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(54) Title: BEAM SHAPING SPECTRALLY FILTERING OPTICS AND LIGHTING DEVICES THEREFOR

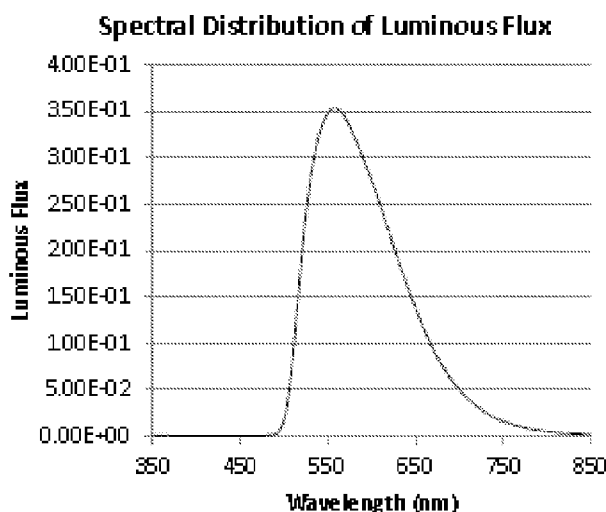


FIG. 9B

(57) Abstract: Related to most light-emitting devices, such as LED luminaires, a filtering, beam-shaping optic is disclosed that controls the spectral content of the emitted light and the shape of the emitted beam. One or more filtering agents is mixed with a non-filtering material used for making an optic and the optic is then formed into a desired shape or configuration to control the beam shape. Light waves in a subrange of the overall wavelength range emitted from the light source are shifted to control the spectral content of the emitted light. Spectral density of the emitted light for various wavelengths is controlled to achieve a desired result, such as minimizing the amount of blue light emitted from outdoor lighting devices, particularly at night. Further, the color content of light emitted is controlled, for example, to minimize damaging effects to light-sensitive objects such as food products, certain art materials, etc.

**BEAM SHAPING SPECTRALLY FILTERING OPTICS
AND LIGHTING DEVICES THEREFOR**

CROSS-REFERENCE TO PROVISIONAL APPLICATIONS

[0001] This application claims the benefit of priority from provisional Application No. 61/947,890, filed March 4, 2014, entitled BEAM-SHAPING SPECTRALLY FILTERING OPTIC, provisional Application No. 62/002,645, filed May 23, 2014, entitled BEAM-SHAPING SPECTRALLY FILTERING OPTIC FOR ILLUMINATION AND PACKAGING OF FOOD PRODUCTS and provisional Application No. 62/006,507, filed June 2, 2014, entitled LIGHTING DEVICE HAVING SPECTRALLY FILTERING OPTICS AND NON-FILTERING OPTICS, the entire contents of each of which is incorporated herein by reference for all that is taught.

BACKGROUND

Field of the Disclosure

[0002] The present disclosure relates generally to lighting devices. More particularly, embodiments of the present disclosure are directed to methods and devices used in connection with the lighting device that alter the photometric distribution of a light-emitting diode (LED), including laser-diodes and quantum LEDs (QLEDs), while simultaneously altering the spectral power distribution (SPD) of the emitted light. Further embodiments include a lighting device that uses both filtering optics and non-filtering optics in a controlled manner to provide a desired lighting environment. Certain other embodiments consistent with the disclosure are used to filter harmful wavelengths of light that adversely affect various food and beverages.

Description of Related Art

[0003] Luminaires, or more specifically, luminaires utilizing poorly designed optical systems and/or those utilizing inefficient legacy light sources, are a well-known example of energy waste within commercial, industrial, municipal and residential applications. In an attempt to address this known source of energy waste many federal, state and local governments have enacted legislation requiring, or at least incentivizing, the replacement of older, energy-inefficient lighting systems, such as incandescent, compact fluorescent (CFL) and High Intensity Discharge (HID) lighting systems, with newer, more energy-efficient systems, such as those utilizing LEDs.

[0004] The United States government has even encouraged the use and adoption of energy-efficient lighting systems by providing federal economic stimulus funding to local and state governments that enact such laws. Additionally, as a means to increase the reliability of the nation's aging electric utility infrastructure and to cooperate with federally mandated conservation efforts, public and investor-owned utilities have aggressively incentivized the replacement of legacy light source technology by providing prescriptive and custom rebates. As a consequence, industry has expeditiously pursued the development and deployment LED lighting technology, a technology largely economically out of reach just a few years ago and, as a result, a number of viable energy-saving LED lighting options has emerged. Of the new and emerging alternative light sources available, high brightness LED technology has become recognized as the undisputed industry light source of choice.

[0005] LED technology, however, has not yet been fully adopted on a broad scale due to several remaining economic factors, such as the initial purchase cost of new luminaires and the cost of installation. Additionally, LED luminaires have brought unexpected consequences when widely used for outdoor or indoor lighting applications. For example, contemporary LEDs produce white light through the conversion of blue light emitted from the die within the LED package, i.e., light emitted within a narrow wavelength (typically within 10nm), occurring approximately between 450-495nm. This blue light is then converted to white light through the use of local or remotely applied phosphors, which absorb some of the blue light emitted

from the LED die. These phosphors are responsible for converting the absorbed blue light into light having longer wavelengths, specifically wavelengths in the green and red regions of the visible spectrum. The combination of the unabsorbed, unconverted, blue light with the light of red and green wavelengths is what provides the appearance of white light.

[0006] Unfortunately, the blue emission produced by high brightness LEDs has been found to have increased negative effects, for example, in regard to fields such as astronomy, and more specifically the observation of the “night sky.” Legacy light sources, such as High Pressure Sodium (HPS) lamps and Low Pressure Sodium (LPS) lamps, are more compatible with astronomy since they emit limited, to virtually no, wavelength of light in the blue range. Additionally, relatively recent studies have correlated the impact of blue-rich light emitted by LEDs to the disruption of the circadian rhythm of humans, as well as other living organisms. As a result, the widespread installation of white light sources rich in blue emission is among the largest concerns of the International Dark Sky organization (IDA).

[0007] There is little debate that recent technological advances has made outdoor lighting more efficient, but at the same time, as previously mentioned; these newer lighting solutions are far richer in blue light wavelengths than legacy sources. Specifically, the energy-efficient white lights being implemented today emit more blue light than the most widely used high intensity discharge (HID) sources, such as Metal Halide (MH), High Pressure Sodium (HPS) and Low Pressure Sodium (LPS). Also, recent medical research has shown that exposure to blue-rich light sources; such as emitted from LEDs, can cause a reduction in naturally occurring human melatonin (MLT) levels.

[0008] Given the connection between blue-rich light and human physiology, attempts should be made to significantly reduce, if not eliminate, prolonged exposure to such sources. This is especially true for humans who are regularly exposed to extended periods of artificial lighting during nighttime hours and/or nocturnal animals which rely on the absence of blue-rich light, e.g., sunlight. While attempts have been made to limit the amount of blue light emitted from LED sources, these efforts have been undertaken as a means to increase the “warmth” of emitted light, or more

specifically, to lower the correlated color temperature (CCT) of the light. That is, by converting a greater amount of emitted blue light to the green and red portions of the visible spectrum, it is possible to change the appearance of the color of light emitted from the source (e.g., its CCT) from “cool white” to “warm white.”

[0009] One known device, depicted in FIG. 1, includes a typical packaged LED light source, which is comprised of a blue light LED chip 12 that emits light 11 with an emission peak in the blue wavelength range. The blue light LED chip is protected by a resin mold 13 which encapsulates a phosphor material 14 that is excited by the blue light 11 emitted from the blue light LED chip. The encapsulated phosphors 14 absorb some of the blue light 11 from the LED and emit green and red light 15, as determined by the phosphor chemistry, which is combined with the non-absorbed blue light 11 emitted from the blue light LED chip. This results in white light 16 being emitted with an emission peak in the blue wavelength range.

[0010] An independent optical filter 17 is then placed in the path of the emitted white light 16, which has a blue emission peak, in an attempt to filter some of the blue light. This results in filtered white light 18, which is claimed to have a “warmer” CCT than unfiltered white light 16. Such warmer white light is necessary for residential or hospitality indoor applications. However, illumination devices that use secondary filter media in an attempt to control the spectral components of the emitted light, such as the one depicted in FIG. 1, are problematic for commercial applications, specifically those applications where a greater level of photometric control is required. Such proposed solutions result in increased optical losses, which leads to lower system efficacy and can potentially cause a shift in the photometric pattern of the emitted light because the light is transmitted through a second surface whose geometry and or refractive index can prevent light from transmitting through it without alterations and losses.

[0011] Additionally, it is known that light causes photodegradation, or spoilage, of food. This photodegradation usually occurs in the constituents of foodstuffs, such as, pigments, fats, proteins and vitamins. Such spoilage manifests itself in several forms, such as, discoloration of the food, inducement of one or more off-flavors and the loss of vitamins. For example, light used to illuminate the food in display cases or

within one's refrigerator is absorbed by the food and causes deterioration of one or more of the mentioned food constituents. This results in discoloration of the surface of the food and can negatively affect consumer acceptance of the goods.

[0012] Further, in liquid food products light is able to penetrate even deeper into the product, i.e., beyond the outer layer, and the affected portions of the liquid are mixed throughout the product as the liquid is agitated through transport, handling, etc. This causes an even larger portion of the food product to be negatively affected by light. The type and extent of the deterioration of the food product depends on several factors. These factors include, the specific type of light source including the particular wavelengths of light that are absorbed by the food, the distance of the light source from the food and the duration of time that the food is exposed to the light, the packaging of the food, the amount of oxygen within the food and the temperature at which the food is stored while exposed to the light.

