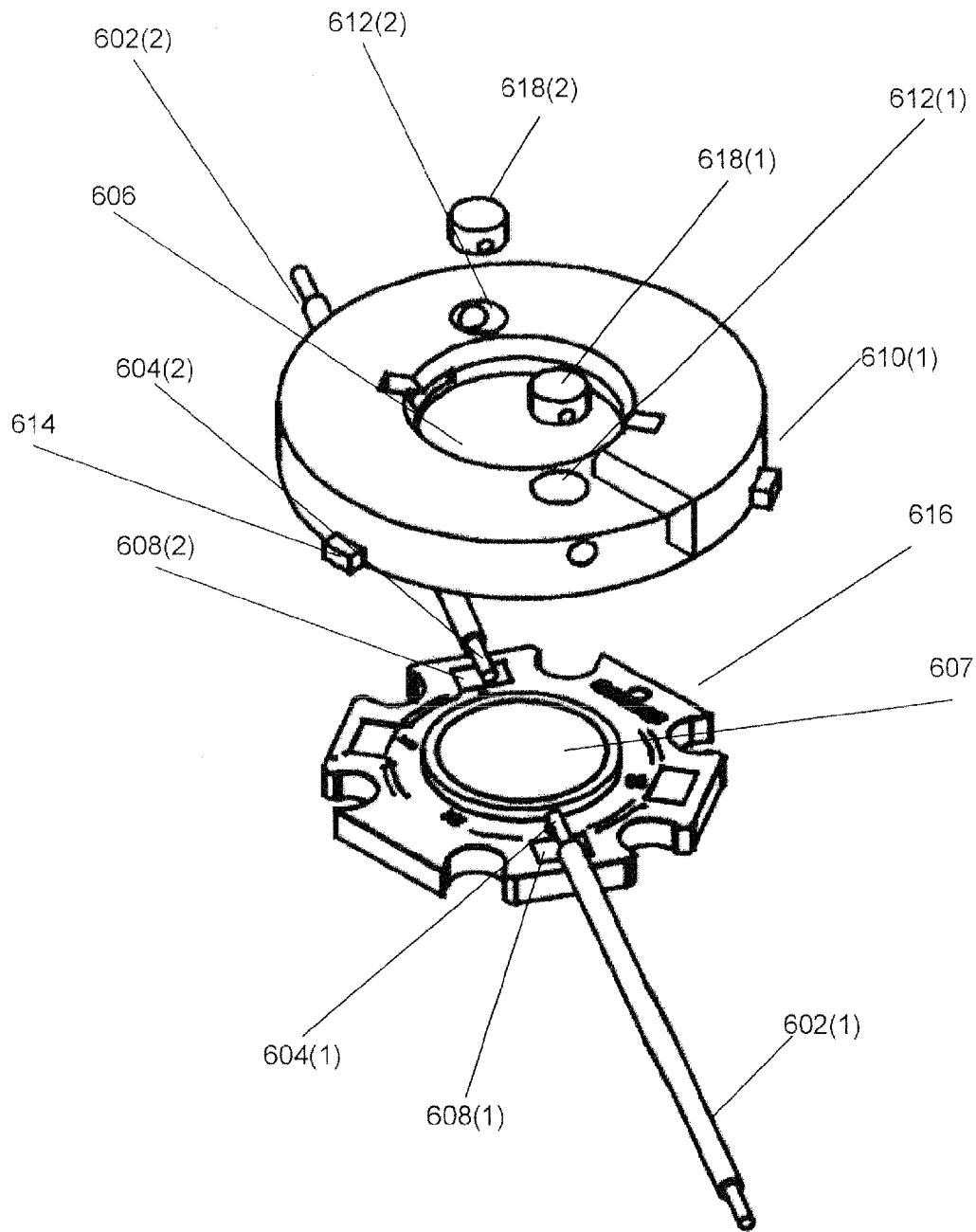


FIG. 6

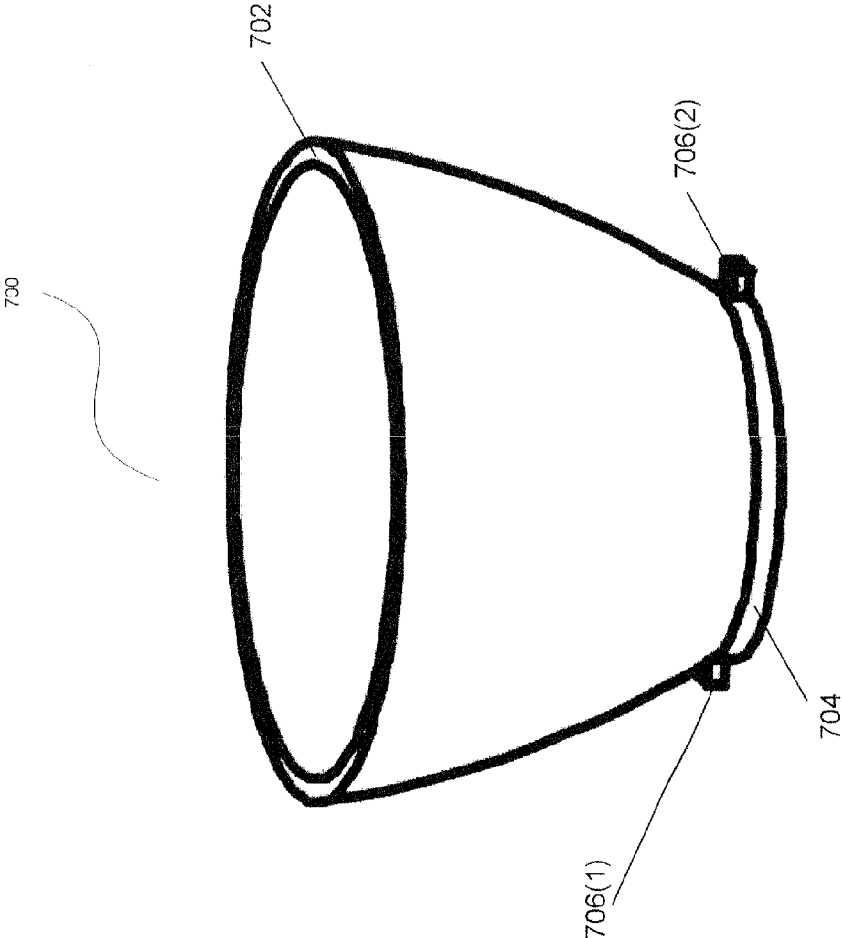


FIG. 7

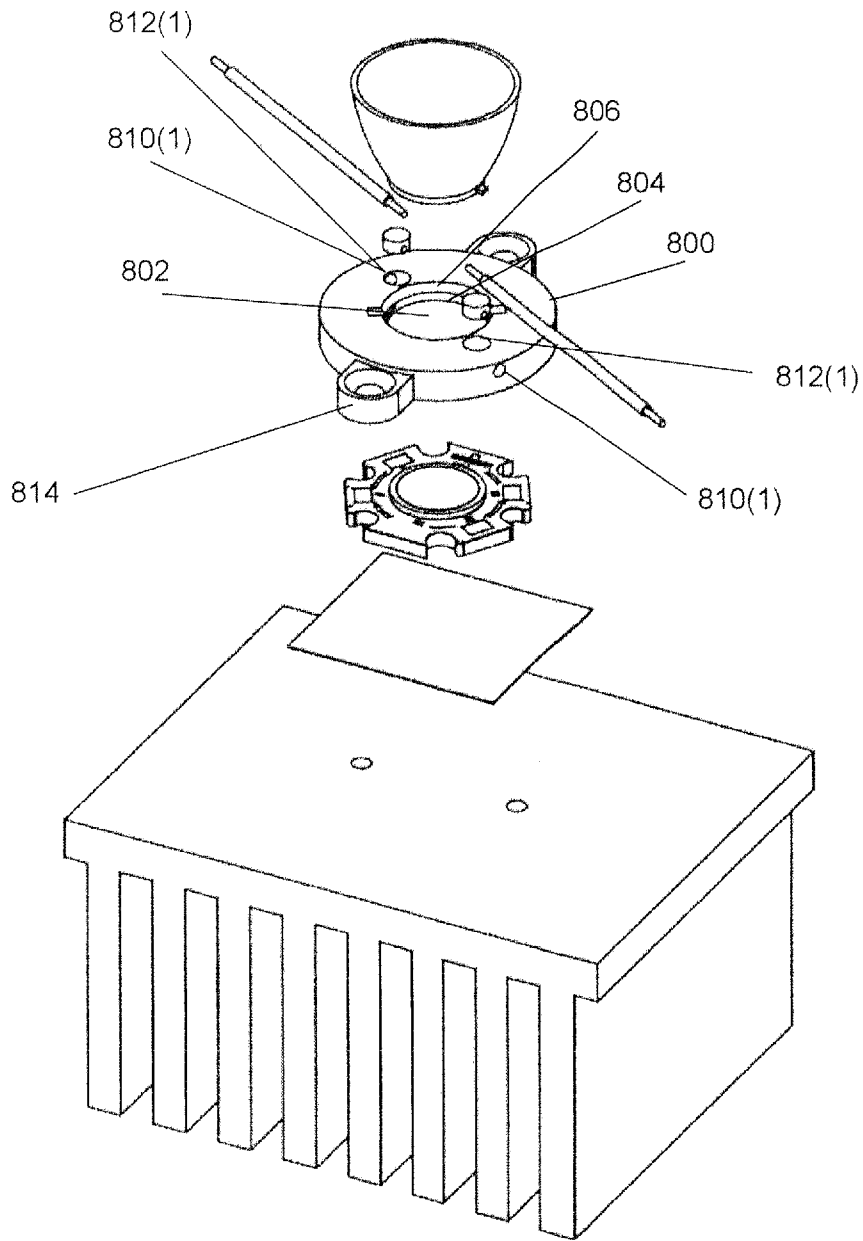


FIG. 8

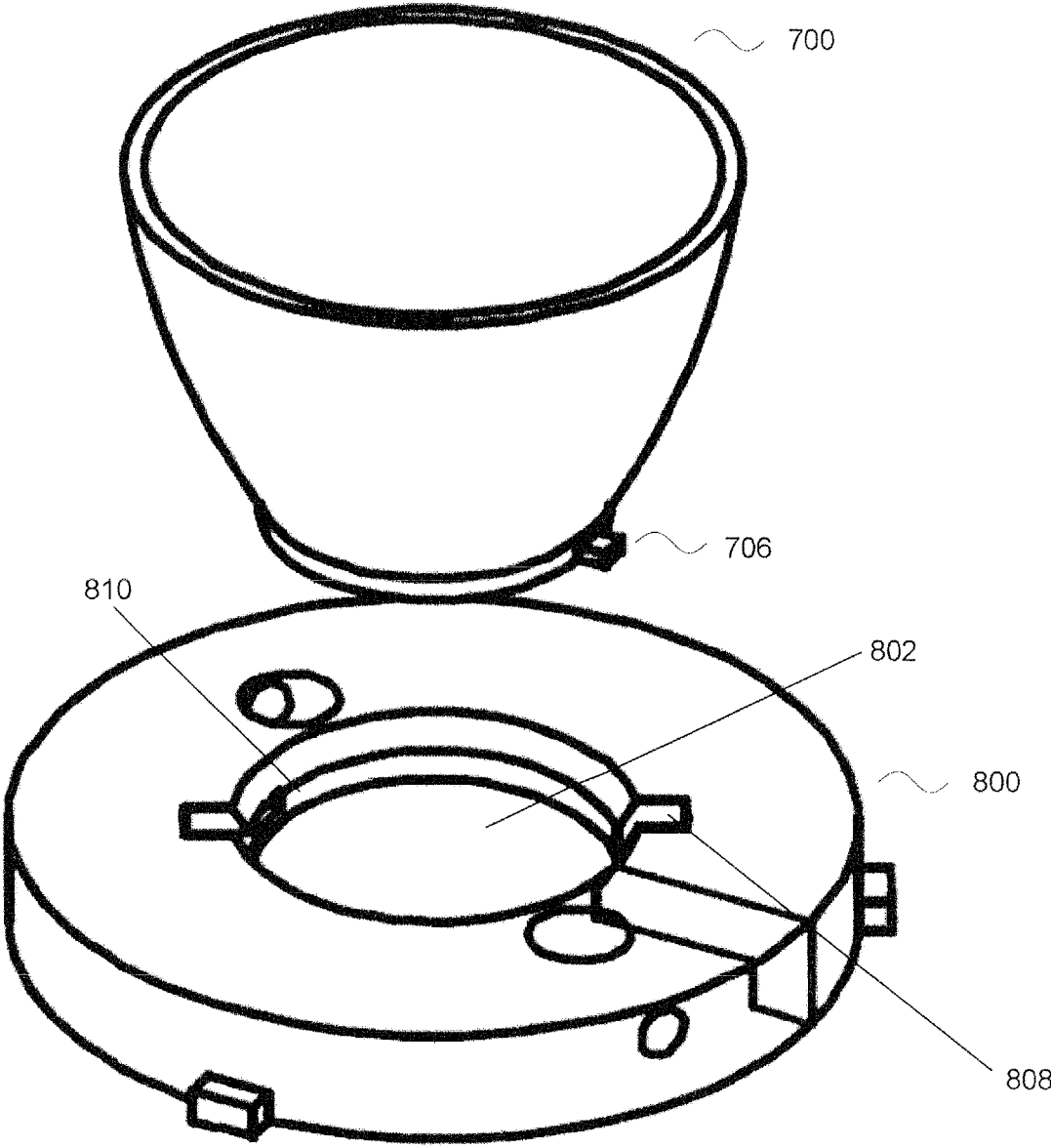


FIG. 9

