

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
12 March 2009 (12.03.2009)

PCT

(10) International Publication Number
WO 2009/032500 A1

(51) International Patent Classification:
H04M 1/22 (2006.01)

(21) International Application Number:
PCT/US2008/073127

(22) International Filing Date: 14 August 2008 (14.08.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/846,360 28 August 2007 (28.08.2007) 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, 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, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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

Published:

- with international search report
- with amended claims

(54) Title: APPARATUS FOR SELECTIVELY BACKLIGHTING A MATERIAL

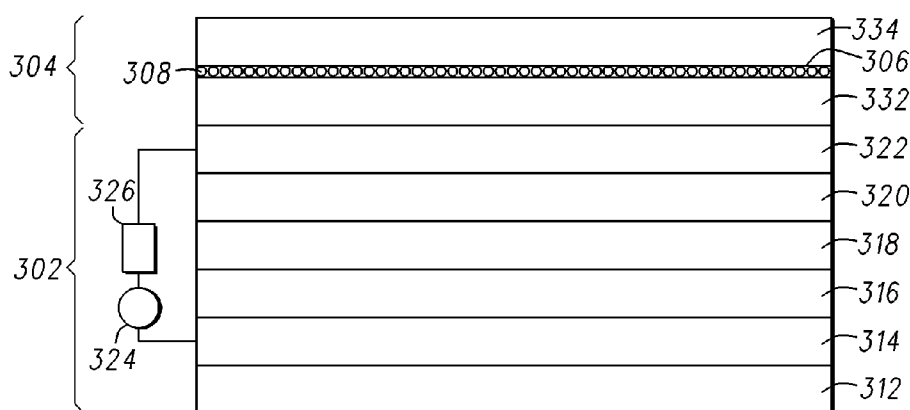


FIG. 3 300

(57) Abstract: A backlighting device (300, 400, 500, 600) emitting light having a first wavelength includes a first radiation emission device (302), e.g., an electroluminescent lamp, for emitting radiation having a second wavelength. A layer (306) of a plurality of photon emitting particles (308), e.g., free standing quantum dots or phosphorus particles, emits light having the first wavelength in response to the first radiation emission device (302), the first wavelength being larger than the second wavelength. A transparent material (116, 120, 122) overlies the layer of a plurality of photon emitting particles (308), wherein the light having a first wavelength passes through the transparent material (116, 120, 122). Optionally, a filter (402) may be placed over the layer (306) to block the radiation having a second wavelength, and a scattering layer (604) may be placed over the layer (306) to scatter wavelength other than the first wavelength. .

APPARATUS FOR SELECTIVELY BACKLIGHTING A MATERIAL

FIELD

[0001] The present invention generally relates to electronic devices and more particularly to a method and apparatus for selectively backlighting a material, for example, a key pad, an icon, or a housing of the electronic devices.

BACKGROUND

[0002] The market for personal electronic devices, for example, cell phones, personal digital assistants (PDA's), digital cameras, and music playback devices (MP3), is very competitive. Manufactures are constantly improving their product with each model in an attempt to reduce costs. Many times these improvements do not relate directly to the functionality of the product.

[0003] The look and feel of personal portable electronic devices is now a key product differentiator and one of the most significant reasons that consumers choose specific models. From a business standpoint, these outstanding designs (form and appearance) increase market share and margin.

[0004] In many portable electronic devices, such as mobile communication devices, individual touch keys, keypads, icons for indicating information, or the housing may be lighted. For keys or a simple icon display on the surface of a housing, for example, light emitting diodes have provided light through a small portion of a surface of the housing to illuminate an icon to a user.

[0005] However, it is desired to consume as little power as possible while maximizing luminance and achieving a more exact wavelength of the emitted light.

[0006] Accordingly, it is desirable to provide a method and apparatus for selectively backlighting a material. Furthermore, other desirable features and characteristics of the present invention will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Embodiments of the present invention will hereinafter be described in conjunction with the following drawing figures, wherein like numerals denote like elements, and

[0008] FIG. 1 is an isometric view of a portable communication device configured to incorporate the exemplary embodiments; and

[0009] FIG. 2 is a block diagram of one possible portable communication device of FIG. 1.

[0010] FIG. 3 is a partial cross sectional view of a first exemplary embodiment;

[0011] FIG. 4 is a partial cross sectional view of a second exemplary embodiment;

[0012] FIG. 5 is a partial cross sectional view of a third exemplary embodiment; and

[0013] FIG. 6 is a partial cross sectional view of a fourth exemplary embodiment;

DETAILED DESCRIPTION

[0014] A combination of light emitting particles formed over a light (radiation) source emitting in the UV or blue spectrum, for example, is used to backlight individual touch keys, keypads, icons, or the housing of an electronic device. In one exemplary embodiment of the light emitting device, an electroluminescent (EL) lamp provides light preferably in the blue spectrum to activate free standing quantum dots (FSQDs) that provide light having a predetermined and specific wavelength. In another exemplary embodiment, a filter is positioned over the light emitting particles to block the light emitted from the light emitting source, thereby ensuring that only light from the light emitting particles emit from the light emitting device. In yet another exemplary embodiment, two light sources are positioned adjacent light emitting particles for modulating the color emitted from the light emitting device. In still another exemplary embodiment, a layer of scattering particles are positioned over the light emitting particles for enabling selective tailoring of color and brightness.

[0015] Though the electronic device may comprise any device in which an external user interface is desired, FIG. 1 is an isometric view of an electronic device 110 comprising a display 112, a control panel 114 including a plurality of touch keys 116, and a speaker 118, all encased in a housing 120. In some embodiments, an icon 122 may be included for providing an indication of a status when lighted. In accordance with an exemplary embodiment, a light emitting device (subsequently described in detail) provides a backlight for one or more of the individual touch keys 116, the entire control panel 114, or at least a portion of the housing 120. Some electronic devices 110, e.g., a cell phone, may include other elements such as an antenna, a microphone, and a camera (none shown). Furthermore, while the preferred exemplary embodiment of an electronic device is described as a mobile communication device, for example, cellular telephones, messaging devices, and mobile data terminals, other embodiments are envisioned, for example, personal digital assistants (PDAs), computer monitors, gaming devices, video gaming devices, cameras, and DVD players.

