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(54) **WHITE LIGHT EMITTING DEVICE WITH
DIMMING CONTROL**

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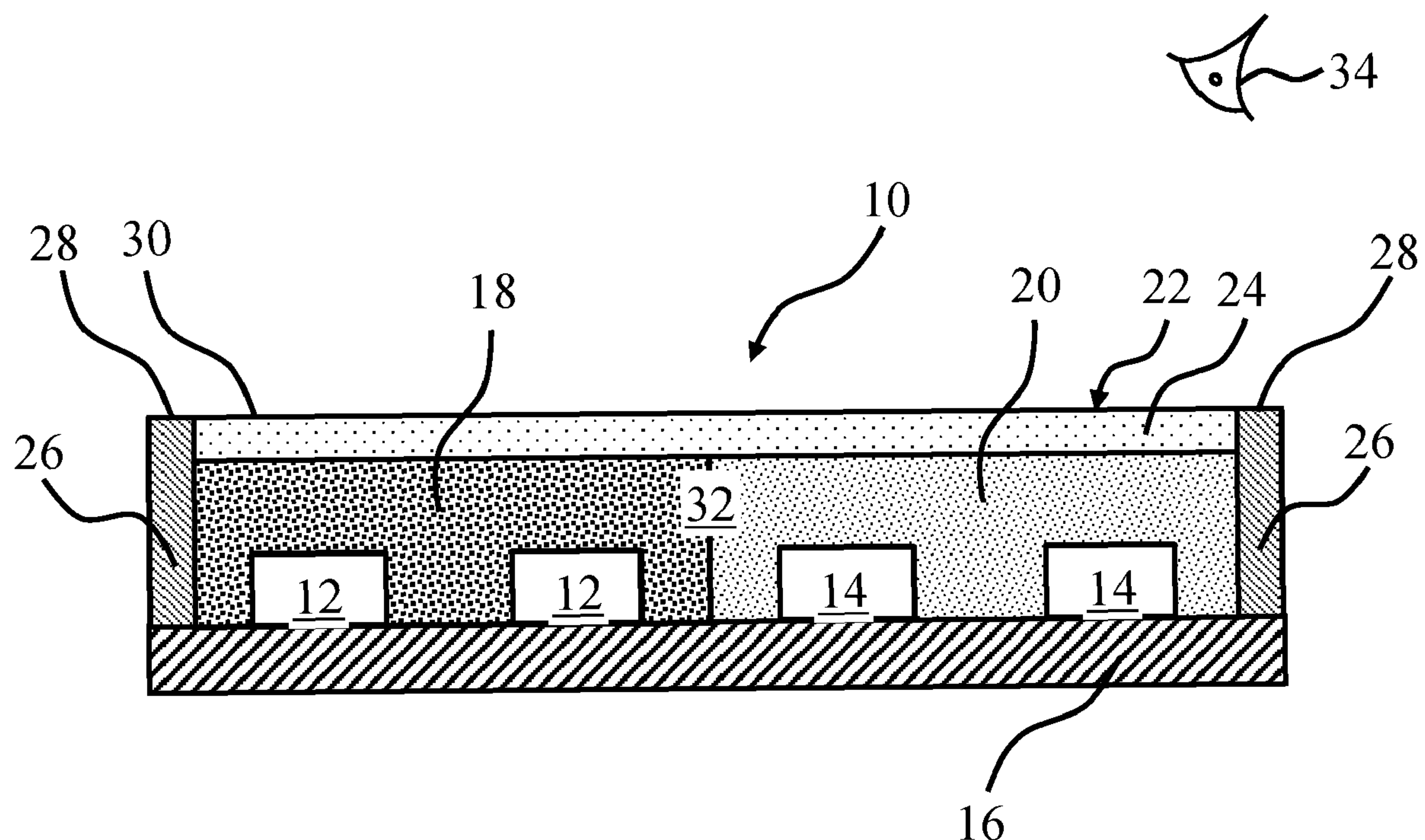
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(57) **ABSTRACT**

A white light emitting device may include a substrate, first LEDs disposed on the substrate, a first photoluminescence material disposed over the first LEDs, second LEDs disposed on the substrate, where the first LEDs and the second LEDs emit blue light at substantially the same wavelength, a second photoluminescence material disposed over the second LEDs, the second photoluminescence material having a composition different from the first photoluminescence material, where an emission product of the white light emitting device is a combination of light emitted from (i) a combination of the first LEDs and the first photoluminescence material, and (ii) a combination of the second LEDs and the second photoluminescence material, and a dimming control connected to the first LEDs and to the second LEDs; where the dimming control is actuable to modify the emission product.



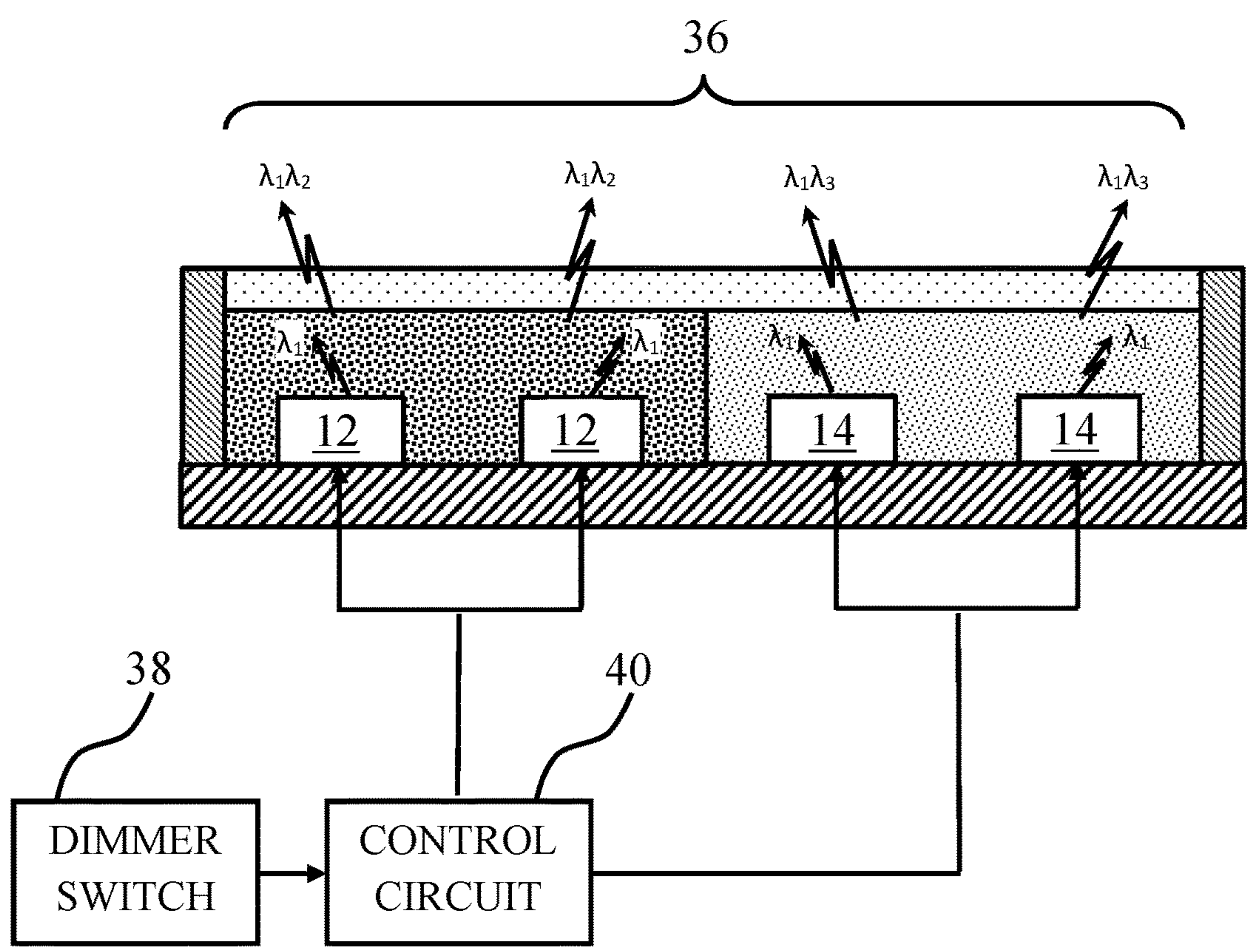
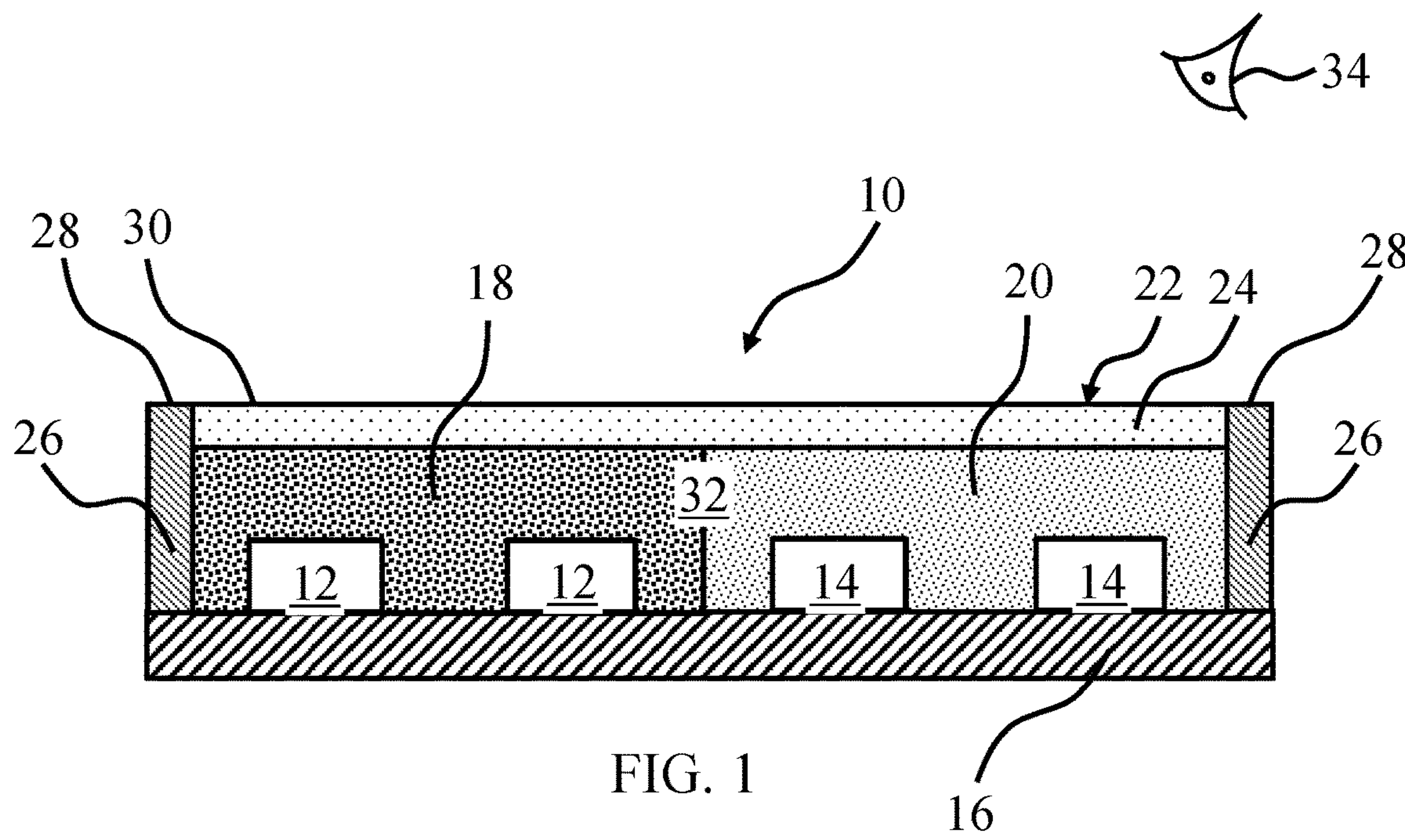