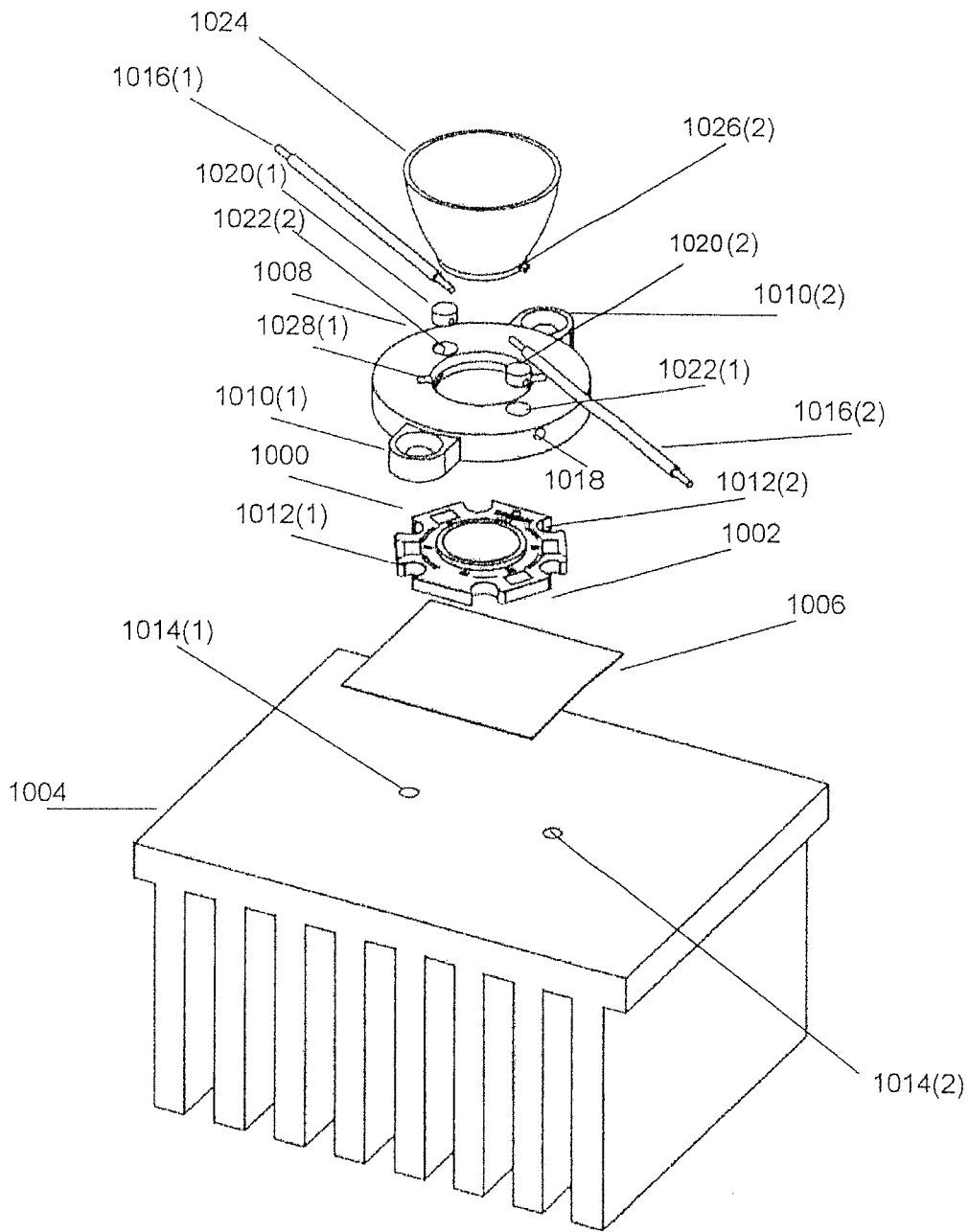


FIG. 10

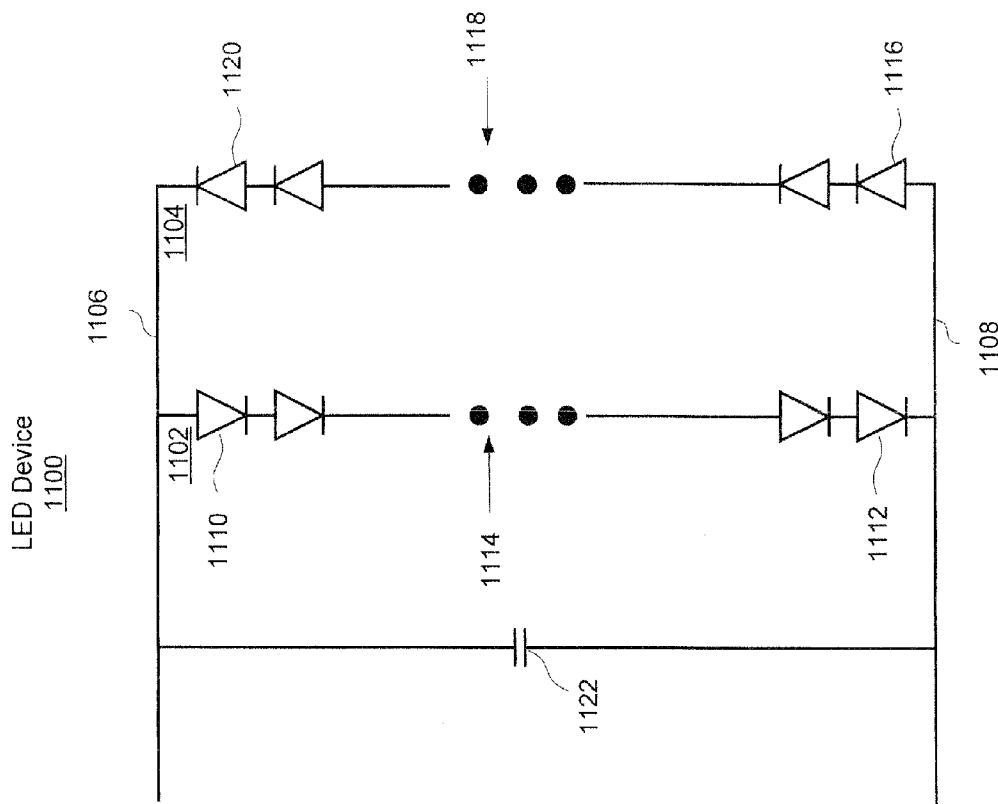


FIG. 11

**DRIVER-FREE LIGHT-EMITTING DEVICE**CROSS-REFERENCE TO RELATED  
APPLICATION(S)

This application claims the benefit of U.S. Provisional Patent Application No. 61/412,743, entitled "Driver-Free Light-Emitting Device," filed on Nov. 11, 2010, which is expressly incorporated by reference herein in its entirety.