[0016] Referring to FIG. 2, a block diagram of an electronic device 210 such as a cellular phone, in accordance with the exemplary embodiment is depicted. Though the exemplary embodiment is a cellular phone, the display described herein may be used with any electronic device in which information, colors, or patterns are to be presented through light emission. The portable electronic device 210 includes an antenna 212 for receiving and transmitting radio frequency (RF) signals. A receive/transmit switch 214 selectively couples the antenna 212 to receiver circuitry 216 and transmitter circuitry 218 in a manner familiar to those skilled in the art. The receiver circuitry 216 demodulates and decodes the RF signals to derive information therefrom and is coupled to a controller 220 for providing the decoded information thereto for utilization in accordance with the function(s) of the portable communication device 210. The controller 220 also provides information to the transmitter circuitry 218 for encoding and modulating information into RF signals for transmission from the antenna 212. As is well-known in the art, the controller 220 is typically coupled to a memory device 222 and a user interface 114 to perform the functions of the portable electronic device 210. Power control circuitry 226 is coupled to the components of the portable communication device 210, such as the controller 220, the receiver circuitry 216, the transmitter circuitry 218 and/or the user interface 114, to provide appropriate operational voltage and current to those components. The user interface 114 includes a microphone 228, a speaker 118 and one or more touch key inputs 116, and the icon 122. The user interface 114 also includes a display 112 which could receive touch screen inputs.

[0017] In accordance with the exemplary embodiments, the controller determines when to activate the backlighting of the user interface 214, icons 116, or housing 120. For example, when a call is received, the backlight may illuminate the housing. Or when a text message is received, the icon may be illuminated to indicate the desired information.

[0018] Referring to FIG. 3, a first exemplary embodiment of the backlighting device 300 for backlighting a keypad, an icon, or at least a portion of the housing thereof includes a light emitting device 304 including a layer 306 of light emitting

particles 308 formed over a light emitting source 302. The light emitting source 302 may emit light having a wavelength preferably in the UV or blue spectrum, but at least having a wavelength equal to or shorter than the wavelength for which the light emitting particles 308 are capable of emitting. The layer 306 of light emitting particles 308 includes any particles capable of emitting light when activated, including preferably free standing quantum dots (FSQDs).

[0019] The light emitting source 302 preferably is an electroluminescent (EL) lamp, which is basically a luminescent capacitor. By applying alternating voltage to the electrodes, phosphor particles that are dispersed in dielectric get excited and emit light. An EL lamp is a solid state, low power, uniform area light source with a thin profile. By applying alternating voltage to the electrodes, phosphor particles that are dispersed in dielectric get excited and emit light through a transparent electrode. EL is an effective thin lighting solution that is used to backlight applications that need to be visible in dark conditions.

[0020] EL lamps offer significant advantages over point light sources such as discrete light emitting diodes (LEDs). For example, the high LED count that is required to evenly light large liquid crystal displays (LCDs) consumes more current than an alternative EL backlight system. In addition, LED solutions normally require a complex light guide design to distribute the light more uniformly across the viewing area of a display. This combination of LEDs and light guide is generally three to four times thicker than an EL lamp solution.

[0021] EL lamps provide many other advantages over LEDs, including uniform lighting, low power consumption and lower heat emission, a thin profile, flexibility and conformability, emission in a wide range of colors, and reliability.

[0022] The light emitting particles 308 in this embodiment are free standing quantum dots (FSQDs), or semiconductor nanocrystallites, whose radii are smaller than the bulk exciton Bohr radius and constitute a class of materials intermediate between molecular and bulk forms of matter. FSQDs are known for the unique

properties that they possess as a result of both their small size and their high surface area. For example, FSQDs typically have larger absorption cross-sections than comparable organic dyes, higher quantum yields, better chemical and photochemical stability, narrower and more symmetric emission spectra, and a larger Stokes shift. Furthermore, the absorption and emission properties vary with the particle size and can be systematically tailored. It has been found that a Cadmium Selenide (CdSe) quantum dot, for example, can emit light in any monochromatic, visible color, where the particular color characteristic of that dot is dependent on the size of the quantum dot.

[0023] FSQDs are easily incorporated into or on other materials such as polymers and polymer composites because FSQDs can be made to be soluble in a variety of media and have little degradation over time. These properties allow FSQD polymers and polymer composites to provide very bright displays, returning almost 100% quantum yield.

[0024] Applications for FSQD polymers and polymer composites include point of purchase and point of sale posters, mobile device housings or logos, segmented displays, including ultraviolet (UV) and infrared (IR) displays, absorbers for UV and IR sensors or detectors, and light emitting diodes (LEDs). Although the visible advantages inherent to FSQD polymers and polymer composites are attractive, control of the output (light intensity) is problematic.

[0025] Quantum Dots (QDs), also known as nanocrystals or Freestanding Quantum Dots (FSQD), are semiconductors composed of periodic groups of II-VI, III-V, or IV-VI materials, for example, CdS, CdSe, CdTe, ZnS, ZnSe, ZnTe, GaAs, GaP, GaAs, GaSb, HgS, HgSe, HgTe, InAs, InP, InSb, AlAs, AlP, AlSb. Alternative FSQDs materials that may be used include but are not limited to tertiary microcrystals such as InGaP, which emits in the yellow to red wavelengths (depending on the size) and ZnSeTe, ZnCdS, ZnCdSe, and CdSeS which emits from blue to green wavelengths. Multi-core structures are also possible such as ZnSe/ZnXS/ZnS, are also possible where X represents Ag, Sr, Te, Cu, or Mn. The

inner most core is made of ZnSe, followed by the second core layer of ZnXS, completed by an external shell made of ZnS.