FIG. 2

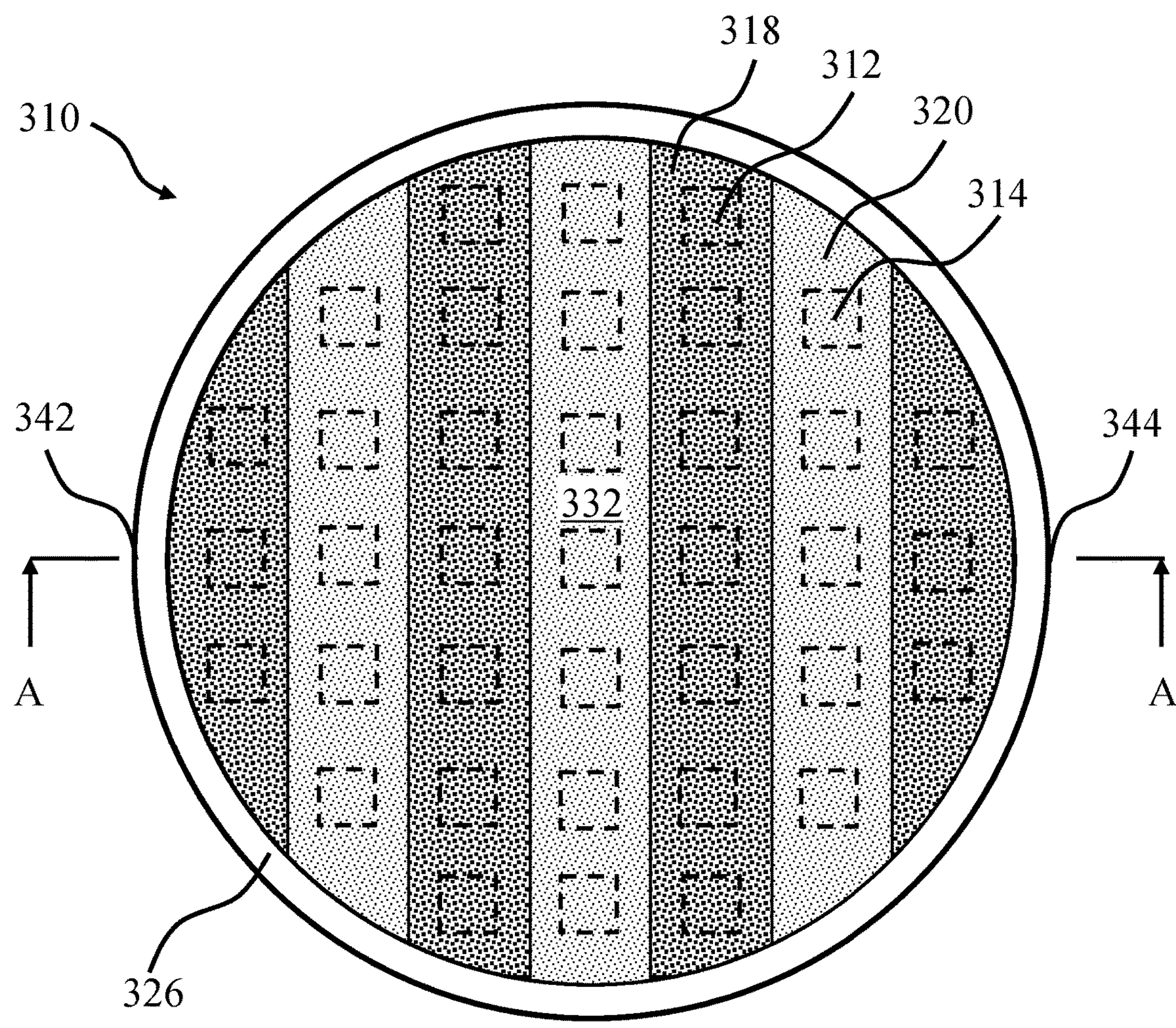
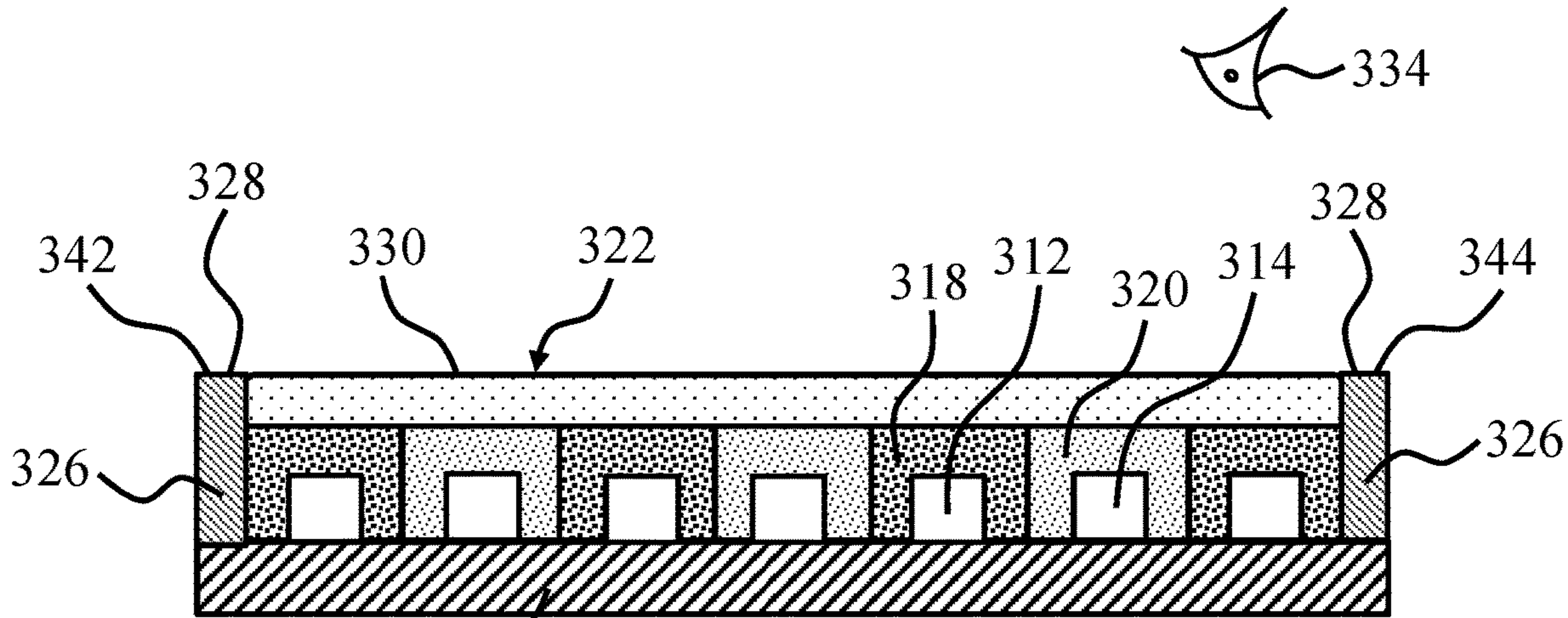