## BACKGROUND

## 1. Field

The present disclosure relates to light sources, and more particularly to a driver-free light-emitting devices.

## 2. Background

Solid state devices, such as light emitting diodes (LED)s, are attractive candidates for replacing conventional light sources such as incandescent, halogen and fluorescent lamps. LEDs have substantially higher light conversion efficiencies than incandescent and halogen lamps and longer lifetimes than all three of these types of conventional light sources. In addition, some types of LEDs now have higher conversion efficiencies than fluorescent light sources and still higher conversion efficiencies have been demonstrated in the laboratory. Finally, LEDs require lower voltages than fluorescent lamps and contain no mercury or other potentially dangerous materials, therefore, providing various safety and environmental benefits.

More recently, solid state devices have been used to replace high-intensity discharge (HID) lamps to provide high levels of light over large areas when energy efficiency and/or light intensity are required. These areas include roadways, parking lots, pathways, large public areas, and other outdoor applications. To increase the intensity of light in these applications, often more than one solid state light emitter is arranged in a package. An example of a solid state light emitter is a light emitting semiconductor chip comprising a p-n junction. An example of a package is a collection of light emitters arranged on a substrate and encapsulated in a phosphor to produce broad spectrum white light. This package is sometimes referred to as an "LED device." A heat sink is often attached to the LED device to dissipate heat generated by the light emitters.

LED devices are subject to various safety testing requirements prescribed by different authorities such as Underwriter Laboratories (UL), Conformite Europeene (CE), and the like. In some of these testing procedures, the LED device must withstand a high potential between the substrate and the heat sink. If the LED device design is unable to withstand the required voltage, an isolated driver may be required to power the LED device. An isolated driver, typically referred to as a "Class 2 driver," provides electrical isolation between the primary power source (e.g., wall plug) and the LED array. If, on the other hand, the LED device design is capable of withstanding the required voltage because sufficient isolation may be achieved between the LED device and heat sink, a non-isolated driver may be used to power the LED device. A non-isolated driver, typically referred to as a "Class 1 driver," is less expensive than a Class 2 driver, and therefore, reduces the manufacturing costs. However, an LED device design that eliminates the need for a driver altogether would provide further cost benefits, as well as improve reliability, reduce maintenance, and simplify the conversion from conventional

light sources currently being used in incandescent, fluorescent, halogen, (HID), and other similar lamps to solid state light emitters.

## SUMMARY

One aspect of a light source includes a plurality of solid state light emitters configured to be powered directly from an AC source, and means for providing an electrically insulating and thermally conductive attachment between the solid state light emitters and a heat sink.

Another aspect of a light source includes a plurality of solid state light emitters configured to be powered directly from an AC source, and a thermally conductive mounting fixture supporting the light emitters, wherein the mounting fixture is configured to be attached to a heat sink while providing electrical insulation between the light emitters and the heat sink.

A further aspect of a light source includes a plurality of solid state light emitters configured to be powered directly from an AC source, and a thermally conductive mounting frame having a center and a periphery, the light emitters positioned in the center of the mounting fixture, and wherein the mounting frame is configured to be attached to a heat sink at the periphery.

It is understood that other aspects of the present invention will become readily apparent to those skilled in the art from the following detailed description, wherein it is shown and described only exemplary configurations of a light source by way of illustration. As will be realized, the present invention includes other and different aspects of a light source and its several details are capable of modification in various other respects, all without departing from the spirit and scope of the present invention. Accordingly, the drawings and the detailed description are to be regarded as illustrative in nature and not as restrictive.

## BRIEF DESCRIPTION OF THE FIGURES

Various aspects of the present invention are illustrated by way of example, and not by way of limitation, in the accompanying drawings, wherein:

FIG. 1 is a conceptual cross-sectional side view illustrating an example of an LED;

FIG. 2 is a conceptual cross-sectional view illustrating an example of an LED coated with a phosphor material;

FIG. 3A is a conceptual top view illustrating an example of a white light source;

FIG. 3B is a conceptual cross-sectional side view of the white light source in FIG. 3A;

FIG. 4A is a perspective bottom view illustrating an example of a mounting fixture;

FIG. 4B is a perspective top view illustrating an example of a mounting fixture in FIG. 4A;

FIG. 5 is an exploded view illustrating an example of an LED device and a heat sink;

FIG. 6 is an exploded view illustrating an example of mounting fixture with means for attaching wire leads from an electrical power source to an LED device;

FIG. 7 is a perspective view illustrating an example of a reflector;

FIG. 8 is an exploded view illustrating an example of a mounting fixture with attachment means for the reflector in FIG. 7;

FIG. 9 is an exploded view illustrating an example of the assembly of the reflector in FIG. 7 and attachment means in FIG. 8;

FIG. 10 is an exploded view illustrating an example of the assembly of an LED device and a heat sink; and

FIG. 11 is a schematic representation illustrating an example of an LED device.

#### DETAILED DESCRIPTION

The present invention is described more fully hereinafter with reference to the accompanying drawings, in which various aspects of the present invention are shown. This invention, however, may be embodied in many different forms and should not be construed as limited to the various aspects of the present invention presented throughout this disclosure. Rather, these aspects are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the present invention to those skilled in the art. The various aspects of the present invention illustrated in the drawings may not be drawn to scale. Rather, the dimensions of the various features may be expanded or reduced for clarity. In addition, some of the drawings may be simplified for clarity. Thus, the drawings may not depict all of the components of a given apparatus (e.g., device) or method.

Various aspects of the present invention will be described herein with reference to drawings that are schematic illustrations of idealized configurations of the present invention. As such, variations from the shapes of the illustrations as a result, for example, manufacturing techniques and/or tolerances, are to be expected. Thus, the various aspects of the present invention presented throughout this disclosure should not be construed as limited to the particular shapes of elements (e.g., regions, layers, sections, substrates, etc.) illustrated and described herein but are to include deviations in shapes that result, for example, from manufacturing. By way of example, an element illustrated or described as a rectangle may have rounded or curved features and/or a gradient concentration at its edges rather than a discrete change from one element to another. Thus, the elements illustrated in the drawings are schematic in nature and their shapes are not intended to illustrate the precise shape of an element and are not intended to limit the scope of the present invention.