[0013] It is, thus, desired to provide an energy-efficient lighting solution that effectively illuminates desired targets while at the same time modifies the spectral power distribution of the light source to a level at or below a desired threshold. It is also desired to control one or more particular spectral components, e.g., by absorbing visible or non-visible wavelengths, such as blue light emitted from the device. Each of these desired affects should be accomplished without significant losses in the luminous flux delivered to the target and while controlling the desired beam shape. It is further desired to provide a lighting solution for various solid and liquid food products that will reduce or eliminate the negative effects of light waves on the food.

SUMMARY OF EXEMPLARY EMBODIMENTS

[0014] In consideration of problematic issues associated with conventional lighting devices, including but not limited to the issues discussed above, a lighting device in accordance with one or more exemplary embodiments of the present application generally relates to an LED device having a single beam-shaping optic coupled thereto. The coupled optic, such as a free-form total internal reflection (TIR) optic, transforms the photometric distribution of the light emitted from the LED to the desired pattern and also provides band-pass filtering to control the spectral power

distribution of the light emitted from the LED. FIGS. 2A-2C illustrate one type of LED optic that can be used in connection with embodiments of the present application. One or more of the LED optical devices consistent with the present application can be utilized within a luminaire assembly to illuminate a desired target area with the desired wavelengths of light.

[0015] More particularly, one or more embodiment includes a beam-shaping TIR optic of engineered resin material, referred to herein simply as resin but including other suitable materials such as glass and silicone. The optic is formed by mixing a filtering agent with a material suitable for an optic, such as acrylic (poly(methyl methacrylate), or simply PMMA)), plastic, silicone, glass, polymer, resin and others. The optic is optically coupled with an LED to transform the photometric distribution of the emitted light to a desired pattern, while at the same time providing some level of band-pass filtering. As a result, the overall spectral power distribution of the luminaire is controlled. While the basic use of TIR optics is known, utilizing a resin that filters and/or performs a Stokes shift on the light by use of a particular material within a TIR optic, such as a dye, phosphors, fluorescing materials and quantum dots, is not. As discussed above, current methods involve filtering the emitted light using a secondary filter media, which causes increased optical losses and potentially shifts the photometric pattern due to the specific geometry and/or refractive index of the lens.

[0016] Light filtering and beam shaping by a single optic in accordance with various embodiments consistent with the disclosure can be used in a variety of applications including, but not limited to, general interior lighting; general exterior lighting; flood-lighting, including lighting for food processing and display; portable lighting; automotive lighting; mobile equipment lighting; art illumination; retail and general display lighting; aircraft and aerospace lighting; lighting for light-sensitive biological and pharmaceutical processes, semiconductor processing and other light sensitive applications.

[0017] Filtering specific wavelengths of light to emit a controlled spectral density and influencing the spectrum in accordance with present application can be used, for example, to limit or prevent specific frequencies of visible or non-visible light from being projected into an environment, for preferential reasons or in an effort to prevent

adverse or undesirable environmental, physiological and/or technical consequences. Improvement of color quality in various lighting applications is another result of carrying out techniques disclosed herein, such as, in regard to the hospitality and retail lighting space.

[0018] In addition to providing a lighting solution that includes spectrally filtering optics further aspects of a lighting device disclosed herein include both filtered and non-filtered optics. According to exemplary embodiments light modules that include one or more filtered optics are provided in a single luminaire along with light modules that have non-filtering optics. Depending on the light output desired, for example, color temperature and other spectral components, the light modules are activated in a controlled manner to achieve the desired effect.

[0019] In accordance with further exemplary embodiments a dynamic system is provided. The dynamic system consists of LED arrays configured with a combination of filtering optics and standard clear, non-filtering, optics, e.g., made of PMMA. According to further exemplary embodiments the dynamic system is combined with a controller, such as either a wireless or wireline controller, that controls which LED, or combinations of LEDs, is activated. According to these exemplary embodiments any combination of filtered and non-filtered optics within a single lighting device, e.g., luminaire, can be achieved.

[0020] According to one or more exemplary embodiments, a self-contained intelligent wireless control module, or PCB integrated design, is provided which contains one or more independently controlled switching outputs and one or more digital and/or analog 0-10V outputs, which can be used to switch power and make operating current adjustments to connected LED power supplies and provide full-range dimming.

[0021] Each intelligent wireless, or wireline, control module is capable of controlling one or more fixtures and can be individually controlled or grouped with other lighting devices. The wireless control module communicates, for example, via 900MHz radio frequency to other devices within a wireless self-organizing and self-healing mesh network.

[0022] Both wireless and non-wireless standalone controller and integrated designs utilize non-volatile memory where time-based adaption or control can be programed, stored and autonomously activated.

[0023] According to one aspect of the invention a lighting device is provided that includes a light source emitting light having a first bandwidth, and a single optic device coupled to the light source, wherein the single optic device filters light having a preselected subrange of wavelengths within the first bandwidth to generate a first filtered light and controls a shape of a beam of said filtered light.

[0024] According to another aspect of the invention a lighting device is provided that includes a first light source emitting light having a first bandwidth, a second light source emitting light having a second bandwidth, a first optic device coupled to the first light source, wherein the first optic device filters light having a preselected subrange of wavelengths within the first bandwidth and generates a first filtered light. The luminaire further includes a second optic device coupled to the second light source, wherein the second optic device permits the second bandwidth of light to pass through it unfiltered. A control device is further provided that is operably connected to the first and second light sources and is operable to control whether light is emitted from one, both or neither of the first and second light sources.

[0025] According to yet another aspect of the invention, a method of making a lighting device is provided that includes mixing a filtering agent with an optical material, shaping the result of the mixing operation to form a filtering optic device and coupling the filtering optic device to at least one LED that emits light waves in a first range of wavelengths. According to this aspect the filtering agent absorbs light waves having a wavelength within a subrange of the first range of wavelengths and the filtering optic device controls a beam shape of the lighting device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Exemplary embodiments of the disclosed device and method are described in detail below by way of example, with reference to the accompanying drawings, in which:

[0027] FIG. 1 illustrates a known method of filtering blue light in accordance with a conventional LED lighting device;

- [0028] FIG. 2A is a perspective view of a TIR optic for an LED lighting device consistent with an exemplary embodiment of the present disclosure;
- [0029] FIG. 2B is a side elevation view of the optic shown in FIG. 2A;
- [0030] FIG. 2C is a front elevation view of the optic shown in FIG. 2A;
- [0031] FIG. 2D is a sectional view of the optic shown in FIG. 2A;
- [0032] FIG. 3 is a candela plot of a bare LED without a coupled optic;
- [0033] FIG. 4 is a candela plot of an LED with the optic shown in FIGs. 2A-2D coupled to it;
- [0034] FIG. 5 is a spectral chart showing the respective wavelengths for radiation in the visible and near visible spectrum.
- [0035] FIG. 6 is a chromaticity diagram illustrating the relative intensities of different color light waves as observed by the human eye during typical daylight conditions;
- [0036] FIG. 7 is a chart showing the different luminous efficacies of different color light waves under photopic, mesopic and scotopic conditions;
- [0037] FIG. 8 is a graph showing the respective transmission curves of exemplary long pass filters for various color light waves in accordance with the present disclosure;
- [0038] FIG. 9A is a graph showing the luminous flux output, as a function of the wavelength, of the emitted light for a luminaire with one or LEDs having respective beam-shaping TIR optics without a wavelength-shifting dye;
- [0039] FIG. 9B is a graph showing the luminous flux output, as a function of the wavelength, of the emitted light for a luminaire with one or LEDs having respective beam-shaping TIR optics that have a wavelength-shifting dye, in accordance with one or more embodiments of the disclosure;
- [0040] FIG. 10 is a perspective view of a single outdoor luminaire device having a plurality of both filtered and non-filters optics in accordance with one or more embodiments;
- [0041] FIG. 11 is a drawing showing a close-up view of a collection of filtered and non-filtered optics in the single luminaire of FIG. 10 in accordance with one or more embodiments;

[0042] FIG. 12 is a table showing a list of twelve different preset values and their corresponding lighting parameter values for controlling the LEDs corresponding to the filtered and non-filtered optics in the luminaire of FIG. 10;

[0043] FIG. 13 is a graph showing the relative intensities of light of different wavelengths corresponding to the preset control values listed in the table of FIG. 12.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0044] Exemplary embodiments of devices consistent with the present disclosure include one or more of the novel features described in detail below. For example, one or more of the exemplary embodiments disclosed include a TIR optic coupled to an LED device, the optic being formed with one or more materials for absorbing a band of visible light waves and shifting the wavelength of at least a portion of the absorbed light bandwidth to one or more wavelengths outside the absorbed bandwidth.

[0045] FIG. 2A is a perspective view of a TIR optical lens 200, or optic, for an LED lighting device in accordance with an exemplary embodiment. FIGs. 2B and 2C are side and front elevation views, respectively, of optic 200. Optic 200 is a free-form optic made of acrylic, or some other appropriate material, such as plastic, silicone, glass, polymer, resin and others. According to the embodiment shown, free-form optic 200 includes one or more reflective or refractive surfaces 210, 220, 230, 240, 250, 260, 270, the shapes of which are uniquely designed to control and shape the emitted light to a desired pattern. FIG. 2D is a cut-away, or sectional, view of optic 200 cut along the center line. The external refractive surfaces are shown in FIG. 2D as well as internal cavity 225, which houses an LED chip (not shown).

[0046] FIG. 3 is a candela plot of a bare board LED in accordance with the present application. More particularly, as illustrated by the dashed line 305 on plot 300 on the left-hand side of FIG. 3, a bare LED (not shown), that is, and LED without a beam shaping TIR optic coupled to it, provides light intensity that is a maximum, about 4,055 candelas in the example shown in FIG. 3, at a point directly below the LED, i.e., 0 degrees vertical angle. The light intensity steadily decreases as the vertical angle increases to about 0.0 candelas at a vertical angle of 90 degrees and

remains at 0.0 candelas at vertical angles greater than 90 degrees, i.e., above the plane of the LED.

