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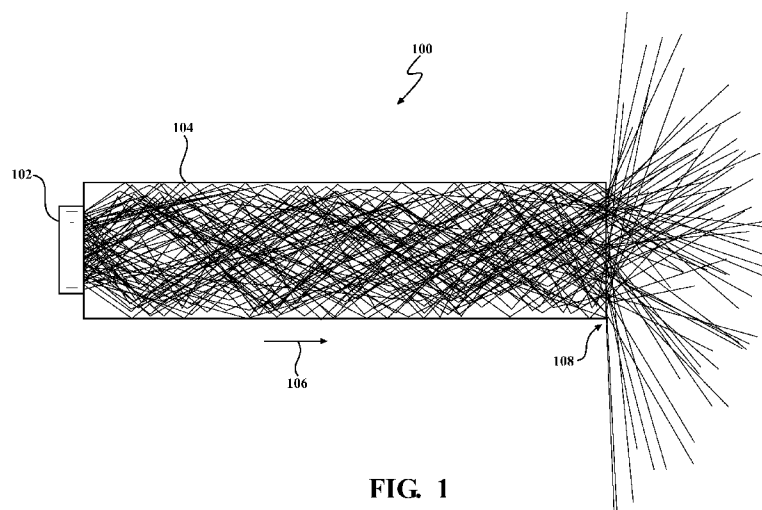


FIG. 1

(57) Abstract: A composition configured to transmit light equally across a light spectrum, the composition comprising an optical polymer and an additive that differentially absorbs light within a wavelength range in the light spectrum.



COMPOSITION AND METHOD OF FORMING A COMPOSITION CONFIGURED TO
TRANSMIT LIGHT EQUALLY ACROSS A LIGHT SPECTRUM

BRIEF SUMMARY

[0001] The subject matter described herein relates to compositions and methods of forming compositions and the cured products thereof configured to transmit light equally across a light spectrum. The compositions include an optical polymer and an additive that differentially absorbs light within a wavelength range in the visible light spectrum.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] FIG. 1 shows a light source coupled to a rod section having extraction elements and illustrating a direction of travel of light through the rod section.

[0003] FIG. 2 (non-invention) shows a Lit-on Test of a non-invention optical device made of an additive-free silicone material.

[0004] FIG. 3 shows a Lit-on Test of an inventive optical device made of an inventive example silicone material.

[0005] FIG. 4 shows a photometric test apparatus including an integrating sphere.

[0006] FIG. 5 (non-invention) shows spectral power distribution comparison results for a non-invention optical device including a light emitting diode (LED) light source and a non-invention silicone rod section made of an additive-free silicone material.

[0007] FIG. 6 (non-invention) shows transmittance values of an additive-free silicone material having a thickness of 3.85 millimeters (mm) through which light was transmitted.

[0008] FIG. 7 (non-invention) shows transmittance values of an additive-free silicone material having a thickness (length) of 300 mm through which light was transmitted.

[0009] FIG. 8 (non-invention) shows transmittance values of an additive-free silicone material having a thickness (length) of 914 mm through which light was transmitted.

[0010] FIG. 9 shows a comparison of transmittance values between a non-invention silicone rod section made of an additive-free silicone material and an inventive example rod section made of an inventive example silicone material.

[0011] FIG. 10 shows a spectral power distribution comparison between an LED light sample, a non-invention silicone rod section made of an additive-free silicone material and an inventive example rod section made of an inventive example silicone material.

[0012] FIG. 11 shows transmittance values of an inventive example rod section made of an inventive example silicone material having a composition including a sodium alumino sulfosilicate additive.

DETAILED DESCRIPTION

[0013] The composition described herein is configured to transmit light equally across a visible light spectrum. In one embodiment, the composition includes an optical polymer and an additive that differentially absorbs light within a wavelength range in the visible light spectrum in such a way that the composition transmits light equally across the visible light spectrum. The “in such a way” means the additive is a material that absorbs relatively more light at some wavelengths in the visible light spectrum and relatively less light at other wavelengths in the visible light spectrum such that a white light entering the composition, or a cured product of curing same (i.e., a cured product formed by curing the composition), and transmitted through the composition, or the cured product, exits the composition or the cured product and is still white light (e.g., is not a yellow light or blue light). That is, the additive has a counter-balancing light absorbance characteristic. The light absorbance characteristic of the additive counter-balances or corrects for the differential light absorbing/transmitting character of the composition or cured product.

[0014] Without the additive, the optical polymer is a material that exhibits a natural color shift as absorbance of light across the visible light spectrum is measured. For example, the optical polymer may be a material that differentially absorbs light across the visible light spectrum. For example, the optical polymer may absorb relatively more light at shortest wavelength in the visible light spectrum, and progressively absorb relatively less and less light as the wavelength is increased across the visible light spectrum. Said another way, the optical polymer may be a material that transmits relatively less light at the shortest wavelength in the visible light spectrum, and progressively transmits relatively more and more light as the wavelength is increased across the visible light spectrum. Such an optical polymer would undesirably cause a color shift toward yellow light region of the visible light spectrum such that a white light that is transmitted through the optical polymer is white when entering the optical polymer would appear to have yellowed where it exits the optical polymer. This color shift may be observed as a positively sloping transmission line from a shorter wavelength (e.g., 360 nm) to a longer wavelength (e.g., 700 nm) in a plot of transmittance versus wavelength.

[0015] In the inventive composition, the additive is chosen for differentially absorbing light across the visible light spectrum in a way that it complements or counter-balances the visible light absorption of the optical polymer. For example, the additive may absorb light at certain wavelengths more than at other wavelengths within the visible light spectrum such that the natural color shift of the optical polymer is counter-balanced or neutralized. That is, the additive may be chosen to absorb yellow light more than blue light such that white light that is transmitted through the inventive composition is white when entering the inventive

composition and remains white when it exits the inventive composition. As a result of the counter-balancing affect of the additive, the inventive composition exhibits an equal light transmission across the visible light spectrum such that the natural color shift of the optical polymer is no longer detectable by an unaided human eye.

[0016] The composition contains the additive at a suitable concentration, based on a total weight of the composition that differentially absorbs light at a desired wavelength or within a desired wavelength range in the visible light spectrum. In a particular embodiment, the optical polymer of the composition is curable and exhibits a high transmission (> 90% at 3 mm sample thickness) across a visible light spectrum. In certain embodiments, the composition includes more than one suitable additive.

[0017] In one embodiment, the composition includes an optical polymer, such as a poly(methyl methacrylate) (PMMA), a polycarbonate (PC), a cyclo olefin copolymer (COC), a cyclic olefin polymer (COP), a polysulfone, a silicone polymer or an optical polyester. In alternative embodiments, the composition includes any suitable optical polymer or optical polymer combination. In a particular embodiment, the optical polymer is derived from an organosiloxane composition including a polymer or polymer combination having a component (A), an organosiloxane compound. Component (A) may include a diorganopolysiloxane, an organopolysiloxane, an organosiloxane copolymer, an organopolysiloxane resin, an organooligosiloxane or a combination of any two or more.

[0018] The organosiloxane composition may further include a component (B), a crosslinking agent. In one embodiment, component (B) is a crosslinking agent including, without limitation, an organohydrogenoligosiloxane, an organohydrogenpolysiloxane, a polyorganohydrogensiloxane, or a combination of any two or more.

[0019] The organosiloxane composition may further include a component (C), a catalyst for enhancing the reaction of component (A) with component (B). In one embodiment, component (C) is a catalyst added in an amount sufficient to promote curing of the composition. Component (C) may include a hydrosilylation catalyst known in the art and commercially available. Suitable hydrosilylation catalysts include, without limitation, any one of a platinum group metal, an organometallic compound thereof, and a combination of any two or more. The platinum group metal includes, and the organometallic compound thereof contains, any one or more of platinum, rhodium, ruthenium, palladium, osmium, and iridium.

[0020] In one embodiment, the composition includes a suitable additive, such as a pigment, a dye or an optically active agent, that differentially absorbs light within a desired wavelength range in the visible light spectrum. In a particular embodiment, the additive absorbs light having a wavelength of 480 nanometers (nm) to 700 nm or, more specifically,

500 nm to 600 nm or, even more specifically, 500 nm to 560 nm, while absorbing relatively less light at other wavelengths in the visible light spectrum. Suitable pigments, dyes or optically active agents include, without limitation, blue pigments and blue dyes capable of absorbing light having a wavelength of 500 nm to 600 nm, for example. In a particular embodiment, the additive is sodium alumino sulfosilicate. In an alternative embodiment, the additive is a material of empirical formula $C_{45}H_{44}N_3NaO_7S_2$.

[0021] Further, in one embodiment, the additive has a concentration based on a total weight of the composition of 0.2 parts per million (ppm) to 2000 ppm or, more specifically, 1.2 ppm to 80 ppm or, even more specifically, 1.2 ppm to 20 ppm.

[0022] The composition may further include one or more additional ingredients. The additional ingredient or combination of ingredients may include, for example, an inhibitor (e.g., of curing of the composition), a mold release agent, a filler, an adhesion promoter, a heat stabilizer, a flame retardant, a reactive diluent, an oxidation inhibitor, or a combination of any two or more thereof.