FIG. 3A



SECTION A-A

FIG. 3B

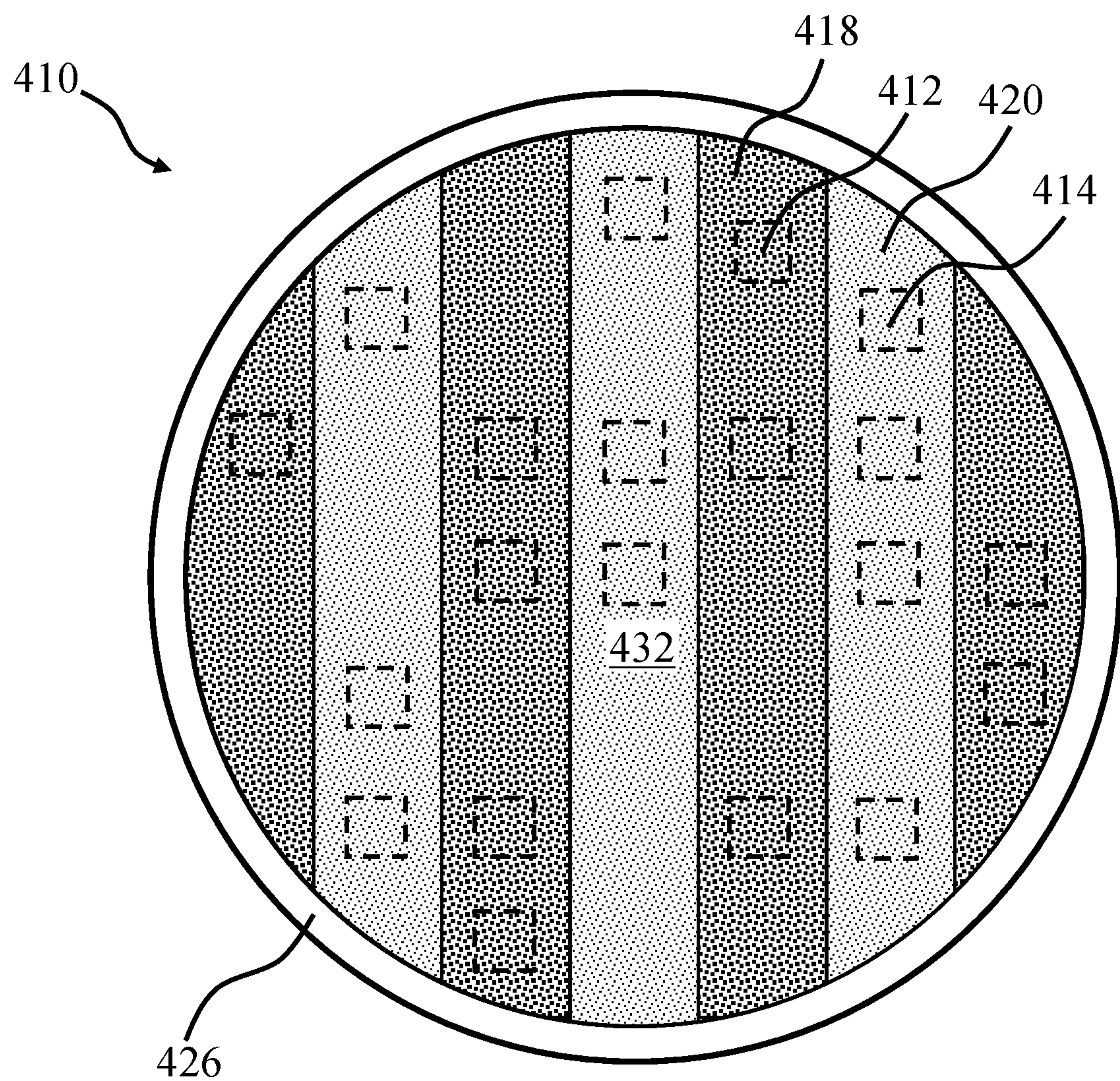


FIG. 4

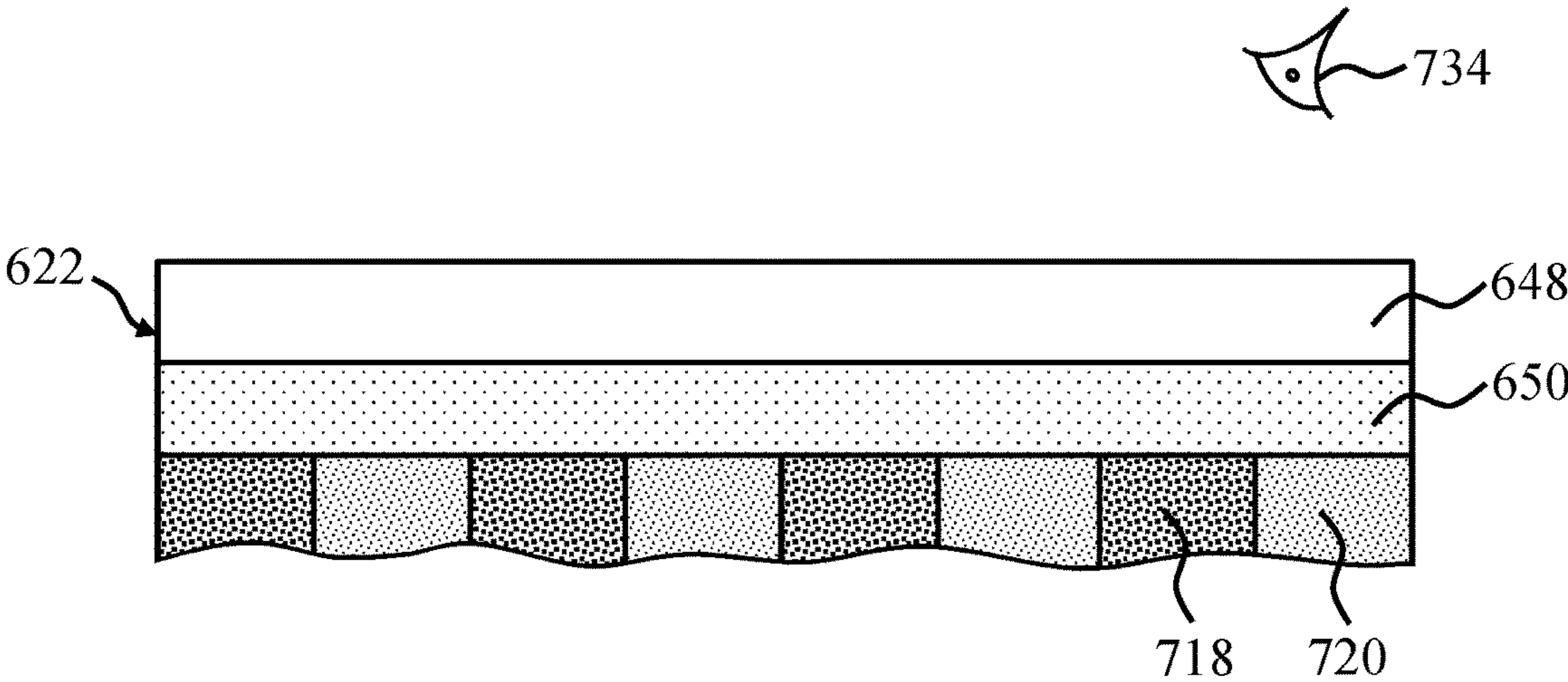
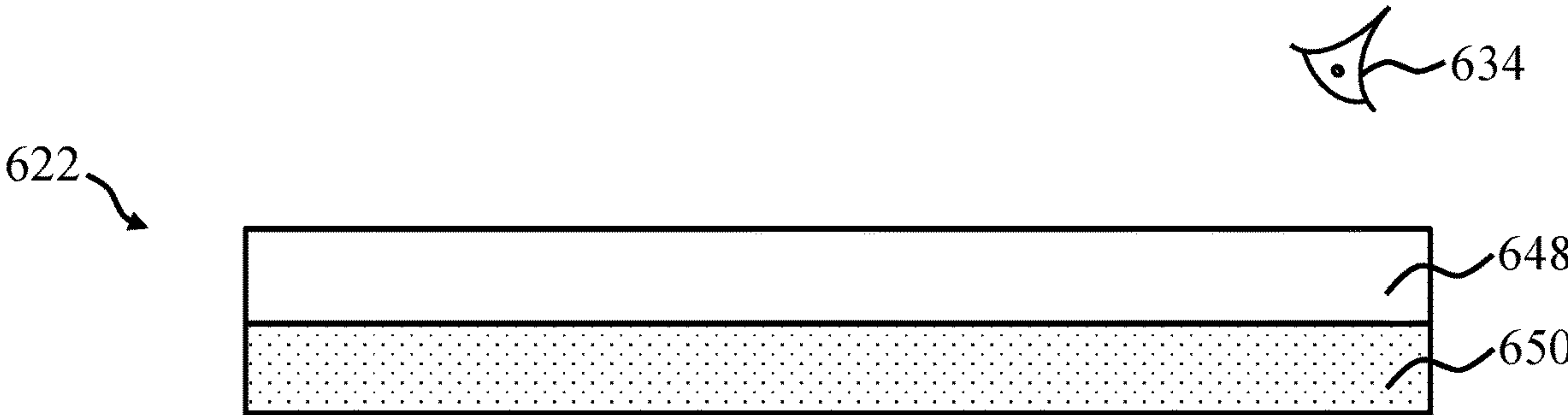
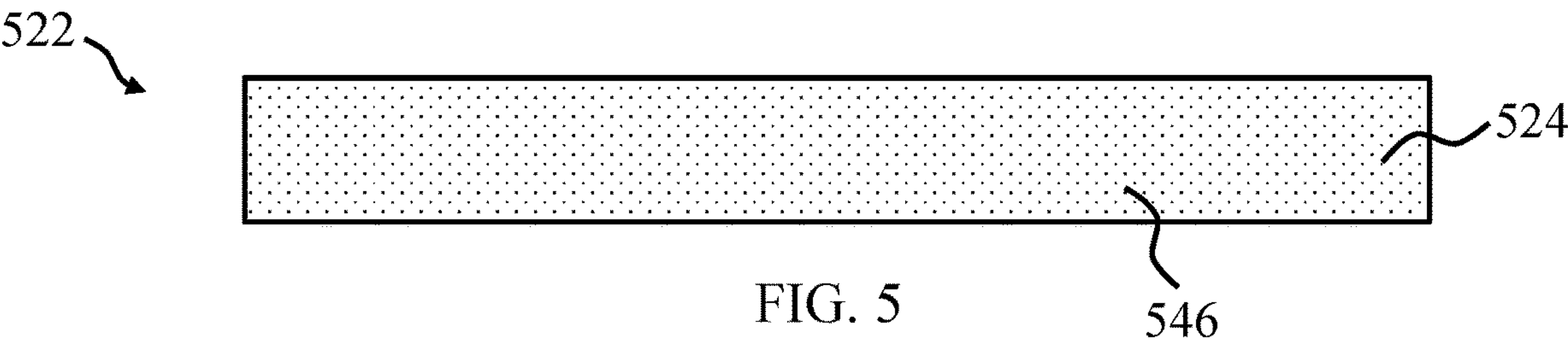
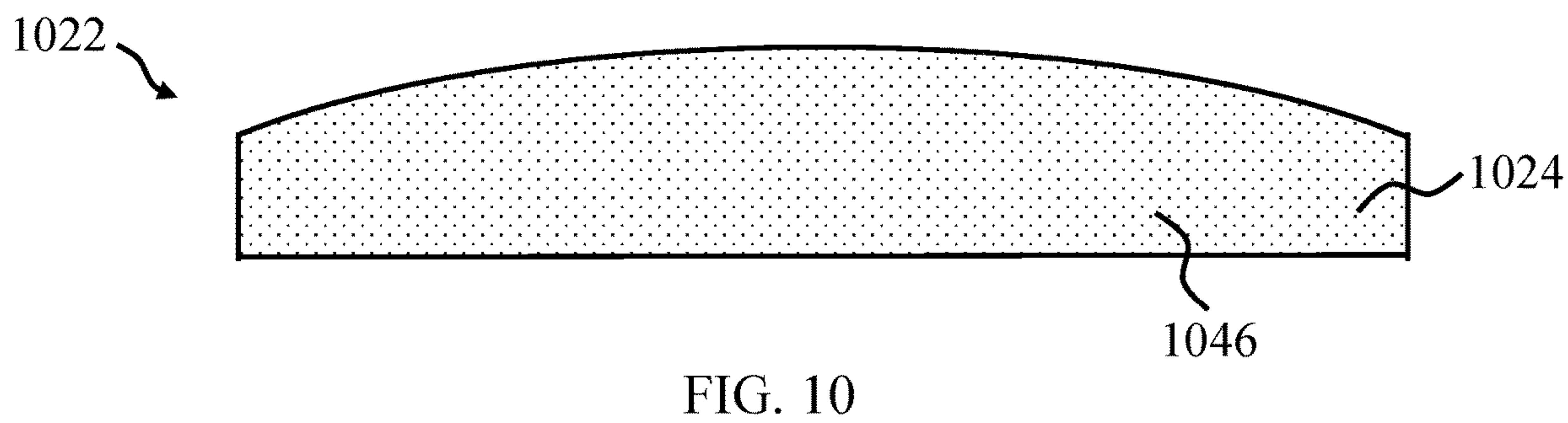
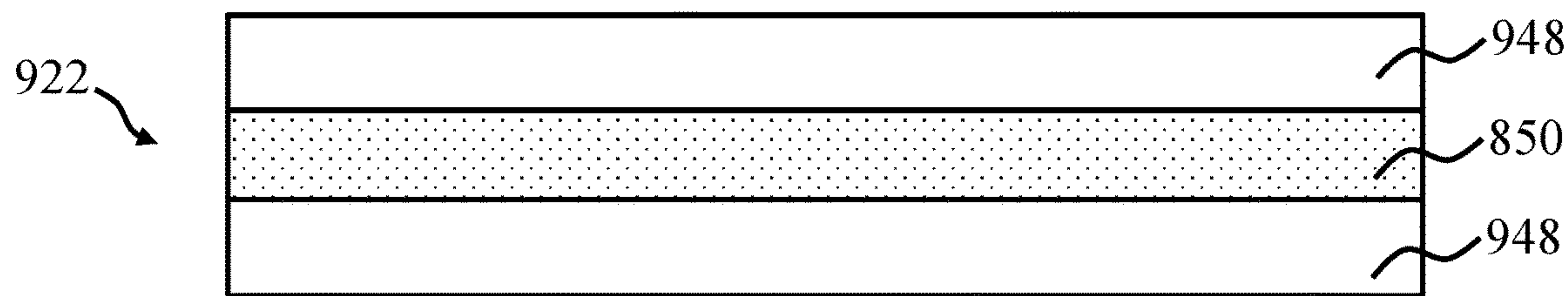
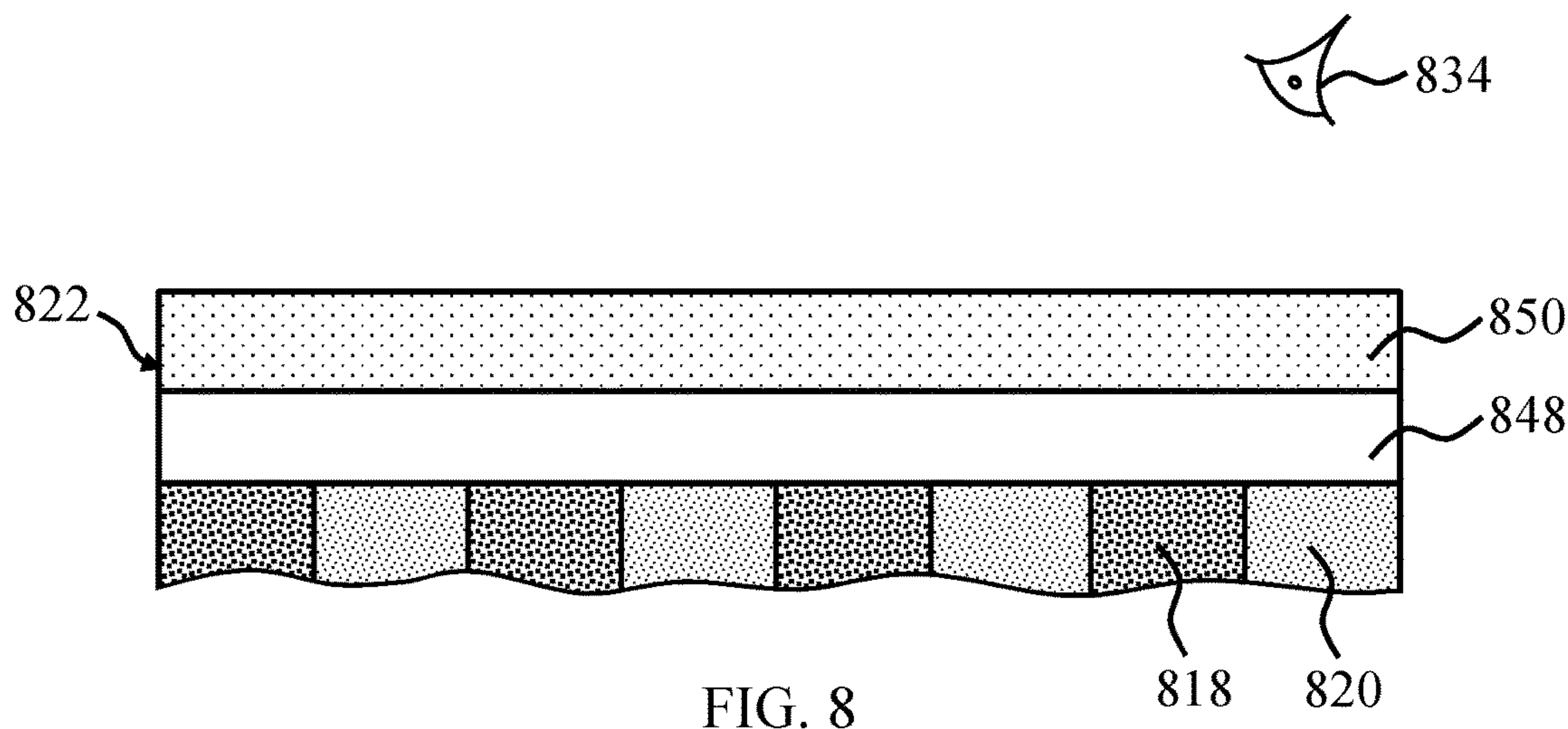