[0047] By way of example and by no means limiting, the right-hand side 350 of FIG. 3 is a candela plot that shows the relative intensity of light for the bare LED as measured from a horizontal plane. As shown by the semi-circular plot 355, a bare LED positioned to illuminate in a vertical direction and without any optic coupled to it provides an even maximum intensity at all horizontal angles. For example, the LED in FIG. 3 is positioned at the spot labeled "X", and at a given height, e.g., 20 feet, above the horizontal plane, e.g., the ground. Plot 355 shows that the maximum intensity, i.e., approximately 4,055 candelas, is illuminated in a consistent circular pattern. That is, the same maximum luminous intensity value, i.e., 4055 candelas, is measured at each lateral angle.

[0048] FIG. 4 is a candela plot similar to the plot shown in FIG. 3, but with one major difference. Instead of measuring the bare LED, as in FIG. 3, FIG. 4 is the candela plot when the TIR optic shown in FIGs. 2A-2D is coupled to the LED. The left-hand side 400 of FIG. 4 includes dotted line plot 405 which has a much more narrow distribution than the corresponding plot in FIG. 3 for the bare LED. Specifically, as shown, the maximum luminous intensity of the LED with optic is shown to be approximately 15,719 candelas and this maximum intensity occurs at a vertical angle of approximately 67.5 degrees, i.e., at the point labeled 410.

[0049] The right-hand side, 450, of FIG. 4 shows the luminous intensity distribution through a plane that includes the maximum candela value, i.e., approximately 15,719 candelas. As shown, an elongated distribution is achieved along the maximum intensity plane at a lateral angle of about 72.5 degrees, i.e., at point 460.

[0050] Thus, as shown in FIGs. 3 and 4, in accordance with one aspect of the present application, by coupling a specifically designed optic, such as the one shown in FIG. 2A-2D, to an LED, it is possible to shape the light from the LED to a desired pattern. The light pattern shown in FIG. 4, for example, would be useful for illuminating an object or objects in an open area, such as in a parking lot or a street.

[0051] Shaping the light beam such that the light intensity is directed in the precise directions desired for a particular purpose is only one aspect of the present application. Controlling the spectral content of the emitted light is another important aspect. For example, in accordance with one exemplary embodiment the spectral content of the emitted light is controlled such that the amount of blue light emitted from the luminaire is vastly reduced or eliminated.

[0052] FIG. 5 is a spectral chart showing the respective wavelengths for radiation in the visible and near visible spectrum. The human eye recognizes, or “sees,” light in the visible spectrum, which includes light waves with wavelengths ranging from about 380nm to about 780nm. The portion of the spectrum with wavelengths below 380nm is known as near-ultra-violet to ultra-violet radiation and wavelengths above 740nm are known as infra-red radiation. Moreover, within the overall range of visible light, each wavelength represents a different color, as seen by the human eye. For example, blue light has a wavelength that ranges from about 435nm to about 500nm, and green light is in the range from about 520nm to about 565nm.

[0053] FIG. 6 illustrates the luminosity function or luminous efficiency function which describes the average spectral sensitivity of human visual perception of brightness. It is based on subjective judgments of which of a pair of different-colored lights is brighter, to describe relative sensitivity to light of different wavelengths. It should not be considered perfectly accurate in every case, but it is a very good representation of visual sensitivity of the human eye and it is valuable as a baseline for experimental purposes. These are referred to as “photopic” conditions. Thus, as illustrated, during photopic conditions the human eye is most sensitive to green light, that is, light with a wavelength of approximately 555nm. As shown in the figure, yellow and cyan are the next most recognizable colors, e.g., from an intensity standpoint, followed by blue and orange and then violet and red.

[0054] FIG. 7 shows the relative difference in the way in which the human eye responds to light of different frequencies, or wavelengths, i.e., luminous efficacy, during daylight (photopic), twilight (mesopic) and extremely low-light (scotopic) conditions, respectively. As shown, when the viewing environment is dark, such as, during night time hours when no moon is shining, the luminous efficacy curve shifts

downward, i.e., to the left in FIG. 7, as compared to the photopic response. Under these conditions the human eye is most sensitive to blue light, e.g., light having a wavelength of about 507nm or so.

[0055] Accordingly, when lighting having a significant amount of blue light, such as the white light LEDs discussed above, is used to illuminate targets outdoors at night, light in the blue wavelength range that is scattered into the environment, e.g. Rayleigh scattering, will have the most impact on the night sky. In other words, humans will recognize the scattered blue light portion of any scattered white light more than colors of other wavelengths. Thus, street lights and flood lights that use bright white LEDs contribute a significant amount of blue light into the sky when the light is either reflected off an object or when the light beam is not sufficiently controlled and some of the light is directly emitted into the sky. Such conditions are a significant cause of light pollution as discussed above.

[0056] In accordance with an exemplary embodiment of the application, targeted blue light wavelengths are absorbed by the physical components of a TIR optic, such as the one depicted in FIGS. 2A-2D, and the emitted spectral content is shifted. For example, a dye that is able to absorb light in blue wavelength range is mixed with an acrylic material used to make the optic. As a result, a band of wavelengths comprising blue light, from the overall white light spectrum outputted from a white light LED, is absorbed by the dye, while light of other wavelengths outside the absorbed band are permitted to pass through the optic. Any scattered light from, for example, a street light employing one or more LED devices in accordance with the present embodiment, that would otherwise contribute to light pollution as discussed above would not be emitted into the night sky.

[0057] According to a further exemplary embodiment, filtered optics in accordance with the invention are used to filter harmful light wavelengths before light of these wavelengths are permitted to come into contact and/or be absorbed by various food products. According to these and other embodiments, specific wavelengths of light, e.g., blue light in the 400-500 nanometer range, is filtered from the emitted light of one or more LEDs. Such LEDs provide illumination of the food

or beverage, such as meat, cheese, milk, and other dairy products, as well as soft drinks, fruit juices and even beer, just to name a few.

[0058] The method by which the specific light waves are filtered from the emitted light include a filtering optic at the light source, such as one or more of the optics described above and illustrated in the drawings. Another method for filtering the appropriate wavelengths of light prior to it being absorbed by solid or liquid food, includes providing packaging for the food that filters the appropriate wavelengths. For example, a bottle for packaging milk, beer or some other beverage that is readily affected by light waves, is produced having a light filtering property.

[0059] The present embodiment would be appealing, for example, to owners/operators of milk/dairy farms and processing facilities which, like others, are very interested, compelled even, to reduce the energy consumption at their facilities as a means to offset electrical lighting and related HVAC costs.

[0060] Unfortunately, as mentioned above, milk is susceptible to “light activated” flavors and nutrient reduction, specifically to wavelengths of light below 500nm, which some producers have attempted to somewhat mitigate through the use of colored packaging (e.g., yellow and/or UV coated). The costs associated with opaque and light-blocking packaging, however, are difficult to recover from the consumer. Additionally, the production, processing, refrigeration and related transportation facilities utilize light sources, such as inefficient Metal Halide & Fluorescent lights, which are targets for more energy-efficient LED lighting technology. While these legacy sources produce UV which has also been shown to affect the quality of the food product, they produce substantially much less blue light in the 400-500nm range, in comparison to LEDs.

[0061] LED light sources were not available when the bulk of the research was conducted for the development of the packing and coating systems used on dairy products. In view of the advancement to LED illumination, therefore, a resin consistent with embodiments disclosed herein offer a suitable improvement over current packaging. Specifically, the current resin used by the dairy and other beverage industries in their bottling processes do not filter or up-shift unwanted wavelengths of light, such as damaging blue light. Resins and other materials made in accordance

with embodiments disclosed herein, however, perform such filtering and shifting, as described above.

[0062] Thus, as the grocery industry shifts towards the use of LED refrigeration case lighting, that is, lighting that contains more blue content than traditional light sources, dairy products packaged in white and/or clear packing will experience far greater spoilage rates. To reduce or eliminate such increased spoilage, filtering optics at the light source and/or packaging made from a resin or other material that absorbs and/or shifts the blue light wavelengths in accordance with one or more embodiments of the invention will overcome the problem.

[0063] Other exemplary embodiments of the present invention that utilize the filtered optics include, but are not limited to, (1) general ambient or task illumination used in food production, processing, refrigerated storage and related transportation (e.g., source to shelf), (2) refrigeration lights used in consumer and professional appliances, (3) refrigeration lights used in professional retail case appliances, (4) interior cargo lights used by dairy, meat, and agricultural transportation industry, and (5) industrial/commercial luminaires utilized in related production/processing/refrigeration/transportation of dairy/meat/produce (i.e., food). Moreover, potential new uses for filtered optics materials that are unrelated to illumination include, (1) product packaging and (2) display case windows.

[0064] Beer, for example, is typically bottled and packaged in areas illuminated with High Pressure Sodium (HPS) lights. This is because HPS lights do not emit a significant amount of light having wavelengths in the critical range of around 350-500nm. If during the bottling process, and through to the case packing operation where the bottles are no longer exposed to the light, the bottles are exposed to light for an inordinate amount of time, such as when a machine breaks down, etc., the content of all of the exposed bottles must be disposed of.

[0065] An exemplary LED that can be used in accordance with one or more embodiments is a bright white light LED such as the Nichia 219B LED by Nichia Corporation. As mentioned above, such white light LEDs tend to emit a significant amount of blue light which ideally should be filtered or Stokes-shifted, to provide a more acceptable spectral content. In accordance with an exemplary embodiment of

the disclosure, a dye for absorbing blue light is mixed into the plastic or acrylic material used to form the TIR optic.