[0023] In one embodiment, an inventive method of forming the composition includes mixing a solution including the optical polymer with an additive that differentially absorbs light within a wavelength range in the visible light spectrum to form the composition. In one embodiment, the mixing step includes mixing with the solution with a quantity of the additive sufficient to ultimately give an inventive composition having the additive at a concentration of 0.2 parts per million to 2000 parts per million based on the total weight of the composition. In a particular embodiment, the mixing step includes mixing the solution with an additive that differentially absorbs light having a wavelength of 500 nanometers to 600 nanometers.

[0024] The composition can then be cured using a suitable curing technique or method known to those having ordinary skill in the art to form a cured composition. In one embodiment, the composition is heated to cure the composition to form the cured product. The heating step may further include injection molding, transfer molding, casting, extrusion, overmolding, compression molding, or cavity molding, for example, to produce a molded, cast, or extruded article.

[0025] Optical device components may be produced using the composition as described herein by a method including shaping the composition and curing the composition to form a cured product, for example, for use in an optical device. Shaping the composition may be performed by injection molding, transfer molding, casting, extrusion, overmolding, compression molding, or cavity molding to produce a molded, cast, or extruded article. The method of shaping the composition will depend on various factors including a size and/or a shape of the optical device to be produced and the composition selected.

[0026] In one embodiment, the cured composition can be used in an optical device application for transmitting light equally across a light spectrum. The optical device can be a charged coupled device, a light emitting diode, a lightguide, an optical camera, a photo-coupler, or a waveguide, for example. In another embodiment, the cured composition can be used in an optical device to facilitate evenly illuminating a surface of the optical device from which light is extracted.

[0027] For example, FIG. 1 shows an optical device 100 that includes a light engine 102 and a rod section 104 having a plurality of extraction elements (not shown) formed on and/or within the rod section 104. As shown in FIG. 1, light propagates through the rod section 104 in a general direction of travel indicated by directional arrow 106 and, as light propagates through the rod section 104, a portion of the light is extracted from the rod section 104, exiting the rod section 104 through the extraction elements. A portion of the light is internally reflected as it travels through the rod section 104 and exits the rod section 104 at an end 108.

[0028] FIG. 2 shows a Lit-on Test (i.e., simply, a test where light source of the optical device is on and emitting light) for a non-invention optical device 200 including a light emitting diode (LED) engine 202 and a rod section 204. During the test, the LED engine 202 transmits a cool white light of 5145K CCT (Kelvin correlated color temperature) through the rod section 204. As shown in FIG. 2, the light extracted from the rod section 204 at or near a first end 206 of the rod section 204 near the LED engine 202 looks cool white while the light exiting the rod section 204 at or near an opposing end 208 of the rod section 204 is yellow and warmer, thus having a substantially increasing change in color shift.

[0029] In contrast, FIG. 3 shows a Lit-on Test for an inventive optical device 300 having a rod section 304 formed of a cured composition including an optical polymer and an additive having a suitable concentration based on a total weight of the composition that differentially absorbs light at a wavelength or within a wavelength range in the visible light spectrum, as described herein. An LED engine 302 provides a cool white light of 5145K CCT that propagates through the rod section 304 formed of the inventive example cured composition. As shown in FIG. 3, the light extracted from the rod section 304 at or near a first end 306 of the rod section 304 near the LED engine 302 looks cool white. The light exiting the rod section 304 at or near an opposing end 308 of the rod section 304 remains cool white light, illustrating minimal or no change in color shift.

[0030] In order to quantify the color separation as shown in FIG. 2 and a relative lack of color separation as shown in FIG. 3, photometric testing is done in an integrated sphere apparatus 400, such as shown in FIG. 4. An LED engine 402 positioned at a first end of a

rod section 404 transmits light through the rod section 404 such that the light exits the rod section 404 at an opposite end 406 and propagates into an integrating sphere 408.

[0031] Some embodiments include any one or more of the following numbered aspects.

[0032] Aspect 1. A composition configured to transmit light equally across a light spectrum, the composition comprising: an optical polymer; and an additive that differentially absorbs light within a wavelength range in the visible light spectrum in such a way that the composition transmits light equally across the visible light spectrum.

[0033] Aspect 2. The composition of aspect 1, wherein the polymer is selected from a poly(methyl methacrylate) (PMMA), a polycarbonate (PC), a cyclo olefin copolymer (COC), a cyclic olefin polymer (COP), a polysulfone, a silicone polymer and an optical polyester.

[0034] Aspect 3. The composition of aspect 1, wherein the additive is selected from a pigment, a dye and an optically active agent.

[0035] Aspect 4. The composition of aspect 1, wherein the additive is a sodium alumino sulfosilicate.

[0036] Aspect 5. The composition of aspect 1, wherein the additive is a sodium alumino sulfosilicate of empirical formula $C_{45}H_{44}N_3NaO_7S_2$.

[0037] Aspect 6. The composition of aspect 1, wherein the additive (e.g., the pigment, dye or optically active agent of aspect 3) absorbs light having a wavelength of 500 nanometers to 600 nanometers while absorbing relatively less light at the other wavelengths of the visible light spectrum.

[0038] Aspect 7. The composition of aspect 1, wherein the additive has a concentration of 0.2 parts per million to 2000 parts per million based on a total weight of the composition.

[0039] Aspect 8. The composition of aspect 1, wherein the additive has a concentration of 1.2 parts per million to 80 parts per million based on a total weight of the composition.

[0040] Aspect 9. The composition of aspect 1, further comprising an additional ingredient selected from the group consisting of: an inhibitor, a mold release agent, a filler, an adhesion promoter, a heat stabilizer, a flame retardant, a reactive diluent, an oxidation inhibitor, and a combination of any two or more thereof.

[0041] Aspect 10. A composition configured to transmit light equally across a light spectrum, the composition comprising: an optical polymer; and an additive that differentially absorbs light within a wavelength range in the visible light spectrum in such a way that the composition transmits light equally across the visible light spectrum, the additive having a concentration of 0.2 parts per million to 2000 parts per million based on a total weight of the composition.

[0042] Aspect 11. A cured product formed by curing the composition of any one of aspects 1 to 10.

[0043] Aspect 12. Use of the cured product of aspect 11 in an optical device application for transmitting light equally across a light spectrum.

[0044] Aspect 13. An optical device comprising the cured product of aspect 11.

[0045] Aspect 14. The optical device of aspect 13 selected from: a charged coupled device, a light emitting diode, a lightguide, an optical camera, a photo-coupler, and a waveguide.

[0046] Aspect 15. Use of the cured product of aspect 11 in an optical device to facilitate evenly illuminating a surface of the optical device from which light is extracted.

[0047] Aspect 16. A method for forming a composition configured to transmit light equally across a light spectrum, the method comprising: mixing a solution comprising an optical polymer with an additive that differentially absorbs light within a wavelength range of the light spectrum to form the composition, wherein the additive differentially absorbs light in such a way that the composition transmits light equally across the visible light spectrum.

[0048] Aspect 17. The method of aspect 16, wherein the mixing step comprises mixing with the solution the additive having a concentration of 0.2 parts per million to 2000 parts per million based on the total weight of the composition.

[0049] Aspect 18. The method of aspect 16, wherein the additive absorbs light having a wavelength of 500 nanometers to 600 nanometers while absorbing relatively less light at other wavelengths of the visible light spectrum.

[0050] Aspect 19. The method of aspect 16, further comprising heating the composition to form the cured product.

[0051] Aspect 20. The method of aspect 19, wherein the heating step further comprises one of injection molding, transfer molding, casting, extrusion, overmolding, compression molding, and cavity molding and the cured product is a molded, cast, or extruded article.

[0052] The following examples are intended to illustrate certain embodiments to one of ordinary skill in the art and should not be interpreted as limiting in the scope of the disclosure set forth in the claims.

[0053] Photometric testing was conducted using a non-invention rod section 204. Table 1 below provides a summary of the results of the photometric test.

TABLE 1

TEST UNIT	CCT (K)	Δ CCT (K)
LED Engine Only	5145	-
LED Engine with Non-invention Rod	3419	-1726

[0054] As shown in Table 1, the light extracted from the rod section 204 has a much lower correlated color temperature (CCT) (3419K) compared to the CCT of the initial light from the LED engine 204 (5145K), and it appears more yellow.

[0055] FIG. 5 provides a spectral power distribution comparison for a non-invention optical device including a light emitting diode (LED) light source and a non-invention silicone rod section made of an additive-free silicone material 1002. By looking at the spectral power distribution results of FIG. 5, when compared to the initial light (line indicated as “LED” in FIG. 5) from the LED engine 202 (FIG. 2) at or near the first end 206 (FIG. 2), light exiting or extracted from the non-invention rod section 204 (FIG. 2) at the opposite second end 208 (FIG. 2) has a significant drop in the blue spectrum which is highlighted in FIG. 5 for line indicated as “1002” by an arrow 502 and, thus, enhanced in the yellow-green spectrum which is highlighted in FIG. 5 by an arrow 504. According to HUE theory, if light in a blue color wavelength is reduced in a rod section, the rod section will look more yellow.