It will be understood that when an element such as a region, layer, section, substrate, or the like, is referred to as being “on” another element, it can be directly on the other element or intervening elements may also be present. In contrast, when an element is referred to as being “directly on” another element, there are no intervening elements present. It will be further understood that when an element is referred to as being “formed” on another element, it can be grown, deposited, etched, attached, connected, coupled, or otherwise prepared or fabricated on the other element or an intervening element.

Furthermore, relative terms, such as “lower” or “bottom” and “upper” or “top,” may be used herein to describe one element’s relationship to another element as illustrated in the drawings. It will be understood that relative terms are intended to encompass different orientations of an apparatus in addition to the orientation depicted in the drawings. By way of example, if an apparatus in the drawings is turned over, elements described as being on the “lower” side of other elements would then be oriented on the “upper” side of the other elements. The term “lower”, can therefore, encompass both an orientation of “lower” and “upper,” depending of the particular orientation of the apparatus. Similarly, if an apparatus in the drawing is turned over, elements described as “below” or “beneath” other elements would then be oriented

“above” the other elements. The terms “below” or “beneath” can, therefore, encompass both an orientation of above and below.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and this disclosure.

As used herein, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The term “and/or” includes any and all combinations of one or more of the associated listed items.

Various aspects of a light source will now be presented. However, as those skilled in the art will readily appreciate, these aspects may be extended to other light sources without departing from the spirit and scope of the invention. The light source may include a plurality of solid state light emitters configured to be powered directly from an AC source, and a means for providing an electrically insulating and thermally conductive attachment between the solid state light emitters and a heat sink. The means for providing an electrically insulating and thermally conductive attachment between the solid state light emitters and a heat sink may be mounting fixture or other suitable device, now known or later developed. The mounting fixture may be configured to be attached to the heat sink while providing electrical insulation between the light emitters and the heat sink. In one configuration of a light source, a thermally conductive mounting frame may support the light emitters at the center and attach to the heat sink at the periphery.

An example of a solid state light emitter is an LED. The LED is well known in the art, and therefore, will only briefly be discussed to provide a complete description of the invention. FIG. 1 is a conceptual cross-sectional side view illustrating an example of an LED. An LED is a semiconductor material impregnated, or doped, with impurities. These impurities add “electrons” and “holes” to the semiconductor, which can move in the material relatively freely. Depending on the kind of impurity, a doped region of the semiconductor can have predominantly electrons or holes, referred to as an n-type or p-type semiconductor region, respectively. In LED applications, the semiconductor includes an n-type semiconductor region and a p-type semiconductor region. A reverse electric field is created at the junction between the two regions, which cause the electrons and holes to move away from the junction to form an active region. When a forward voltage sufficient to overcome the reverse electric field is applied across the p-n junction, electrons and holes are forced into the active region and combine. When electrons combine with holes, they fall to lower energy levels and release energy in the form of light.

Referring to FIG. 1, the LED 101 includes a substrate 102, an epitaxial-layer structure 104 on the substrate 102, and a pair of electrodes 106 and 108 on the epitaxial-layer structure 104. The epitaxial-layer structure 104 comprises an active region 116 sandwiched between two oppositely doped epitaxial regions. In this example, an n-type semiconductor region 114 is formed on the substrate 102 and a p-type semi-



conductor region **118** is formed on the active region **116**, however, the regions may be reversed. That is, the p-type semiconductor region **118** may be formed on the substrate **102** and the n-type semiconductor region **114** may be formed on the active region **116**. As those skilled in the art will readily appreciate, the various concepts described throughout this disclosure may be extended to any suitable epitaxial-layer structure. Additional layers (not shown) may also be included in the epitaxial-layer structure **104**, including but not limited to buffer, nucleation, contact and current spreading layers as well as light extraction layers.

The electrodes **106** and **108** may be formed on the surface of the epitaxial-layer structure **104**. The p-type semiconductor region **118** is exposed at the top surface, and therefore, the p-type electrode **106** may be readily formed thereon. However, the n-type semiconductor region **114** is buried beneath the p-type semiconductor region **118** and the active region **116**. Accordingly, to form the n-type electrode **108** on the n-type semiconductor region **114**, a portion of the active region **116** and the p-type semiconductor region **118** is removed to expose the n-type semiconductor region **114** therebeneath. After this portion of the epitaxial-layer structure **104** is removed, the n-type electrode **108** may be formed.

One or more light emitters may be used to construct an LED device. An LED device having multiple light emitters disposed on a single substrate, as will be described in connection with FIG. 2, is sometimes referred to as an "LED array." However, as those skilled in the art will readily appreciate, the present invention is not limited to LED arrays, and may be extended to any suitable LED device or other suitable solid state light source. One example of an LED device will now be presented with reference to FIG. 2. FIG. 2 is a conceptual top view illustrating an example of an LED device. In this example, an LED device **200** is configured with multiple LEDs **201** arranged on a substrate **202**. The substrate **202** may be made from any suitable material that provides mechanical support to the LEDs **201**. Preferably, the material is thermally conductive to dissipate heat away from the LEDs **201**. The substrate **202** may include a dielectric layer (not shown) to provide electrical insulation between the LEDs **201**. The LEDs **201** may be electrically coupled in parallel and/or series by a conductive circuit layer, wire bonding, or a combination of these or other methods on the dielectric layer.

The LED device may be configured to produce white light. White light may enable the LED device to act as a direct replacement for conventional light sources used today in incandescent, halogen, fluorescent, HID, and other suitable lamps. There are at least two common ways of producing white light. One way is to use individual LEDs that emit wavelengths (such as red, green, blue, amber, or other colors) and then mix all the colors to produce white light. The other way is to use a phosphor material or materials to convert monochromatic light emitted from a blue or ultra-violet (UV) LED to broad-spectrum white light. The present invention, however, may be practiced with other LED and phosphor combinations to produce different color lights.

An example of a LED device will now be presented with reference to FIG. 3. FIG. 3A is a conceptual top view illustrating an example of a white light LED device and FIG. 3B is a conceptual cross-sectional side view of the white light LED device in FIG. 3A. The white light LED device **300** is shown with a substrate **302** which may be used to support multiple LEDs **301**. The substrate **302** may be configured in a manner similar to that described in connection with FIG. 2 or in some other suitable way. In this example, the substrate includes a plurality of slots **310** along the periphery. A phosphor material **308** may be deposited within a cavity defined by

an annular, or other shaped, or other boundary **309** that extends circumferentially, or in any shape, around the upper surface of the substrate **302**. The annular boundary **309** may be formed with a suitable mold, or alternatively, formed separately from the substrate **302** and attached to the substrate **302** using an adhesive or other suitable means. The phosphor material **308** may include, by way of example, phosphor particles suspended in an epoxy, silicone, or other carrier or may be constructed from a soluble phosphor that is dissolved in the carrier.