[0066] One known dye that can be incorporated into the plastic optic in accordance with the present embodiment is DYE 500nmLP by Adam Gates & Company, LLC of Hillsborough, New Jersey. This particular dye is a yellow free flowing powder material that can be melted and mixed evenly with the plastic or acrylic material used for forming the main optic structure. One suitable material is an acrylic polymer resin material, such as Plexiglas® V825 by Altuglas International.

[0067] FIG. 8 illustrates the transmission curve for the 500nmLP dye. More particularly, curve 810 shows the relative transmission levels for radiation that impinges on the dye. As shown, 100% of radiation having a wavelength above 500nm is transmitted and 0% of radiation having wavelength below about 480nm is transmitted. Radiation with wavelengths between 480nm and 500nm is substantially absorbed by the dye. In other words, virtually blue light, including violet and ultra-violet light, is absorbed by the dye and all green, yellow, orange and red light, including magenta and infra-red light, is permitted to pass through the dye. Also, optics in accordance with embodiments of the present invention, including embodiments of direct LED optics and embodiments where various packaging is made of the spectrally filtering resin or other material, are made from one or more different processes, including various forms of blow-molding, such as, extrusion blow molding, injection blow molding, stretch blow molding and reheat and blow molding.

[0068] In accordance with an embodiment of the disclosure, at least some of the light waves emitted from the LED and entering the optic is Stokes-shifted to a higher wavelength. That is, due to the properties of fluorescent material, the light that is absorbed in the dye, i.e., in the present example, blue light, is re-emitted at wavelengths higher than the absorbed blue light. Thus, not only is the amount of blue light ultimately emitted from the optic virtually removed, but the luminous flux, i.e., the perceived power of the light emitted from the optic, is not reduced by a value near as high as the amount of light absorbed. In other words, in addition to light having a wavelength of about 455nm, or so, i.e., blue light, being removed from the emitted spectrum, additional light having wavelengths above 455nm is also emitted.

[0069] FIG. 9A is a graph showing the luminous flux output as a function of the wavelength of the emitted light for a luminaire in accordance with one or more embodiments of the disclosure. In this exemplary embodiment, TIR optics similar to the optic of FIGS. 2A-2D were coupled to each LED but no dye was mixed into the acrylic material used to form the TIR optic. Specifically, a flood light luminaire having 72 individual broad-spectrum white light LEDs coupled to respective optic devices was configured and various test measurements were observed. As shown in FIG. 9A, the light emitted from the luminaire has a first maxima 910 at wavelengths of about 450nm and a second maxima 920 at about 560nm.

[0070] FIG. 9B is a graph that shows the luminous flux for the same luminaire as the one used in connection with FIG. 9A, but with one major difference. The fluorescent dye discussed above is mixed in with the acrylic material when forming the TIR optic. As shown in FIG. 9B, the spectral content of the light emitted from the luminaire is devoid of radiation wavelengths less than about 455nm, e.g., corresponding to the first maxima 910 in FIG. 9A. Moreover, the spectrum of the emitted light has shifted towards higher wavelengths. For example, the peak wavelength in FIG. 9B is about 560nm, i.e., which corresponds to the second maxima in FIG. 9A. However, the peak luminous flux in FIG. 9B, i.e., at 560nm, is greater in magnitude than the value corresponding to the second maxima in 9A. This indicates that at least some of the absorbed blue light, e.g., around 455nm, has been shifted to green light, e.g., 560nm.

[0071] While various embodiments have been chosen to illustrate the disclosed method and device, it will be understood by those skilled in the art that other modifications may be made without departing from the scope of the disclosure as defined by the appended claims. For example, the exemplary embodiment described above for removing blue light from the spectrum of emitted light and controlling the beam shape for illuminating an outdoor object, such as a road, etc., is merely one practical application of the present disclosure. Specifically, it is contemplated that other wavelengths of radiation can be absorbed and used to shift the spectral content, and other beam shapes as defined by the configuration of the optic and are within the spirit and scope of the disclosure.

[0072] For example, it has been found that at night, artificial light disrupts the human body's biological clock, i.e., the circadian rhythm and, thus, humans exposed to inordinate amounts of light experience higher rates of sleep dysfunction. Moreover, research has shown that excess light, particularly at night, may contribute to the causation of cancer, diabetes, heart disease, and obesity. Blue light tends to be the most disruptive on the human body, especially at night.

[0073] Independent experiments have found that blue light suppressed melatonin for about twice as long as green light and shifted circadian rhythms by twice as much. Thus, various lighting applications would benefit from reducing the amount of emitted blue light and possibly shifting some of the blue light to green or red light and such applications are intended to be within the scope of this disclosure.

[0074] It should be understood that the method and device disclosed herein is not limited to any one or limited range of wavelengths of radiated beam shapes. More particularly, another application, by way of example, for the beam-shaping and spectral content controlling nature of the disclosure related to illumination of artwork. That is, all light causes irreversible damage to artworks. The extent of the deterioration depends on the type of light source, its intensity and the length of exposure the artwork is subjected to. Because light damage to artwork is accumulative, the longer the artwork is exposed, the more extensive the damage.

[0075] Natural light is an intense source of energy and contains ultra-violet (UV) radiation. Because most artworks are composed of organic materials, for example, as found in various paint, artworks are particularly vulnerable to UV wavelengths. This causes different forms of damage, including discoloration. Radiation in the visible spectrum also causes a large amount of damage and discoloration to artworks. Thus, controlling the spectral content of the emitted radiation when illuminating artworks and also controlling the beam shape to provide an efficient illumination pattern can be a useful tool for effectively displaying artwork and simultaneously protecting the artwork from undue radiation damage.

[0076] FIGS. 10 and 11 illustrate a luminaire in accordance with a further exemplary embodiment where both filtered and non-filtered optics, each corresponding to one or more LEDs, are utilized to achieve a customized lighting

solution. According to this embodiment, a controller unit (not shown) is used to activate the LEDs corresponding to the filtered and non-filtered optics in a controlled manner. For example, a number of preset control values are used to alter which particular LEDs are activated at a particular time of day, thus achieving a desired lighting effect depending on the particular preset values used. An exemplary wireless controller consistent with the embodiments disclosed herein is disclosed in U.S. published patent application number 2012-0136485, the entire contents of which are incorporated herein by reference. Although the controller disclosed in this U.S. published application can be used, other controllers, either wireless or wireline, can also be used consistent with these and other embodiments.

[0077] According to one aspect of these exemplary embodiments, the wireless controls provide programmable LED lighting which reduces and filters the wavelengths in traditional light sources that emulate daylight. A luminaire with filtered and non-filtered optics according to this embodiment is programmed with presets to provide varying degrees of light “adaption” from, for example, dusk-to-dawn or customized for the particular application. Preset modes allow desired reduction of the “blue light” wavelengths of light during the night time operation of the luminaire.

[0078] FIG. 12 is a chart providing twelve (12) exemplary “presets,” 1-12, listed in the left-hand column. Corresponding to each preset value are respective power, CCT, illuminance and CRI values. According to a time-of-day timer or some other pre-programmed set of controls, varying amounts of “blue light” is filtered from the overall emitted light from the luminaire. As illustrated, different control values can be used depending on whether the lighting device, e.g., luminaire, is located in an urban or mixed use setting, a low population density area, or an area such as a national park or other protected environment.

[0079] FIG. 13 shows a series of spectral distributions emitted from a given luminaire equipped with both filtered and non-filtered optics in accordance with the present embodiment. According to this embodiment the individual LEDs corresponding to the optics are controlled in accordance with the presets, 1-12, listed in the table of FIG. 12. As shown, as different combinations of LEDs corresponding

to filtered and non-filtered optics are operated in accordance with the preset values, the amount of “blue light” in the wavelength band near 450 nm is altered. More particular, in the embodiment of FIG. 13 the relative intensity of the “blue light” emitted from the luminaire is reduced from about 23.0 when preset value 1 is used down to about 1.0 when the preset value 12 is used. This enables a desired spectral content to be achieved in a controllable manner using the same luminaire populated with both filtered and non-filtered optics.

WHAT IS CLAIMED IS:

1. A lighting device comprising:
 - a light source emitting light having a first bandwidth; and
 - a single optic device coupled to said light source, wherein said single optic device filters light having a preselected subrange of wavelengths within said first bandwidth to generate a first filtered light and controls a shape of a beam of said filtered light.
2. The lighting device recited in claim 1, wherein said subrange of wavelengths comprises light having wavelengths in the range from 435nm to 500nm.
3. The lighting device recited in claim 1, wherein said single optic device shifts light from within a first predetermined wavelength range to light within a second predetermined wavelength range and said first predetermined wavelength range includes light having wavelengths within said preselected subrange of wavelengths.
4. The lighting device recited in claim 1, wherein said single optic device is a free-form optic made of a material into which a filtering agent is disposed prior to forming the single optic device and said filtering agent filters said light having a preselected subrange of wavelengths.
5. A lighting device comprising:
 - a first light source emitting light having a first bandwidth;
 - a second light source emitting light having a second bandwidth;
 - a first optic device coupled to said first light source, wherein said first optic device filters light having a preselected subrange of wavelengths within said first bandwidth and generates a first filtered light;
 - a second optic device coupled to said second light source, wherein said second optic device permits said second bandwidth of light to pass through it unfiltered; and
 - a control device operably connected to said first and second light sources and operable to control whether light is emitted from one, both or neither of said first and second light sources.

6. The lighting device recited in claim 5, wherein said control device is a wireless control device operable to control each of said first and second light sources via wireless control signals.

7. The lighting device recited in claim 1, wherein said preselected subrange of wavelengths corresponds to a range of wavelengths that damage or otherwise deteriorate one or properties of a food product when absorbed by said food product.

