(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 April 2012 (19.04.2012)

PCT

(10) International Publication Number
WO 2012/050994 A2

(51) International Patent Classification:
H01L 33/64 (2010.01) *H01L 33/48* (2010.01) *H01L 33/62* (2010.01)

(21) International Application Number: PCT/US2011/054560

(22) International Filing Date: 3 October 2011 (03.10.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/404,985 13 October 2010 (13.10.2010) US
13/227,961 8 September 2011 (08.09.2011) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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(54) Title: LIGHT EMITTING DEVICES AND METHODS

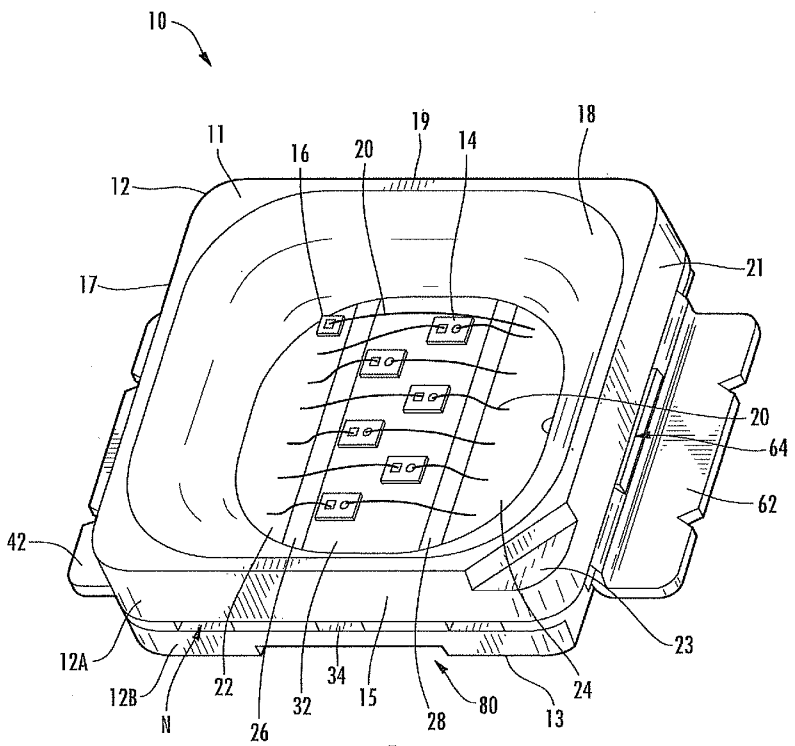


FIG. 1

(57) Abstract: Light emitting devices and methods such as light emitting diodes (LEDs) are disclosed for use in higher voltage applications. Variable arrangements of LEDs are disclosed herein. Arrangements can include one or more LED chips connected in series, parallel, and/or a combination thereof. LED chips can be disposed in a package body having at least one thermal element and one or more electrical components.

WO 2012/050994 A2

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

DESCRIPTION

LIGHT EMITTING DEVICES AND METHODS

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application Serial No. 61/404,985 filed October 13, 2010 and U.S. Continuation-In-Part Patent Application Serial No. 13/227,961 filed September 8, 2011, the disclosure of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The subject matter disclosed herein relates generally to light emitting devices and methods. More particularly, the subject matter disclosed herein relates to light emitting devices and methods for use in higher voltage applications.

BACKGROUND

Light emitting devices, such as light emitting diodes (LEDs), may be utilized in products for providing white light (e.g., perceived as being white or near-white), and are developing as replacements for incandescent, fluorescent, and metal halide light products. A representative example of an LED lamp comprises a package having at least one LED chip, a portion of which can be coated with a phosphor such as, for example, yttrium aluminum garnet (YAG). The LED chip can produce an emission of a desired wavelength within the LED lamp, and the phosphor can in turn emit yellow fluorescence with a peak wavelength of about 550 nm on receiving the emission. At least a portion of the emission from LED chip can be transmitted through the phosphor, while at least a portion can be absorbed by the phosphor. The portion of the light that is transmitted through the phosphor is mixed with the yellow light emitted by the phosphor, and the viewer perceives the mixture of light emissions as white light. As an alternative to phosphor-converted white light, red, blue, and green (RGB) light emitting devices may be operated in combination to produce light that is perceived as white. Conventional LEDs, packages and methods producing white light can be designed for lower voltage applications.

Despite availability of various LEDs and LED packages in the marketplace, a need remains for improved packages suitable for applications such as those utilizing higher voltages, to enhance light output performance, enhance thermal performance, improve device reliability, and to promote ease of manufacture.

SUMMARY

In accordance with this disclosure, novel light emitting devices and methods are provided that are capable of adapting to various application and electrical requirements. It is, therefore, an object of the subject matter disclosed herein to provide light emitting devices and methods comprising improved reliability in higher voltage applications.

These and other objects of the present disclosure as can become apparent from the disclosure herein are achieved, at least in whole or in part, by the subject matter described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

A full and enabling disclosure of the subject matter disclosed herein including the best mode thereof to one of ordinary skill in the art is set forth more particularly in the remainder of the specification, including reference to the accompanying figures, in which:

Figure 1 illustrates a perspective top view of a light emitting diodes (LED) package and LEDs according to an aspect of the subject matter herein;

Figure 2 illustrates a perspective view of components of LED packages according to an aspect of the subject matter herein;

Figure 3 illustrates an end view of LED components shown in Figure 2;

Figure 4 illustrates a perspective bottom view of an LED packages according to an aspect of the subject matter herein;

Figure 5 illustrates a top plan view of the LED package shown in Figure 1;

Figure 6 illustrates a top plan view of LEDs according to an aspect of the subject matter herein;

Figure 7 illustrates a top plan view of LEDs according to an aspect of the subject matter herein;

Figure 8 illustrates a top plan view of LEDs according to an aspect of the subject matter herein;

Figure 9 illustrates a side view of LED packages according to an aspect of the subject matter herein;

Figure 10 illustrates a cross sectional view of LED packages according to an aspect of the subject matter herein;

Figures 11A and 11B illustrate LED packages according to an aspect of the subject matter herein; and

Figures 12A and 12B illustrate LED packages according to an aspect of the subject matter herein.

DETAILED DESCRIPTION

Reference will now be made in detail to possible aspects or embodiments of the subject matter herein, one or more examples of which are shown in the figures. Each example is provided to explain the subject matter and not act as a limitation. In fact, features illustrated or described as part of one aspect or embodiment can be used in another embodiment to yield still a further embodiment. It is intended that the subject matter disclosed and envisioned herein covers such modifications and variations.

As illustrated in the various figures, some sizes of structures or portions are exaggerated relative to other structures or portions for illustrative purposes and, thus, are provided to illustrate the general structures of the subject matter disclosed herein. Furthermore, various aspects of the subject matter disclosed herein are described with reference to a structure or a portion being formed on other structures, portions, or both. As will be appreciated by those of skill in the art, references to a structure being formed "on" or "above" another structure or portion contemplates that additional structure, portion, or both may intervene. References to a structure or a portion being formed "on" another structure or portion without an intervening structure or portion are described herein as being formed "directly on" the structure or portion. Similarly, it will be understood that when an element is referred to as being “connected”, “attached”, or “coupled” to another element, it can be directly connected, attached, or coupled to the other element, or intervening elements may be present. In contrast, when an element is referred to as being “directly connected”, “directly attached”, or “directly coupled” to another element, no intervening elements are present.

Furthermore, relative terms such as "on", "above", “upper”, “top”, “lower”, or “bottom” are used herein to describe one structure's or portion's relationship to another structure or portion as illustrated in the figures. It will be understood that relative terms such as "on", "above", “upper”, “top”, “lower” or “bottom” are intended to encompass different orientations of the device in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, structure or portion described as "above" other structures or portions would now be oriented "below" the other structures or portions. Likewise, if devices in the figures are rotated along an axis, structure or portion described as "above", other structures or portions would now be oriented "next to" or "left of" the other structures or portions. Like numbers refer to like elements throughout.

Light emitting devices according to embodiments described herein may comprise group III-V nitride (e.g., gallium nitride) based light emitting diodes (LEDs) or lasers fabricated on a silicon carbide substrate, such as those devices manufactured and sold by Cree, Inc. of Durham, North Carolina. For example, Silicon carbide (SiC) substrates/layers discussed herein may be 4H polytype silicon carbide substrates/layers. Other silicon carbide candidate polytypes, such as 3C, 6H, and 15R polytypes, however, may be used. Appropriate SiC substrates are available from Cree, Inc., of Durham, N.C., the assignee of the subject matter herein, and the methods for producing such substrates are set forth in the scientific literature as well as in a number of commonly assigned U.S. Patents, including but not limited to U.S. Patent No. Re. 34,861; U.S. Patent No. 4,946,547; and U.S. Patent No. 5,200,022, the disclosures of which are incorporated by reference herein in their entireties.

As used herein, the term "Group III nitride" refers to those semiconducting compounds formed between nitrogen and one or more elements in Group III of the periodic table, usually aluminum (Al), gallium (Ga), and indium (In). The term also refers to binary, ternary, and quaternary compounds such as GaN, AlGaN and AlInGaN. The Group III elements can combine with nitrogen to form binary (e.g., GaN), ternary (e.g., AlGaN), and quaternary (e.g., AlInGaN) compounds. These compounds may have empirical formulas in which one mole of nitrogen is combined with a total of one mole of the Group III elements. Accordingly, formulas such as AlxGa1-xN where 1>x>0 are often used to describe these compounds. Techniques for epitaxial growth of Group III nitrides have become reasonably well developed and reported in the appropriate scientific literature, and in commonly assigned U.S. Patents including: U.S. Patent No. 5,210,051; U.S. Patent No. 5,393,993; and U.S. Patent No. 5,523,589, the disclosures of which are hereby incorporated by reference herein in their entireties.