In an alternative configuration of a white light emitting element, each LED may have its own phosphor layer. As those skilled in the art will readily appreciate, various configurations of LEDs and other light emitting cells may be used to create a white light emitting element. Moreover, as noted earlier, the present invention is not limited to solid state lighting devices that produce white light, but may be extended to solid state lighting devices that produce other colors of light.

FIG. 4 is an exploded view illustrating a conceptual example of a mounting fixture for attaching an LED device, or other package of light emitters, to a heat sink, where FIG. 4A depicts a bottom view and FIG. 4B depicts a top view. The mounting fixture **400** includes a means for attaching the mounting fixture to an LED device **408**. Such an LED device may be, by way of example, an LED device as depicted in FIG. 3. The illustrated example of the attachment means includes a plurality of protrusions **402** matching in shape the plurality of slots **310** in the substrate **302** of the LED device from FIG. 3. In one configuration of a mounting frame, the tolerance of surfaces of the matching slots is such that a fit which enables the LED device **408** to be inserted in and removed from the mounting fixture **400** without tools, prevents the LED device **408** from falling from the mounting fixture **400** during subsequent manipulation. One skilled in the art will appreciate that although a particular configuration of attaching an LED device **408** to a mounting fixture **400** has been described, the LED device **408** may be attached in other ways, by way of example, with screws, clamps, glue, and the like. One skilled in the art will further appreciate that because the shape of the LED device **408** and, consequently the mounting fixture **400**, is well suited for many applications, other shapes are within the scope of the present invention.

As will be explained in greater detail later, the mounting fixture **400** may be attached to a heat sink to dissipate heat generated by the LED device **408**. In order to electrically insulate the substrate **302** (see FIG. 3) from the heat sink, an intermediate layer may be disposed between the substrate **302** and the heat sink. The intermediate layer may be a material with high thermal conductivity and high electrical insulating properties, e.g., silicon paste, silicon pad, or other materials known to a person skilled in the art. In one configuration of a mounting fixture, the bottom face **404** of the mounting fixture **400** and the bottom face of the substrate **302** (see FIG. 3) of the LED device **408** are aligned to be substantially level and flat, i.e., the irregularities in the level and flatness would not cause gaps between the bottom face of the substrate **302** and an intermediate layer when the substrate **302** is attached to the heat sink.

Alternatively, the bottom face of the substrate **302** (see FIG. 3) may be recessed, i.e., disposed below the bottom face **404** of the mounting fixture **400** by a dimension allowing for dimensional distortion of the intermediate layer due to a pressure exerted on the intermediate layer when the substrate **302** is attached to a heat sink. Such an arrangement ensures consistent pressure among the components.

The means for achieving the above-described alignment comprises a plurality of protrusions **412** formed in the body

**410** of the mounting fixture **400** which act as stops preventing the LED device **408** to slide through the opening in the body **410**. The height of the plurality of protrusions **412** establishes either the substantially level and flat or the recessed alignment.

To accommodate attachment of the substrate **302** to a heat sink, the mounting fixture **400** comprises attachment means. In one configuration of a mounting fixture, depicted in FIG. 4, the means comprises a plurality of semi-circular flanges **406** for locating screws, the means being located at a distance away from the outside of the substrate **302** (see FIG. 3). One skilled in the art will appreciate that other shape of the flanges **406**, or a continuous flange, are within the scope of the present invention. The distance between the outside of the substrate **302** and the location of the screws is determined in accordance with a testing voltage and an applicable standard. As a means of an example, the UL test standard recommends an air-gap distance as a function of applied voltage, e.g., 6 mm air-gap distance for 240 volts.

In an alternative configuration of a mounting fixture depicted in FIG. 5, the mounting fixture **500** comprises attachment means depicted as a plurality of locking posts **502**, perpendicular to the side wall **504**. A person skilled in the art will appreciate that although the locking posts **502** are depicted as flange-shaped, other shapes, e.g., pins, allowing for the below described locking action are within the scope of the present invention.

A heat sink **506** comprises attachment means enabling screw less attachment of the mounting fixture **500** to the heat sink **506**. A diameter of an opening **508** is dimensioned to accept the mounting fixture **500**. A plurality of slots **510**, matching the plurality of locking posts **502**, is introduced into the heat sink **506**. The plurality of slots **510** does not extend through the height of the heat sink **506**, but ends in second plurality of slots **512**, matching the plurality of slots **510**, introduced into the heat sink **506**. The second plurality of slots **512** starts on the bottom of the plurality of slots **510** and is parallel with or tilted downwards towards the bottom of the heat sink **506**.

To attach the mounting fixture **500** to the heat sink **506**, the plurality of locking posts **502** are aligned with the plurality of slots **510** and the mounting fixture **500** is disposed into the opening **510**. When the locking posts **502** reach the bottom of the slots **510** the mounting fixture **500** is twisted in the direction of the plurality of slots **512**. The friction between the plurality of locking posts **502** and the plurality of slots **512** keeps the mounting fixture **500** to the heat sink **506**.

A plurality of openings **514** (two openings **514(1)**, **514(2)** shown), are introduced into the heat sink **506**, to allow wire leads **516(1)**, **516(2)** to reach the mounting fixture **500** and be attached to an LED device **518**. As depicted a screw less attachment as disclosed in reference to FIG. 6 and associated text, two electrically non-conducting caps **522(1)**, **522(2)** are also shown in FIG. 5.

Referring now to FIG. 6, the mounting fixture **600** further comprises means for attaching wire leads **602**, from an electrical power source (not shown) to the LED device **600** without the need of soldering and further without exposing non-insulated part **604** of the wire leads **602** to touch. As depicted, the opening **606** in the mounting fixture **600** is dimensioned to accommodate the electrical and optical layers **607**. Consequently, the mounting fixture **600** extends above at least two attachment points **608** (two attachment points **608(1)**, **608(2)** shown), of the LED device **600**. The attachment points **608** comprise a soldering pad or any other means for providing electric power to the electrical and optical layers **607**. At least two openings **610** (two openings **610(1)**, **610(2)** shown), are

introduced into the mounting fixture **600** extending above the attachment point **608**. The openings **610(1)**, **610(2)** can extend throughout the thickness of the mounting fixture **600** or, alternatively, be blind on the inside of the mounting fixture **600**.