[0026] FSQDs range in size from 2-10 nanometers in diameter (approximately 10^2 - 10^7 total number of atoms). At these scales, FSQDs have size-tunable band gaps, in other words their spectral emission depends upon size. Whereas, at the bulk scale, emission depends solely on the composition of matter. Other advantages of FSQDs include high photoluminescence quantum efficiencies, good thermal and photo-stability, narrow emission line widths (atom-like spectral emission), and compatibility with solution processing. FSQDs are manufactured conventionally by using colloidal solution chemistry.

[0027] FSQDs may be synthesized with a wider band gap outer shell, comprising for example ZnO, ZnS, ZnSe, ZnTe, CdO, CdS, CdSe, CdTe, MgS, MgSe, GaAs, GaN, GaP, GaSb, HgO, HgS, HgSe, HgTe, InAs, InN, InP, InSb, AlAs, AlN, AlP, AlSb. The shell surrounds the core FSQDs and results in a significant increase in the quantum yield. Capping the FSQDs with a shell reduces non-radiative recombination and results in brighter emission. The surface of FSQDs without a shell has both free electrons in addition to crystal defects. Both of these characteristics tend to reduce quantum yield by allowing for non-radiative electron energy transitions at the surface. The addition of a shell reduces the opportunities for these non-radiative transitions by giving conduction band electrons an increased probability of directly relaxing to the valence band. The shell also neutralizes the effects of many types of surface defects. The FSQDs are more thermally stable than organic phosphors since UV light will not chemically breakdown FSQDs. The exterior shell can also serve as an anchor point for chemical bonds that can be used to modify and functionalize the surface.

[0028] Due to their small size, typically on the order of 10 nanometers or smaller, the FSQDs have larger band gaps relative to a bulk material. It is noted that the smaller the FSQDs, the higher the band gap. Therefore, when impacted by a photon (emissive electron-hole pair recombination), the smaller the diameter of

the FSQDs, the shorter the wavelength of light will be released. Discontinuities and crystal defects on the surface of the FSQD result in non-radiative recombination of the electron-hole pairs that lead to reduced or completely quenched emission of the FSQD. An overcoating shell, e.g., ZnS, having a thickness, e.g., of up to 5 monolayers and higher band gap compared to the core's band gap is optionally provided around the FSQDs core to reduce the surface defects and prevent this lower emission efficiency. The band gap of the shell material should be larger than that of the FSQDs to maintain the energy level of the FSQDs. Capping ligands (molecules) on the outer surface of the shell allow the FSQDs to remain in the colloidal suspension while being grown to the desired size. The FSQDs may then be placed within the display by a printing process, for example. Additionally, a light (radiation) source (preferably a ultra violet (UV) source) is disposed to selectively provide photons to strike the FSQDs, thereby causing the FSQDs to emit a photon at a frequency comprising the specific color as determined by the size tunable band gap of the FSQDs.

[0029] A layer comprising a plurality of FSQDs disposed between an electron transport layer (or hole blocking layer) and a hole transport layer. Application of a voltage potential across the structure will create a saturation of a larger population of electron or hole pairs (excitons) that quenches the emission of the photonicly excited emission. The light from the light source excites electrons from the ground state of the FSQDs into a higher electric energy/vibration state. The applied electric field of the voltage potential injects the electrons into free holes (including those in the ground energy state), prohibiting the electrons in a higher energy state to return to the ground energy state. Since photon emission only occurs when the electron relaxes into the ground-level energy state, photon emission is reduced. The level of photon emission from the FSQDs may be controlled by varying the voltage potential.

[0030] The exemplary embodiments described herein may be fabricated using known lithographic processes as follows. The fabrication of integrated circuits, microelectronic devices, micro electro mechanical devices, microfluidic devices,

and photonic devices, involves the creation of several layers of materials that interact in some fashion. One or more of these layers may be patterned so various regions of the layer have different electrical or other characteristics, which may be interconnected within the layer or to other layers to create electrical components and circuits. These regions may be created by selectively introducing or removing various materials. The patterns that define such regions are often created by lithographic processes. For example, a layer of photoresist material is applied onto a layer overlying a wafer substrate. A photomask (containing clear and opaque areas) is used to selectively expose this photoresist material by a form of radiation, such as ultraviolet light, electrons, or x-rays. Either the photoresist material exposed to the radiation, or that not exposed to the radiation, is removed by the application of a developer. An etch may then be applied to the layer not protected by the remaining resist, and when the resist is removed, the layer overlying the substrate is patterned. Alternatively, an additive process could also be used, e.g., building a structure using the photoresist as a template.

[0031] Though various lithography processes, e.g., photolithography, electron beam lithography, and imprint lithography, ink jet printing, may be used to fabricate the light emitting device, a printing process is preferred. In the printing process, the FSQD ink in liquid form is printed in desired locations on the substrate. Ink compositions typically comprise four elements: 1) functional element, 2) binder, 3) solvent, and 4) additive. Graphic arts inks and functional inks are differentiated by the nature of the functional element, i.e. the emissive quantum dot. The binder, solvent and additives, together, are commonly referred to as the carrier which is formulated for a specific printing technology e.g. tailored rheology. The function of the carrier is the same for graphic arts and printed electronics: dispersion of functional elements, viscosity and surface tension modification, etc. One skilled in the art will appreciate that an expanded color range can be obtained by using more than three quantum dot inks, with each ink having a different mean quantum dot size. A variety of printing techniques, for example, Flexo, Gravure, Screen, inkjet may be used. The Halftone method, for example, allows the full color range to be realized in actual printing.

[0032] The following detailed description is merely exemplary in nature and is not intended to limit the invention or the application and uses of the invention. Furthermore, there is no intention to be bound by any theory presented in the preceding background or the following detailed description.