Although various embodiments of LEDs disclosed herein may include a substrate, it will be understood by those skilled in the art that the crystalline epitaxial growth substrate on which the epitaxial layers comprising an LED are grown may be removed, and the freestanding epitaxial layers may be mounted on a substitute carrier substrate or submount which may have better thermal, electrical, structural and/or optical characteristics than the original substrate. The subject matter disclosed herein is not limited to structures having crystalline epitaxial growth substrates and may be used in connection with structures in which the epitaxial layers have been removed from their original growth substrates and bonded to substitute carrier substrates.

Group III nitride based LEDs according to some embodiments of the present subject matter, for example, may be fabricated on growth substrates (such as a silicon carbide substrates) to provide horizontal devices (with both electrical contacts on a same side of the LED) or vertical devices (with electrical contacts on opposite sides of the LED). Moreover, the growth substrate may be maintained on the LED after fabrication or removed (e.g., by etching, grinding, polishing, etc.). The growth substrate may be removed, for example, to reduce a thickness of the resulting LED and/or to reduce a forward voltage through a vertical LED. A horizontal device (with or without the growth substrate), for example, may be flip chip bonded (e.g., using solder) to a carrier substrate or printed circuit board, or wire bonded. A vertical device (without or without the growth substrate) may have a first terminal solder bonded to a carrier substrate or printed circuit board and a second terminal wire bonded to the carrier substrate or printed circuit board. Examples of vertical and horizontal LED chip structures are discussed by way of example in U.S. Publication No. 2008/0258130 to Bergmann et al. and in U.S. Patent No. 7,791,061 to Edmond et al., the disclosures of which are hereby incorporated by reference herein in their entireties.

Referring now to Figures 1-12B, Figure 1 illustrates a top perspective view of one aspect or embodiment of a light emitting device and package, for example an LED package, generally designated **10**. LED package **10** can comprise a body **12** that can defining a reflector cavity **18** and housing one or more LED chips **14** mounted over an upper surface of one or more thermal elements. LED chips **14** can either mount directly to a thermal element, or upon one or more intervening substrates (not shown) between the one or more LED chips **14** and thermal element. LED chips **14** can thermally connect to the one or more thermal elements. LED chips **14** can electrically connect to one or more electrical components. LED package **10** can further comprise an electrostatic discharge (ESD) protection device **16** mounted over a top surface of an electrical component. For example, ESD protection device **16** can comprise a Zener diode, ceramic capacitor, transient voltage suppression (TVS) diode, multilayer varistor, a Shottky diode and/or any other ESD device known in the art. ESD protection device **16** can electrically communicate with first and second electrical components through for example, an electrically conductive wire **20** using wirebonding technology.

Still referring to Figure 1, body **12** can comprise an upper face **11**, a lower face **13** and at least one exterior side wall. Upper face **11** can comprise a corner notch **23** that can convey electrical properties of the package, for example, the side of body **12** comprising the cathode and/or anode. Lower face can comprise one or more recesses generally designated **80** defined therein. In one aspect, body **12** can comprise four exterior side walls **15**, **17**, **19**, and **21**, respectively. In other aspects, body 12 can comprise only one exterior wall thereby forming a substantially round body. Exterior walls **15**, **17**, **19**, and **21** can comprise a substantially similar and/or substantially equal length dimension such that LED package **10** comprises a substantially square footprint. In other aspects, the length of the one or more exterior walls may be unequal such that body **12** comprises a rectangular footprint and/or any other shaped footprint desired by the manufacturer and/or an end user. For example, body **12** can comprise a substantially rounded footprint, or a footprint comprising regular and/or irregular polygonal shapes.

Body **12** can comprise any suitable material, such as for example a material selected from the group consisting of molded plastic, thermoset plastic, thermoplastic, polymeric, ceramic, nylon, liquid crystal polymer (LCP), reinforced polymers (polymers comprising fibers, ceramics, or composites), and polyphthalamide (PPA) wherein body **12** can be disposed around thermal and electrical components thereby retaining such elements. For example, body **12** can form about a thermal element comprising a heat transfer material **32**. Body **12** can simultaneously form about one or more electrical components comprising for example, first and second electrical lead components **22** and **24**, respectively. In one aspect, body **12** can be form using a molding process, such as injection molding a thermoplastic and/or thermoset material that can be electrically insulating. Any other forming method known in the art may be used, however, including sintering and/or molding in combination with sintering. Body **12** can be white or otherwise light in color to minimize light absorbed by LED package **10**. In addition, body **12** can comprise an upper body portion **12A** and a lower body portion **12B** as may be formed, for example, in upper and lower molding die portions (not shown) respectively. Reflector cavity **18** can form, for example, as the inverse of a central protrusion of an upper molding die. One or more isolating portions of the body may form between respective thermal and electrical components. For example first and second isolating portions **26** and **28** can form which can electrically and/or thermally isolate one or more thermal elements from one or more electrical components. During or after formation of the body, one or more LED chips **14** can mount over heat transfer material **32** and electrically connect to one or both first and second lead components **22** and **24**, respectively, using conductive wire **20**.

Referring now to Figures 2 and 3, a leadframe element, generally designated **30**, is shown. Leadframe element **30** can comprise at least one thermal element and one or more electrical components. Thermal element can comprise heat transfer material **32** or substrate such as, for example, a heat slug. Thermal element can be isolated, electrically and/or thermally from one or more electrical components. Electrical components can comprise first and second lead components **22** and **24**, respectively. First and second lead components **22** and **24** may also be collectively referred to as “leads”. Thermal element **32** can optionally be disposed between respective medial ends **38** and **58** of first and second lead components **22** and **24**, respectively. Body **12** can be molded, disposed, or otherwise formed about leadframe element **30** such that heat transfer material **32** can be disposed on a bottom floor of reflector cavity **18**. Body **12** can encase at least a portion of leadframe element **30** thereby retaining portions of heat transfer material **32** and portions of first and second lead components **22** and **24**, respectively. One or more protruding portions **34** of heat transfer material can be exposed along external walls **15** and **19** of body **12** to assist with retention of heat transfer material **32**.

One or more leadframe elements **30** can initially comprise a sheet (not shown) of elements. The leadframe elements **30** can be formed and/or singulated from the sheet using any suitable method, for example, stamping, cutting, and/or bending one or more portions of the sheet and/or leadframe elements **30** within the sheet. Body **12** of LED package **10** can form about at least a portion of leadframe element **30** and a multitude of LED package subassemblies can be formed about the sheet of leadframe elements **30**. The multitude of LED package subassemblies can be separated into individual LED packages **10** by cutting, shearing, or otherwise separating adjacent to exterior walls **15** and **19** and terminal ends **40** and **60** of the first and second lead components, **22** and **24**, respectively, from the sheet of elements. Such separation can expose protruding portions **34** of heat transfer material **32** along exterior walls **15** and **19** of each LED package **10**.

Still referring to Figures 2-3, electrical components comprising first and second lead components **22** and **24** formed from a leadframe element **30** are disclosed. First and second lead components **22** and **24** can serve as a respective anode and cathode connections supplying the LED chips **14** with current sufficient to cause light emission. First and second lead components **22** and **24** can comprise a metal or any other suitable electrically conducting material known in the art. First lead component **22** can comprise a respective substrate portion **36**, a medial end **38**, an opposing terminal end **40**, a tab portion **42**, at least one aperture **44**, and one or more bends, for example, first and second bends **46** and **48**, respectively. First aperture **44** can form one or more lead segments within first lead component **22**. For example, in one aspect first lead component **22** comprises one aperture **44** and two lead segments **50** and **52**. Second lead component **24** can be adjacent and symmetrical with respect to first lead component **22**. Additionally, second lead component **24** can comprise features similar in both form and function to features of first electrical lead component **22**. For example, second lead component **24** can comprise a respective substrate portion **56**, a medial end **58**, an opposing terminal end **60**, a tab portion **62**, at least one aperture **64**, and one or more bends, for example, first and second bends **66** and **68**, respectively. Each respective lead component **22** and/or **24** can comprise one or more notches **N** which can become retained within body **12** at exterior walls **15** and **19**. The one or more notches **N** can assist with and handling and placement of LED package **10**. For example, notches **N** can provide areas which a leadframe having an array of package housings retains the housings in place until the appropriate time when the LED packages **10** are singulated. The one or more bends, for example, respective first and second bends **46**, **48**,

66, and/or **68** can be defined in lead components **22** and **24** before, during, or preferably after formation of body **12** of LED package **10**. Referring to second lead component **24**, second aperture **64** can form one or more lead segments within second lead component **24**. For example, in one aspect second lead component **24** comprises one aperture **64** and two lead segments **61** and **63**. Any number of apertures and/or lead segments can exist in a given electrical lead component.