Another at least two openings **612** (two openings **612(1)**, **612(2)** shown), are introduced into the mounting fixture **600** connecting the inside of the openings **610(1)**, **610(2)** with the bottom face **614** of the mounting fixture **600**. When the LED device **616** is inserted in the mounting fixture **600** an electrically conducting contact **618** is in contact with the attachment point **608(1)** and protrudes into the opening **610(1)**. The wire leads **602** from an electrical power source (not shown) to the LED device **616** inserted into the at least two openings **610(1)**, **610(2)** attach to the protruding end of the electrically conducting contact **618**.

A person skilled in the art will appreciate that the above-described attachment means can be implemented in many alternatives known from respective related technologies. By means of an example, the electrically conducting contact **618** can be attached to the attachment point **608**, e.g., by soldering. The attachment between the wire leads (not shown) and the protruding end of the electrically conducting contact **618** can then be implemented by inserting the wire leads **602** into the at least two openings **610(1)**, **610(2)** and pinning the wire leads between the opening **610** and the electrically conducting contact **618** by inserting the LED device **616** in the mounting fixture **600**. By means of another example, the electrically conducting contact **618** can be disposed into the at least two openings **612(1)**, **612(2)** and come into contact with the attachment point **608** by inserting the LED device **616** in the mounting fixture **600**. The attachment between the wire leads **602** and the protruding end of the electrically conducting contact **618** can then be implemented by inserting the wire leads **602** into the at least two openings **610(1)**, **610(2)** thus pinning the wire leads between the opening **610** and the electrically conducting contact **618**. The conducting contact **618** is enclosed by an electrically non-conducting cap **620** (not shown); consequently, the conducting contact **618** is not exposed to touch.

FIG. 7 depicts a conceptual example of a reflector **700**. The reflector **700** comprises a body **702** and a flange **704**. A plurality of locking posts **706**, perpendicular to the bottom flange serve as attachment means to a mounting fixture **800** depicted in FIG. 8. A person skilled in the art will appreciate that although the locking posts **706** are depicted as flange-shaped, other shapes, e.g., pins, allowing for the below described locking action are within the scope of the disclosed aspect.

FIG. 8 depicts a conceptual example of a mounting fixture **800** comprising attachment means enabling disassemble able attachment of the reflector **700** (see FIG. 7) to the mounting fixture **800**. The opening **802** is dimensioned both as to the diameter and the height of the face **804** to accept the bottom flange **704**. Above the height of the face **804**, the opening **802** is relieved with an included angle greater than the greatest included angle of the reflector body **702**, creating a face **806**, thus enabling the mounting fixture **800** to be used without modification with reflectors with different included angles. A plurality of slots **808** (matching the plurality of locking posts **706**) is introduced into the mounting fixture **800**. The plurality of the slots **808** does not extend through the height of the mounting fixture **800**. A second plurality of slots **810** (matching the plurality of the slots **808**) is introduced into the mounting fixture **800**. The second plurality of slots **810** starts on the bottom of the plurality of slots **808** and is parallel with or tilted downwards or upwards in reference to the bottom of the mounting fixture **800**.

Referring now to FIG. 9, which for clarity retained the references from FIG. 7 and FIG. 8, to attach the reflector **700** to the mounting fixture **800**, the plurality of locking posts **706** are aligned with the plurality of slots **808** and the reflector flange **704** is disposed into the opening **802**. When locking posts **706** reach the bottom of the slots **808** the reflector is twisted in the direction of the slots **810**. The friction between the plurality of locking posts **706** and the plurality of slots **810** keeps the reflector **700** attached to the mounting fixture **800**.

A person skilled in the art will appreciate that the different aspects disclosed in reference to a particular figure and an associated text are not to be considered as applicable only to the particular figure and the associated text, but can be combined to result in a mounting fixture best suited for a given design goal. Consequently, a particular mounting fixture may, but does not have to include all the different aspects of the present invention disclosed herein. Thus, by means of an example, if a mounting fixture is to be used with a LED device comprising soldering pads, it may be difficult or costly to design solder free wire leads connection. However, other disclosed aspects of the present invention, e.g., screw free attachment of the mounting fixture to a heat sink, disassemblable attachment of a reflector to the mounting fixture and/or other disclosed aspects can be incorporated in the final design of the mounting fixture. Furthermore, a screw free attachment of the mounting fixture to a heat sink will not work if a design goal requires the heat sink to be flat.

By means of a particular example refer back to FIG. 8, showing a reflector **700** (see FIG. 7) disassembled from the mounting fixture **800**, but comprises at least two slots **810** (two openings **810(1)**, **810(2)** shown), for lead wires (not shown) ending in matching plurality of openings **812** through which the lead wires are soldered to an attachment point (not shown) on a substrate (not shown). Furthermore, the mounting fixture **800** comprises openings **814(1)**, **814(2)** for locating screws (not shown) as described in connection with FIG. 4, because the fixture is intended to be mounted on a flat heat sink.

FIG. 10 depicts an exploded view of a conceptual assembly of an exemplary light-emitting device array **1000** and a flat heat sink **1004**. In order to electrically insulate the LED device substrate **1002** from the heat sink **1004**, an intermediate layer **1006** is disposed between the substrate **1002** and the heat sink **1004**. The intermediate layer **1006** comprises a material with high thermal conductivity and high electrically insulating property, e.g., silicon paste, silicon pad or other materials known to a person skilled in the art. A mounting fixture **1008** (such as a mounting fixture according to FIG. 4 or FIG. 8 and associated text) is used to attach the LED device **1000** to the heat sink **1004**. The attachment is provided by a plurality of screws (not shown) fitting into a plurality of semi-circular flanges **1010** (two flanges shown). The plurality of screws passes through a plurality of slots **1012** in the substrate **1002** and is threaded into a plurality of holes **1014** in the heat sink **1004**. Wire leads **1016** from an electrical power source are attached to the LED device **1000**. As shown, the wire leads **1016** are inserted into the openings **1018** and attach to the protruding end of the electrically conducting contacts **1020** inserted into the at least two openings **1022**. As shown, a reflector **1024** is attached to the mounting fixture **1008** by means of a plurality of locking posts **1026** aligned with plurality of slots **1028**.

The various aspects of a mounting fixture described above provide a means by which an electrically insulating and thermally conductive attachment between one or more light emitters, e.g., an LED device, and a heat sink may be achieved. However, as those skilled in the art will readily appreciate

from this disclosure, the mounting fixture may be modified in various other ways. These modifications, as well as other techniques for providing an electrically insulating and thermally conductive attachment between one or more light emitters and a heat sink, will be readily apparent to those skilled in the art from the various teachings throughout this disclosure and are well within the scope of the present invention. By providing electrical insulation between the light emitters and the heat sink, the need for an isolated driver, i.e., Class 2 driver, is eliminated.