Comparative Examples

[0056] An additive-free silicone material sample having a length of 50 millimeters (mm), a width of 50 mm, and a thickness of 3.85 mm was made to measure its transmittance values across wavelengths within a light spectrum as shown in FIG. 6. A transmittance value of the sample at a wavelength of 450 nanometers (nm) is 0.9916 and a transmittance value of the sample at a wavelength of 550 nm is 0.9958. Therefore, a difference between the transmittance value at a wavelength of 450 nm and the transmittance value at a wavelength of 550 nm is 0.4%. In one embodiment, the additive-free silicone material sample is inventive Example 1 shown later along with Comparative Examples 1 and 2 in Table 3. Comparative Example 3 is shown below in Table 2. Comparative Example 3 shows a cured product with a combination of properties prepared using a vinyl content in the silicone resin and a combination of polymers having two different viscosities, a lower viscosity polymer and a higher viscosity polymer.

Table 2

Ingredient	Comparative Example 3
Polymer (A1) low viscosity	0
Polymer (A3) low viscosity	41.3
Polymer (A2) high viscosity	17.8
Resin	40.5
Resin	0
Crosslinker	0
Crosslinker	4.6
Catalyst	3 ppm
Inhibitor	0
Inhibitor	0.2

SiH/Vi ratio	1.4
% Vi in Resin	1.95
Hardness	74
Tensile Strength (mPa.s)	11.6
Elongation (%)	82

[0057] Other silicone material samples may include the following non-limiting examples shown in Table 3 below.

Table 3

Ingredient	Comparative Example 1	Comparative Example 2	Inventive Example 1
Polymer (A1)	67	0	33.5
Polymer (A2)	0	71	35.5
Resin	31	27	29
Crosslinker	5.4	4.3	4.8
Catalyst	3 ppm	3 ppm	3 ppm
Inhibitor	0.01	0.01	0.01
SiH/Vi ratio	1.5	1.5	1.5
% Vi in Resin	2.0	2.0	2.0
Hardness	48	42	45
Tensile Strength (mPa.s)	4.6	5.0	6.2
Elongation (%)	52	205	117

[0058] FIG. 7 shows transmittance values across wavelengths within a light spectrum of an additive-free silicone material having a length of 300 mm. The values are calculated based on the test data of a sample with a length of 50 mm and an extinction coefficient calculated using the following equation:

$$T_d = e^{-kd}, \quad \text{Eq. (1)}$$

wherein T_d is the transmittance value of the sample with a length, d , k is an extinction of the coefficient, and e is a natural logarithm.

[0059] As shown in FIG. 7, the transmittance value of the sample at a wavelength of 450 nm is 0.5163 and the transmittance value of the sample at a wavelength of 550 nm is 0.7215. Therefore, a difference between the transmittance value at a wavelength of 450 nm and the transmittance value at a wavelength of 550 nm is 28%.

[0060] FIG. 8 shows transmittance values across wavelengths within a light spectrum of an additive-free silicone material having a length of 914 mm. As shown in FIG. 8, when a length of a sample is predicated to be 914 mm (about 3 feet), the transmittance value at a wavelength of 450 nm is 0.1334 and the transmittance value at a wavelength of 550 nm is 0.3700. Therefore, a difference between the transmittance value at a wavelength of 450 nm and the transmittance value at a wavelength of 550 nm is increased to 64%.

[0061] This color shifting is due to a change in transmittance of light through an additive-free silicone material, as indicated in FIGS. 6 to 8 for different thickness materials by the slope of a plot of absorbance or light transmission versus wavelength of light across the visible light spectrum. The inventive example compositions described herein and the cured products made from the inventive example compositions provide for equal light transmission across a light spectrum. With equal light transmission across a light spectrum, a plot of light transmission across the light spectrum would show no slope. In one embodiment, the inventive example composition includes at least one additive that differentially absorbs a quantity of light at the green-yellow spectrum (500 nm to 600 nm) while maintaining a high light transmission at the blue spectrum (430 nm to 480 nm).

[0062] An inventive example composition sample including Example 3 above with an additive as described herein having a length of 50 mm, a width of 50 mm, and a thickness of 3.85 mm was made to measure its transmittance values across the wavelengths within a light spectrum. FIG. 9 provides comparative transmittance values between the transmittance value of the additive-free silicone sample 902 (902 is the reference number in FIG. 9, whereas without reference to a drawing the additive-free silicone material may be referred to herein by its composition number "1002") and the transmittance value of the inventive example composition sample 904 of the present disclosure.

[0063] Photometric testing was conducted using a rod section formed by curing the inventive example composition and a rod section formed of the additive-free silicone material (Example 3 above). Table 4 below provides a summary of comparative results of the photometric test.

TABLE 4

TEST UNIT	CCT (K)	Δ CCT (K)*
LED Engine Only	5145	0
LED Engine with Non-invention Rod	3419	-1726
LED Engine with Present Disclosure Rod	5118	-27

*relative to the CCT (K) for the LED Engine Only

[0064] FIG. 10 shows a spectral power distribution comparison between an LED light indicated by line 1000 ("LED" in key in FIG. 10), a rod section formed of the additive-free

silicone material indicated by line 1002 ("1002" in key in FIG. 10) and a rod section formed by curing the inventive example composition indicated by line 1004 ("Inventive Example" in key in FIG. 10) of the present disclosure. In Fig. 10, the Y axis is the radiant power (P). For example, if the radiant power of light at a wavelength of 450 nm divided by the radiant power of light at a wavelength of 550 nm is generally designated by alpha or " α " (i.e., $\alpha = P_{450} / P_{550}$ wherein the radiant power of light at a wavelength of 450 nm / the radiant power of light at a wavelength of 550 nm) and if the radiant power of light at a wavelength of 450 nm divided by the radiant power of light at a wavelength of 650 nm light is generally designated by beta or " β " (i.e., $\beta = P_{450} / P_{650}$ wherein the radiant power of light at a wavelength of 450 nm / the radiant power of light at a wavelength of 650 nm light), then a desired range of α , β values That define flatness of transmittance across the wavelength can be determined as described above. Therefore, a desired range is $85\% < \alpha_{\text{-rod}} / \alpha_{\text{-LED}} < 115\%$, and $70\% < \beta_{\text{-rod}} / \beta_{\text{-LED}} < 130\%$.

[0065] FIG. 11 shows transmittance values of an inventive example composition of the present disclosure including sodium aluminosulfosilicate as the additive.

[0066] As shown above, the inventive example composition of the present disclosure reduces or eliminates issues with coloring shifting and uneven transmission of light across the visible light spectrum. Light traveling through the materials made of the inventive example composition have no or minimal color shift regardless of the length of the light pathway through the material.

[0067] Compositions of the present disclosure may be useful for the fabrication of optical devices, such as lightguides and LED packages, for example. Products prepared by curing these compositions may provide one or more benefits including, without limitation, evenness of transmittance of visible light through the cured composition across the visible light spectrum (e.g., equal absorbance or equal transmittance of white light through the cured composition such that white light entering the cured composition is transmitted and exits the cured composition as white light, not yellow light) enhanced light transmission, and increased lifetimes of LED packages. The methods may form shapes of the compositions and cured products that have geometries, and the compositions and the cured products may have geometries including, but not limited to, cylindrical, rectangular, simple convex lenses, patterned lenses, textured surfaces, domes, and caps. In optical device applications, the composition may be pre-manufactured by molding (injection or transfer) or casting processes. Alternatively, a process for molding over an optical device assembly, called "overmolding" or "insert molding" on a rigid or flexible substrate may also be performed using the composition described herein. The surface of the cured product is not sticky, and has an elastoplastic character. This combination of properties makes the

composition suitable for overmolding as well as other applications. The lightguide described above may be used to transmit light from a light source to a viewing surface by internal reflection. Such applications include backlighting units for displays, vehicle lighting, and message board applications.

WHAT IS CLAIMED IS:

1. A composition configured to transmit light equally across a light spectrum, the composition comprising:

an optical polymer; and

an additive that differentially absorbs light within a wavelength range in the visible light spectrum in such a way that the composition transmits light equally across the visible light spectrum.

2. The composition of claim 1, wherein the polymer is selected from a poly(methyl methacrylate) (PMMA), a polycarbonate (PC), a cyclo olefin copolymer (COC), a cyclic olefin polymer (COP), a polysulfone, a silicone polymer and an optical polyester.

3. The composition of claim 1 or 2, wherein the additive is selected from a pigment, a dye and an optically active agent.

4. The composition of any one of claims 1-3, wherein the additive is a sodium alumino sulfosilicate.

5. The composition of any one of claim 1-4, wherein the additive is a sodium alumino sulfosilicate of empirical formula $C_{45}H_{44}N_3NaO_7S_2$.

6. The composition of any one of claims 1-5, wherein the additive absorbs light having a wavelength of 500 nanometers to 600 nanometers while absorbing relatively less light at the other wavelengths of the visible light spectrum.

7. The composition of any one of claims 1-6, wherein the additive has a concentration of 0.2 parts per million to 2000 parts per million based on a total weight of the composition.