Tab portions **42** and **62** can oppose first and second medial ends **38** and **58**. Upon formation of body **12**, first and second tab portions **42** and **62**, respectively, can extend outwardly away from a center of LED package **10** and terminate at respective distal ends **40** and **60**. Apertures **44** and **64** of respective lead components **22** and **24** can separate substrate portions **36** and **45** into multiple electrical lead segment, for example, **50**, **52**, **61**, and **63**. In one embodiment, each of lead components **22** and **24** can include multiple apertures serving to separate the components into more than two (e.g., three or more) electrical lead segments. A first portion of each aperture **44** and **64** can be filled with the same material forming the body **12**. A second portion of each aperture **44** and **64** can be disposed outside exterior walls **17** and **21** of body **12** such that individual electrical lead segments **50, 52, 61,** and **63** can be separated from each of the remaining lead segments **50**, **52**, **61**, and **63** by the apertures **44** and **64** along exterior walls **17** and **21**of the body **12**. Each lead component **22** and **24** can comprise respective first and second bends **46**, **48**, **66**, and **68**. Bends **46**, **48**, **66**, and **68** can comprise first and second bent portions **47** and **67**, respectively. Bent portions **47** and **67** can be orthogonal to each of respective substrate portions **36** and **56** and tab portions **42** and **62** of first and second lead components **22** and **24**, respectively. Bent portions **47** and **67** can be disposed between corresponding substrate portions **36** and **56** and tab portions **42** and **62**. In addition, bent portions **47** and **67** can comprise perpendicular elements downwardly along exterior walls **17** and **21** of body **12**. Bent portions **47** and **67** can comprise transition areas transitioning linear substrate portions **36** and **56** of first and second lead components **22** and **24**, respectively, perpendicularly into respective linear tab portions **42** and **62**. Tab portions **42** and **62** can be located parallel and along a different plane from corresponding substrate portions **36** and **56**. Bent portions **47** and **67** can transition respective substrate portions **36** and **56** into the respective tab portions **10** and **62**.

One or more apertures, for example apertures **44** and **64** can extend at least partially into first bends **48** and **68** of respective lead components. Apertures **44** and **64** can provide multiple benefits including promoting secure retention of lead components **22** and **24** within the body. In addition, apertures **44** and **64** can reduce the amount of lead material (e.g., metal) subject to being bent to form the first bends **46** and **66**. This can reduce the cost of the overall package and reduce an amount of bending force required to form first bends **46** and **66**. Bending can position at least a portion of each electrical lead component **22** and **24** into first and second tapered portions **25** and **27** (Figure 9) of body **12**.

As Figure 3 illustrates, heat transfer material **32** can comprise an upper surface **70**, a lower surface **72**, and one or more lateral protrusions, for example first and second lateral protrusions **74** and **76**, respectively. Heat transfer material **32** can optionally comprise a lower protrusion **78** comprising lower surface **72** which can extend from recess **80** disposed in the lower face **13** of LED package **10**. Lateral protrusions **74** and **76** can promote secure retention of the heat transfer material **32** by body **12** and can also reduce a potential for leakage (e.g., of solder and/or encapsulant) along interfaces between body **12** and the heat transfer material **32**. Such lateral protrusions **74**, **76** can be varied in number, size, shape, and/or orientation (Figures12A and 12B). Heat transfer material **32** can conduct heat away from LED chips **14** and LED package **10** improving heat dissipation properties thereof.

Figure 4 illustrates a perspective bottom view of LED package, generally designated **10**. The bottom view can also be representative of a higher voltage LED package **90** (Figures 6 to 8). LED package **10** can comprise body **12** forming about leadframe element **30** and heat transfer material **32**. Heat transfer material **32** can extend from a recess **80** formed in lower face **13** of LED package **10**. In one aspect, heat transfer material **32** can comprise bottom surface **72** flush with recess **80** of LED package **10**. In other aspects, heat transfer material **32** can comprise lower protruding portion **78** extending from recess **80** of LED package **10**. Lower protrusion **78** can comprise any height and width dimension known in the art. Recess **80** can provide a space thereby allowing any overflow of attachment materials (not shown), for example, solder and/or flux to move into recess **80**. This feature can eliminate or reduce the need to clean residue left behind by an attachment process, for example, using a "no-clean" solder. Recess **80** can also allow more access for solvents to remove flux after the reflow process if using for example, a "clean" solder which must undergo a cleaning process. Because of process variability, the amount of solder and/or flux that can be dispersed for connecting components, such as heat transfer material **32** and an external circuit (not shown), for example a printed circuit board (PCB) can vary significantly. As solder and/or flux can be very difficult to remove from substrates such as PCBs, recess **80** provides a space for any excess solder and/or flux to flow into thereby producing the area(s) needing cleaning afterwards. One or more exposed portions (Figure 10) of heat transfer material **32** can also be positioned or otherwise located within recess **80**.

Still referring to Figure 4, first and second tab portions **42** and **62** of respective first and second lead components **22** and **24** can outwardly extend from approximately a center portion of LED package **10** and bend externally to comprise substantially horizontal components. In the alternative, tab portions **42** and **62** can extend from LED package **10** and bend inwardly towards each other. Thus, tab portions **42** and **62** may comprise a "J-bend" and/or "gull-wing" type of orientation as known in the art. Tab portions **42** and **62** can be substantially flush with lower face **13** of LED package. Tab portions **42** and **62** can electrically connect and mount over an external circuit and heat sink (not shown), for example, a PCB using any attachment method and materials desired. For example, standard soldering techniques can connect tab portions

42 and **62**, as well as heat transfer element **32** to an external circuit or substrate wherein solder can wet bottom surfaces of each component. Heat transfer material **32** can thermally connect to and mount over a heat sink and/or external circuit. Such attachment methods can further comprise for example, soldering LED package **10** and PCB in a reflow oven or placing LED package**10** and PCB on a hotplate. Any suitable solder material desired and capable of securing thermal and electrical components, that is heat transfer material **32** and tabs **42** and **62** of respective lead components **22** and **24** to PCB may be used. For example, attachment materials can comprise solder pastes of gold, tin, silver, lead and/or copper (Au, Sn, Ag, Pb, and/or Cu), reflow solder flux, and/or any combination thereof. For example, Sn 96.5/Ag 3.0/Cu 0.5 is a common Pb-free solder as is Sn 95.5/Ag 3.8/Cu 0.7.

Heat transfer material **32** as illustrated by Figure 4 can comprise a single component formed integrally as one piece or it can comprise several components assembled together using any assembling process desired and/or known in the art. For example, lower protruding portion **78** can be formed integrally as one piece of heat transfer material **32** or can assemble to heat transfer material **32** such that it extends from a base portion of heat transfer material **32**. In one aspect, heat transfer material **32** can comprise an intermediary thermal structure for transferring heat to another structure such as a heat transfer layer or a heat sink for further heat dissipation. In this aspect, heat transfer material **32** can comprise a thermal structure with limited heat capacity and capable of heating up quite quickly if not effectively connected thermally to a further heat transfer device such as an actual heat sink.

Figures 5 to 8 illustrate top views of LED packages, generally designated **10** and **90**, the packages comprising variable arrangements of LED chips **14**. One or more LED chips **14** can be arranged over thermal component, for example, heat transfer material **32**, and the arrangements can vary depending upon the application. Figure 5 illustrates one or more LED chips **14** disposed in electrical communication with each of first and second lead components, **22** and **24**, respectively. LED chips **14** can electrically connect to first and second lead components **22** and **24** using conductive wires **20** such that a first portion **82A** of LED chip **14** electrically connects to first electrical lead component **22** and a second portion **82B** of LED chip electrically connects to second electrical lead component **24**. First portion **82A** and second portion **82B** of LED chip **14** can comprise different electrical polarity, that is, one of first and second portions **82A** and **82B**, respectively, acts as an anode and the remaining portion acts as a cathode such that electrical current can be driven through each LED chip **14** thereby generating light emission. As Figure 5 illustrates, connecting each of the one or more LED chips **14** of a plurality of chips to each of the first and second lead components **22** and **24** comprises a first arrangement, or electrical configuration. In this electrical configuration, each LED chip **14** can be arranged in parallel with the remaining LED chips **14** of the plurality. That is, each LED chip **14** can receive less than or approximately the same voltage from a power source, enabling lower voltage power sources to be used. When arranged in parallel, LED chips **14** can also mount over heat transfer material **32**. In one aspect, LED chips can mount directly to heat transfer material **32**. In the alternative, LED chips **14** can mount to one or more intervening substrates (not shown) disposed between LED chip **14** and heat transfer material **32**.

The LED configuration described and illustrated by Figure 5 allows a package to operate with a power source comprising, for example, approximately 3.2 volts (V). In some applications, it may be desirable for LED packages to operate at lower voltages, for example, of less than approximately 3.2 V, for example, approximately 1.5 to 2 V or approximately 2 V to 3.2 V. In other applications, it may be desirable for LED packages to operate at higher voltages. Figures 6 to 8 illustrates examples, without limitation, of LED packages, generally designated **90**, which can be operable for applications having voltage greater than approximately 3.2 V. For example, in one aspect, LED package **90** may be operable within a range of approximately 3.2 to 5 V. In other aspects, LED package **90** can be operable within a range of 5 to 10 V. In other aspects, LED package **90** can be operable within a range of approximately 10 to 20 V. In further aspects, LED package **90** can be operable at voltages greater than 20 V. LED package **90** can comprise variable arrangements of LED chips **14** within the package, and having the remaining features of LED package **90** of similar form and function as described with respect to LED package **10**. For example, LED package **90** can comprise a molded body **12** about leadframe element **30** (Figures 1 to 4), the leadframe comprising heat transfer material **32** and first and second lead components **22** and **24**, respectively.

Figures 6 to 8 illustrate higher voltage packages, such as LED package **90**. In accordance with the subject matter herein, higher voltage packages can be accomplished in part by varying the arrangement, or electrical configuration, of LED chips **14** within the package. For example, Figures 6 to 8 illustrate LED package **90** comprising one or more LED chips **14** electrically connected in series with at least one other LED chip **14**. LED package **90** can comprise a first lead component **22** and a second lead component **24**. One of the first and second lead components **22** and **24**, respectively, can operate as a cathode and the remaining as an anode for supplying current to the one or more LED chips **14**. First and second lead components **22** and **24**, respectively, can protrude and/or extend outwardly from the body for example, from a lateral side and/or a bottom surface of the LED package **90**. Lead components **22** and **24** can bend externally forming bent portions **47** and **67** which can extend downwardly and parallel external sides **17** and **21**. LED package **90** can comprise first and second lead components **22** and **24** extending from a center portion of the body and bending externally to form linear, outwardly extending first and second tab portions **42** and **62**, respectively. One or more LED chips **14** can electrically communicate to first and/or second lead components **22** and **24** by using one or more electrically conductive wires **20**. First and second lead components **22** and **24** can also be electrically and/or thermally isolated from a heat transfer material **32** upon which the one or more LED chips **14** may be directly or indirectly mounted. One or more isolating portions **26** and **28** of the

LED package **90** can thermally and/or electrically isolate heat transfer material **32** from first and second lead components, **22** and **24**, respectively.