FIG. 7



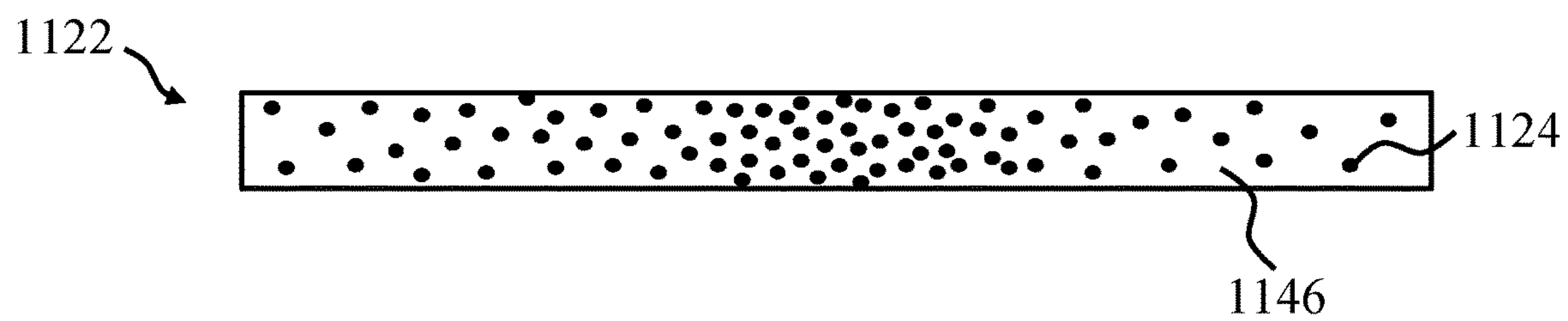


FIG. 11

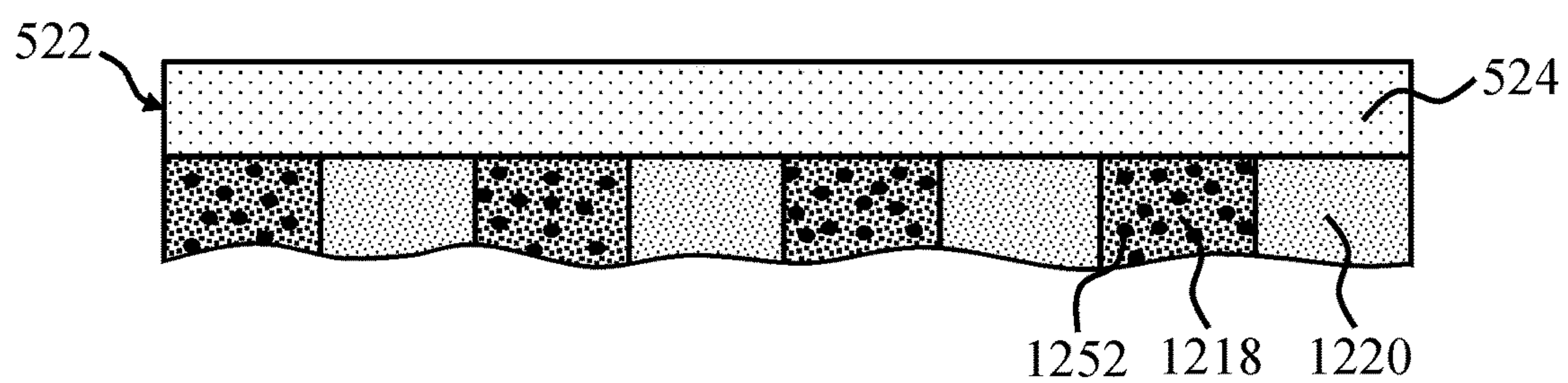


FIG. 12

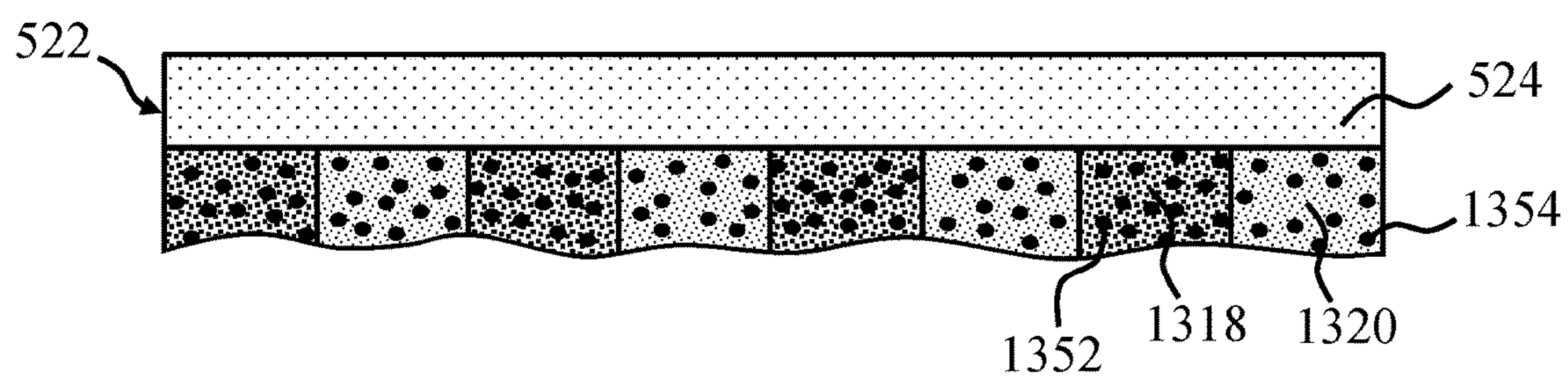


FIG. 13

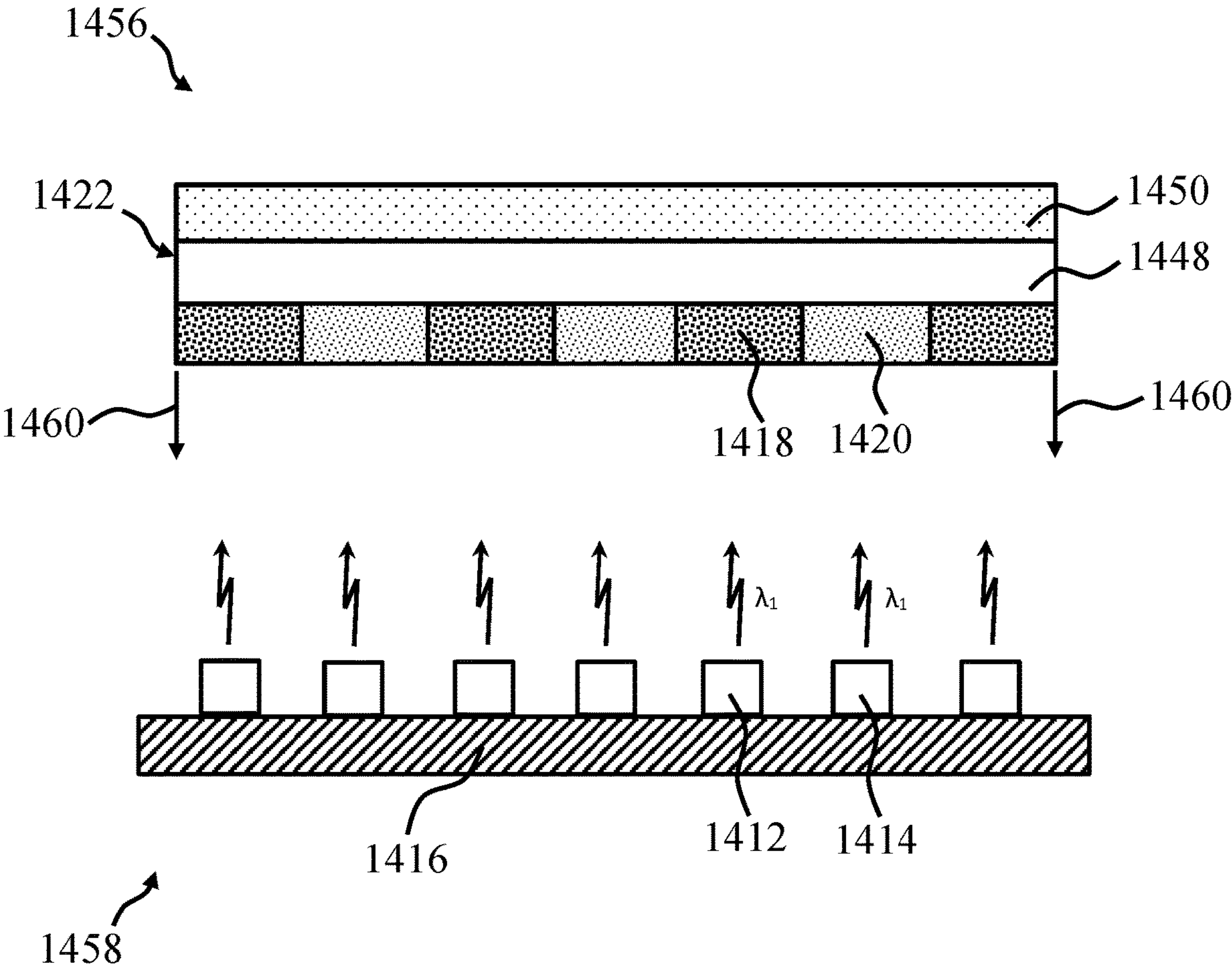


FIG. 14

WHITE LIGHT EMITTING DEVICE WITH DIMMING CONTROL

[0001] This patent application is a continuation of U.S. patent application Ser. No. 16/293,176, filed on Mar. 5, 2019, which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] Embodiments of the present invention are directed to white light emitting devices; in particular, although not exclusively, to color tunable white light emitting devices. More particularly, although not exclusively, embodiments concern white light emitting devices comprising a diffusing layer.

BACKGROUND

[0003] White light emitting LEDs (“white LEDs”) include one or more photoluminescence materials (typically inorganic phosphor materials), which absorb a portion of the excitation light (typically blue) emitted by the LED and re-emit light of a different color (wavelength). The portion of the blue light generated by the LED that is not absorbed by the photoluminescence material combined with the light emitted by the photoluminescence material provides light which appears to the eye as being white in color. Due to their long operating life expectancy (>50,000 hours) and high luminous efficacy (100 lumens per watt and higher), white LEDs are rapidly replacing conventional fluorescent, compact fluorescent and incandescent lamps.

[0004] A color tunable white light emitting device typically comprises multiple LEDs. There are various forms of color tunable LEDs. One form is Chip Scale Packaging (CSP) in which each LED chip (die) is individually coated with the photoluminescence material. Typically, multiple CSP LEDs are then packaged to form the color tunable white light emitting device. While this form of LED generates white light having good color uniformity, it is relatively expensive to manufacture since each LED chip requires an individual uniform thickness coating of photoluminescence material. Since the manufacturing process takes more time due to the intricacies involved in individually coating each LED chip, this process is expensive. Moreover, CSP can require the use of more photoluminescence material, thereby further increasing costs. The luminous efficacy of CSP LEDs can be relatively lower compared with other LED forms.