8. A light-filtering material used for packaging a food product, wherein said light-filtering material includes a substance that receives illumination light from a light source and filters light having a preselected subrange of wavelengths from said illumination light to generate a first filtered light that causes less photodegradation on said food product than said illumination light.

9. A method of making a lighting device comprising:
mixing a filtering agent with an optical material;
shaping the result of said mixing to form a filtering optic device;
coupling said filtering optic device to at least one LED that emits light waves in a first range of wavelengths, wherein said filtering agent absorbs light waves having a wavelength within a subrange of said first range of wavelengths and said filtering optic device controls a beam shape of said lighting device.

10. The method recited in claim 9 wherein said filtering optic device is a TIR optic.

11. The methods of claim 9 wherein said subrange of said first range of wavelengths includes light having wavelengths in the range of 400 to 500 nanometers.

12. The method recited in claim 9 further comprising combining said filtering optic device with a non-filtering optic device within a luminaire device, wherein said non-filtering optic device does not include said filtering agent.

13. The method recited in claim 9 wherein said filtering agent includes one or more of a dye, phosphors, fluorescing material and quantum dots.

14. The method recited in claim 9 wherein said optical material includes one or more of a resin, glass, polymer and silicone.

15. A luminaire comprising:
at least one LED that emits light in a first range of wavelengths;
at least one filtering optic coupled to said at least one LED, wherein said filtering optic shifts light in a first subrange of said first range of wavelengths to light having wavelengths in a second subrange of wavelengths different than said first subrange and said filtering optic further controls a shape of a beam of said light emitted from said LED.

16. The luminaire recited in claim 15 wherein an amount of luminous flux in said second subrange is greater after said light in said first subrange is shifted to said second subrange.

17. The luminaire recited in claim 15 wherein said first subrange of wavelengths is between 400 and 500 nanometers and each wavelength in said second subrange is greater than or equal to 500 nanometers.

18. The luminaire recited in claim 15 wherein said luminaire is installed to illuminate food products.

19. The luminaire recited in claim 15 further comprising:
at least one non-filtering optic coupled to said at least one LED, wherein said non-filtering optic emits light in said first range of wavelengths; and
a controller configured to control which LEDs corresponding to each respective filtering and non-filtering optics is energized to emit light.

20. The luminaire recited in claim 19 wherein said luminaire is installed to illuminate one or more objects that are sensitive to specific wavelengths of light and said controller is configured to minimize an amount of light emitted by said filtering and non-filtering optics in said specific wavelengths.

1/9

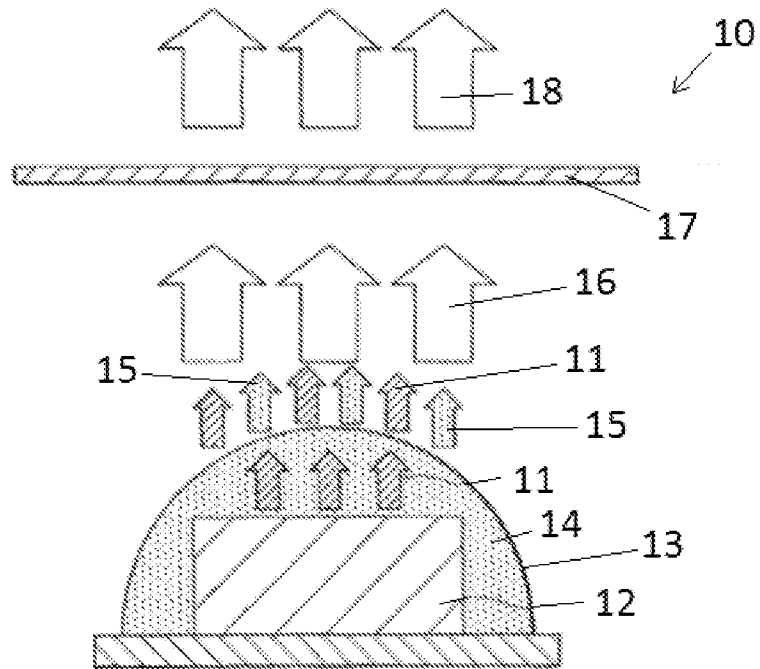


FIG. 1
(PRIOR ART)