[0033] In a first exemplary embodiment of the backlighting device 300, depicted in FIG. 3, an EL device (light emitting source) 302 includes a substrate 312 that has a bottom electrode 314 situated thereon. The substrate 312 and electrode 314 do not need to be optically transmissive, because the light is emitted from the opposite side of the device 302, that is, not through the substrate and electrode. A layer of electroluminescent material 318 (phosphor) and a dielectric layer 316 are situated between the bottom electrode 314 and a top electrode 322. A source of alternating voltage 324 is coupled to the top and bottom electrodes to energize the electroluminescent material when selected by activation of the switch 326. An optically transmissive insulating or dielectric layer 320 is disposed between the top electrode and the phosphor 318.

[0034] The light emitting device 304 includes a substrate 332 that includes one or more layer, typically provided as support for a layer 306 of FSQDs 308, or protection of device 302, or both. The substrate 332 is formed of a transparent, sturdy, thin material such as glass, ceramic, insulated metal, but may comprise a flexible polymer such as polyethylene terephthalate (PET) or polyethylene naphthalate (PEN). An optional structure 334 is provided as a protective layer over the layer 306.

[0035] When the layer 306 of the plurality of FSQDs 308 are impacted with light, from the EL device 302, having a wavelength shorter than that which would be emitted by the FSQDs 308, an electron in each of the FSQDs 308 so impacted is excited to a higher level. When the electron falls back to its ground state, a photon is emitted having a wavelength determined by the diameter of the FSQD 308.

[0036] It is understood that the light source 302 may be positioned in any location wherein its output may be applied to the light emitting device 304, and may comprise any frequency below that provided as output from the FSQDs 308, but preferably comprises either a wavelength in the blue or ultraviolet (UV) spectrum. It is recognized that the substrate 332 may comprise a rigid structure or a flexible structure.

[0037] FIG. 4 is a partial cross section of a second exemplary embodiment of a backlighting device 400 having a filter 402 disposed over the backlighting device 300 as shown in FIG. 3 (elements in FIG. 4 similar to those of FIG. 3 have the same reference numeral). The filter 402 filters the light emitted from the EL device 302, thereby allowing only the light from the FSQDs 308 to be emitted from the backlighting device 400. For example, if the EL device 302 emits blue light and the FSQDs 308 emit red light, the filter will block the blue light. Only the red light will be emitted from the backlighting device 400. It will be appreciated by one skilled in the art that other constructions are possible. For example, filter 402 may be placed between layer 302 and layer 306 when device 302 has substantial emission in the UV. In this case, filter 402 transmits the desired UV radiation, but blocks the visible radiation. Other configurations with multiple filters are also possible. Furthermore, the filter 402 may function as a protective layer, eliminating the need for the layer 334.

[0038] FIG. 5 is a partial cross section of a third exemplary embodiment of a backlighting device 500 having a second EL device (light emitting source) 302' disposed on the bottom of the backlighting device 300, and more specifically on the bottom of the EL device 302 opposed to the light emitting device 304 (elements in FIG. 5 similar to those of FIG. 3 have the same reference numeral). In this embodiment, EL device 302 and light emitting device 304 will be transparent to the wavelength of light emitting from EL device 302'.

[0039] An example of the operation of this third exemplary embodiment is where the EL device 302' produces green light, the EL device 302 produces mostly

blue light with elements of green, and the FSQDs 308 have a diameter that produces green light (note the wavelength of blue is shorter than green). The blue light from the EL device 302 excites the FSQDs 308, thereby causing green light to be emitted from the backlighting device 500. Any green light emitted from the EL device 302' will not be absorbed by the FSQDs and will also be emitted from the backlighting device 500. The voltages 324, 324' may be adjusted for controlling the intensity of the green light emitted from the backlighting device 500. It will be appreciated by one skilled in the art that all electrodes and substrates in device 302 should be transmissive in some degree to the emitted radiation from device 302'. Or, in some manner, the light from device 302' is passed to the viewer in combination with the light emitted from layer 308. A benefit from this construction is that multiple colors can be obtained by combining colors from layer 308 and devices 302 and 302'.

[0040] FIG 6 is a partial cross section of a fourth exemplary embodiment of a backlighting device 600 having a layer 602 including scattering particles 604 disposed over the backlighting device 300 as shown in FIG. 3 (elements in FIG. 6 similar to those of FIG. 3 have the same reference numeral). The scattering particles 604 may be of different dimensions, but will have a diameter equal to or smaller than the scattered radiation wavelength. Therefore, the scattering particles 604 will scatter the light from the EL device 302 away from the viewer (and any ambient light entering the backlighting device 600 back toward the viewer), but will not scatter the light from the FSQDs 308 toward the viewer. This scattering will allow for a light emitted from the backlighting device 600 to be more closely aligned with the wavelength of the FSQDs 308 and enhances the brightness from layer 306 in cases where backscattering of ambient light toward the viewer is desirable. It should be recognized that the layer of photon emitting particles 308, in addition to FSQDs, may alternatively comprise other photon emitting material such as phosphorous particles.

[0041] The FSQDs 308 in any of the embodiments may include FSQDs having two or more wavelengths, which would provide various desired colors depending

on the size of the FSQDs and/or a mix of different compositions of matter. Furthermore, the EL devices 302, 302' could include a plurality of segments, each emitting a different color.

[0042] This scattering, known as Mie and Rayleigh scattering, may be accomplished by integrating particles into a polymeric, e.g., silicone, key pad to enable selective tailoring of key pad color and brightness. The scattering particles may be formed over the light emissive particles, as shown in FIG. 6, or mixed in with the light emissive particles. Rayleigh scattering, which is a limiting case of Mie scattering, is applicable when the radius (r) of the scattering sphere is much smaller than the wavelength (λ) of the incident light,. This represents a practical lower limit to the size of the scattering particles.