[0005] Another form of color tunable white light emitting devices is Chip on Board (COB) in which multiple LED chips (dies) are located on a substrate before one or more photoluminescence materials is disposed thereon. The luminous efficacy of white light emitting devices in the form of COB is generally superior to the luminous efficacy of white light emitting devices in the form of CSP. However, COB LEDs can suffer from generation of white light having low color uniformity compared with other forms.

[0006] The present invention intends to address and/or overcome the limitations discussed above by presenting new designs and method not hitherto contemplated nor possible by known constructions. More particularly, there is a need for a cost-effective white light emitting device that generates light with improved color uniformity.

SUMMARY OF THE INVENTION

[0007] According to an aspect of the present invention, there is provided a white light emitting device comprising a first LED and a second LED disposed on a substrate, a first photoluminescence material layer disposed over at least said first LED, a second photoluminescence material layer disposed over at least said second LED, and a diffusing layer disposed over said first and second photoluminescence layers, said diffusing layer comprising light scattering particles.

[0008] The white light emitting device formed according to an embodiment of the present invention exhibits enhanced color uniformity of generated white light due to the combination of the first/second photoluminescence material layers and the diffusing layer disposed thereover. Enhanced color uniformity is particularly advantageous when the device is used in large beam optics. Moreover, compared with CSP LEDs, for example, the amount of photoluminescence material used may also be reduced thereby providing a more cost-effective manner of manufacturing the white light emitting device. This is because the diffusing layer comprising light scattering particles increases the probability that a photon will result in the generation of photoluminescence light by directing light back into the first or second photoluminescence layers. Thus, the amount of photoluminescence material required to generate a given color temperature of light can be reduced since more of the first/second LED light is converted to photoluminescence light owing to the diffusing layer.

[0009] Further, COB LEDs provided with a diffusing layer thereon are able to generate white light having a luminous efficacy that is comparable or greater than white light generated by CSP LEDs.

[0010] Hence, the present invention is the provision of a white light emitting device that does not suffer from the disadvantages discussed above such as high cost of manufacture and low color uniformity of white light generated.

[0011] It may be that the first photoluminescence material layer comprises a first phosphor material and/or the second photoluminescence material layer comprises a second phosphor material. The first and second phosphor materials may be different. It may be that the first photoluminescence material layer comprises a first quantum dot material (QD) and/or the second photoluminescence material layer comprises a second quantum dot (QD) material.

[0012] The first phosphor material may be excitable to generate white light having a correlated color temperature of 2700K to 3500K.

[0013] The second phosphor material may be excitable to generate white light having a correlated color temperature of 5000K to 6500K.

[0014] In this way, the white light emitting device may be a color temperature tunable white light emitting device.

[0015] The white light emitting device may comprise alternating arrays of first LEDs and second LEDs. Such a white light emitting device lends itself to a tunable configuration in which the arrays of the first and second LEDs can be arranged according to the desired requirements of light to be generated.

[0016] More particularly, the white light emitting device may comprise alternating strips of the first and second photoluminescence material layers associated with the alternating arrays of first LEDs and second LEDs. Such an arrangement is particularly advantageous because it simplifies the manufacturing process thereby reducing costs. For

example, compared to CSP LEDs which are individually coated with a photoluminescence material, the inventors have discovered that disposing the first and second photoluminescence materials as “layers” in the form of alternating strips over the first and second LEDs is significantly more time-efficient and cost-effective. That is a plurality of first/second LEDs can be covered/disposed with a first/second photoluminescence material rather than coating each LED individually.

[0017] The diffusing layer may be in direct contact with the first and/or second photoluminescence material layer. This may improve the amount of light being scattered by the light scattering particles.

[0018] The diffusing layer may comprise a light transmissive material and light scattering particles. The light transmissive material may allow the light scattering material to be suspended therein.

[0019] It may be that the light scattering particles are incorporated in the light transmissive material. This may simplify the manufacturing process of the diffusing layer and improve its robustness and reliability.

[0020] The light scattering particles may be substantially uniformly distributed through the light transmissive material. Having uniformly distributed light scattering particles within the light transmissive material may enhance the uniformity of light generated by the white light emitting device.

[0021] The diffusing layer may comprise a layer of the light transmissive material and a layer of the light scattering particles. The layer of light scattering particles can be deposited directly onto the light layer of light transmissive material by for example screen printing. Alternatively, the layer of light scattering particles can be manufactured separately. This alternative configuration may provide more flexibility in the way the diffusing layer is manufactured, since the light transmissive layer and the layer of light scattering particles may be separately manufactured before assembly, which could be more cost-effective in some instances.

[0022] It may be that the layer of the light transmissive material is disposed between the layer of the light scattering particles and the first and/or second photoluminescence material layers. Such a configuration may provide greater distance between the light scattering particles and the first and/or second photoluminescence material layers and this can improve color uniformity since color mixing of light can occur within the layer of light transmissive material.

[0023] The layer of the light scattering particles may be disposed between the layer of the light transmissive material and the first and/or second photoluminescence material layers. In such a configuration, the layer of light transmissive material may act as a protective layer to the layers of the light scattering particles and the first and/or second photoluminescence material layers. It may be that the layer of light transmissive is the outermost layer or faces outwardly.

[0024] The diffusing layer may comprise two layers of the light transmissive material and a layer of the light scattering particles disposed therebetween. This configuration may provide a greater distance between the light scattering particles and the first and/or second photoluminescence material layers, as well as the layer of light transmissive material may act as a protective layer.

[0025] It may be that at least one of the first photoluminescence material layer, the second photoluminescence material layer, or the diffusing layer comprises light scattering particles. Thus, light scattering particles may be contained in the first photoluminescence material layer and the diffusing layer; in the second photoluminescence material layer and the diffusing layer; or in the first photoluminescence material layer, the second photoluminescence

material layer and the diffusing layer. The inclusion of light scattering particles in the first and/or second photoluminescence material layers increases the probability that a photon will result in the generation of photoluminescence light thereby reducing the amount of photoluminescence material required. Further, this inclusion of light scattering particles in the photoluminescence layer(s) may improve the uniformity of the white light generated by the light emitting device generated still further.

[0026] The first photoluminescence material layer and/or the second photoluminescence material layer may comprise light scattering particles incorporated in a light transmissive material. The light transmissive material may allow the light scattering particles to be distributed more uniformly by suspension therein, for instance.

[0027] The white light emitting device of claim 1, wherein the substrate is light transmissive. The substrate can comprise a circuit board such as a metal core printed circuit board (MCPCB).

[0028] The light scattering particles may have an average particle size selected such that they scatter excitation light generated by the first and second LEDs relatively more than they scatter light generated by the first and second photoluminescence material layers, optionally the average particle size may be in a range from about 100 nm to about 200 nm.

[0029] One benefit of this approach, especially within the diffuser layer, is that by selecting an appropriate particle size and concentration per unit area of the light scattering particles, an improvement is obtained in the white color appearance of an LED device in its OFF state. Another benefit is an improvement to the color uniformity of emitted light from the white light emitting device for emission angles over a $\pm 60^\circ$ range from the emission axis. Moreover, the use of a diffusing layer having an appropriate particle size and concentration per unit area of the light scattering particles can substantially reduce the quantity of photoluminescence material required to generate a selected color of emitted light, since the diffusing layer increases the probability that a photon will result in the generation of photoluminescence light by directing light back into the photoluminescence layer(s). It may be that inclusion of a diffusing layer in direct contact with the photoluminescence layer(s) can reduce the quantity of phosphor material required to generate a given color emission product, e.g. by up to 40%. As used herein, “direct contact” means that there are no intervening layers or air gaps.

[0030] The light transmissive medium may be disposed between the diffusing layer and the first and/or second photoluminescence layers.

[0031] The amount of light scattering particles may vary across the diffusing layer. For instance, there may be more light scattering particles towards the center of the light emitting device than its edges. The center of the light emitting device may be considered the center of the substrate, for instance.

[0032] The thickness of the diffusing layer may vary.

[0033] The concentration of light scattering particles within the diffusing layer may vary.

[0034] By varying the thickness of the light diffusing layer and/or the concentration of light scattering particles within the diffusing layer, the light scattering properties can be appropriately selected depending on the desired output of the white light emitting device.

[0035] The light scattering particles may comprise titanium dioxide (TiO_2), barium sulfate (BaSO_4), magnesium oxide (MgO), silicon dioxide (SiO_2) or aluminum oxide (Al_2O_3), for example.

[0036] The light transmissive material may comprise a curable liquid polymer such as a polymer resin, a monomer resin, an acrylic, an epoxy, a silicone or a fluorinated polymer.

[0037] The substrate may comprise a circuit board such as a metal core printed circuit board (MCPCB).

[0038] In another aspect, the present invention encompasses a method of manufacturing a white light emitting device, comprising the steps of: providing an array of first LEDs; dispensing a first photoluminescence material layer at least over said array of first LEDs; providing an array of second LEDs; dispensing a second photoluminescence material layer at least over said array of second LEDs; and dispensing a diffusing layer over said first and second photoluminescence material layers.

[0039] To reduce the variation in emitted light color with emission angle, the weight loading of light scattering particles to light transmissive material may be in a range from 0.1 to 50% wt or 5 to 10% wt.

[0040] In another aspect, the present invention envisages a white light emitting device comprising alternating arrays of first LEDs and second LEDs disposed on a substrate, a first photoluminescence material layer disposed over at least said array of first LEDs, a second photoluminescence material layer disposed over at least said array of second LEDs, and a diffusing layer disposed over said first and second photoluminescence material layers, the diffusing layer comprising light scattering particles, wherein the first photoluminescence material layer comprises a first phosphor material excitable to generate white light having a first correlated color temperature, the second photoluminescence material layer comprises a second phosphor material excitable to generate white light having a second correlated color temperature.

[0041] It may be that the first phosphor material is excitable to generate white light having a correlated color temperature of 2700K to 3500K and/or the second phosphor material is excitable to generate white light having a correlated color temperature of 5000K to 6500K.

[0042] According to another aspect of the present invention, there is provided a component for a white light emitting device, comprising alternating strips of first and second photoluminescence material layers disposed on a substrate, and a diffusing layer disposed over said alternating strips of first and second photoluminescence material layers, the diffusing layer comprising light scattering particles, wherein the first photoluminescence material layer comprises a first phosphor material excitable to generate white light having a first correlated color temperature, and the second photoluminescence material layer comprises a second phosphor material excitable to generate light having a second correlated color temperature.

[0043] It may be that the first correlated color temperature is from 2700K to 3500K and/or the second correlated color temperature is from 5000K to 6500K.

BRIEF DESCRIPTION OF THE DRAWINGS

[0044] These and other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures, wherein:

[0045] FIG. 1 is a sectional view of a white light emitting device in accordance with an embodiment of the invention;

[0046] FIG. 2 is a sectional view of the white light emitting device of FIG. 1 with color tunable control;

[0047] FIG. 3A is a plan view of a white light emitting device in accordance with an embodiment of the invention;

[0048] FIG. 3B is cross sectional side view through A-A;

[0049] FIG. 4 is a plan view of a white light emitting device in accordance with an embodiment of the invention;

[0050] FIG. 5 is a sectional view of a diffusing layer in accordance with an embodiment of the invention;

[0051] FIG. 6 is a sectional view of a diffusing layer in accordance with another embodiment of the invention;

[0052] FIG. 7 is a sectional view of a diffusing layer in contact with photoluminescence material layers in accordance with an embodiment of the invention;

[0053] FIG. 8 is a sectional view of a diffusing layer in contact with photoluminescence material layers in accordance with another embodiment of the invention;

[0054] FIG. 9 is a sectional view of a diffusing layer in accordance with another embodiment of the invention;

[0055] FIG. 10 is a sectional view of a diffusing layer in accordance with another embodiment of the invention;

[0056] FIG. 11 is a sectional view of a diffusing layer in accordance with another embodiment of the invention;

[0057] FIG. 12 is a sectional view of a diffusing layer in contact with photoluminescence material layers in accordance with another embodiment of the invention;

[0058] FIG. 13 is a sectional view of a diffusing layer in contact with photoluminescence material layers in accordance with another embodiment of the invention; and

[0059] FIG. 14 is a sectional view of a component and a separate LED array for a white light emitting device in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0060] Embodiments of the present invention will now be described in detail with reference to the drawings, which are provided as illustrative examples of the invention so as to enable those skilled in the art to practice the invention. Notably, the figures and examples below are not meant to limit the scope of the present invention to a single embodiment, but other embodiments are possible by way of interchange of some or all of the described or illustrated elements. Moreover, where certain elements of the present invention can be partially or fully implemented using known components, only those portions of such known components that are necessary for an understanding of the present invention will be described, and detailed descriptions of other portions of such known components will be omitted so as not to obscure the invention. In the present specification, an embodiment showing a singular component should not be considered limiting; rather, the invention is intended to encompass other embodiments including a plurality of the same component, and vice-versa, unless explicitly stated otherwise herein. Moreover, applicants do not intend for any term in the specification or claims to be ascribed an uncommon or special meaning unless explicitly set forth as such. Further, the present invention encompasses present and future known equivalents to the known components referred to herein by way of illustration. Throughout this specification like reference numerals are used to denote like parts.