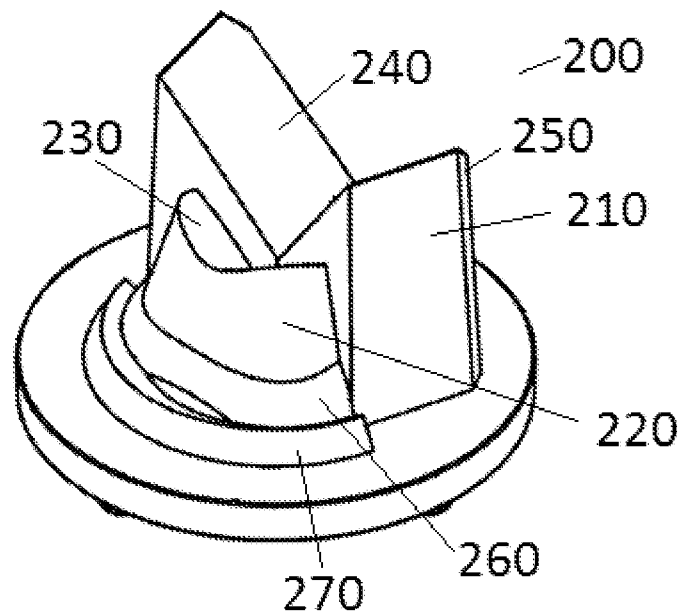


FIG. 2A

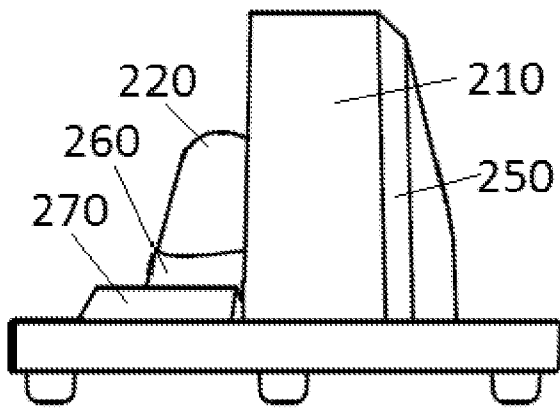


FIG. 2B

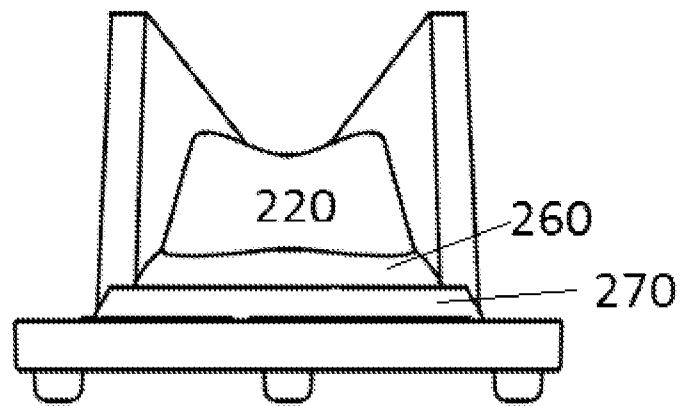


FIG. 2C

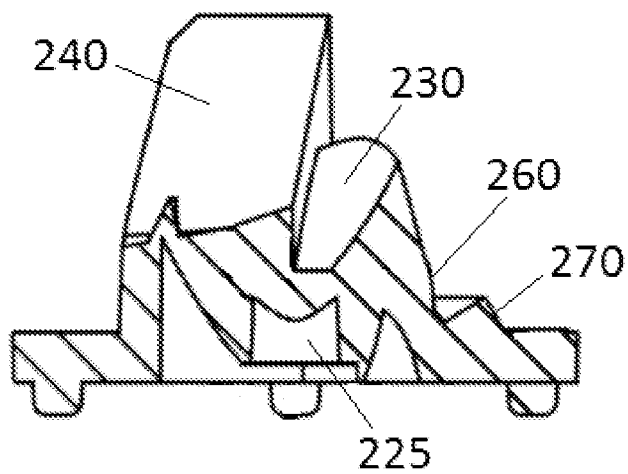


FIG. 2D

3/9

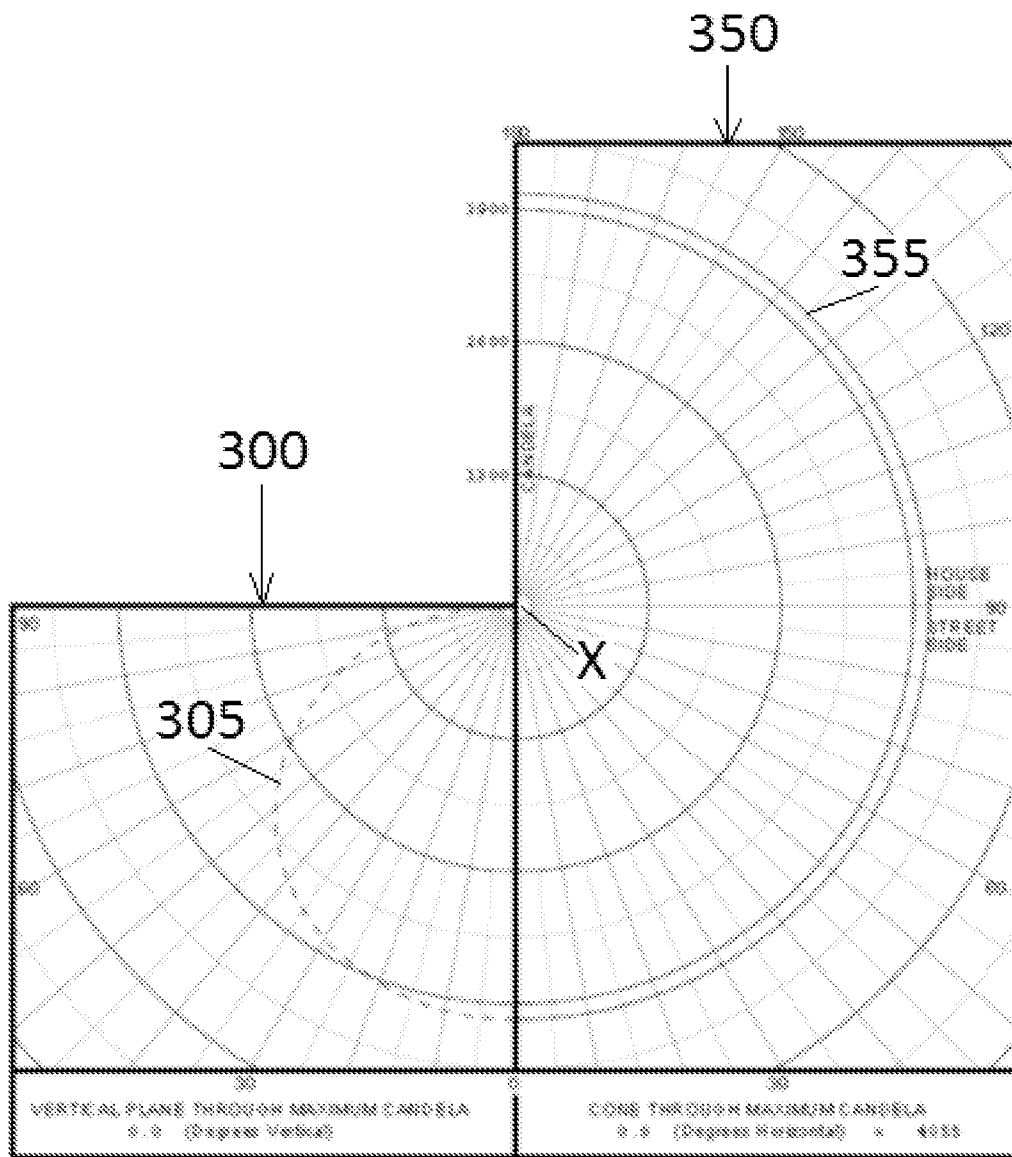


FIG. 3

4/9

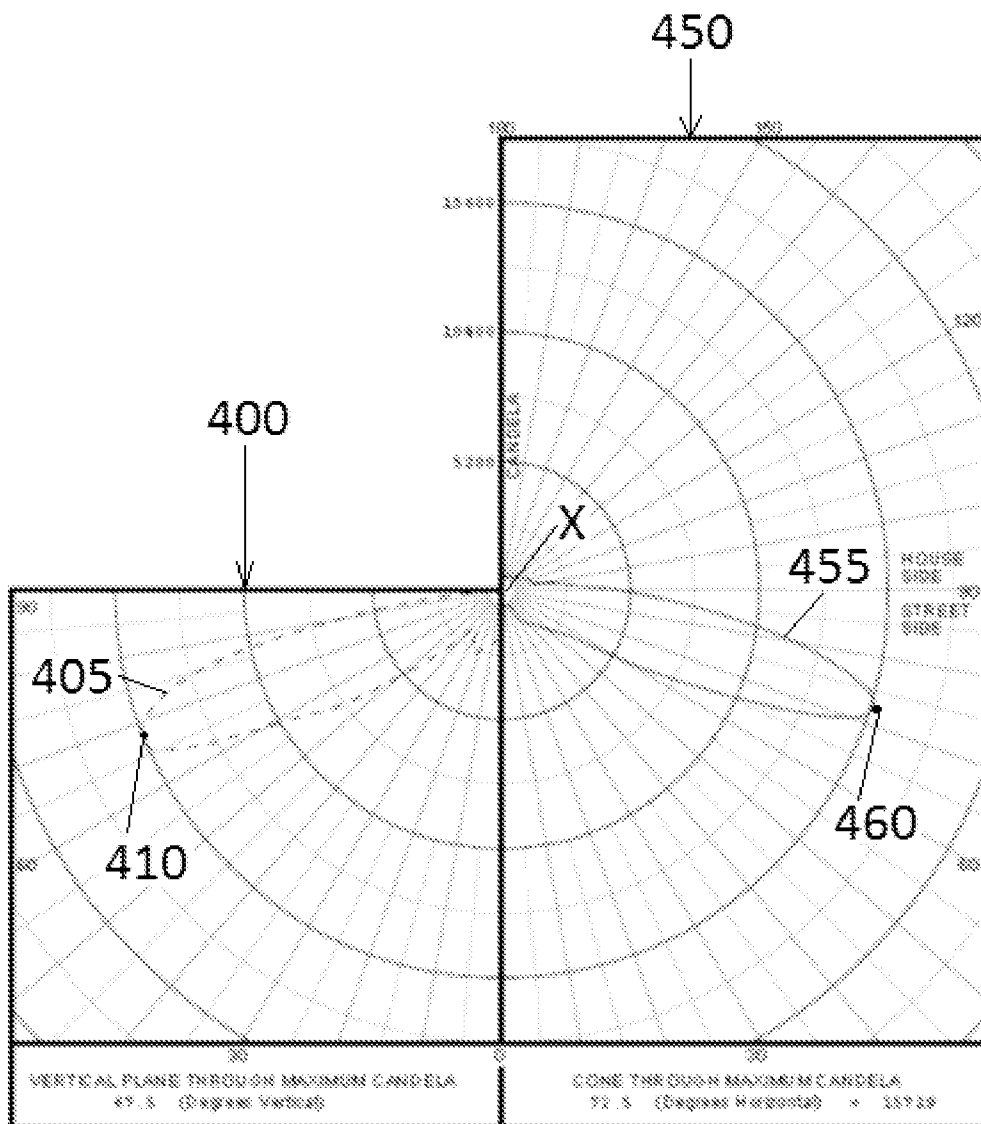
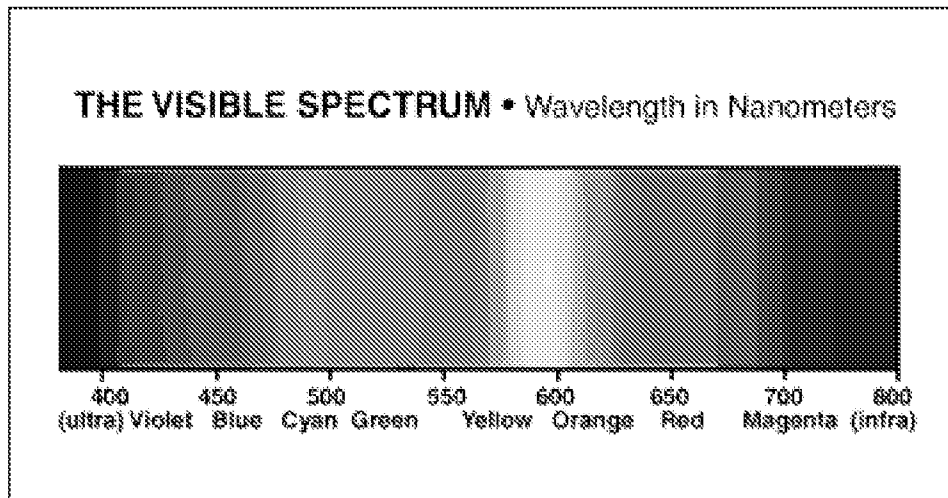
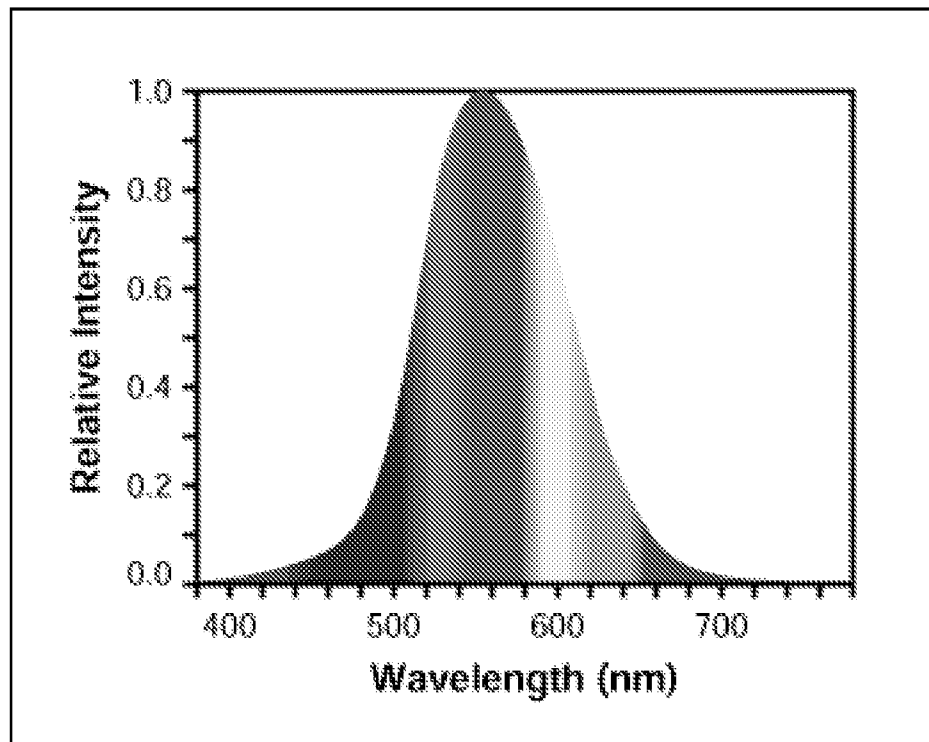