8. The composition of any one of claims 1-7, wherein the additive has a concentration of 1.2 parts per million to 80 parts per million based on a total weight of the composition.

9. The composition of any one of claims 1-8, further comprising an additional ingredient selected from the group consisting of: an inhibitor, a mold release agent, a filler, an adhesion promoter, a heat stabilizer, a flame retardant, a reactive diluent, an oxidation inhibitor, and a combination of any two or more thereof.

10. A composition configured to transmit light equally across a light spectrum, the composition comprising:

an optical polymer; and

an additive that differentially absorbs light within a wavelength range in the visible light spectrum in such a way that the composition transmits light equally across the visible light spectrum, the additive having a concentration of 0.2 parts per million to 2000 parts per million based on a total weight of the composition.

11. A cured product formed by curing the composition of any one of claims 1 to 10.

12. Use of the cured product of claim 11 in an optical device application for transmitting light equally across a light spectrum.

13. An optical device comprising the cured product of claim 11.

14. The optical device of claim 13 selected from: a charged coupled device, a light emitting diode, a lightguide, an optical camera, a photo-coupler, and a waveguide.

15. Use of the cured product of claim 11 in an optical device to facilitate evenly illuminating a surface of the optical device from which light is extracted.

16. A method for forming a composition configured to transmit light equally across a light spectrum, the method comprising:

mixing a solution comprising an optical polymer with an additive that differentially absorbs light within a wavelength range of the light spectrum to form the composition, wherein the additive differentially absorbs light in such a way that the composition transmits light equally across the visible light spectrum.

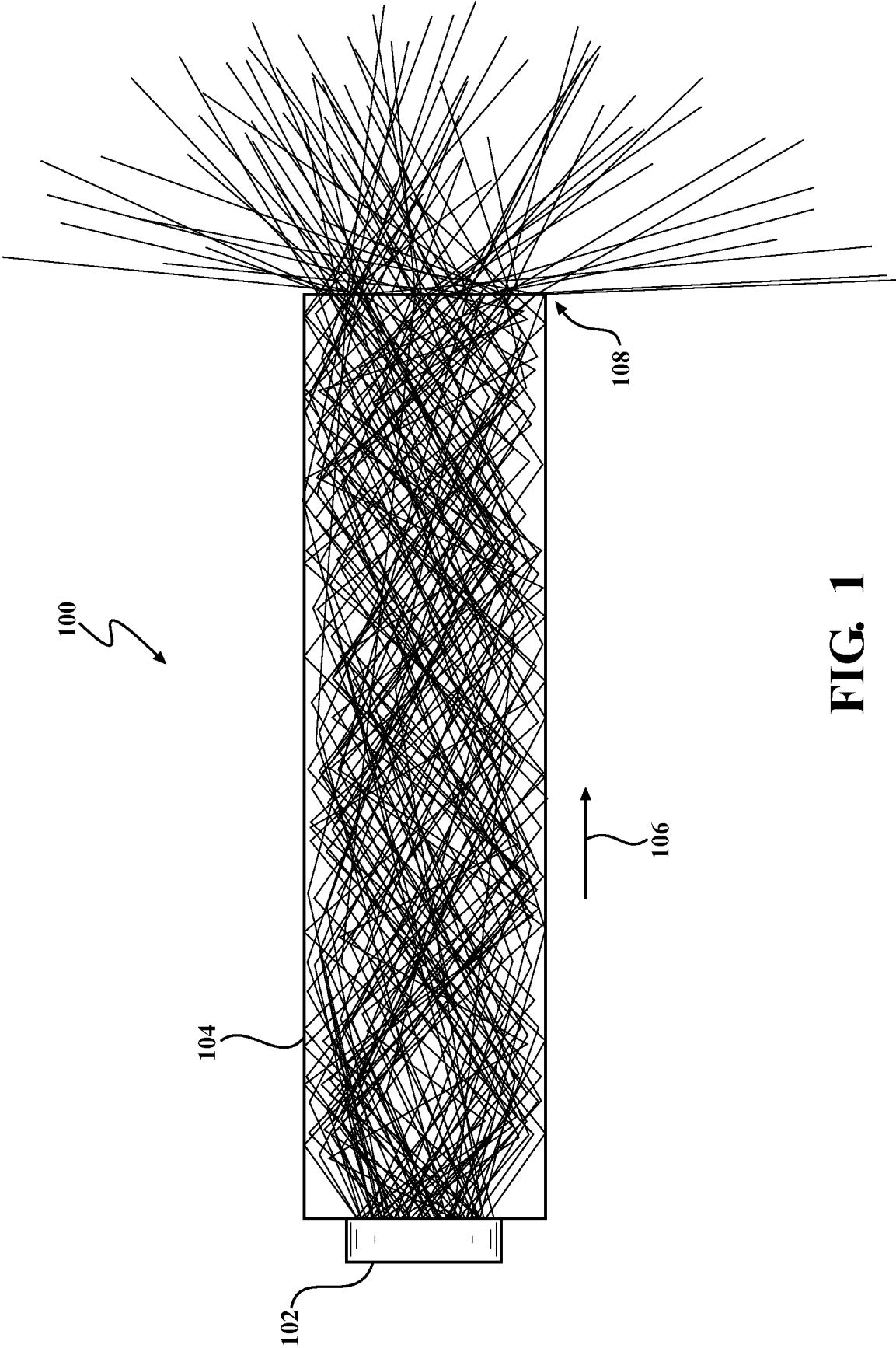


FIG. 1

2/11

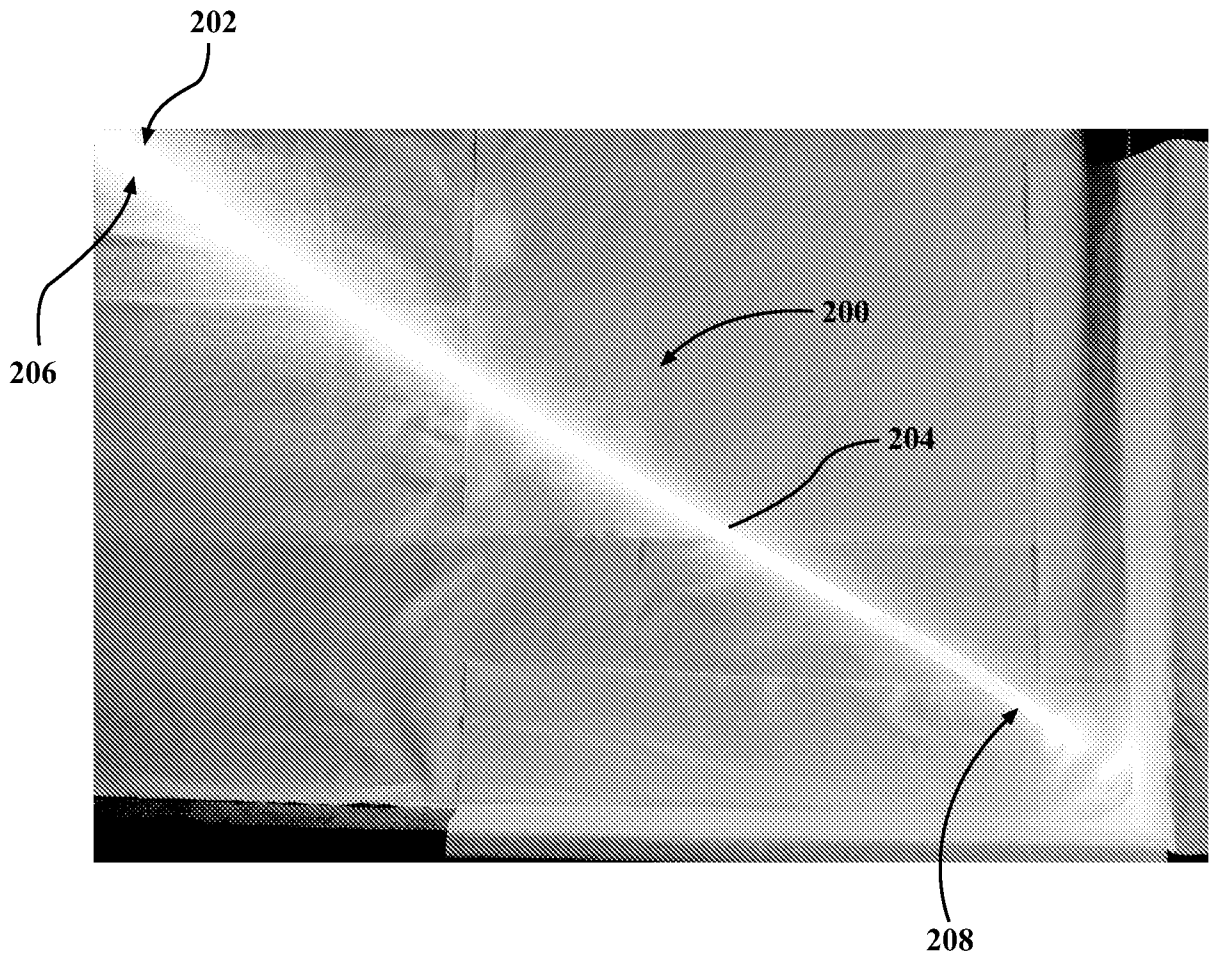
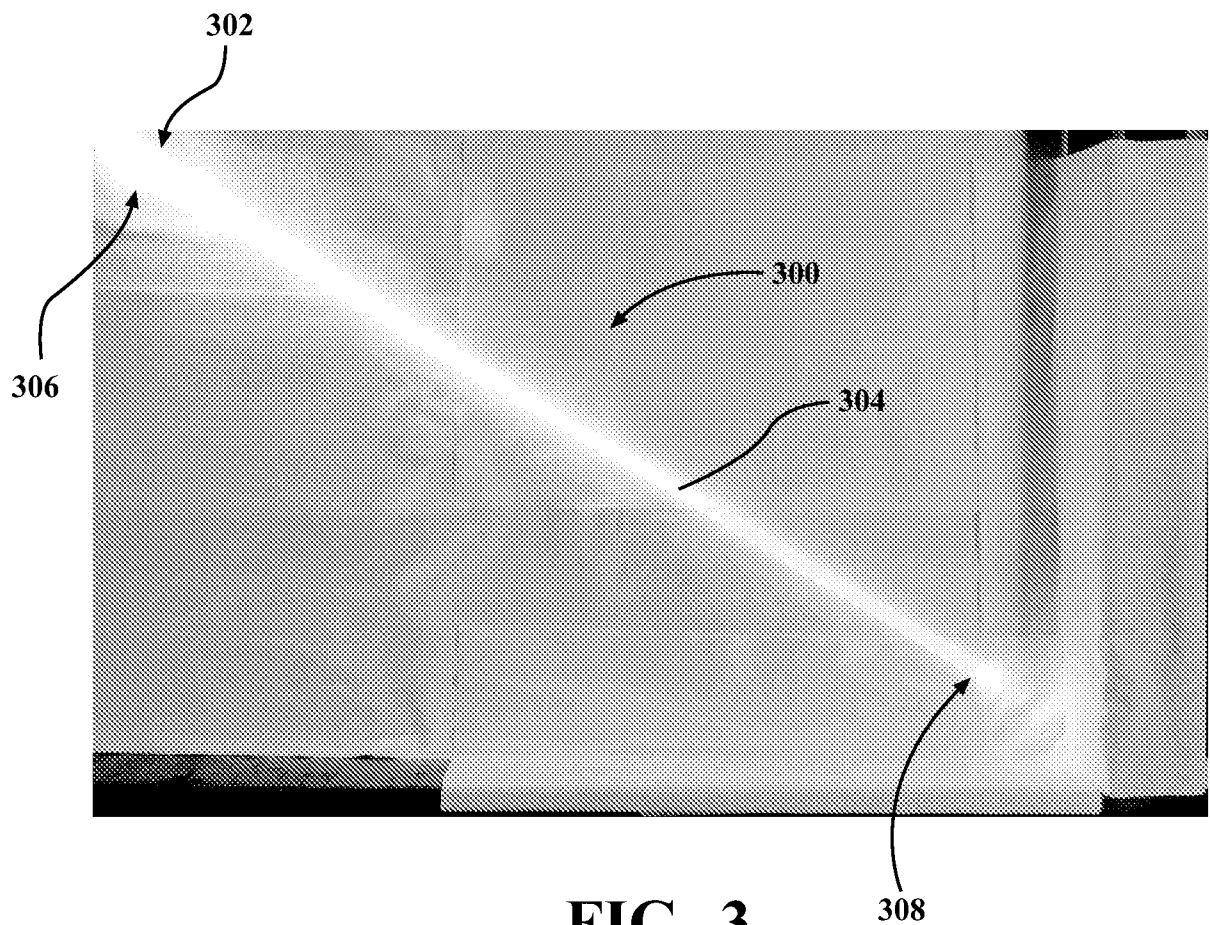