[0061] A white light emitting device **10** in accordance with an embodiment of the invention will now be described with reference to FIG. **1** which show a sectional side view of the device.

[0062] The device **10** comprises first LEDs **12** and second LEDs **14** disposed on a substrate **16** (e.g. MCPCB); a first photoluminescence material layer **18** disposed over at least said first LEDs **12**; a second photoluminescence material layer **20** disposed over at least said second LEDs **14**; and a diffusing layer **22** disposed over said first and second photoluminescence layers **18**, **20**; said diffusing layer **22** comprising light scattering particles **24**.

[0063] More particularly, FIG. **1** shows a sectional view of two rows of first LEDs **12** adjacent two rows of second LEDs **14** in a chip on board (COB) type arrangement. Only one LED of each row is shown in FIGS. **1** and **2**; there being a total of four rows (two for first LEDs **12** and two rows for second LEDs **14**). In this embodiment, the first and second LEDs **12**, **14** are InGaN (indium gallium nitride) blue LEDs which are operable to generate blue light having a peak wavelength in a wavelength range 400 to 480 nm (typically 450 to 470 nm). The two rows of first LEDs **12** and two rows of second LEDs **14** are deposited on a planar substrate **16**. Towards the edges of the planar substrate **16** is located a peripheral wall **26** which surrounds (encloses) the two rows of first LEDs **12** and two rows of second LEDs **14**. Typically, the wall **26** surrounds the two rows of first LEDs **12** and two rows of second LEDs **14**. In other embodiments, the wall may delineate one or more sides of the substrate.

[0064] A first photoluminescence material layer **18** comprising a first phosphor material (typically green and red emitting phosphor materials) is deposited onto the planar substrate **16** and, in this embodiment, completely covers the two rows of first LEDs **12**. The first phosphor material is excitable to generate white light having a correlated color temperature of about 2700K to 3500K (warm white light). Similarly, the second photoluminescence material layer **20** comprising a second phosphor material (Typically a green phosphor material) is deposited onto the planar substrate **16** and, in this embodiment, completely covers the two rows of second LEDs **14**. The second phosphor material is excitable to generate white light having a correlated color temperature of 5000K to 6500K (cool white light). In this way, the first and second photoluminescence material layers **18**, **20** are located adjacent one another and also contained within the wall **26**.

[0065] A planar diffusing layer **22**, having similar dimensions to those of the planar substrate **16**, is disposed over and on top of both the first photoluminescence material layer **18** and second photoluminescence material layer **20**, and is also contained inside the wall **26**. The upper surfaces **28** of the upright walls **26** together with the upper surface **30** of the planar diffusing layer **22** define a flush surface. The planar diffusing layer **22**, the planar substrate **16**, and wall **26** define an interior volume **32** which houses and encloses the first and second photoluminescence material layers **18**, **20** and the two rows of first LEDs **12** and the two rows of second LEDs **14**.

[0066] The white light emitting device **10**, to an observer **34**, exhibits enhanced color uniformity of generated white light due to the combination of the first and second photoluminescence material layers **18**, **20** and the diffusing layer **22** disposed thereover. Compared with CSP LEDs, for example, the amount of photoluminescence material used may also be reduced thereby providing a more cost-effective manner of manufacturing the white light emitting device **10**. This is because the diffusing layer **22** comprising light scattering particles **24** increases the probability that a photon will result in the generation of photoluminescence light by

directing light back into the first or second photoluminescence layers. Thus, the amount of photoluminescence material required to generate a given color temperature of light can be reduced since more of the first/second LED **12**, **14** light is converted to photoluminescence light owing to the diffusing layer **22**.

[0067] Referring now to FIG. **2**, there is shown the white light emitting device of FIG. **1** with dimming control. The first and second photoluminescence material layers **18**, **20** are operable to absorb a proportion of the blue light λ_1 generated by the two rows of first LEDs **12** and the two rows of second LEDs **14** and convert it to light of a different wavelength by a process of photoluminescence. In this embodiment, the first photoluminescence material layer **18** converts the blue light λ_1 to λ_2 , and the second photoluminescence material layer **20** converts the blue light λ_1 to λ_3 . Not all of the blue light λ_1 generated by the two rows of first LEDs **12** and the two rows of second LEDs **14** is absorbed by the first and second photoluminescence material layers **18**, **20** and some of it is emitted through the diffusing layer **22**. The emission product **36** of the white light emitting device **10** thus comprises the combined light of wavelengths λ_1 , λ_2 , λ_3 generated by the by the two rows of first LEDs **12** and the two rows of second LEDs **14** and the first and second photoluminescence material layers **18**, **20**. The CCT of the emission product **36** is thus a combination of the CCT of light (λ_1) generated by the two rows of first LEDs **12** and the two rows of second LEDs **14**, the CCT of light (λ_2) generated by the first photoluminescence material layer **18**, and the CCT of light (λ_3) generated by the second photoluminescence material layer **20**.

[0068] In this embodiment, the combination of light (λ_1) generated by the two rows of first LEDs **12** and light (λ_2) generated by the first photoluminescence material layer **18** generates light having a CCT corresponding to a warm yellowish white (a correlated color temperature of about 2700K to 3500K). Similarly, the combination of light (λ_1) generated by the two rows of second LEDs **14** and light (λ_3) generated by the second photoluminescence material layer **20** generates light having a CCT corresponding to a cool blueish white (a correlated color temperature of about 5000K to 6500K). Therefore, the emission product **34** of the white light emitting device **10** in this example would be a combination of the warm yellowish white light deriving from (λ_1)/(λ_2), the cool blueish white light deriving from (λ_1)/(λ_3).

[0069] A dimmer switch **38** may be operably connected to a control circuit **40** which is operably connected to the two rows of first LEDs **12** and the two rows of second LEDs **14**. The dimmer switch **38** is configured to generate a continuous range of output powers to be used for controlling (tuning) the color temperature and dimming level of the white light emitting device **10**. The control circuit **40** is configured to translate the generated output power into an on/off arrangement and/or adjustable power arrangement for the two rows of first LEDs **12** and the two rows of second LEDs **14**.

[0070] While the variation in color temperature of an incandescent light bulb is directly related to the output power of the dimmer switch, the CCT of the emission product **36** of the light emitting device **10** is not directly related to the output power of the dimmer switch **38**. As such, the control circuit **40** must translate the output power of the dimmer switch **38** into a control arrangement for the two rows of first LEDs **12** and the two rows of second LEDs **14** such that the white light emitting device **10** dimming behavior resembles that of a dimmable incandescent light bulb—that is on dimming its color temperature changes from cool white at full power to warm white when dimmed.

[0071] Because the emission product 36 of the white light emitting device 10 is a combination of light (λ_1) generated by the two rows of first LEDs 12 and the two rows of second LEDs 14 and light (λ_2, λ_3) generated by the first and second photoluminescence material layers 18, 20, the CCT of the emission product 36 can be changed by modifying the combination of light. In this way, a CCT corresponding to a warm yellowish white color may be generated by having a larger portion of the emission product 36 originate from the first photoluminescence material layer 18 (e.g., region generating light with a CCT corresponding to a warm yellowish white) and a smaller portion of the emission product 36 originate from the second photoluminescence material layer 20 (e.g., region generating light with a CCT corresponding to a cool blueish white). A CCT corresponding to a cool blueish white color may be generated by having a smaller portion of the emission product 36 originate from the first photoluminescence material layer 18 and a larger portion of the emission product 36 originate emanate from the second photoluminescence material layer 20.

[0072] The emission product 36 may be modified, for example, by altering the on/off configuration of the two rows of first LEDs 12 and the two rows of second LEDs 14. Thus, the CCT of the emission product 36 may grow closer to a warm yellowish color as some or all of the second LEDs 14 corresponding to the second photoluminescence material layer 20 are turned off while the two rows of first LEDs 12 corresponding to the first photoluminescence material layer 18 remain on. Conversely, if a emission product 36 having a CCT with a cool blueish is color is desired, some or all of the first LEDs 12 corresponding to the first photoluminescence material layer 18 may be turned off while the two rows of second LEDs 14 corresponding to the second photoluminescence material layer 20 remain on.

[0073] Thus, by configuring the control circuit 40 of the white light emitting device 10 to translate output power of the dimmer switch 38 into a corresponding on/off configuration of the two rows of first LEDs 12 and the two rows of second LEDs 14, the white light emitting device 10 may be tuned like a typical incandescent light bulb.

[0074] Alternatively, in another embodiment, instead of an on/off control, individual power levels (typically current) are adjusted by the control circuit 40 to the two rows of first LEDs 12 and the two rows of second LEDs 14, so that a selected ratio of the emissions λ_2, λ_3 from the first and second photoluminescence material layers 18, 20 is obtained to generate a desired CCT of the emission product 36. In this approach, the CCT of the emission product 36 corresponds to a cool blueish white color or a warm yellowish white color depending upon the relative amounts of power that are provided to the two rows of first LEDs 12 and the two rows of second LEDs 14.

[0075] With reference to FIGS. 3A and 3B, there is shown a plan view of a white light emitting device 310 in accordance with an embodiment of the invention, and a cross section side view through A-A (of FIG. 3A). The white light emitting device 310 is similar to the white light emitting device 10 of FIG. 1. Therefore, like reference numerals are used in FIG. 3 to denote like features.

[0076] In this embodiment, the white light emitting device 310 has a circular shape. Thus, the substrate 316 is planar and disk shaped. Forming another chip on board arrangement, alternating arrays (rows) of first LEDs 312 and second LEDs 314 are configured from one circumferential point 342 to the diametrically opposing circumferential point 344. In this embodiment, the arrays are in the form of rows. As illustrated, the circular substrate 316 comprises a total of seven rows of alternating arrays of first LEDs 312 and second LEDs 314, wherein the first and second LEDs 312, 314 are substantially symmetrically distributed over the

entirety on the circular substrate 316. The circular substrate 316 also comprises about its entire perimeter a wall 326 which encloses all the arrays of first LEDs 312 and second LEDs 314. In this embodiment, the first and second LEDs 312, 314 are InGaN (indium gallium nitride) blue LEDs which are operable to generate blue light having a peak wavelength in a wavelength range 400 to 480 nm (typically 450 to 470 nm).

[0077] A first photoluminescence material layer 318 comprising a first phosphor material (typically green and red emitting phosphor materials) is deposited onto the circular substrate 316 and, in this embodiment, completely covers the arrays of first LEDs 312. The first phosphor material is excitable to generate white light having a correlated color temperature of about 2700K to 3500K (warm white light). Similarly, the second photoluminescence material layer 320 comprising a second phosphor material (typically a green phosphor material) is deposited onto the circular substrate 316 and, in this embodiment, completely covers the arrays of second LEDs 314. The second phosphor material is excitable to generate white light having a correlated color temperature of 5000K to 6500K (cool white light). In this way, the first and second photoluminescence material layers 18, 20 are located adjacent one another and also contained within the upright walls 26. In this way, the white light emitting device 310 comprises a total of seven alternating strips of the first and second photoluminescence material layers 18, 20 associated with the alternating arrays of first and second LEDs 312, 314.