Figures 6 to 8 illustrate LED chips **14** comprising variable arrangements and electrical configurations within LED package **90**. That is, one or more LED chips **14** can be connected to first and second lead components **22** and **24**, respectively, in series, parallel, and/or a combination thereof. This can be accomplished using a wirebonding process wherein one or more LED chips **14** can electrically connect in series to another LED chip **14** using one or more conductive wires **20**. The first and last LED chips **14** of a given series can then connect to first and second lead components **22** and **24**, respectively, using conductive wires **20** for driving current through the LED chips **14**. When LED chips **14** are wired in series, the voltage from a power source can be divided, or otherwise dispersed, between LED chips **14**. That is, a higher power source can be used with LEDs, LED packages, and methods because the voltage will be divided across the series of one or more LED chips **14**. The higher voltage generated by the power source can comprise a series of respective lower voltages passing through each individual LED chip **14**. As disclosed previously, the power source voltage can operate in a range from 5 to 20V for some applications, and in other applications it may be desirable to operate at greater than 20V.

Figure 6 illustrates an arrangement of LED chips **14**, the arrangement generally designated **92**. Arrangement **92** comprises three LED chips **14** arranged in an electrical configuration. Here, LED chips **14** are illustrated as electrically connected in a series arrangement. The first LED chip **14** of the series can be connected to first lead component **22** and the final LED chip in the series arrangement can be connected to second lead component **24**. This is similar to an alternative arrangement illustrated in Figure 7, generally designated **94**, of LED chips **14** within LED package **90**. Arrangement **94** comprises six LED chips electrically connected in a series arrangement within LED package **90**. The first LED chip **14** of the series can be electrically connected to first lead component **22**, and the final LED chip **14** of the series comprising arrangement **94** can be electrically connected to second lead component **24**. The respective first and last LED chips **14** within a series connect to lead components such that current can be supplied to the entire series of LED chips **14**. Arrangements **92** and **94** illustrated herein can comprise any number or type of LED chips **14**. In general, series arrangements can be more efficient if the same type of LED chip **14** is used such that voltage distributes, or otherwise disperses consistently and evenly through each chip in the series.

Figure 8 illustrates an arrangement comprising LED chips **14** mounted in a combination utilizing both series and parallel electrical configurations. For example, Figure 8 illustrates an arrangement, generally designated **96**. Arrangement **96** can comprise, for example, two groups of three LED chips **14**, wherein at least one LED chip **14** comprising each group can be electrically connected in series to at least one other LED chip **14** within the respective group. A first group LED chips, generally designated **98**A can then electrically connect in parallel with a second group of LED chips, generally designated **98**B. Each of the first and second groups **98**A and **98**B, respectively, can comprise one or more LED chips **14** electrically connected in series, the first and last LED chips **14** comprising each of the respective series can connect to first and second lead components **22** and **24**, respectively. Thus, arrangement **96** utilizes electrical configurations comprising each of a series configuration and a parallel configuration, wherein each of first and second groups **98**A and **98**B comprises one or more LED chips **14** connected in series while first group **98**A can connect in parallel to second group **98B**. Note that arrangements **92**, **94**, and **96** depicted in Figures 6 to 8, can comprise any number of chips mounted in a series, not limited to the arrangements shown. Arrangement **96** can likewise comprise any number of groups connected in parallel. When wiring in series, attention should be given to assure the correct LED terminal of respective LED chips **14** are wirebonded to electrically connect the chips. As depicted earlier, LED chips **14** can comprise a first portion **82A** and a second portion **82B**, the portions comprising different electrical polarities. That is, the first portion **82A** can comprise negative terminal and the second portion **82B** can comprise a positive terminal or vice versa. When connecting LED chips in series, first portion **82A** of a preceding LED chip **14** should preferably become wirebonded and electrically connected to second portion **82B** of a subsequent LED chip **14**. Otherwise, the LED chips **14** may not illuminate as current may not adequately be supplied to the series. As disclosed previously, arrangement **96** can comprise any number of groups and is not limited to the first and second groups, **98**A and **98**B as shown. The combination of LED chips mounted in both series and parallel can be adjusted for a given application and/or desired voltage source. Thus, LED chips **14** can advantageously be connected either in parallel, in series, or using a combination thereof to accommodate various voltage applications.

Still referring to Figures 6 to 8, for illustration purposes and without limitation, LED chips **14** are illustrated as arranged in series in a zigzag configuration of series alignment or design although any suitable alignment or configuration of the LED chips can be used. For example, and without limitation, LED chips **14** may be arranged in series horizontally and/or vertically, in a grid or in an array or even in a combination thereof. Also, regarding different applications using LED packages, and in general, wiring objects in parallel can drain a power supply faster than wiring objects in series, as objects in parallel can end up drawing more current from the power supply. It can also be helpful if all of the LEDs chips being used have the same power specifications.

Figure 9 illustrates a side view of LED package, generally designated **90**. Figure 9 could also illustrate LED package **10**, as each of LED packages **10** and **90** could comprise similar features of similar form and function with the exception of an arrangement of LED chips **14** within the packages. Figure 9 illustrates body **12** comprising upper body portion **12A** and lower body portion **12B** as may be formed, for example, in upper and lower molding die portions (not shown) respectively. One or more tapered portions, for example first and second tapered portions **25** and **27** can be defined by exterior side walls **17** and

21 of body **12** and can be adjacent to (e.g., below) locations where first and second lead components **22** and **24** extend through the exterior side walls **17** and **21**. Such first and second tapered portions **25**, **27** can be arranged to receive the bent portion **47**, **67** or at least part of the thickness of the bent portion **47**, **67** of first and second lead components **22** and **24**. Each of first and second tapered portions **25** and **27** can comprise a depth relative to the corresponding exterior side wall **17** and **21**. The depth of each first and second tapered portion **25** and **27** can preferably comprise a depth substantially equal to or greater than an average thickness of the first and second electrical lead components **22** and **24**, respectively. First and second tapered portions **25** and **27** can provide multiple benefits. For example, first and second tapered portions **25** and **27** can substantially eliminate a presence of material immediately disposed below the first bends **46** and **66** thereby reducing an amount of stress applied to body **12** during formation of the first bends **46** and **66** which can form subsequent to the leadframe element **30** being retained in body **12**. Another benefit of first and second tapered portions **25** and **27** is to enable each of first bends **46** and **66** to have a tighter bending radius. This can reduce or eliminate outward extension of the bent portions **47** and **67** which can be substantially parallel to external walls **17** and **21** and at least substantially perpendicular to lower face **13** and first and second lead components **22** and **24** thereby reducing the effective footprint of LED package **10**. Reduction of effective footprint of LED packages can enable such packages **10** to be mounted in higher densities upon an external substrate (not shown), and/or optionally overlaid with a Lambertian reflector or diffuser having reduced hole spacing (e.g., within a backlit display device, such as a LCD display). Thus, tapered portions **25** and **27** can enable LED packages such as **10** and **90** to exhibit enhanced light performance by enabling higher flux density and/or greater lighting uniformity.

Figure 10 illustrates a cross-sectional view of LED package **90**. Reflector cavity **18** can be filled, coated, or otherwise covered with an encapsulant **E**. Encapsulant **E** can comprise any suitable material known in the art and can optionally comprise a phosphor or a lumiphor to interact with light emitted by the one or more LED chips **14** and responsively emit light of a desired wavelength spectrum. For illustration purposes, encapsulant **E** is shown as disposed and filling reflector cavity **18** essentially flush with an upper face **11** of body **12**. Encapsulant **E**, however, may be filled to any suitable level within the reflector cavity **18** or even exceed and extend above reflector cavity **18**.

Figure 10 illustrates one or more exposed portions of heat transfer material **14**. For example, heat transfer material **32** can comprise exposed portions **73**, **75**, **77**, **72**, **81**, **83**, and **85** protruding from and disposed within recess generally designated **80** of LED package **90**. Each exposed portion **73**, **75**, **77**, **72**, **81**, **83**, and **85** can comprise an external surface of heat transfer material **32**, which can be formed integrally as one piece or from more than one portion such as protruding portion **78** illustrated in Figures 3 and 4. Figure 10 also illustrates heat transfer material **32** extending the full thickness of lower portion **12B** of body **12**. First and second lead components **22** and **24**, respectively, rest above lower portion **12B** of body **12** and can be disposed between the respective upper **12A** and lower **12B** portions of body **12**. As illustrated by Figures 3 and 4, first and second lead components **22** and **24** can comprise substrates **36**, **56** which can be located on a parallel plane above respective tab portions **42** and **62** and orthogonally arranged with respect to bent portions **47** and **77**.