FIG. 2
(non-invention)

3/11



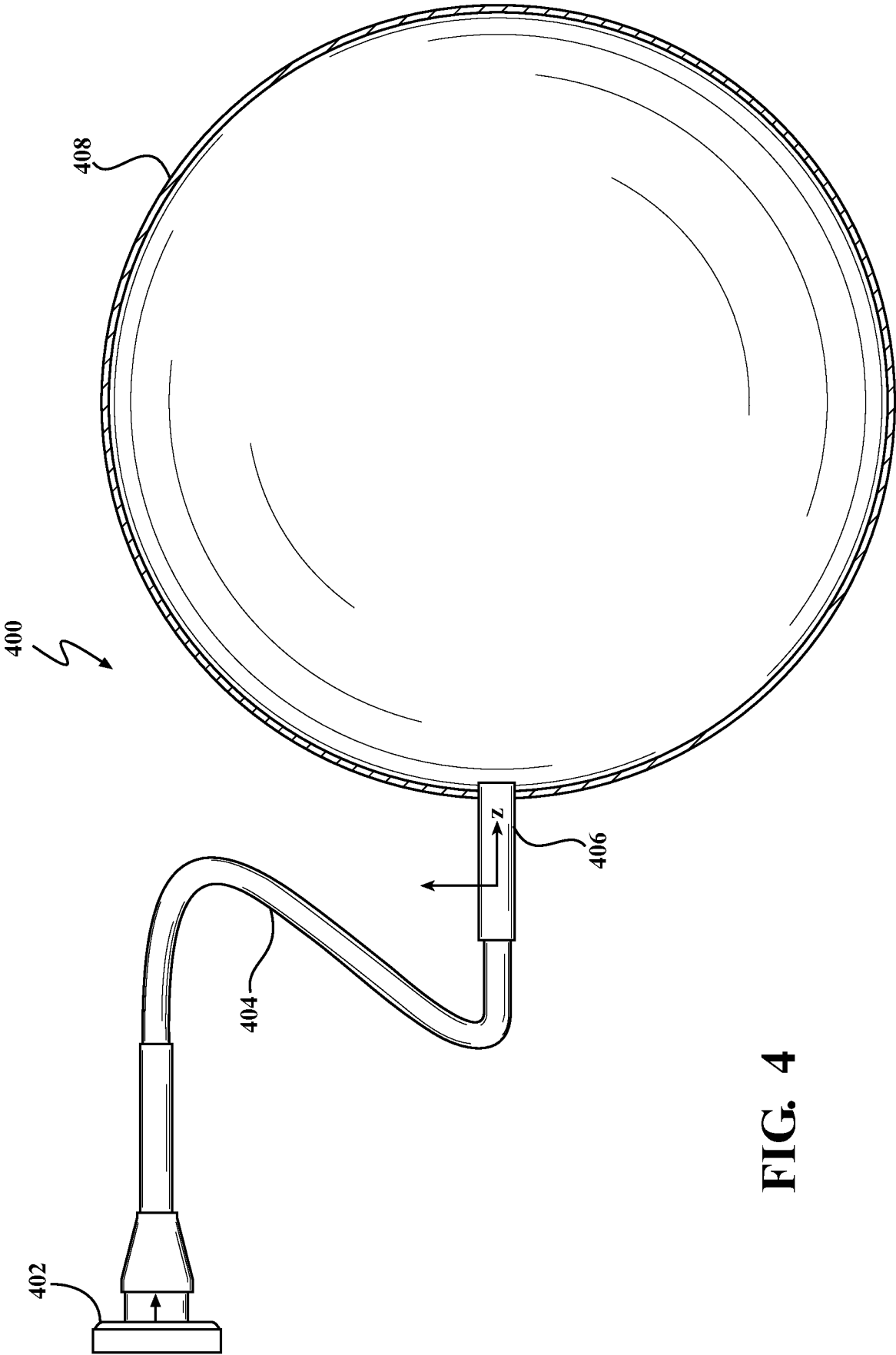


FIG. 4

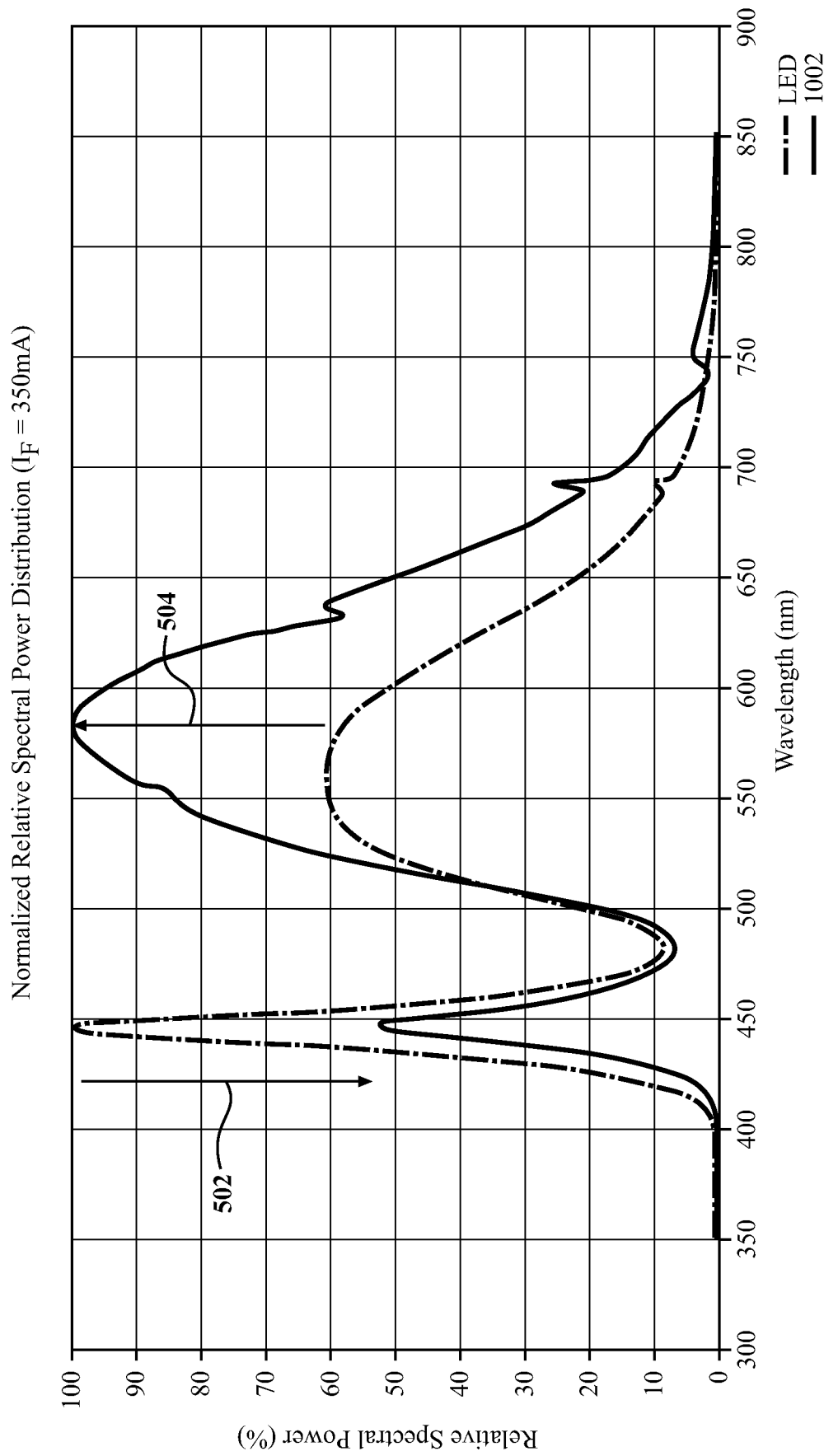


FIG. 5
(non-invention)