[0078] A circular and planar diffusing layer 322, having slightly smaller dimensions to those of the circular substrate 316, is disposed over and on top of both the first photoluminescence material layer 318 and second photoluminescence material layer 320, and is also contained inside the upright wall 26. The upper surface 328 of the upright wall 326 together with the upper surface 330 of the circular diffusing layer 322 define a flush surface. The circular diffusing layer 322, the circular substrate 316, and wall 326 define an interior volume 332 which houses and encloses the first and second photoluminescence material layers 18, 20 and the alternating arrays of first LEDs 312 and second LEDs 314.

[0079] A method of manufacturing the white light emitting device 310, for example, comprises the steps of: providing an array of first LEDs 312; dispensing a first photoluminescence material layer 318 at least over said array of first LEDs 312; providing an array of second LEDs 314; dispensing a second photoluminescence material layer 320 at least over said array of second LEDs 314; and dispensing a diffusing layer 322 over said first and second photoluminescence material layers 318, 320. In this embodiment, the diffusing layer 322 is in direct contact with the first and second photoluminescence material layers 318, 320. Although, it will be appreciated that, in other embodiments, the diffusing layer may be in direct contact with only the first or second photoluminescence material layer.

[0080] The white light emitting device 310, to an observer 334, exhibits enhanced color uniformity of generated white light due to the combination of the first and second photoluminescence material layers 18, 20 and the diffusing layer 322 disposed thereover. Compared with CSP LEDs, for example, the amount of photoluminescence material used may also be reduced thereby providing a more cost-effective manner of manufacturing the white light emitting device 310. This is because the diffusing layer 322 comprising light scattering particles 324 increases the probability that a photon will result in the generation of photoluminescence light by directing light back into the first or second photoluminescence layers. Thus, the amount of photoluminescence material required to generate a given color temperature of

light can be reduced since more of the first/second LED **312**, **314** light is converted to photoluminescence light owing to the diffusing layer **322**.

[0081] Table 1 tabulates values for a white light emitting device without a diffusing layer. More particularly, the white light emitting device comprises a first LED and a second LED disposed on a substrate, a first photoluminescence material layer disposed over at least said first LED, a second photoluminescence material layer disposed over at least said second LED. The device having a nominal correlated color temperature (CCT) of 2700 K. A first batch containing six samples of the device without a diffusing layer were prepared and tested, and the parameter data including light intensity (lm), luminous efficacy LE (lm/W), chromaticity CIE x,y, CRI-Ra, and CRI-R9 for each sample is shown in Table 1 together with an average value for each parameter.

TABLE 1

White light emitting device performance without a diffusing layer							
Number	Intensity (lm)	LE (lm/W)	Chromaticity		CCT (K)	CRI	
			CIE x	CIE y		Ra	R9
1	1980.0	112.1	0.4631	0.4216	2740	95.0	67.3
2	1991.0	112.8	0.4632	0.4212	2735	95.1	68.0
3	2007.0	113.8	0.4636	0.4212	2729	95.2	68.4
4	1979.0	112.3	0.4628	0.4210	2740	95.0	67.4
5	1976.0	113.3	0.4626	0.4195	2731	95.5	69.5
6	1979.0	112.5	0.4618	0.4203	2747	94.7	66.4
Avg	1985.3	112.8	0.4629	0.4208	2737	95.1	67.8

[0082] Table 2 tabulates values for a white light emitting device having a 5% wt diffusing layer. More particularly, the white light emitting device comprising a first LED and a second LED disposed on a substrate, a first photoluminescence material layer disposed over at least said first LED, a second photoluminescence material layer disposed over at least said second LED, and a diffusing layer disposed over said first and second photoluminescence layers, said diffusing layer comprising light scattering particles. The 5% wt diffusing layer denotes a loading of 5 weight percent of scattering particles in 95 weight percent liquid silicone (e.g. light transmissive material). The device having a nominal correlated color temperature (CCT) of 2700 K. The first batch containing six samples of the device with a 5% wt diffusing layer were prepared and tested, and the parameter data including light intensity (lm), CIE x,y, CRI-Ra, and CRI-R9 for each sample is shown in Table 2 together with an average value for each parameter.

TABLE 2

White light emitting device performance without a diffusing layer							
Number	Intensity (lm)	LE (lm/W)	Chromaticity		CCT (K)	CRI	
			CIE x	CIE y		Ra	R9
1	1960.0	110.85	0.4668	0.4247	2712	94.4	64.7
2	1980.0	112.02	0.4669	0.4240	2705	94.6	65.3
3	1990.0	112.84	0.4674	0.4243	2701	94.6	65.7
4	1960.0	111.22	0.4665	0.4243	2713	94.4	64.4
5	1950.0	111.79	0.4664	0.4228	2703	94.9	66.5
6	1960.0	111.38	0.4656	0.4235	2720	94.2	63.6
Avg	1966.7	111.68	0.4666	0.4239	2709	94.5	65.0

[0083] Comparing the average data values of Tables 1 and 2, it can be seen that by including a 5% wt diffusing layer there is a negligible change in CIEx(0.46289 compared with 0.4666), CIE y (0.4208 compared with 0.4239), CRI-Ra (95.1 compared with 94.5), and CRI-R9 (67.8 compared with 65.0). Tables 1 and 2 also show that there is only a negligible change in light intensity (1985.3 lm compared with 1966.7 lm) and luminous efficacy (112.8 lm/W compared with 111.7 lm/W). Therefore, the data demonstrates that the performance and characteristics of the white light emitting device do not degrade with the inclusion of a 5% wt diffusing layer. However, the observer will observe a significant improvement in the color uniformity of light generated by the white light emitting device formed according to the invention, compared with a device devoid of a diffusing layer. The inventors have also found that the white

light emitting device of the present invention advantageously has a superior light intensity output and luminous efficacy than an equivalent device utilizing CSP LEDs without a diffusing layer.

[0084] Table 3 tabulates values for a white light emitting device without a diffusing layer. More particularly, the white light emitting device comprises a first LED and a second LED disposed on a substrate, a first photoluminescence material layer disposed over at least said first LED, a second photoluminescence material layer disposed over at least said second LED. The device having a nominal correlated color temperature (CCT) of 2700 K. A second batch containing six samples of the device without a diffusing layer were prepared and tested, and the parameter data including light intensity (lm), efficacy (lm/W), CIE x,y, CRI-Ra, and CRI-R9 for each sample is shown in Table 3 together with an average value for each parameter.

TABLE 3

White light emitting device performance without a diffusing layer							
Number	Intensity (lm)	LE (lm/W)	Chromaticity		CCT (K)	CRI	
			CIE x	CIE y		Ra	R9
7	1958.0	111.4	0.4641	0.4217	2726	95.1	68.1
8	1991.0	113.4	0.4628	0.4214	2742	95.0	67.3
9	1953.0	110.7	0.4631	0.4199	2726	95.5	69.4
10	1994.0	113.1	0.4630	0.4216	2741	94.9	67.3
11	2000.0	113.1	0.4647	0.4211	2714	94.8	65.5
Avg	1979.2	112.3	0.4635	0.4211	2730	95.1	67.5

[0085] Table 4 tabulates values for a white light emitting device having a 10% wt diffusing layer. More particularly, the white light emitting device comprising a first LED and a second LED disposed on a substrate, a first photoluminescence material layer disposed over at least said first LED, a second photoluminescence material layer disposed over at least said second LED, and a diffusing layer disposed over said first and second photoluminescence layers, said diffusing layer comprising light scattering particles. The 10% wt diffusing layer denotes a loading of 5 weight percent of scattering particles in 90 weight percent liquid silicone (e.g. light transmissive material). The device having a nominal correlated color temperature (CCT) of 2700 K. The second batch containing six samples of the device with a 10% wt diffusing layer were prepared and tested, and the parameter data including light intensity (lm), efficacy (lm/W), CIE x,y, CRI-Ra, and CRI-R9 for each sample is shown in Table 4 together with an average value for each parameter.

TABLE 4

White light emitting device performance without a diffusing layer							
Number	Intensity (lm)	LE (lm/W)	Chromaticity		CCT (K)	CRI	
			CIE x	CIE y		Ra	R9
7	1920.0	109.2	0.4720	0.4260	2653	94.5	64.6
8	1940.0	110.4	0.4711	0.4258	2663	94.3	63.8
9	1910.0	108.2	0.4713	0.4243	2650	94.9	65.9
10	1950.0	110.5	0.4713	0.4259	2662	94.4	64.0
11	1960.0	110.7	0.4729	0.4253	2636	94.9	66.8
Avg	1936.0	109.8	0.4717	0.4246	2653	94.6	65.0

[0086] Comparing the average data values of Tables 3 and 4, it can be seen that by including a 10% wt diffusing layer there is only a negligible change in CIEx(0.4635 compared with 0.4717), CIE y (0.4211 compared with 0.42456), CRI-Ra (95.1 compared with 94.6), and CRI-R9 (67.5 compared with 65.0). Tables 3 and 4 also show that there is only a negligible change in light intensity (1985.3 lm compared with 1966.7 lm) and luminous efficacy (112.3 lm/W compared with 109.8 lm/W). Therefore, the data demonstrates that the performance and characteristics of the white light emitting device do not degrade with the inclusion of a 10% wt diffusing layer. However, the observer will observe a significant improvement in the color uniformity of light generated by the white light emitting device formed according to the invention, compared with a device devoid of a diffusing layer.

[0087] Referring to FIG. 4, there is shown a white light emitting device **410** formed according to an embodiment of

the invention. The white light emitting device **410** is the same as the white light emitting device **310** shown in FIG. 3A except that it comprises fewer first and second LEDs **412**, **414**. More particularly, the first and second LEDs **412**, **414** are substantially non-symmetrically (non-uniformly) distributed. Despite, the non-symmetrical distribution, the observer **434** (not shown) exhibits enhanced color uniformity of generated white light due to the combination of the first and second photoluminescence material layers **418**, **420** and the diffusing layer **422** (not shown) disposed thereover. Compared with CSP LEDs, for example, the amount of photoluminescence material used may also be reduced thereby providing a more cost-effective manner of manufacturing the white light emitting device **410**. This is because the diffusing layer **422** (not shown) comprising light scattering particles **424** (not shown) increases the probability that a photon will result in the generation of photoluminescence light by directing light back into the first or second

photoluminescence layers **418**, **420**. Thus, the amount of photoluminescence material required to generate a given color temperature of light can be reduced since more of the first/second LED **412**, **414** light is converted to photoluminescence light owing to the diffusing layer **422** (not shown).

[0088] Referring to FIG. 5, there is shown a side sectional view of an embodiment of a diffusing layer **522**. The diffusing layer **522** has a rectangular cross section and is essentially planar in form. The diffusing layer **522** comprises a light transmissive material **546** and light scattering particles **524**. In this embodiment, the light scattering particles **524** are incorporated in the light transmissive material **546** and are substantially uniformly distributed through the light transmissive material **546**. However, it will be appreciated that in other embodiments the light scattering particles may not be uniformly distributed in a light transmissive medium/material. The light scattering particles **524** can have an average particle size selected such that they scatter excita-

tion light generated by the first and second LEDs relatively more than they scatter light generated by the first and second photoluminescence material layers, and in this embodiment the average particle size being in a range from about 100 nm to about 200 nm. The light scattering particles **524** are formed from titanium dioxide or other materials as defined herein.

[0089] Referring to FIG. 6, there is shown a side sectional view of another embodiment of a diffusing layer **622**. Similar to the embodiment of FIG. 5, the diffusing layer **622** has a rectangular cross section and is essentially planar in form. However, in this embodiment the diffusing layer **622** comprises a layer of the light transmissive material **648** and a layer of the light scattering particles **650**. The layer of light scattering particles **650** may be formed in accordance with the diffusing layer **522** of FIG. 5, for instance. As shown in FIG. 6, the layer of the light transmissive material **648** is directly in contact with and disposed above the layer of the light scattering particles **650** so that the layer of the light transmissive material **648** appears closest to the observer **634**.