FIG. 4

5/9

**FIG. 5****FIG. 6**

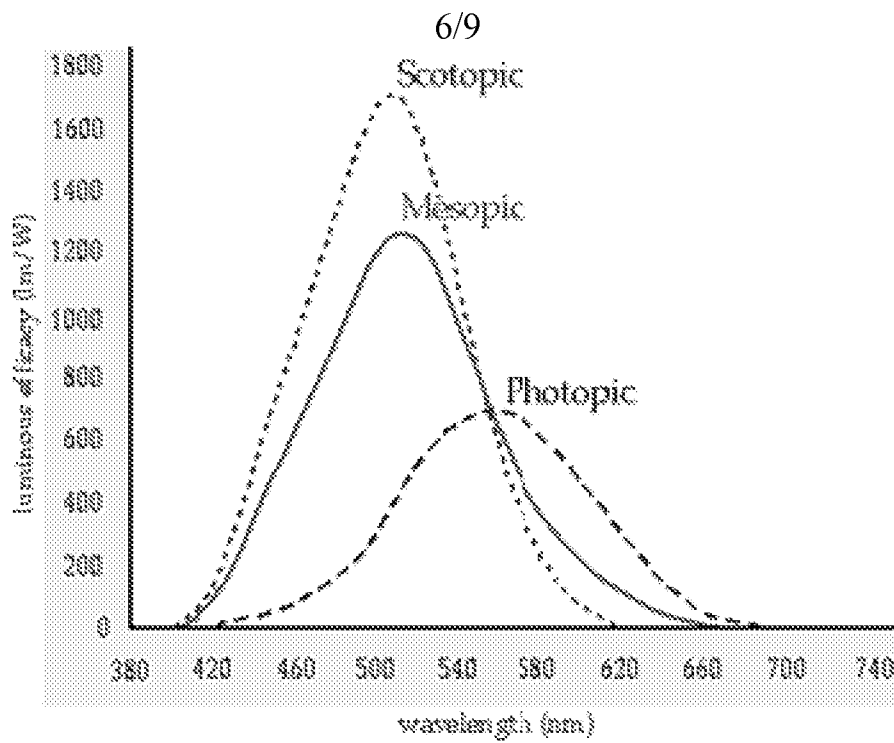


FIG. 7

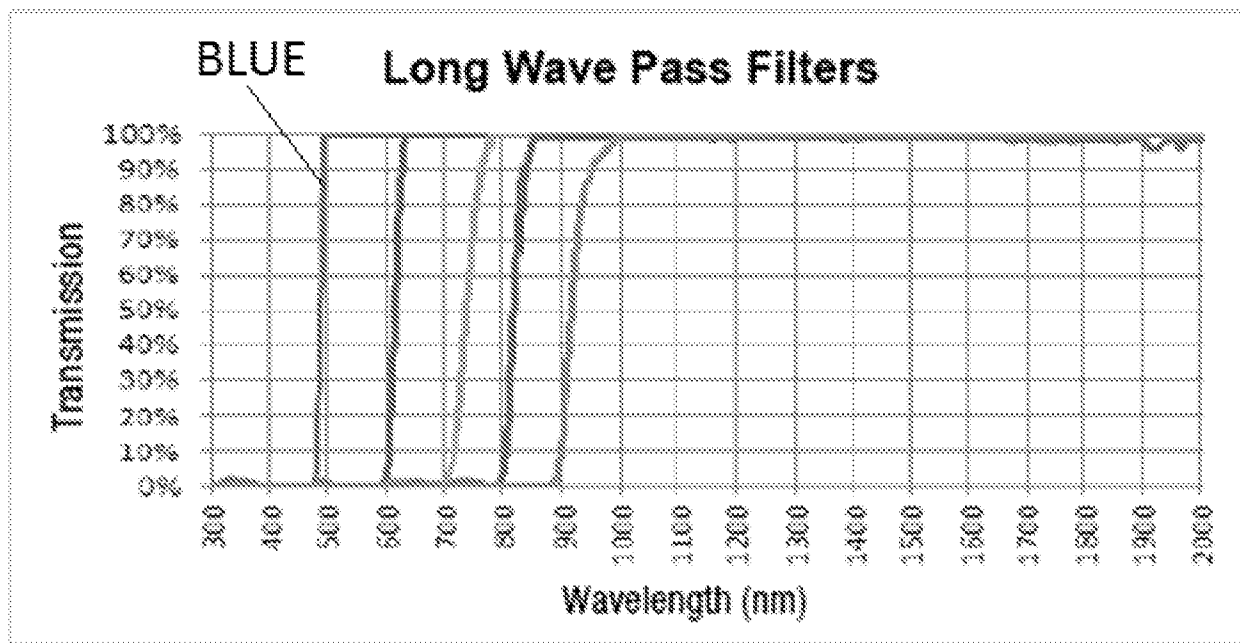
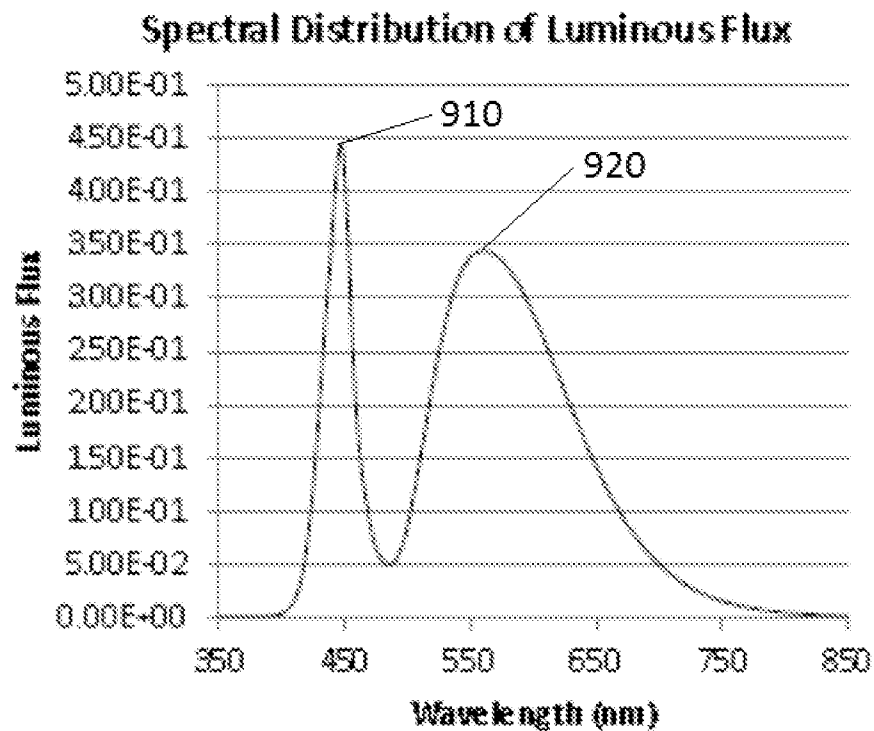
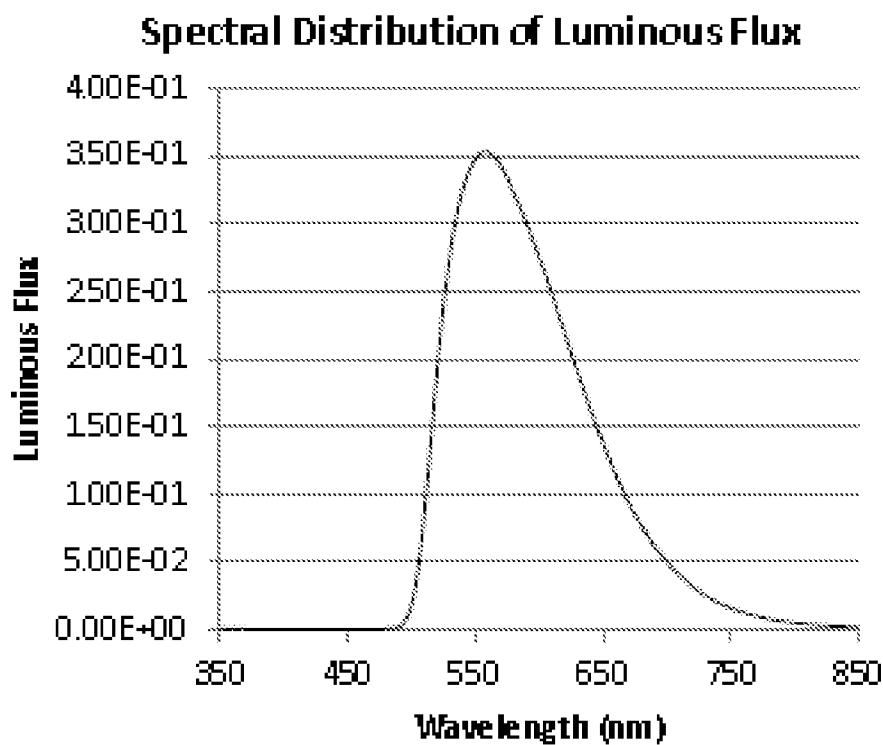