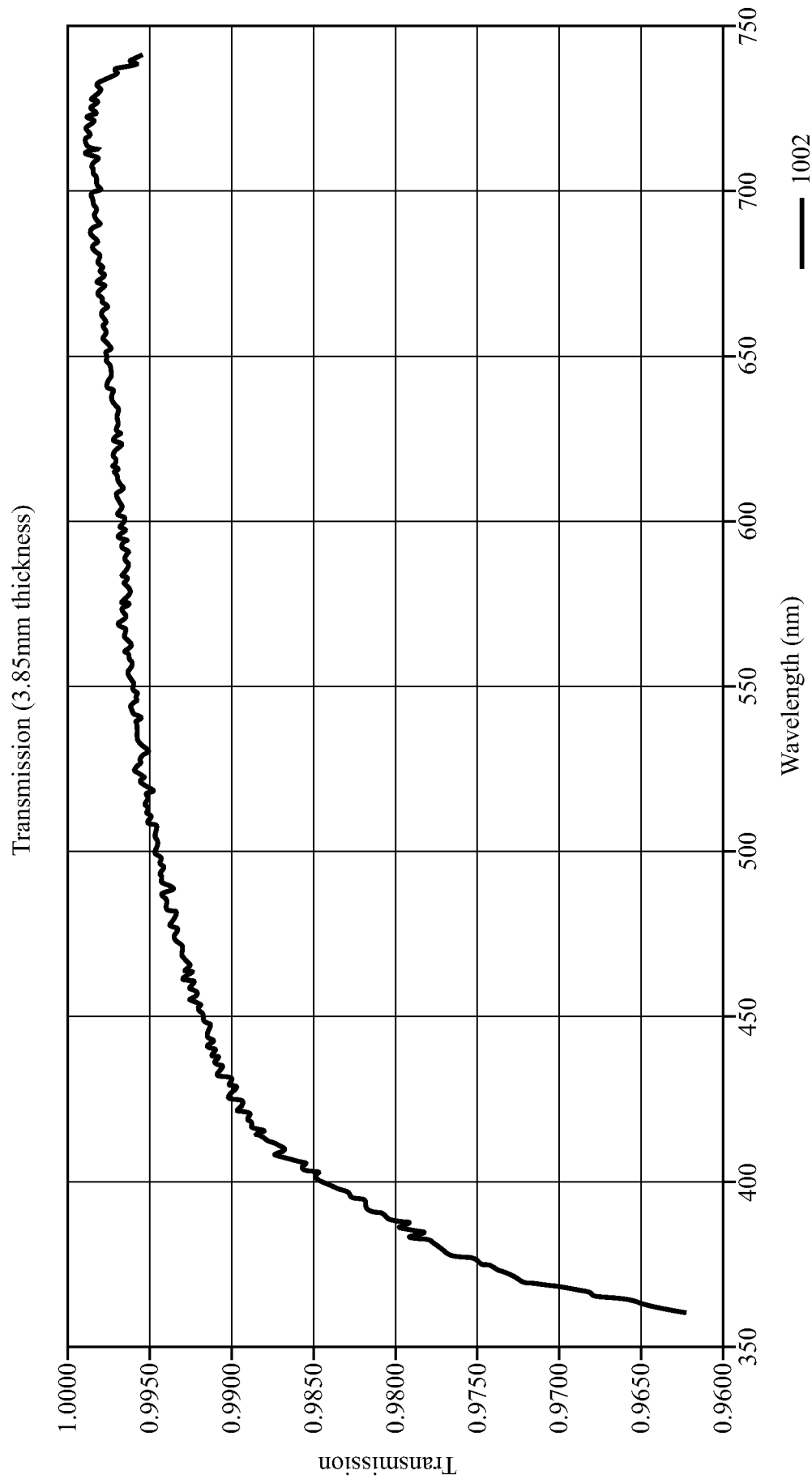


FIG. 6
(non-invention)

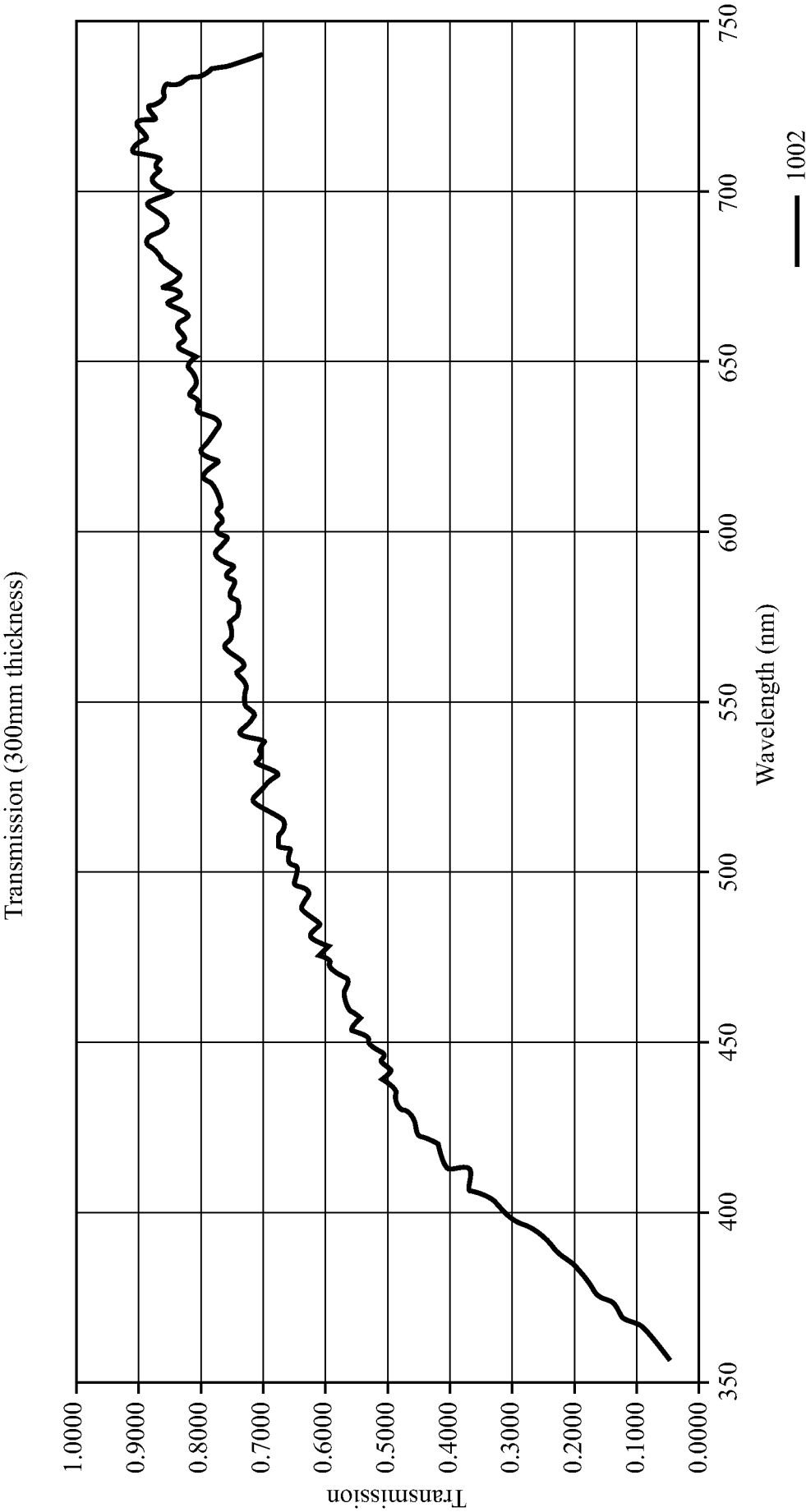


FIG. 7
(non-invention)