[0043] The amount of Rayleigh scattering that occurs to light is dependent upon the size of the particles and the wavelength of the light. The scattering coefficient, and therefore the intensity of the scattered light, varies for small size parameter inversely with the fourth power of the wavelength. The intensity I of light scattered by small particles from a beam of unpolarized light of wavelength λ and intensity I_0 is given by:

$$I = I_0 \times N_0 \times \frac{1 + \cos^2 \theta}{2R^2} \left(\frac{2\pi}{\lambda} \right)^4 \left(\frac{n^2 - 1}{n^2 + 1} \right)^2 \left(\frac{d}{2} \right)^6$$

where R is the distance to the scattering particles, θ is the scattering angle, n is the refractive index of the particle, N_0 is Avogadro's number, and d is the diameter of the particle. For example, in the ideal case $I/I_0 = 1$ (no losses), $\theta = 0$ (direct view), $R = 8$ inches (2.03 E8 nm) (typical distance), $\lambda = 630$ nm (wavelength for the color red), $n = n_2/n_1$, $n_1 = 1.41$ (silicone), and $n_2 = 1.45716$ (silica), the particle size $d = 9.8$ nanometers.

[0044] The strong wavelength dependence of the scattering ($\sim \lambda^{-4}$) means that blue light is scattered much more than red light, i.e., scattering is more effective at

short wavelengths. Furthermore, Rayleigh and Mie scattering can be considered to be elastic scattering since the photon energies of the scattered photons is not changed. Mie scattering is less dependent on wavelength and is more effective when the size of the particle approaches the wavelength of the radiation to be scattered. Mie scattering represents a practical upper boundary for forward scattering the light. Thus, to forward scatter 630 nm light a practical particle size range is between 10 nm and 630 nm.

[0045] While at least one exemplary embodiment has been presented in the foregoing detailed description, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing an exemplary embodiment of the invention, it being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope of the invention as set forth in the appended claims.

CLAIMS

1. A backlighting device for emitting light having a first wavelength, comprising:
 - a first radiation emission device for emitting radiation having a second wavelength; and
 - a layer of a plurality of photon emitting particles emitting light having the first wavelength in response to the first radiation emission device, the first wavelength being larger than the second wavelength.
2. The backlighting device of claim 1 further comprising a transparent material overlying the layer through which the light having a first wavelength passes.
3. The backlighting device of claim 1 further comprising a filter disposed over the layer of a plurality of photon emitting particles that prevents the radiation having a second frequency from passing therethrough while allowing the light to pass therethrough.
4. The backlighting device of claim 1 further comprising a layer including scattering particles disposed over the layer of a plurality of photon emitting particles that scatters the radiation and light having wavelength other than the first wavelength.
5. The backlighting device of claim 1 further comprising a second radiation emission device disposed on a side of the first radiation emission device opposed to the layer of a plurality of photon emitting particles, for emitting light having the first wavelength.
6. The backlighting device of claim 1 wherein the transparent material comprises one of a touch key, an icon, and at least a portion of a housing of an electronic device.

7. The backlighting device of claim 1 wherein the first radiation emission device comprises an electroluminescent lamp.
8. The backlighting device of claim 1 wherein the layer comprises free standing quantum dots.
9. The backlighting device of claim 1 wherein the layer comprises phosphorus particles.

10. A backlighting device emitting light having a first wavelength, comprising:
 - a first radiation emission device for emitting radiation having a second wavelength; and
 - a layer of a plurality of free standing quantum dots emitting light having the first wavelength in response to being impacted by the light having a second wavelength, the first wavelength being larger than the second wavelength.
11. The backlighting device of claim 10 further comprising a transparent material overlying the layer of a plurality of photon emitting particles, wherein the light having a first wavelength passes through the transparent material.
12. The backlighting device of claim 10 further comprising a filter disposed over the layer of a plurality of photon emitting particles that prevents the light having a second wavelength from passing therethrough while allowing the light having a first wavelength to pass therethrough.
13. The backlighting device of claim 10 further comprising a layer including scattering particles disposed over the layer of a plurality of photon emitting particles that scatters the light having a second wavelength.
14. The backlighting device of claim 10 further comprising a second electroluminescent lamp disposed contiguous to the first electroluminescent lamp, for emitting light having the first wavelength.
15. The backlighting device of claim 11 wherein the transparent material comprises one of a touch key, an icon, and at least a portion of a housing of an electronic device.

16. A backlighting device emitting light having a first wavelength, comprising:
- a first radiation emission device for emitting radiation having a second wavelength; and
 - a layer of a plurality of photon emitting particles emitting light having the first wavelength in response to the first radiation emission device, the first wavelength being larger than the second wavelength, the photon emitting particles comprising one of free standing quantum dots and phosphorus particles.
17. The backlighting device of claim 16 further comprising a transparent material overlying the layer of a plurality of photon emitting particles, wherein the light having a first wavelength passes through the transparent material.
18. The backlighting device of claim 16 further comprising a filter disposed over the layer of a plurality of photon emitting particles that prevents the radiation having a second frequency from passing therethrough while allowing the light to pass therethrough.
19. The backlighting device of claim 16 further comprising a layer including scattering particles disposed over the layer of a plurality of photon emitting particles that scatters the radiation and light having wavelength other than the first wavelength.
20. The backlighting device of claim 16 further comprising a second radiation emission device disposed on a side of the first radiation emission device opposed to the layer of a plurality of photon emitting particles, for emitting light having the first wavelength.
21. The backlighting device of claim 17 wherein the transparent material comprises one of a touch key, an icon, and at least a portion of a housing of an electronic device.

22. The backlighting device of claim 16 wherein the first radiation emission device comprises an electroluminescent lamp.