Figures 11A and 11B illustrate simplified schematic cross-sectional views of body **12** which can form LED package **10** and/or **90**. LED packages can comprise reflector cavity **18** bounded by a floor **F**. Floor **F** can comprise portions of first and second lead components **22** and **24**, isolating portions **26** and **28**, as well as top surface **70** of heat transfer material **32**. Reflector cavity **18** can be bounded along edges by external side walls **15**, **17**, **19**, and **21**. Reflector cavity **18** can comprise any shape, for example, reflector cavity **18** can comprise a rounded wall defining rounded reflector cavity **18** or reflector cavity **18** can comprise inner walls defining a substantially square reflector cavity **18**. Reflector cavity **18** can comprise any size and/or shape known in the art. Reflector cavity **18** can comprise one or more portions which can transition from inclined portions and/or substantially straight portions with walls perpendicular external walls **15**, **17**, **19** and **21**. For example, reflector cavity **18** can comprise a first portion having angle **θ** relative to a plane perpendicular to floor **F**. Similarly, and possibly in the same package, reflector cavity **18** can comprise an angle **φ** relative to a plane perpendicular to floor **F**. In one aspect, reflector cavity **18** comprises an incline angle **θ** of at least approximately 20 degrees. In another aspect, angle **θ** can comprise at least approximately 30 degrees. In further aspects, angle **θ** can comprise at least approximately 40 degrees. Incline angle **θ** can also comprise at least about 45 degrees, or at least about 50 degrees.

Referring to Figure 11B, reflector cavity can comprise inclined at an angle **φ** of at least about 30 degrees, at least about 40 degrees, or at least about 50 degrees. In further embodiments, the angle **φ** can comprise about 55 degrees, or at least about 60 degrees. Such angles **θ** and **φ** can be greater than typically employed in conventional LED packages. Although the reflector cavity **18** portions described herein can comprise straight walls angled from the floor of the cavity to the upper edge of the package, alternative embodiments may comprise segmented and/or curved cross-sections, that is, the wall extending from the floor **F** to the upper edge of the package can comprise non-linear cross-sections along at least a portion thereof. If such walls are curved or segmented, then the inclination angles mentioned above may correspond to an average angle of a curved or segmented wall, or an angle between endpoints of such a wall. Reflector cavities **18** comprising alternating angles enables a frontal area of the reflector cavity **18** to be maximized relative to the square-shaped upper face **11** , while providing desirably diffuse output beam characteristics, particularly when multiple LEDs are disposed within reflector cavity **18**.

Referring to Figures 12A and 12B, alternative embodiments of heat transfer material **32** are illustrated. Heat transfer material **32** can comprise upper surface **70,** lower surface **72,** lower protruding portion **78**, and lateral protrusions **74** and **76** protruding outward from lateral side walls of the material. Figure 12A discloses lateral protrusions **74** and **76** which can be non-linear and curve upwardly. Figure 12B illustrates an alternative embodiment wherein heat transfer material **32** comprises upwardly angled, or otherwise tapered, lateral protrusions **74** and **76** extending outward and upward from side walls of heat transfer material **32**. Lateral protrusions **74** and **76** can comprise any size, shape, and/or arrangement desired. For example, downwardly curved and/or angled lateral protrusions may be employed. Likewise, any combinations of the foregoing lateral protrusions may be employed. Lateral protrusions may be formed using any suitable manufacturing method known in the art. For example, stamping, forging, extruding, milling, and/or machining may be used to form lateral protrusions **74** and **76**. In some cases, lateral protrusions **74** and **76** can be replaced with, or supplemented by, recesses (not shown) in external side walls of heat transfer material **32** to provide a similar sealing utility, with such recesses being formable using similar methods outlined above. Heat transfer material **72** can comprise a surface upon which one or more LED chips **14** can mount over and wherein a reflector cavity **18** can be disposed about the LED chips **14**.

Embodiments of the present disclosure shown in the drawings and described above are exemplary of numerous embodiments that can be made within the scope of the appended claims. It is contemplated that the configurations of LED devices, methods, and packages capable of higher voltage applications can comprise numerous configurations other than those specifically disclosed.

CLAIMS

What is claimed is:

1. An arrangement of light emitting diodes (LEDs), the arrangement comprising:

a leadframe comprising a first lead component and a second lead component;

a thermal element isolated from the first and second lead components; and

a first group of LEDs arranged over the thermal component, wherein the first group of LEDs comprises a first LED electrically connected in series to a second LED.

2. The arrangement according to claim 1, further comprising a package body formed about a portion of the thermal element and a portion of each of the first and second lead components.

3. The arrangement according to claim 2, wherein the thermal element is thermally and electrically isolated from the first and second lead components by isolating portions of the package body.

4. The arrangement according to claim 3, wherein the package body comprises a molded plastic body.

5. The arrangement according to claim 1, wherein the first group of LEDs is electrically connected in parallel to a second group of LEDs.

6. The arrangement according to claim 5, wherein the second group of LEDs comprises a preceding LED electrically connected in series to a subsequent LED.

7. The arrangement according to claim 6, wherein the first group comprises LEDs arranged in a first zigzag configuration and the second group comprises LEDs arranged in a second zigzag configuration.

8. An arrangement of light emitting diodes (LEDs), the arrangement comprising:

a first group of LEDs comprising a first LED electrically connected in series to a second LED;

a second group of LEDs; and

wherein the first group of LEDs is electrically connected in parallel to the second group of LEDs.

9. The arrangement according to claim 8, wherein the second group of LEDs comprises a preceding LED electrically connected in series to a subsequent LED.

10. The arrangement according to claim 8, wherein the first and second groups of LEDs are electrically connected to first and second lead components.

11. The arrangement according to claim 10, wherein the first and second groups of LEDs are arranged over a thermal element.

12. The arrangement according to claim 11, comprising a package body molded about a portion of each of the first and second lead components wherein the package body is molded about a lateral protrusion of the thermal element, the package body forming a cavity disposed about the first and second groups of LEDs.

13. The arrangement according to claim 12, wherein the package body comprises encapsulant in at least a portion of the cavity.

14. The arrangement according to claim 12, wherein the package body comprises a recess formed in a bottom surface of the package body.

15. A method of arranging light emitting diodes (LEDs), the method comprising:

providing a first group of LEDs wherein a first LED in the first group is electrically connected in series to a second LED in the first group;

providing a second group of LEDs; and

electrically connecting the first group of LEDs in parallel with the second group of LEDs.

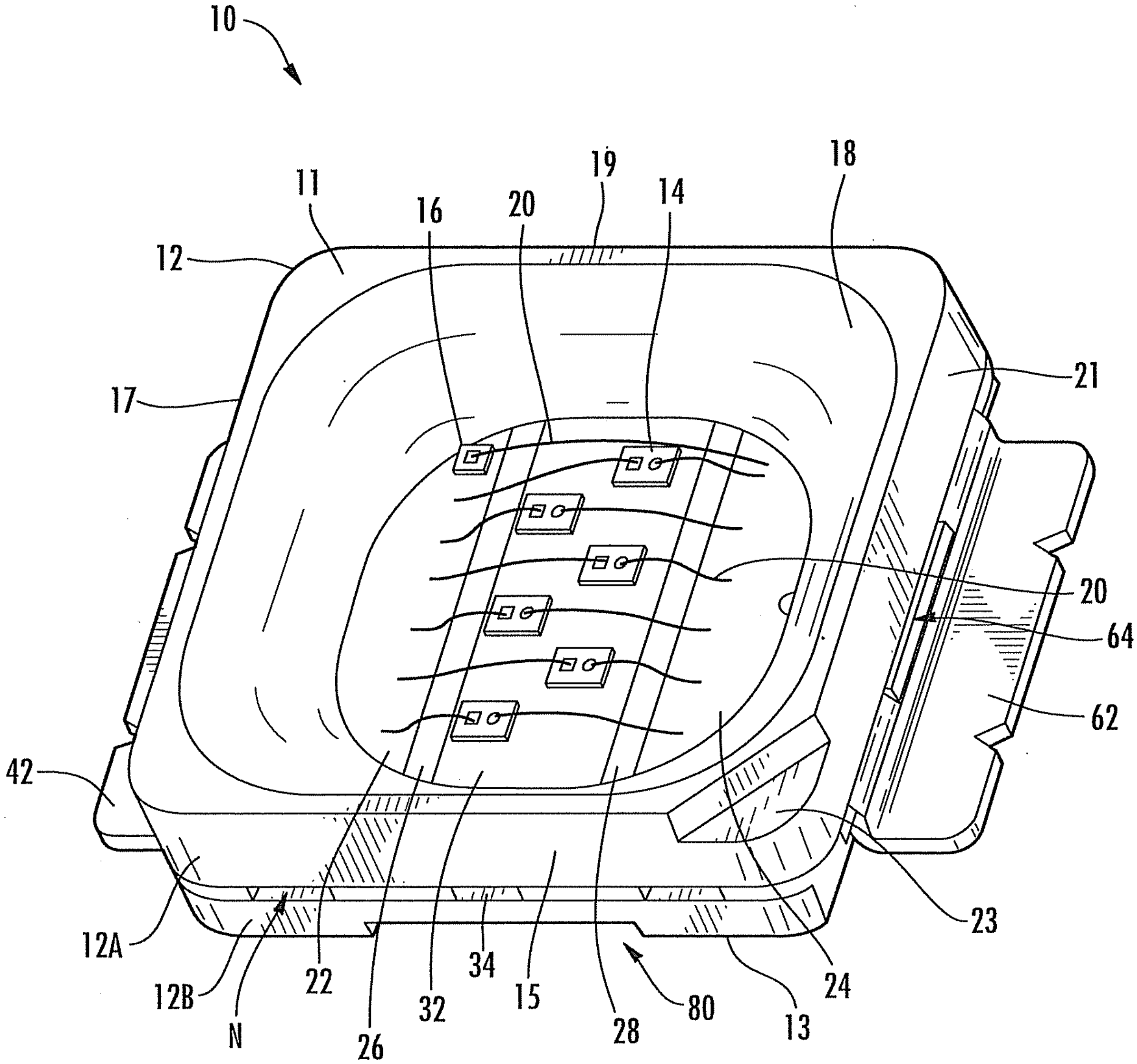
16. The method according to claim 15, wherein providing the second group of LEDs comprises providing a second group of LEDs comprising a preceding LED electrically connected in series to a subsequent LED.