FIG. 8

7/9

**FIG. 9A****FIG. 9B**

8/9

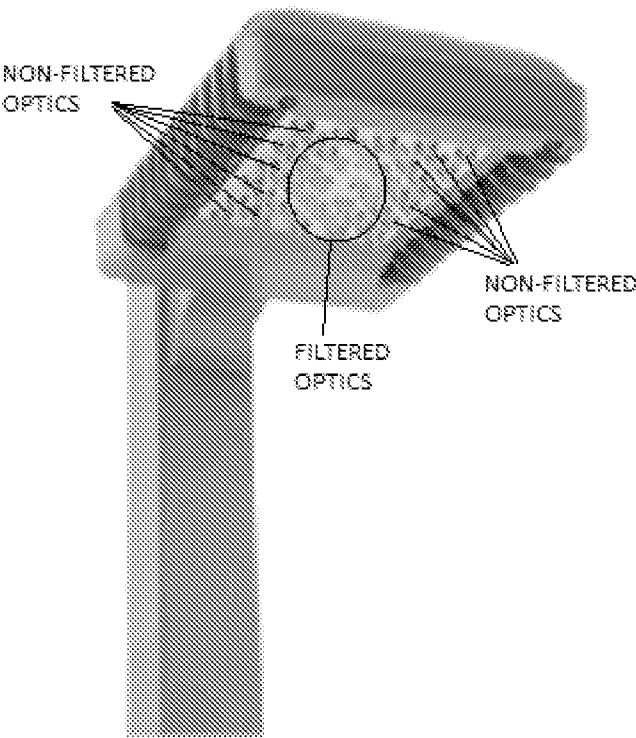


FIG. 10

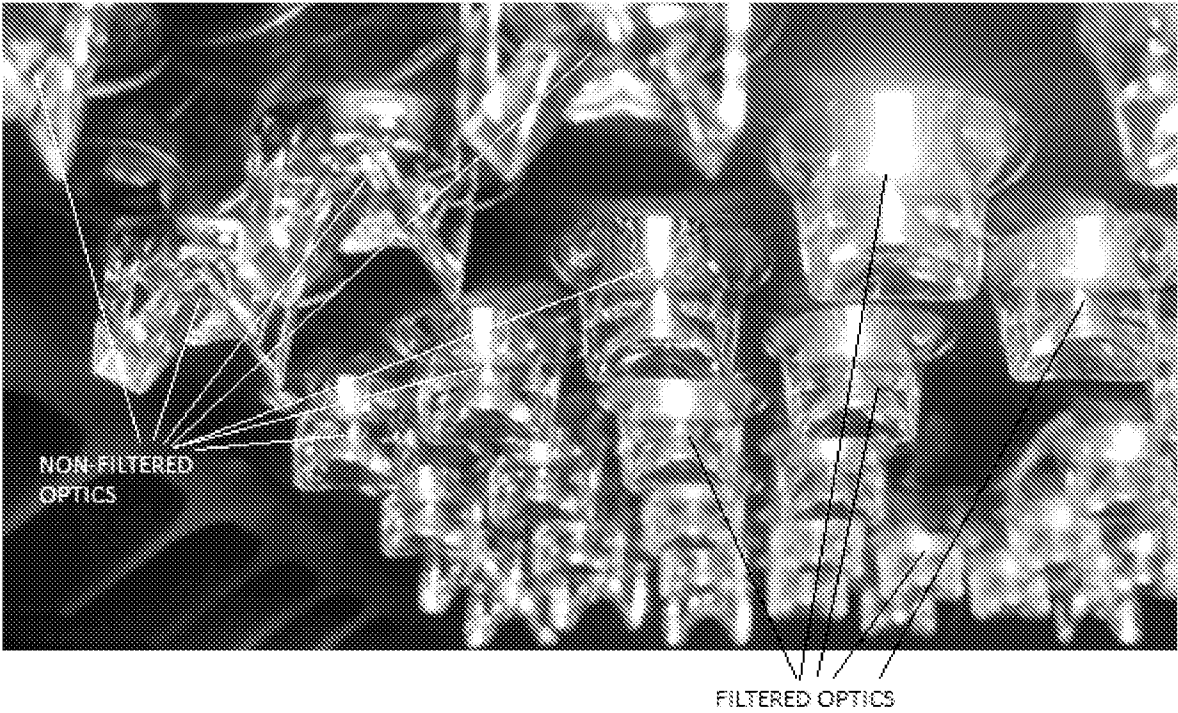


FIG. 11

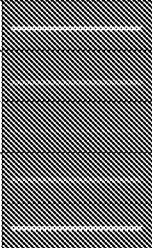
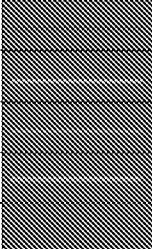
Preset	Power (watts)	CCT	Illuminance	CFI	Illustration Reference	Environmental Zone		XXX
1	116	5612	1399	70		Zone 1	City Centers, Mixed Use Development	1.4
2	112	5538	1236	67				1.4
3	100	5641	1558	70				1.4
4	94	5749	2219	72				1.4
5	88	5737	2101	72				1.4
6	80	5750	2596	72		Zone 2	Low Population Density	1.3
7	74	5582	1085	48				1.3
8	67	5791	2559	73				1.3
9	61	5579	1166	65				1.3
10	54	5794	2603	73				1.3
11	48	5717	1977	71		Zone 3	National Parks and Protected Environments	1.2
12	41	5677	1708	70				1.2

FIG. 12

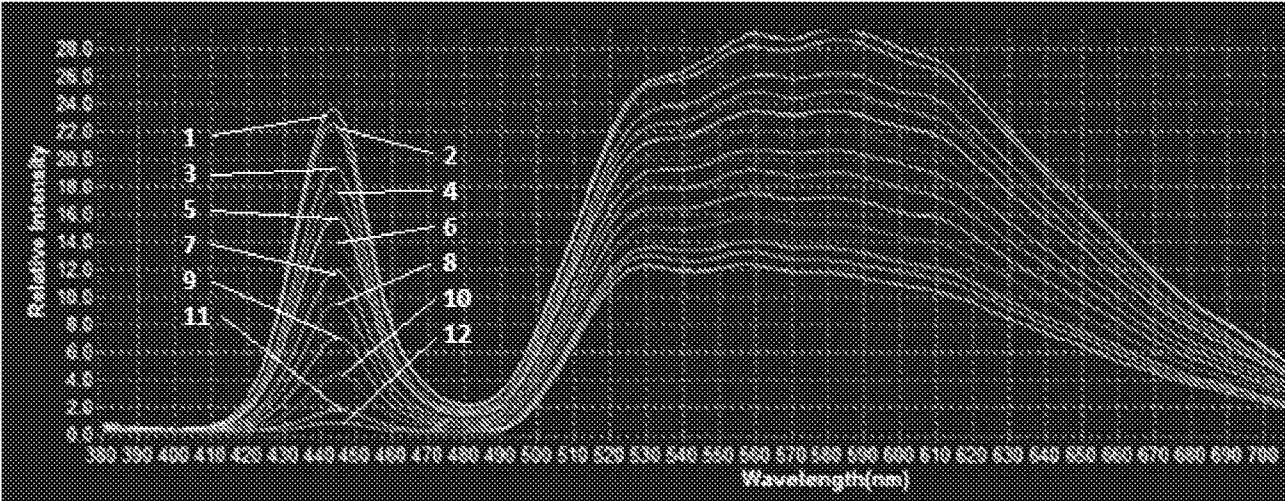


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/018766

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B19/00 A61B19/00 F21K99/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02B A61B F21K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/237361 A1 (SAKAI RYO [JP] ET AL) 23 September 2010 (2010-09-23) paragraph [0019] - paragraph [0025] paragraph [0049] - paragraph [0050]; example 1 table 1	1,3,4
X	----- EP 2 701 213 A1 (TOSHIBA INC KK [JP]; TOSHIBA MATERIALS CO LTD [JP]) 26 February 2014 (2014-02-26) paragraph [0047] - paragraph [0052] paragraph [0054] - paragraph [0058]; example 1 figures 3,19 ----- -/-	1-4



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

13 May 2015

Date of mailing of the international search report

05/08/2015

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

von Hentig, Roger

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/018766

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2013 229593 A (MITSUBISHI CHEM CORP) 7 November 2013 (2013-11-07) abstract paragraph [0011]; claims 1-3 paragraph [0055] - paragraph [0058] paragraph [0089] - paragraph [0090] figures 6,7,8,10,11 -----	1-4
A	US 2006/102914 A1 (SMITS WILLEM H [NL] ET AL) 18 May 2006 (2006-05-18) paragraph [0056] - paragraph [0065] figures 8-11 -----	1,3,4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/018766

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-4

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-4

relate to a lighting device wherein a light source emitting light having a first bandwidth and an optic device coupled to said light source, wherein said single optic device filters light having a preselected sub-range of wavelengths from 435nm to 500nm within said first bandwidth to generate a first filtered light.

2. claims: 5-7

relate to a lighting device having a first and a second light source for emitting light in a second bandwidth.

3. claim: 8

relates to a light filtering material used for packaging a food product.

4. claims: 9-20

relate to a method for fabricating a lighting device including a TIR optic and a luminaire comprising a wavelength shifter for shifting the emission wavelength of a LED light from a range between 400nm and 500nm to a range of equal or greater than 500nm.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2015/018766

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010237361 A1	23-09-2010	KR 20100068446 A TW 200926457 A US 2010237361 A1 WO 2009037848 A1	23-06-2010 16-06-2009 23-09-2010 26-03-2009
EP 2701213 A1	26-02-2014	CN 103493226 A EP 2701213 A1 US 2014036499 A1 WO 2012144087 A1	01-01-2014 26-02-2014 06-02-2014 26-10-2012
JP 2013229593 A	07-11-2013	CN 103843163 A EP 2833422 A1 JP 2013229593 A US 2014362885 A1 WO 2013147195 A1	04-06-2014 04-02-2015 07-11-2013 11-12-2014 03-10-2013
US 2006102914 A1	18-05-2006	CN 101160670 A EP 1866975 A1 JP 2007148332 A KR 20070117689 A TW I393841 B US 2006102914 A1 WO 2006103582 A1	09-04-2008 19-12-2007 14-06-2007 12-12-2007 21-04-2013 18-05-2006 05-10-2006