[0090] Referring to FIG. 7, there is shown a side sectional view of the diffusing layer **622** of FIG. 6 directly in contact with and disposed above alternating strips of first and second photoluminescence material layers **718**, **720** (partially shown in FIG. 7). In this arrangement, as seen from an observer **734**, the layer of light transmissive material **648** is the outermost layer and faces outwardly towards the observer **734**. More particularly, the layer of the light scattering particles **650** is disposed between the layer of the light transmissive material **648** and the alternating strips of first and second photoluminescence material layers **718**, **720**. In such a configuration, the layer of light transmissive material **648** may act as a protective layer to the layer of the light scattering particles **650** and the alternating strips of first and second photoluminescence material layers **718**, **720**.

[0091] Referring to FIG. 8, there is shown a side sectional view of an alternative embodiment of a diffusing layer **822** directly in contact with and disposed above alternating strips of first and second photoluminescence material layers **818**, **820** (partially shown in FIG. 8). The diffusing layer **822** is the same as the diffusing layer **622** of FIGS. 6 and 7, except that the layer of the light scattering particles is transposed with the layer of the light transmissive material. Hence, in this arrangement, as seen from an observer **834**, the layer of the light scattering particles **850** is the outermost layer and faces outwardly towards the observer **834**. More particularly, the layer of the light transmissive material **848** is disposed between the layer of the light scattering particles **850** and the alternating strips of first and second photoluminescence material layers **818**, **820**. In such a configuration, provides greater distance between the layer of light scattering particles **850** and the first and second photoluminescence material layers **818**, **820**.

[0092] Referring to FIG. 9, there is shown a side sectional view of a diffusing layer **922** in accordance with another embodiment of the invention. In this embodiment, the diffusing layer **922** comprises two layers of the light transmissive material **948** and a layer of the light scattering particles **950** disposed therebetween. This configuration provides a greater distance between the layer of light scattering particles **950** and the first and second photoluminescence material layers **918**, **920**, as well as the layers of light transmissive material **948** acting as a protective layer.

[0093] Referring to FIG. 10, there is shown a side sectional view of a diffusing layer **1022** in accordance with another embodiment of the invention. In this embodiment, the diffusing layer **1022** is the same as the diffusing layer **522** of FIG. 5, except the diffusing layer **1022** has a different shape (convex shape). The diffusing layer **1022** has a shape having a cross section which is rectangular with an arch along one of its longer sides. Thus, the cross section defines a shape in which the thickness of the diffusing layer **1022** varies across its width. Of course, it will be appreciated that the thickness of the diffusing layer may vary across its length, in other embodiments. In this way, the amount of light scattering particles **1024** may vary across the diffusing layer **1022**. For instance, in this embodiment, there are more light scattering particles **1024** towards the center of the light diffusing layer **1022** than its edges. By varying the thickness of the light diffusing layer **1022**, the light scattering properties can be appropriately selected depending on the desired output of the white light emitting device with which it is utilized.

[0094] Referring to FIG. 11, there is shown a side sectional view of a diffusing layer **1122** in accordance with another embodiment of the invention. In this embodiment, the diffusing layer **1122** is the same as the diffusing layer **522** of FIG. 5, except the diffusing layer **1122** has a different distribution of light scattering particles **1124** within the light transmissive material **1146**. In this embodiment, the light scattering particles **1124** are incorporated in the light transmissive material **1146** and are not uniformly distributed through the light transmissive material **1146**. Instead, in this embodiment, the concentration of light scattering particles **1124** within the diffusing layer **1122** varies along its width. Of course, it will be appreciated that the concentration of light scattering particles **1124** within the diffusing layer **1122** may vary across its length, in other embodiments. In this way, the amount of light scattering particles **1124** may vary across the diffusing layer **1122**. For instance, in this embodiment, there is a higher concentration of light scattering particles **1124** towards the center of the light diffusing layer **1122** than its edges. By varying the concentration of light scattering particles **1124** in the light diffusing layer **1022**, the light scattering properties can be appropriately selected depending on the desired output of the white light emitting device with which it is utilized.

[0095] FIG. 12 is a sectional view of the diffusing layer **522** of FIG. 5 directly in contact with and disposed above alternating strips of first and second photoluminescence material layers **1218**, **1220** (partially shown in FIG. 12). In this embodiment, while the diffusing layer **522** comprises light scattering particles **524**, the first photoluminescence material layer **1218** also comprises light scattering particles **1252**. This may improve the uniformity of the white light generated by the light emitting device generated still further.

[0096] FIG. 13 is a sectional view of the diffusing layer **522** of FIG. 5 directly in contact with and disposed above alternating strips of first and second photoluminescence material layers **1318**, **1320** (partially shown in FIG. 13). In this embodiment, while the diffusing layer **522** comprises light scattering particles **524**, the first and second photoluminescence material layers **1318**, **1320** also comprise light scattering particles **1352**, **1354** respectively. This may improve the uniformity of the white light generated by the light emitting device generated even further.

[0097] Referring to FIG. 14, there is shown a component 1456 and a separate LED array 1458 for a white light emitting device in accordance with an embodiment of the invention. In this embodiment, the component 1456 comprises a diffusing layer 1422 disposed over alternating strips of first and second photoluminescence material layers 1418, 1420. The diffusing layer 1422 comprising a layer of light scattering particles 1450 and a layer of light transmissive material 1448. In this embodiment, the alternating strips of first and second photoluminescence material layers 1418, 1420 are in direct contact with the layer of light transmissive material 1448 of the diffusing layer 1422, such that the layer of light transmissive material 1448 is disposed between the layer of light scattering particles 1450 and the alternating strips of first and second photoluminescence material layers 1418, 1420.

[0098] The first photoluminescence material layer 1418 comprises a first phosphor material excitable to generate white light having a correlated color temperature of 2700K, and the second photoluminescence material layer 1420 comprises a second phosphor material excitable to generate light having a correlated color temperature of 5000K.

[0099] There is also shown a separate LED array 1458 having an alternating array of first and second LEDs 1412, 1414 disposed on a substrate 1416.

[0100] The component 1456 and LED array 1458 function in the manner described herein. The component 1456 may be assembled with the LED array 1458 in the direction indicated by arrows 1460 so that the alternating strips of the first and second photoluminescence material layers 1418, 1420 can be associated with the alternating arrays of first LEDs and second LEDs 1412, 1414.

[0101] It will be appreciated that the present invention is not restricted to the specific embodiments described and that variations can be made that are within the scope of the invention.

[0102] As used in this document, both in the description and in the claims, and as customarily used in the art, the words “substantially,” “approximately,” and similar terms of approximation are used to account for manufacturing tolerances, manufacturing variations, manufacturing and operational imprecisions, and measurement inaccuracy and imprecision that are inescapable parts of fabricating and operating any mechanism or structure in the physical world.

[0103] While the invention has been described in detail, it will be apparent to one skilled in the art that various changes and modifications can be made and equivalents employed, without departing from the present invention. It is to be understood that the invention is not limited to the details of construction, the arrangements of components, and/or the method set forth in the above description or illustrated in the drawings. Statements in the abstract of this document, and any summary statements in this document, are merely exemplary; they are not, and cannot be interpreted as, limiting the scope of the claims. Further, the figures are merely exemplary and not limiting. Topical headings and subheadings are for the convenience of the reader only. They should not and cannot be construed to have any substantive significance, meaning or interpretation, and should not and cannot be deemed to indicate that all of the information relating to any particular topic is to be found under or limited to any particular heading or subheading. Therefore, the invention is not to be restricted or limited except in accordance with the following claims and their legal equivalents.

What is claimed is:

1. A white light emitting device comprising:
 - a substrate;
 - a plurality of first LEDs disposed on said substrate,
 - a first photoluminescence material disposed over said plurality of first LEDs;
 - a plurality of second LEDs disposed on said substrate, wherein said first LEDs and said second LEDs emit blue light at substantially the same wavelength;
 - a second photoluminescence material disposed over said plurality of second LEDs, said second photoluminescence material having a composition different from said first photoluminescence material; and
 - a dimming control connected to said plurality of first LEDs and to said plurality of second LEDs;
 wherein an emission product of the white light emitting device is a combination of light emitted from (i) a combination of said first LEDs and said first photoluminescence material, and (ii) a combination of said second LEDs and said second photoluminescence material; and
 - wherein said dimming control is actuable to modify said emission product.
2. The white light emitting device of claim 1, wherein said dimming control comprises:
 - a control circuit connected to said at least one first LED and to said at least one second LED; and
 - a dimmer switch 38 connected to said control circuit.
3. The white light emitting device of claim 1, wherein said combination of said first LEDs and said first photoluminescence material emits light at a first correlated color temperature (CCT) of substantially 2700K to 3500K, and wherein said combination of said second LEDs and said second photoluminescence material emits light at a second correlated color temperature (CCT) of substantially 5000K to 6500K.
4. The white-light emitting device of claim 3, wherein said dimming control is actuable to modify said emission product by differentially altering the on/off configurations of said first LEDs and said second LEDs.
5. The white-light emitting device of claim 4, wherein said dimming control is actuable to modify said emission product by differentially altering the on/off configurations of said first LEDs and said second LEDs by turning off at least one of said first LEDs.
6. The white-light emitting device of claim 4, wherein said dimming control is actuable to modify said emission product by differentially altering the on/off configurations of said first LEDs and said second LEDs by turning off at least one of said second LEDs.
7. The white-light emitting device of claim 3, wherein said dimming control is actuable to modify said emission product by differentially adjusting power levels to said first LEDs and said second LEDs.
8. The white-light emitting device of claim 7, wherein said differentially adjusting power levels comprises differentially adjusting current levels to said first LEDs and said second LEDs.
9. The white-light emitting device of claim 7, wherein said dimming control is actuable to modify said emission product by differentially adjusting power levels to said first LEDs and said second LEDs by decreasing the power level to said first LEDs by a greater amount than decreasing the power level to said second LEDs.

10. The white-light emitting device of claim 7, wherein said dimming control is actuable to modify said emission product by differentially adjusting power levels to said first LEDs and said second LEDs by decreasing the power level to said second LEDs by a greater amount than decreasing the power level to said first LEDs.

11. The white light emitting device of claim 1, wherein said first LEDs are arranged in at least one first row; wherein said second LEDs are arranged in at least one second row; wherein at least one said row of said first LEDs is covered by a strip of first photoluminescence material; and wherein at least one said row of said second LEDs is covered by a strip of second photoluminescence material different from said first photoluminescence material.

12. The white light emitting device of claim 11, wherein at least one said first row is adjacent at least one said second row.

13. The white light emitting device of claim 11, wherein a plurality of said first rows alternate with a plurality of said second rows.

14. A method of controlling the emission product of a white light emitting device, comprising:

possessing a white light emitting device comprising a substrate, a plurality of first LEDs disposed on said substrate, a first photoluminescence material disposed over said plurality of first LEDs, a plurality of second LEDs disposed on said substrate, wherein said first LEDs and said second LEDs emit blue light at substantially the same wavelength, a second photoluminescence material disposed over said plurality of second LEDs, said second photoluminescence material having a composition different from said first photoluminescence material, wherein an emission product of the white light emitting device is a combination of light

emitted from (i) a combination of said first LEDs and said first photoluminescence material, and (ii) a combination of said second LEDs and said second photoluminescence material;

modifying said emission product by adjusting the amount of light emitting from said combination of said first LEDs and said first photoluminescence material relative to said combination of said second LEDs and said second photoluminescence material.

15. The method of claim 14, wherein said modifying comprises differentially altering the on/off configurations of said first LEDs and said second LEDs

16. The method of claim 14, wherein said modifying comprises differentially adjusting power levels to said first LEDs and said second LEDs.

17. The method of claim 14, wherein said modifying comprises differentially adjusting current levels to said first LEDs and said second LEDs.

18. The method of claim 14, wherein said combination of said first LEDs and said first photoluminescence material emits warm white light and wherein said combination of said second LEDs and said second photoluminescence material emits cool white light.

19. The method of claim 18, wherein said white light emitting device further comprises a dimming control connected to said first LEDs and to said second LEDs, wherein said modifying comprises actuating said dimming control.

20. The method of claim 19, wherein said modifying comprises translating an input received by said dimming control into corresponding output to said first LEDs and said second LEDs to tune said emission product from cool white at full power to warm white at less than full power.

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