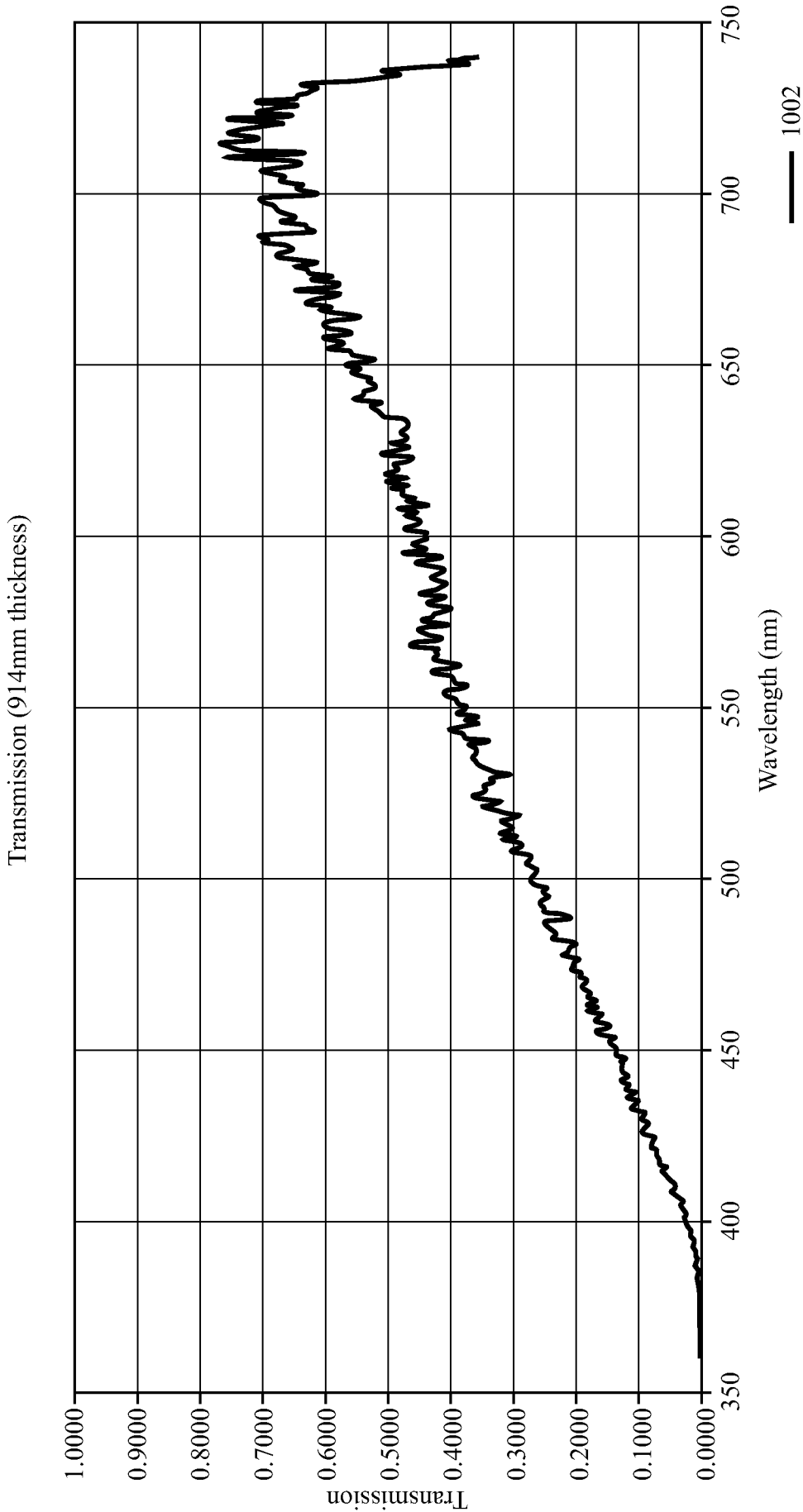


FIG. 8
(non-invention)