17. The method according to claim 15, further comprising electrically connecting each of the first and second groups of LEDs to first and second lead components.

18. The method according to claim 17, further comprising arranging the first and second group of LEDS within a package body such that each of the first and second groups comprises a zigzag series configuration.

19. The method according to claim 18, wherein the package body comprises molded plastic.

20. The method according to claim 19, further comprising filling at least a portion of the package body with an encapsulant comprising a phosphor.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12A
12B
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FIG. 1

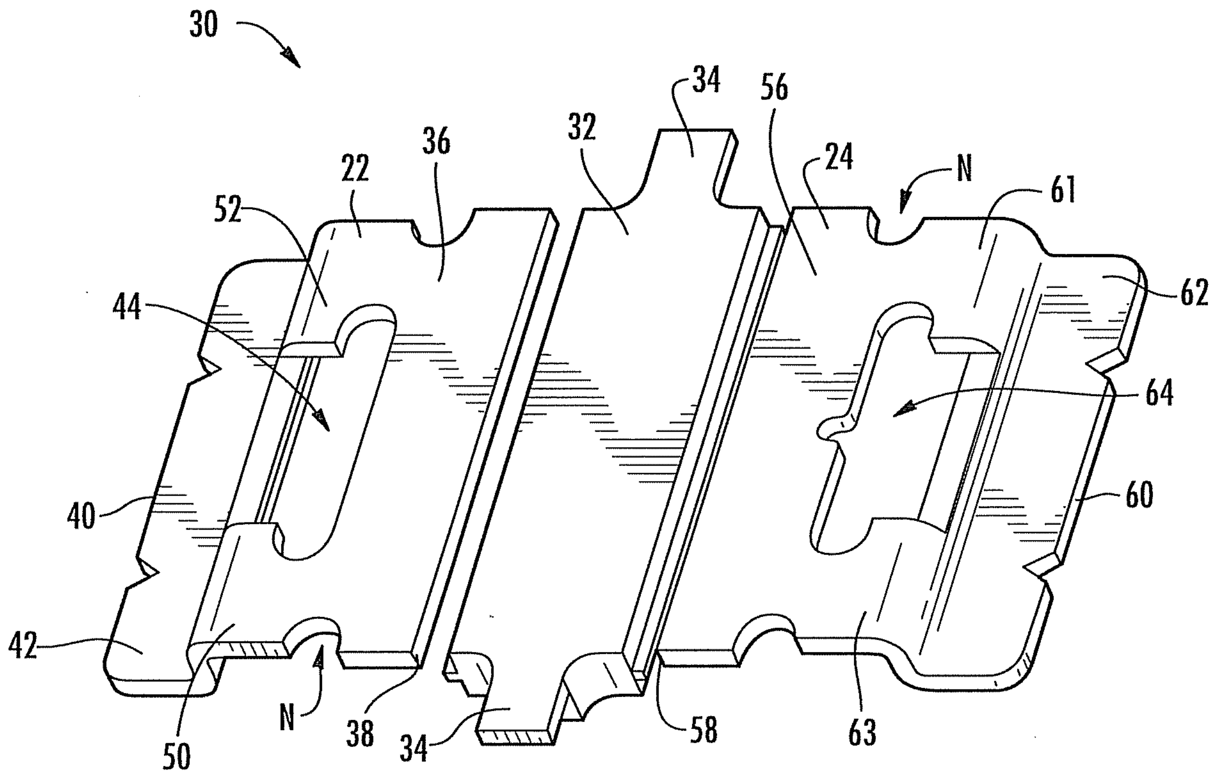
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FIG. 2

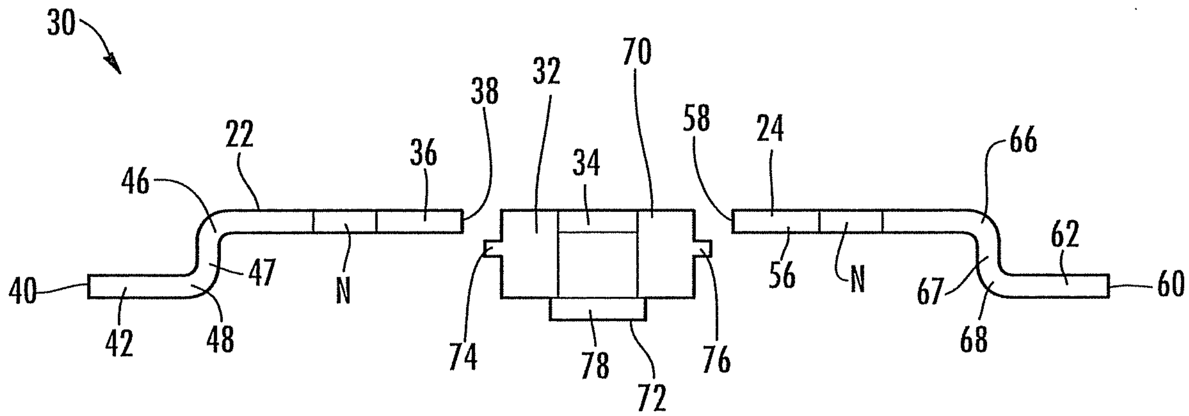
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FIG. 3

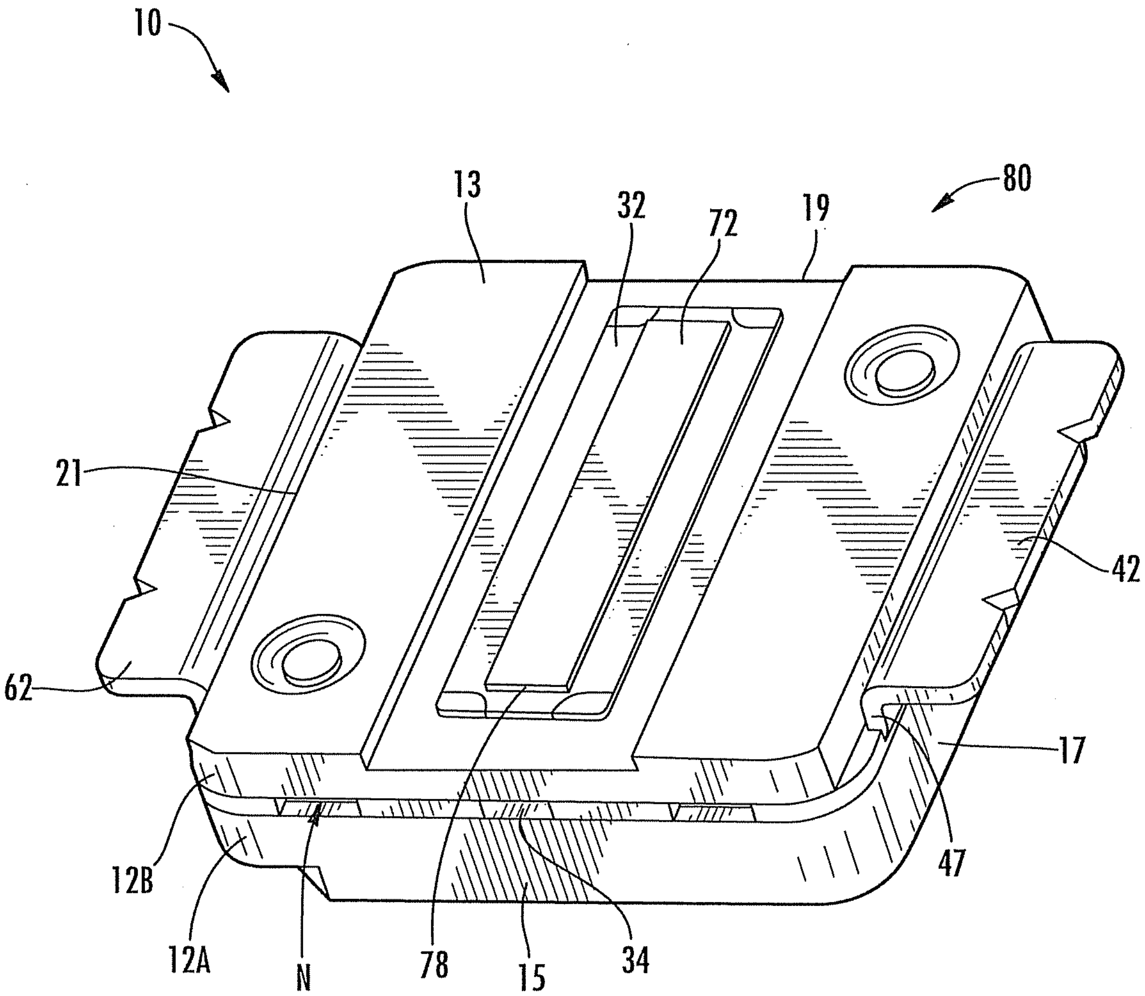
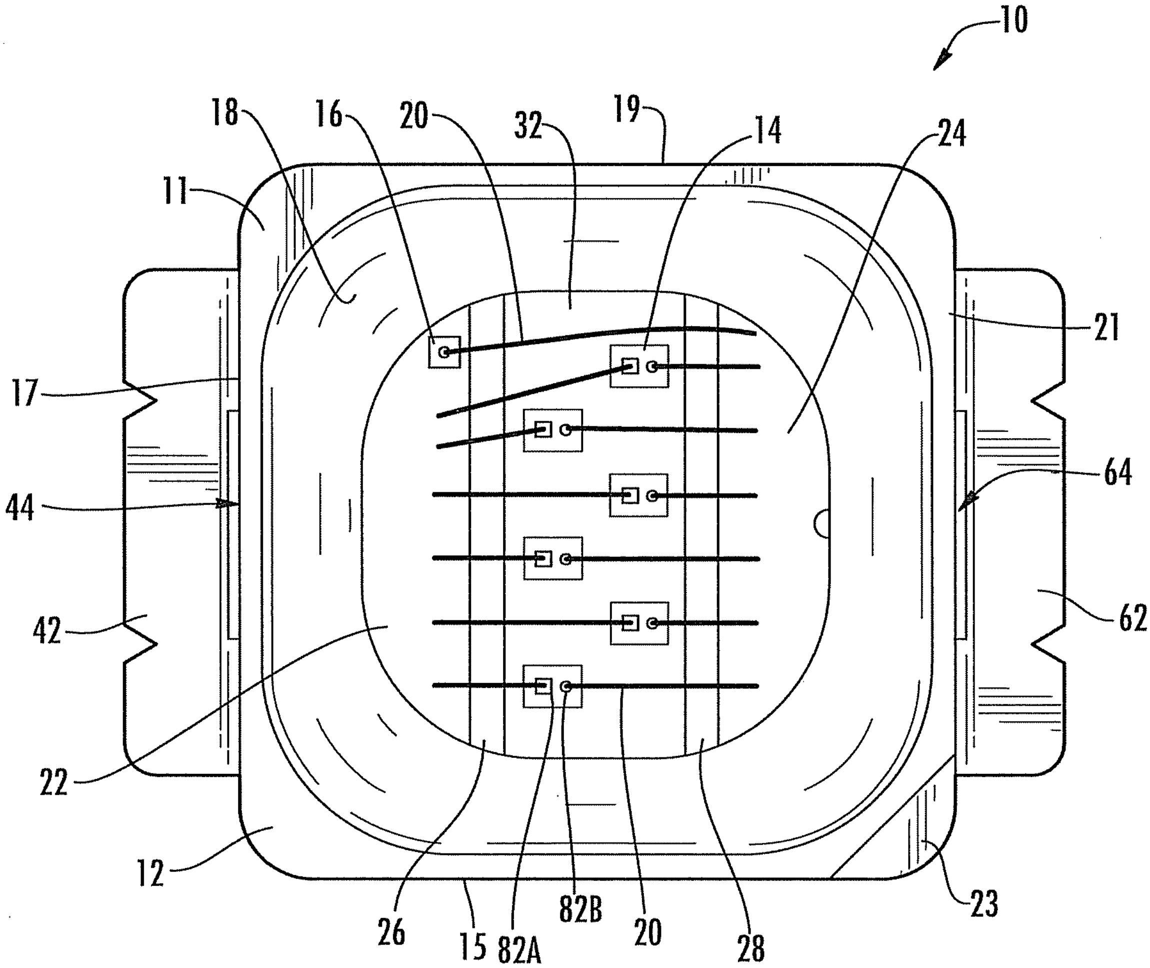