AMENDED CLAIMS

received by the International Bureau on 07 January 2009 (07.01.2009)

1. A backlighting device for emitting light having a first wavelength, comprising:
an electroluminescent lamp for emitting radiation having a second wavelength; and
a layer of quantum dots emitting light having the first wavelength in response to the first radiation emission device, the first wavelength being larger than the second wavelength.
2. The backlighting device of claim 1 further comprising a transparent material overlying the layer of quantum dots through which the light having a first wavelength passes.
3. The backlighting device of claim 1 further comprising a filter disposed over the layer of quantum dots that prevents the radiation having a second frequency from passing through while allowing the light to pass through.
4. The backlighting device of claim 1 further comprising a layer of scattering particles disposed over the layer of quantum dots that scatters the radiation and light having wavelength other than the first wavelength.
5. The backlighting device of claim 1 further comprising a second radiation emission device disposed on a side of the first radiation emission device opposed to the layer of quantum dots, for emitting light having the first wavelength.
6. The backlighting device of claim 1 wherein the transparent material comprises one of a touch key, an icon, and at least a portion of a housing of an electronic device.
7. The backlighting device of claim 1 wherein the layer of quantum dots further comprises phosphorus particles.

8. A backlighting device emitting light having a first wavelength, comprising:
 an electroluminescent lamp for emitting radiation having a second wavelength; and
 a layer of a plurality of free standing quantum dots emitting light having the first wavelength in response to being impacted by the light having a second wavelength, the first wavelength being larger than the second wavelength.
9. The backlighting device of claim 8 further comprising a transparent material overlying the layer of a plurality of photon emitting particles, wherein the light having a first wavelength passes through the transparent material.
10. The backlighting device of claim 8 further comprising a filter disposed over the layer of a plurality of photon emitting particles that prevents the light having a second wavelength from passing through while allowing the light having a first wavelength to pass through.
11. The backlighting device of claim 8 further comprising a layer including scattering particles disposed over the layer of a plurality of photon emitting particles that scatters the light having a second wavelength.
12. The backlighting device of claim 8 further comprising a second electroluminescent lamp disposed contiguous to the first electroluminescent lamp, for emitting light having the first wavelength.
13. The backlighting device of claim 9 wherein the transparent material comprises one of a touch key, an icon, and at least a portion of a housing of an electronic device.

14. A backlighting device emitting light having a first wavelength, comprising:
an electroluminescent lamp for emitting radiation having a second wavelength; and
a layer of quantum dots and phosphorus particles emitting light having the first wavelength in response to the first radiation emission device, the first wavelength being larger than the second wavelength.
15. The backlighting device of claim 14 further comprising a transparent material overlying the layer of quantum dots and phosphorus particles, wherein the light having a first wavelength passes through the transparent material.
16. The backlighting device of claim 14 further comprising a filter disposed over the layer of quantum dots and phosphorus particles that prevents the radiation having a second frequency from passing through while allowing the light to pass through.
17. The backlighting device of claim 14 further comprising a layer including scattering particles disposed over the layer of quantum dots and phosphorus particles that scatters the radiation and light having wavelength other than the first wavelength.
18. The backlighting device of claim 14 further comprising a second radiation emission device disposed on a side of the electroluminescent lamp opposed to the layer of quantum dots and phosphorus particles, for emitting light having the first wavelength.
19. The backlighting device of claim 15 wherein the transparent material comprises one of a touch key, an icon, and at least a portion of a housing of an electronic device.

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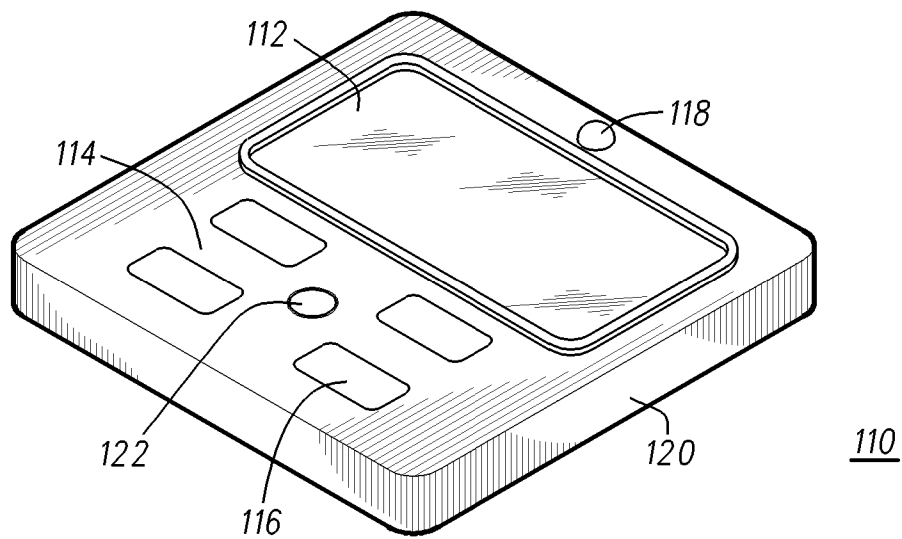