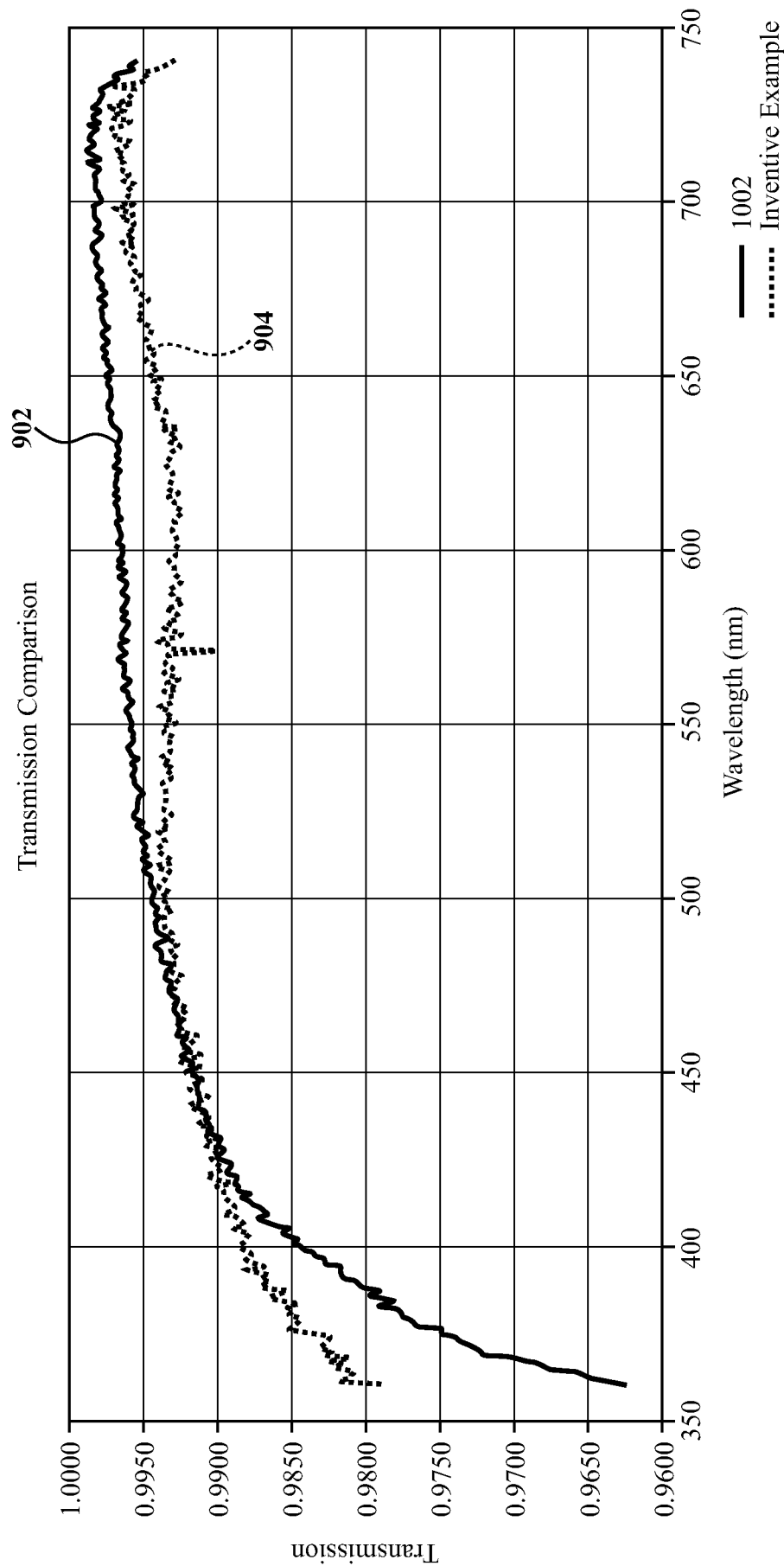


FIG. 9

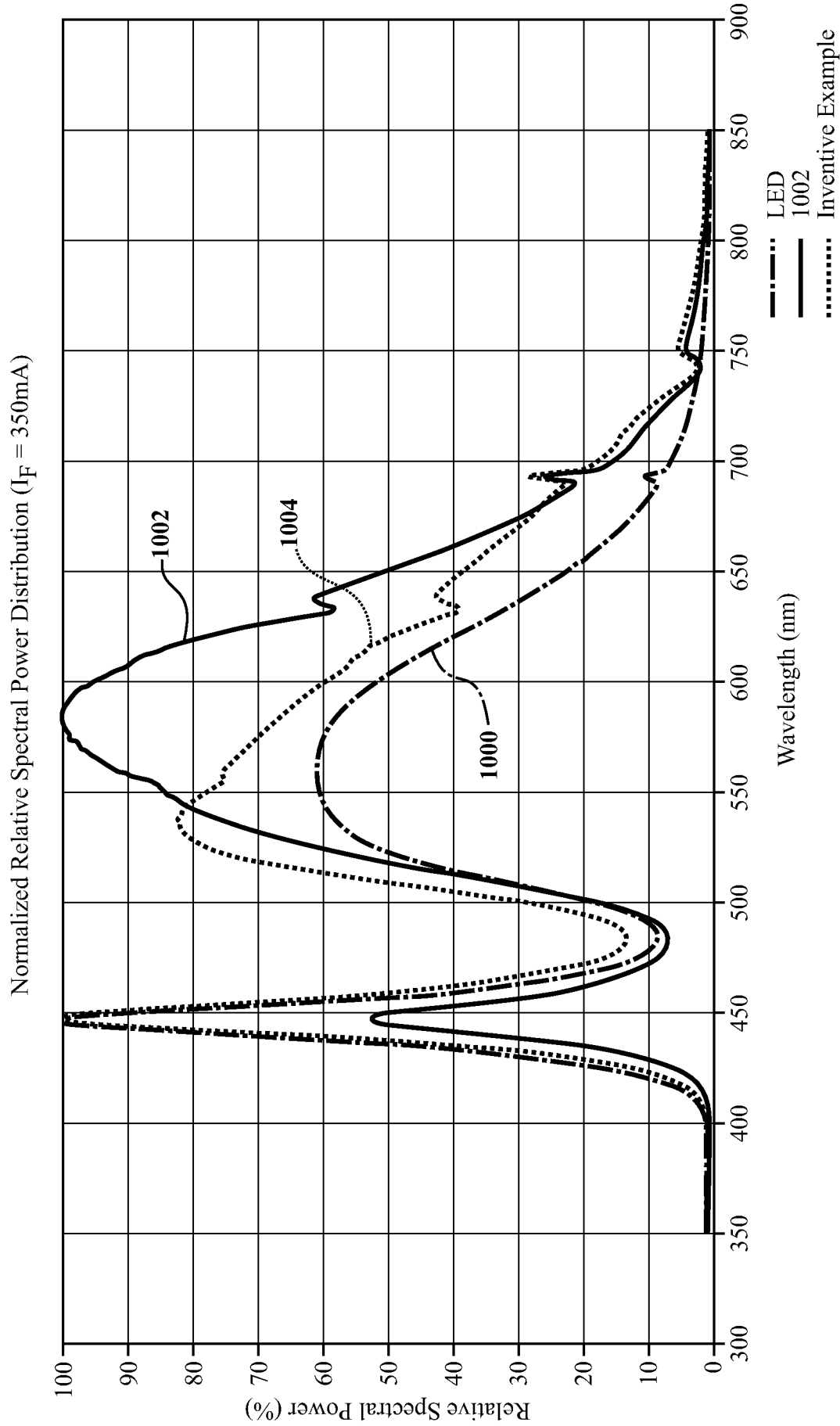


FIG. 10

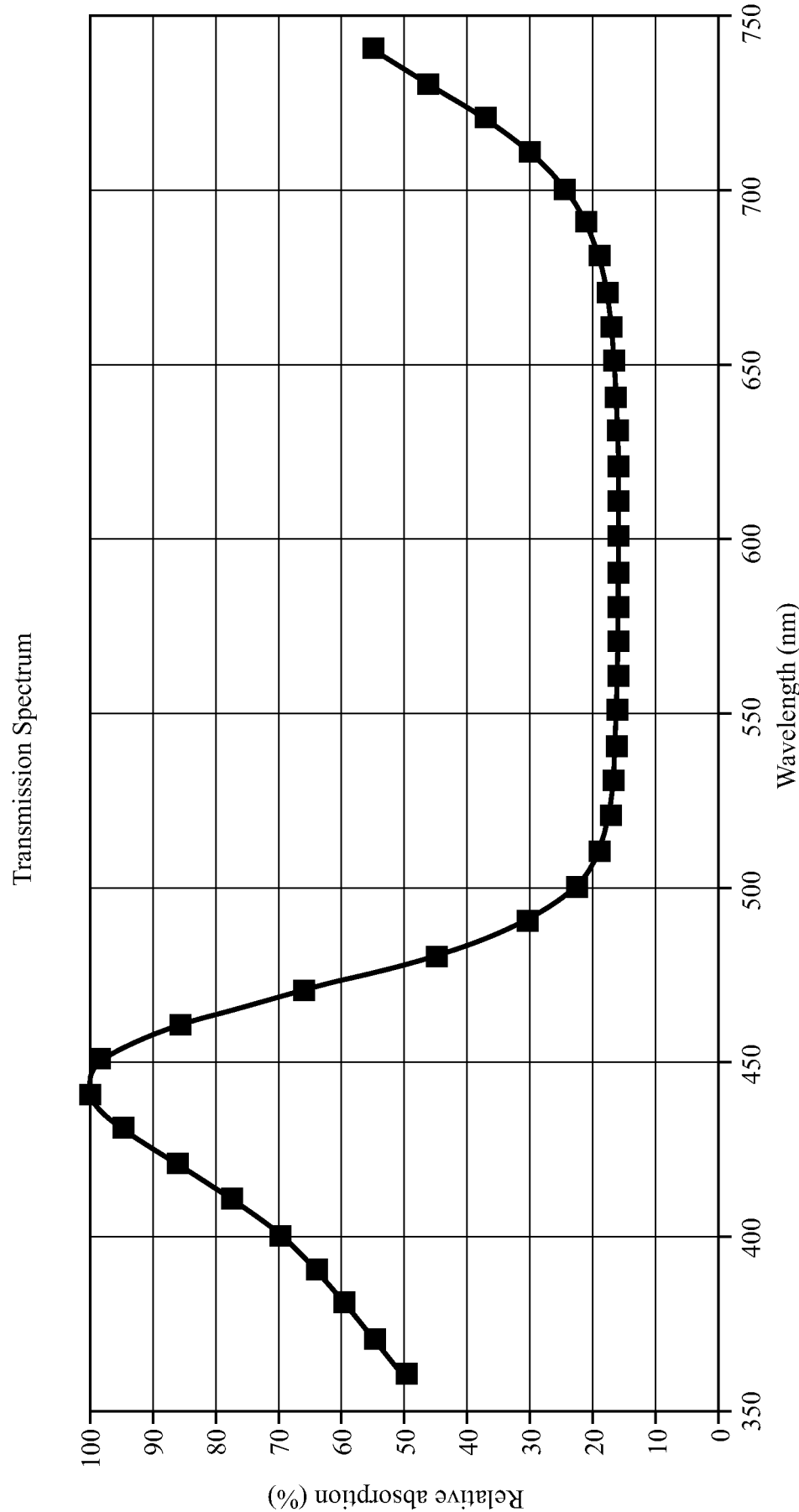


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/022646**A. CLASSIFICATION OF SUBJECT MATTER****C08L 101/12(2006.01)i, C08K 5/548(2006.01)i, C08K 5/544(2006.01)i, G02B 1/04(2006.01)i**

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)

C08L 101/12; C08K 5/548; C08K 5/544; G02B 1/04

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: optical polymer, dye, pigment, color shift, optical device, light transmission

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6526213 B1 (ILENDA, CASMIR STANISLAUS et al.) 25 February 2003 see abstract; column 1, line 50 - column 2, lines 9, column 3, lines 20-37, column 4, line 62 - column 5, line 2; claims 1, 3; table 2.	1-3, 10, 16
A	US 2012-0010703 A1 (PAUL, MARLENE L. et al.) 12 January 2012 See abstract; claims 25, 27-28.	1-3, 10, 16
A	US 2008-0043200 A1 (ISHAK, ANDREW W.) 21 February 2008 See abstract; claims 1, 3-6.	1-3, 10, 16
A	US 2012-0300160 A1 (LEE, JINHOON et al.) 29 November 2012 See abstract; claim 1.	1-3, 10, 16
A	US 2004-0065870 A1 (DO, JUNG YUN et al.) 08 April 2004 See abstract; claim 1.	1-3, 10, 16



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

29 May 2015 (29.05.2015)

Date of mailing of the international search report

29 May 2015 (29.05.2015)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORTInternational application No.
PCT/US2015/022646**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

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

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 12-15
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
Claims 12-15 are unclear since they refer to claims which are not searchable due to not being drafted in accordance with the second and third sentence of Rule 6.4(a).
3. ☒ Claims Nos.: 4-9, 11
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

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

Remark on Protest

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

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/022646

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