FIG. 4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82B
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FIG. 5

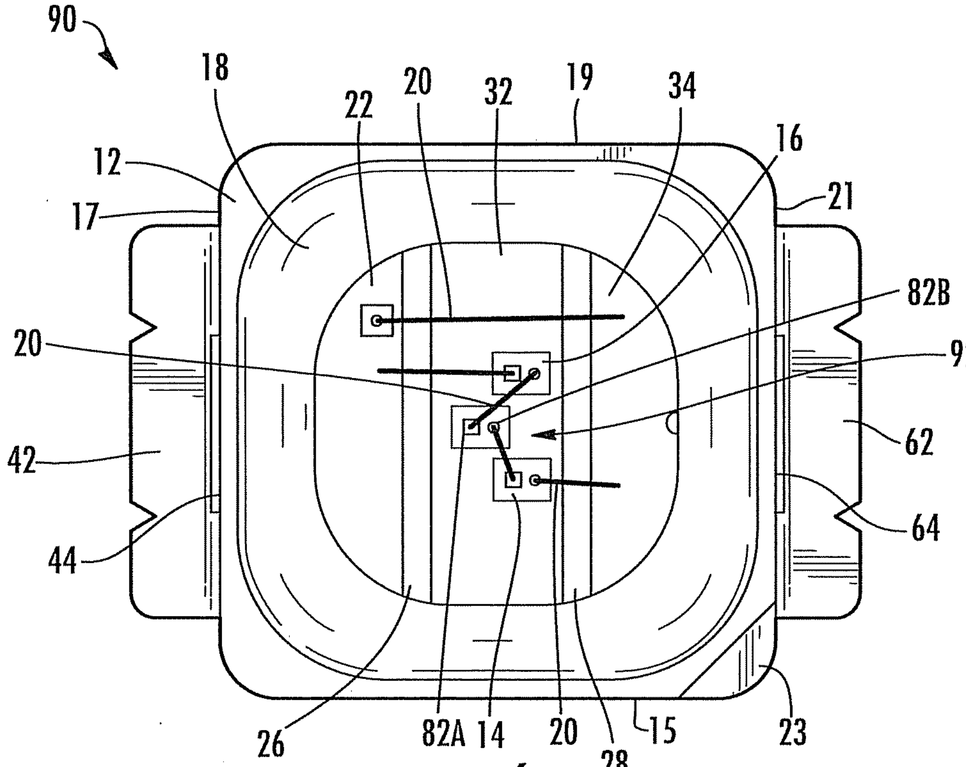
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FIG. 6

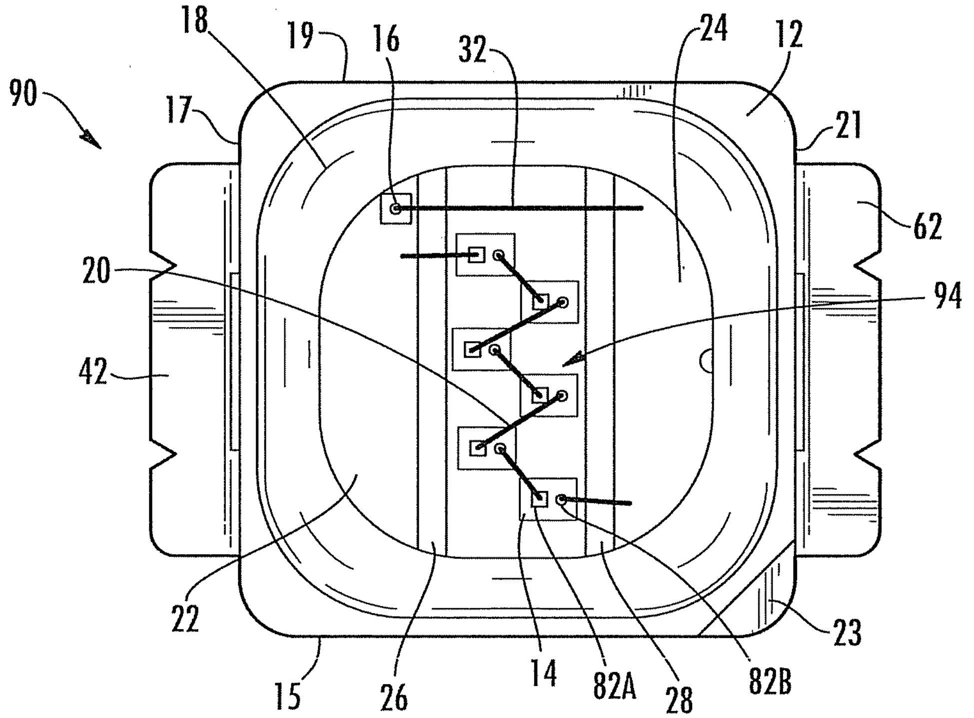
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FIG. 7