In one configuration of a light source, an LED device that is electrically insulated from the heat sink a mounting fixture or by some other means may be operated driver free, i.e., without a non-isolating or Class 1 driver. In this configuration, the LED device may be powered directly from an AC power. A schematic representation illustrating an example of an LED device having this configuration is shown in FIG. 11. The LED device **1100** includes a parallel circuit having a first branch **1102** and a second branch **1104**. The first and second branches **1102**, **1104** connect at a first common point **1106** and a second common point **1108**. The first and second common points **1106**, **1108** provide connection points for an AC power source.

The first branch **1102** is shown with a plurality of LEDs coupled in series. More specifically, the first branch **1102** includes an input LED **1110**, a plurality of intermediate LEDs **1112**, and an output LED **1114**. The input LED **1110** has an anode coupled to the first common point **1106** and a cathode coupled to the first LED in the series of intermediate LEDs **1112**. The output LED **1114** has a cathode coupled to the second common point **1108** and an anode coupled to the last LED in the series of intermediate LEDs **1112**. Each intermediate LED **1112** has an anode coupled to the cathode of the preceding LED and a cathode coupled to the anode of the following LED.

The second branch **1104** is shown with a plurality of LEDs coupled in series. The second branch **1104** is coupled between the first and second common points **1106**, **1108** with reverse polarity of the first branch **1102**. More specifically, the second branch **1104** includes an input LED **1116**, a plurality of intermediate LEDs **1118**, and an output LED **1120**. The input LED **1116** has an anode coupled to the second common point **1108** and a cathode coupled to the first LED in the series of intermediate LEDs **1118**. The output LED **1120** has a cathode coupled to the first common point **1106** and an anode coupled to the last LED in the series of intermediate LEDs **1118**. Each intermediate LED **1118** has an anode coupled to the cathode of the preceding LED and a cathode coupled to the anode of the following LED.

An AC source (not shown) may be coupled across the first and second common points **1106**, **1108**. With this configuration, the LEDs in the first branch **1102** will emit light during one half of the AC waveform and the LEDs in the second branch **1104** will emit light during the other half of the AC waveform. A capacitor or capacitor-like device **1122** may be coupled across the first and second common points **1106**, **1108** to reduce flicker as the AC waveform transitions between the positive and negative cycles.

The number of LEDs in a branch will vary depending upon the particular application and the overall design constraints imposed on the system. For example, the number of LEDs in a branch might be dictated by the voltage rating of the LEDs. Fewer LEDs may be used in each branch when reduced light is acceptable by placing a series resistor (not shown) in each branch to provide a voltage drop and limit the current. Those

skilled in the art will be readily able to determine the appropriate design for each branch for any particular lighting application.

The various aspects of a light source are provided to enable one of ordinary skill in the art to practice the present invention. Various modifications to, and alternative configurations of, the lighting source presented throughout this disclosure will be readily apparent to those skilled in the art, and the concepts disclosed herein may be extended to other lighting applications. Thus, the claims are not intended to be limited to the various aspects of a light source presented throughout this disclosure, but are to be accorded the full scope consistent with the language of the claims. All structural and functional equivalents to the elements of the various aspects of a light source described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed under the provisions of 35 U.S.C. §112, sixth paragraph, unless the element is expressly recited using the phrase "means for" or, in the case of a method claim, the element is recited using the phrase "step for."

What is claimed is:

1. A light source, comprising:
  - a plurality of solid state light emitters configured to be powered directly from an AC source; and
  - a thermally conductive mounting frame having a center and a periphery, the light emitters being positioned in the center of the mounting frame, wherein the mounting frame is configured to be attached to a heat sink at the periphery, wherein the mounting frame comprises one or more first openings configured to receive one or more wires, and one or more second openings configured to receive one or more electrically conductive contacts, and wherein the one or more first openings and the one or more second openings are arranged such that when the one or more wires are inserted into the one or more first openings and the one or more electrically conductive contacts are inserted into the one or more second opening, the one or more wires and the one or more electrically conductive contacts attach.
2. The light source of claim 1, wherein the light emitters comprises:
  - one or more first light emitters connected in series and one or more second light emitters connected in series, the one or more first light emitters being connected in parallel to the one or more second light emitters with reverse polarity; and
  - one or more capacitors electrically coupled to the one or more first light emitters and the one or more second light emitters to reduce flicker.
3. The light source of claim 1 further comprising a reflector, wherein the mounting frame supports the reflector.
4. The light source of claim 1, wherein the mounting frame comprises a flange at the periphery, the flange having one or more openings for one or more screws to attach the mounting frame to a heat sink.

5. The light source of claim 1, wherein the mounting frame comprises one or more locking posts at the periphery, the locking posts being configured to attach the mounting frame to a heat sink.

6. The light source of claim 1 further comprising a substrate supporting the light emitters.

7. The light source of claim 6, wherein the mounting frame supports the substrate.

8. A light source, comprising:

- a plurality of solid state light emitters configured to be powered directly from an AC source; and
- a thermally conductive mounting fixture supporting the light emitters, wherein the mounting fixture is configured to be attached to a heat sink while providing electrical insulation between the light emitters and the heat sink, wherein the mounting fixture comprises one or more first openings configured to receive one or more wires, and one or more second openings configured to receive one or more electrically conductive contacts, and wherein the one or more first openings and the one or more second openings are arranged such that when the one or more wires are inserted into the one or more first openings and the one or more electrically conductive contacts are inserted into the one or more second opening, the one or more wires and the one or more electrically conductive contacts attach.

9. The light source of claim 8 further comprising phosphor, and wherein light emitters are encapsulated in the phosphor.

10. The light source of claim 8 further comprising a reflector, wherein the mounting fixture supports a reflector.

11. The light source of claim 8 further comprising a heat sink, wherein the mounting fixture is attached to the heat sink.

12. The light source of claim 8, wherein the light emitters comprises one or more first light emitters connected in series and one or more second light emitters connected in series, one or more first light emitters being connected in parallel to one or more second light emitters with reverse polarity.

13. The light source of claim 12 further comprises one or more capacitors electrically coupled to the one or more first light emitters and the one or more second light emitters to reduce flicker.

14. The light source of claim 8 further comprising a substrate supporting the light emitters.

15. The light source of claim 14, wherein the substrate is electrically conductive.

16. The light source of claim 8, wherein the mounting fixture comprises a center and a periphery, the light emitters being positioned in the center of the mounting fixture, wherein the mounting fixture is configured to be attached to the heat sink at a periphery of the mounting fixture.

17. The light source of claim 16, wherein the mounting fixture comprises a flange at the periphery, the flange having one or more openings and one or more screws to attach the mounting fixture to a heat sink.

18. The light source of claim 16, wherein the mounting fixture comprises one or more locking posts configured to attach the mounting fixture to a heat sink.