FIG. 1

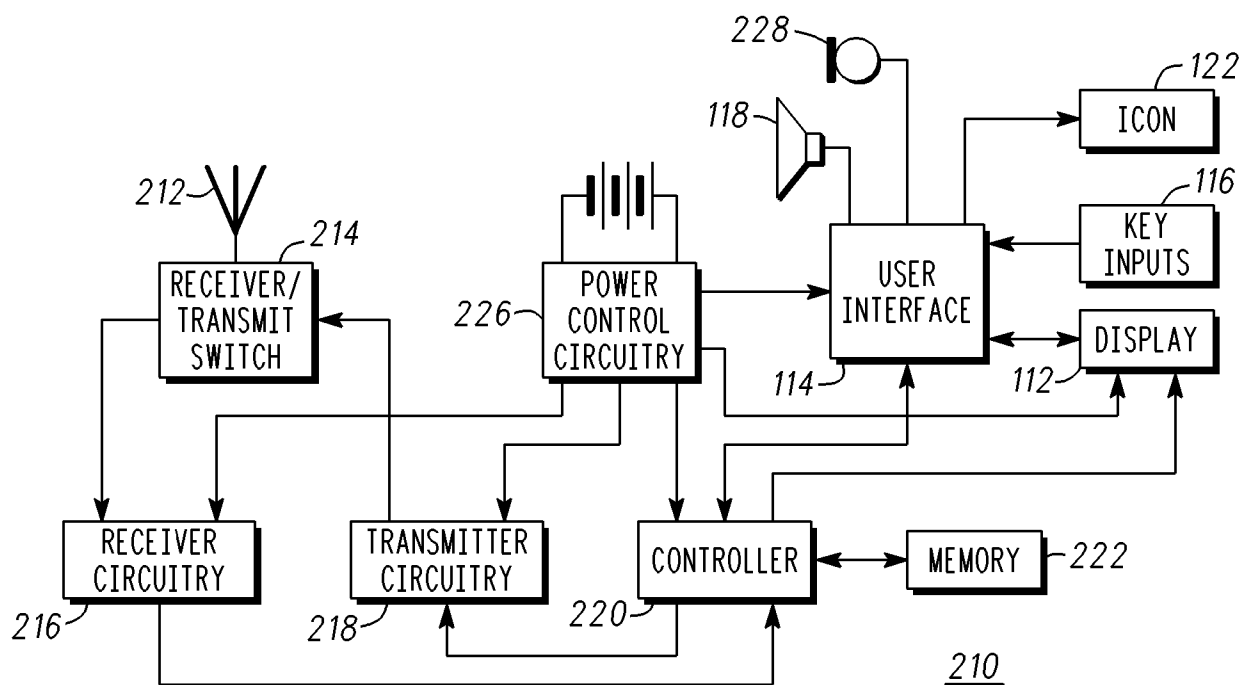


FIG. 2

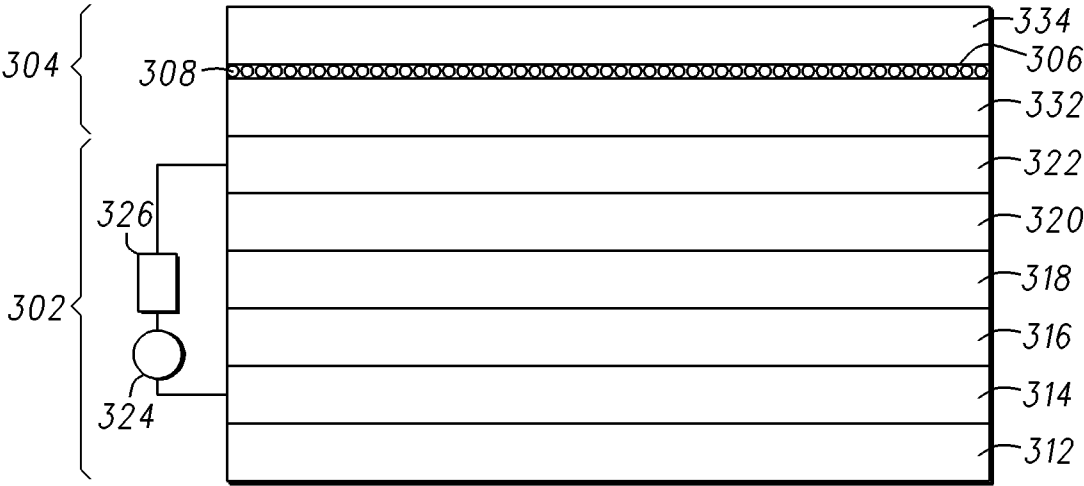


FIG. 3 300

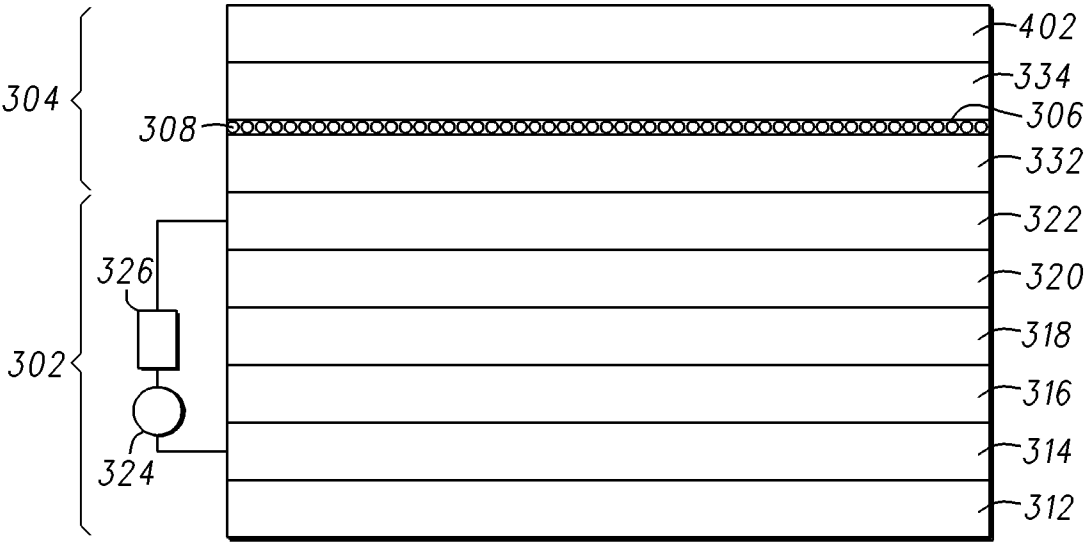


FIG. 4 400

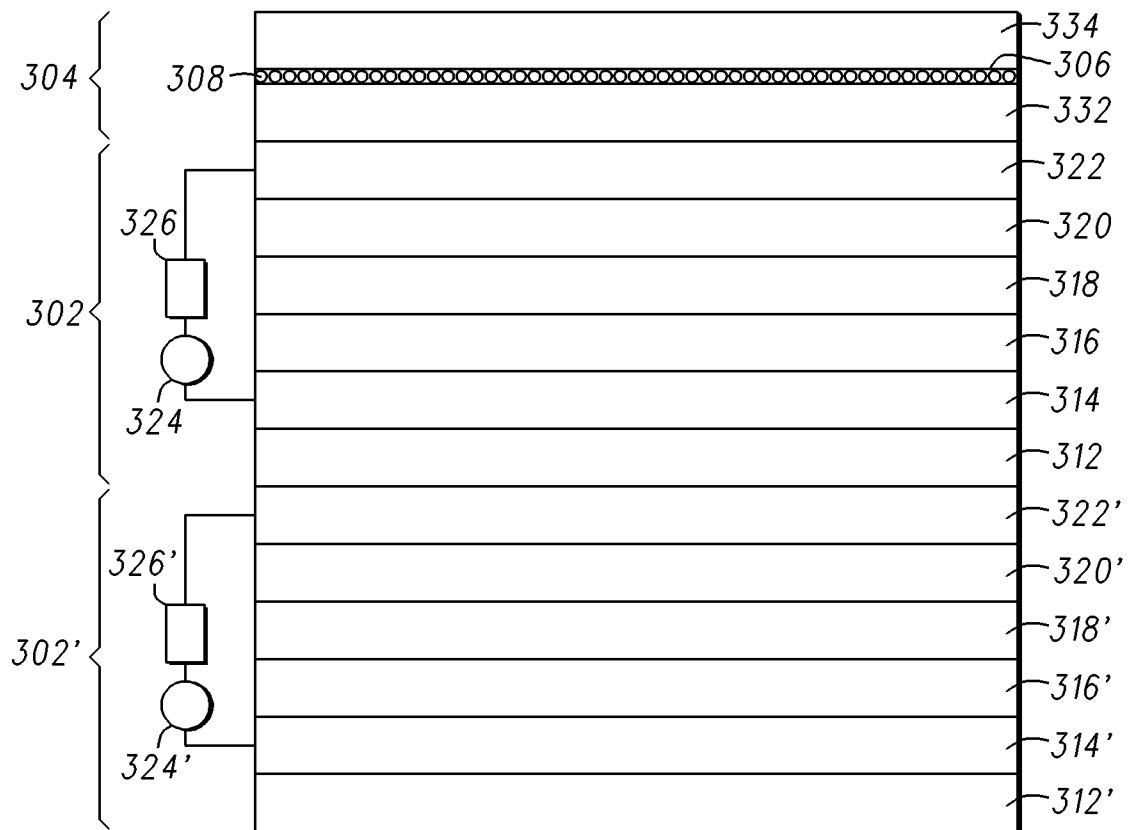


FIG. 5 500

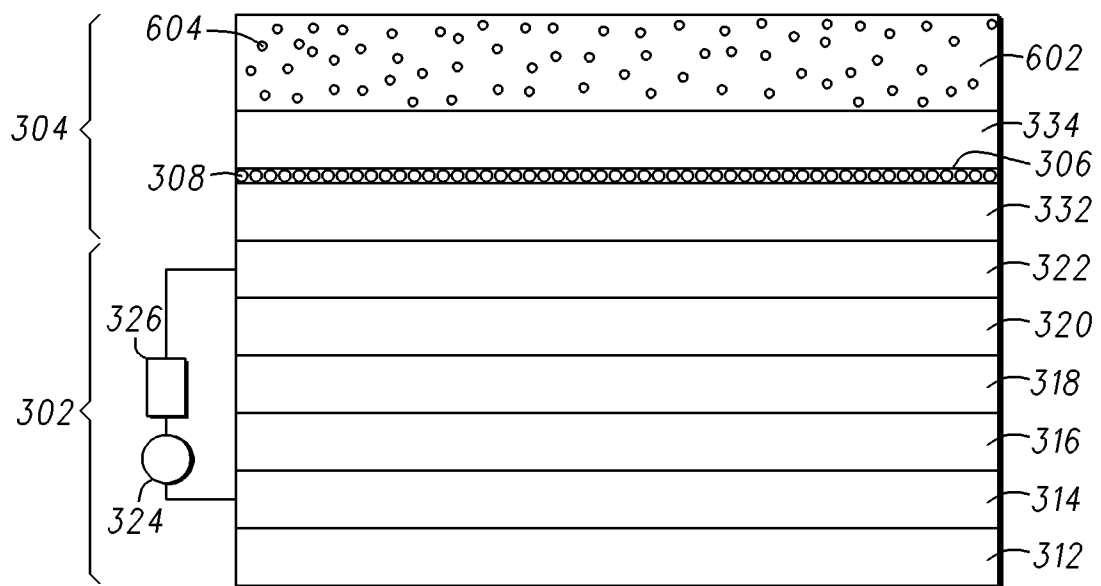


FIG. 6 600

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2008/073127

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04M1/22

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)

H04M

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 practical, search terms used)

EPO-Internal, COMPENDEX, 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 2007/081329 A1 (CHUA JANET B Y [MY] ET AL) 12 April 2007 (2007-04-12) abstract figure 4 paragraph [0024] - paragraph [0036]	1-5, 7-14, 16-20,22
Y	-----	6,15,21
X	JP 11 224556 A (PORIMATEC KK) 17 August 1999 (1999-08-17) abstract figure 1	1-3,6,7, 9,16-18, 21,22
Y	-----	6,15,21
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

21 October 2008

Date of mailing of the international search report

03/12/2008

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INTERNATIONAL SEARCH REPORT

International application No

PCT/US2008/073127

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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International application No

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