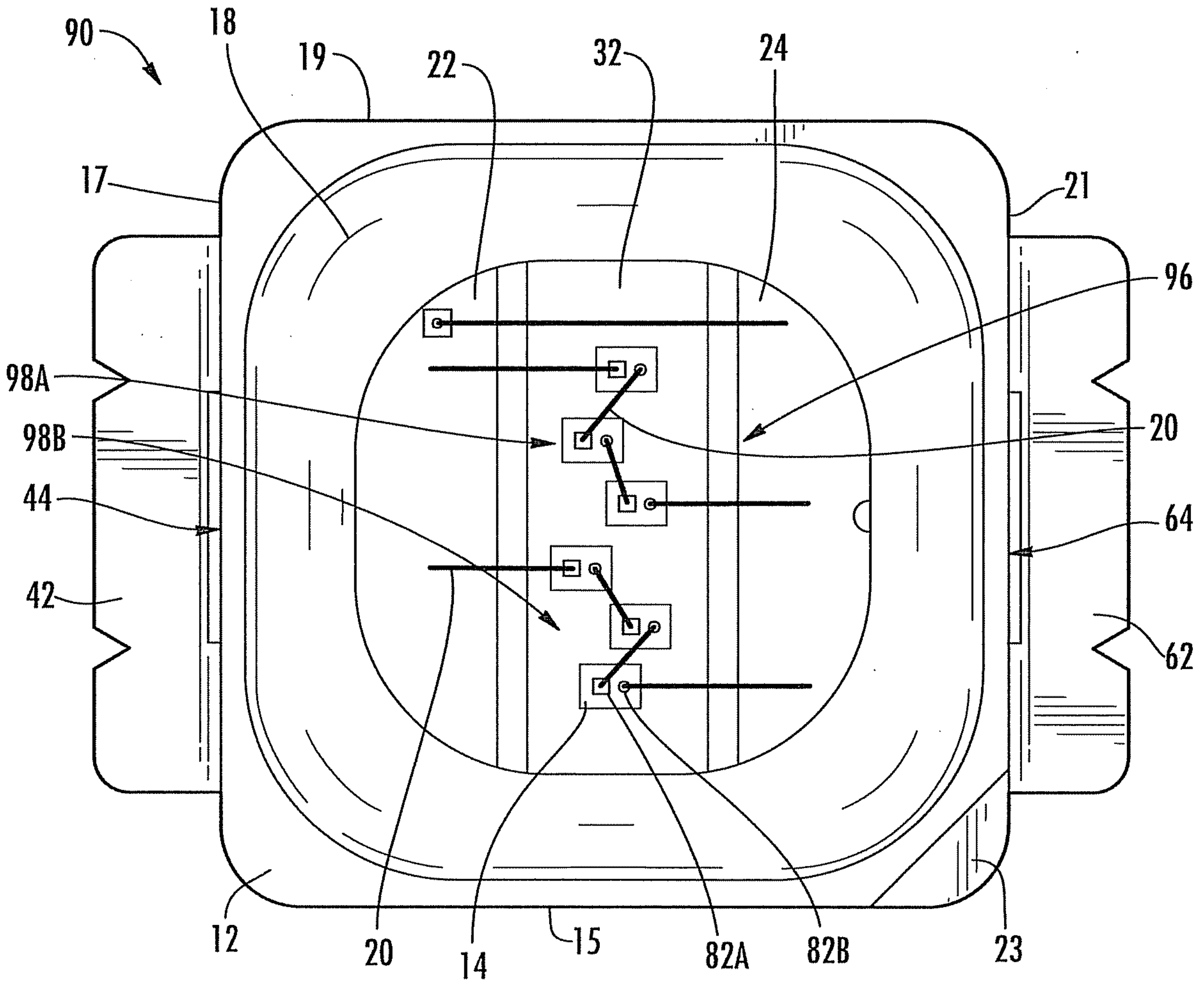
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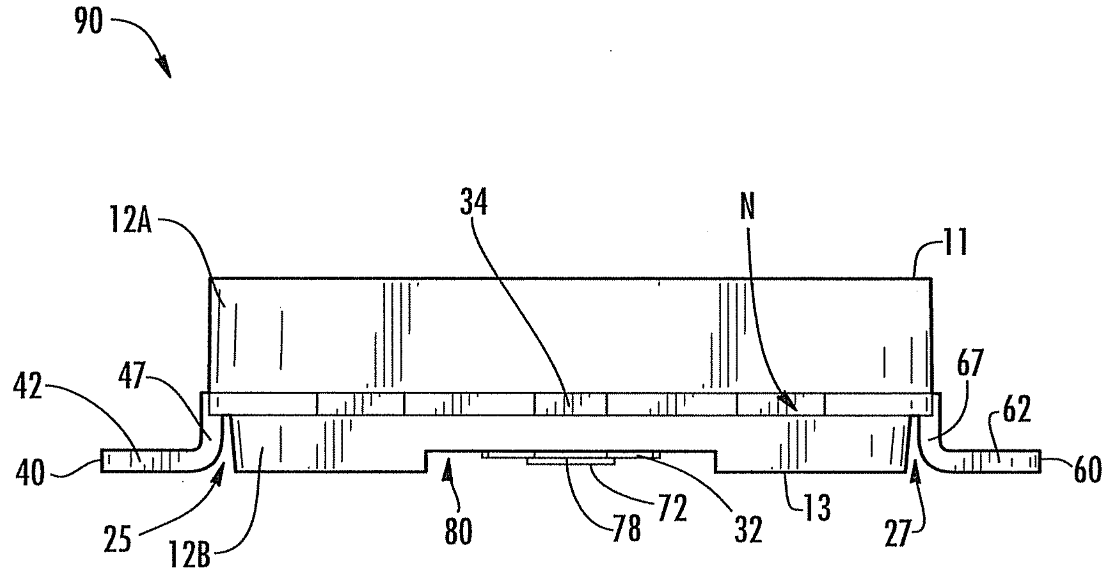
FIG. 8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60
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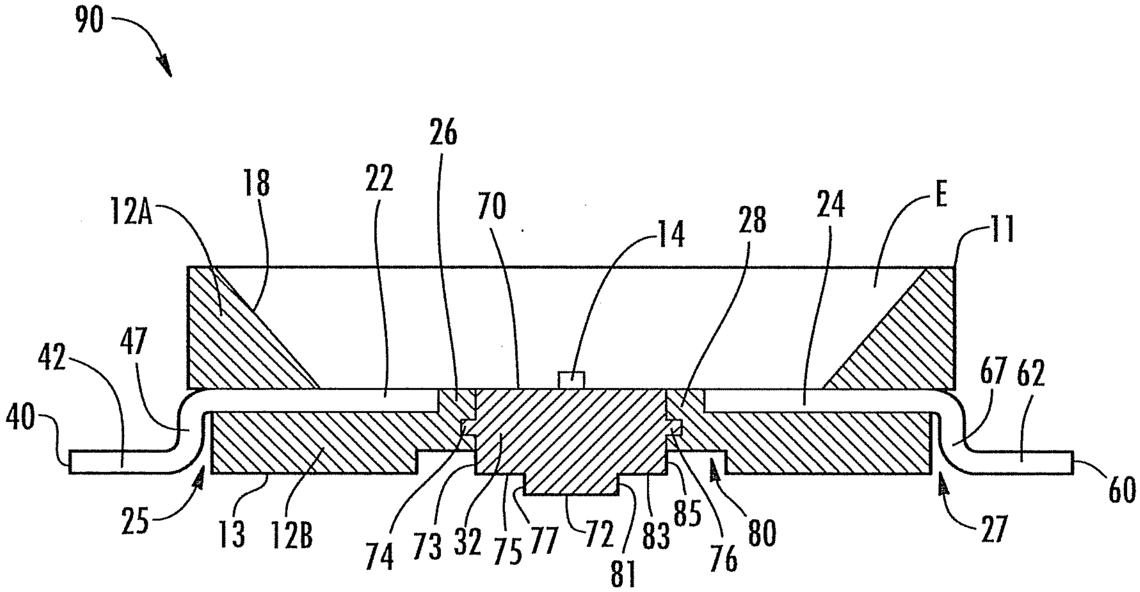
12B
78
27

FIG. 9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85
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FIG. 10

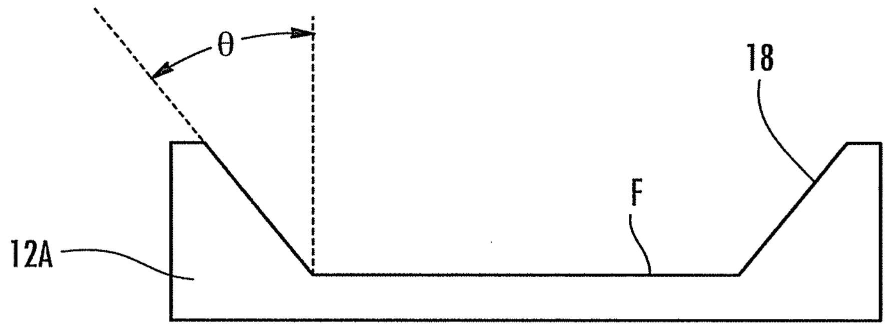

FIG. 11A

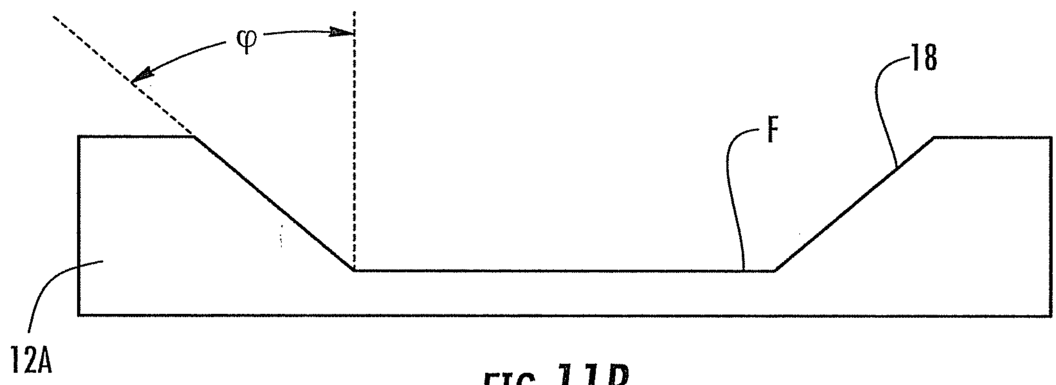

FIG. 11B

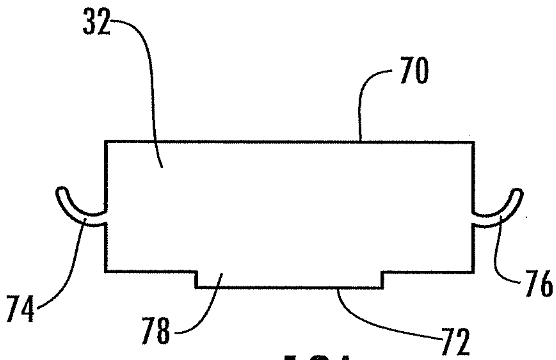

FIG. 12A

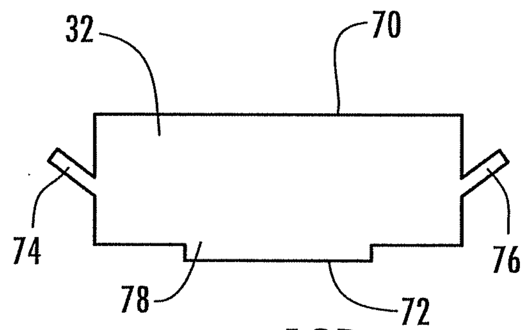

FIG. 12B