



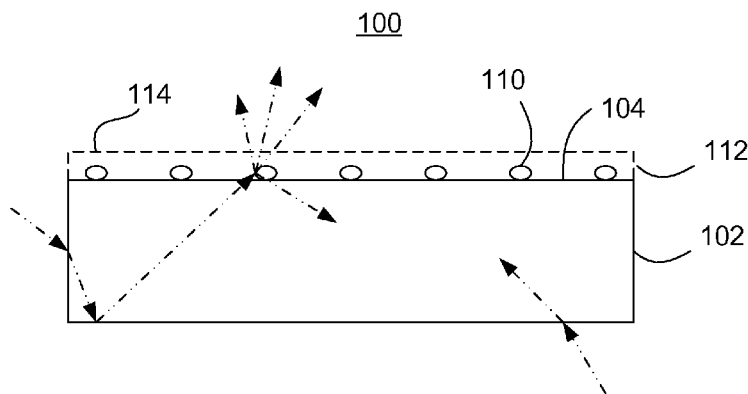
- (51) International Patent Classification:  
G02B 5/02 (2006.01) G02B 26/00 (2006.01)  
G02F 1/13357 (2006.01)
- (21) International Application Number:  
PCT/US2013/035371
- (22) International Filing Date:  
5 April 2013 (05.04.2013)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
61/620,677 5 April 2012 (05.04.2012) US
- (71) Applicant: CORNING INCORPORATED [US/US]; 1 Riverfront Plaza, Corning, NY 14831 (US).
- (72) Inventors; and
- (71) Applicants : BAKER, David, Eugene [US/US]; 6413 Mossy Bank Park Road, Bath, NY 14810 (US). ETIENNE, Michael [HT/US]; 146 High Road, Corning, NY 14830 (US). LOGUNOV, Stephan, Lvovich [US/US]; 2780 Pinewood Circle, Corning, NY 14830 (US). NOLAN, Daniel, Aloysius [US/US]; 10762 Skyline Drive, Corning, NY 14830 (US). SENARATNE, Wageesha [LK/US]; 109 Hylan Terrace, Horseheads, NY 14845 (US). ZENTENO, Luis, Alberto [US/US]; 38 Katie Lane, Painted Post, NY 14870 (US).
- (74) Agent: BEALL, Thomas, R; Corning Incorporated, Intellectual Property Department, SP-TI-03-01, Corning, NY 14831 (US).

- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

- Published:**
- with international search report (Art. 21(3))
  - before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) Title: METHODS AND APPARATUS FOR PROVIDING DISPLAY COMPONENTS

FIG. 1



(57) Abstract: Methods and apparatus for providing one or more components for a display system, particularly for producing dif-fused light.

WO 2013/152256 A1

**METHODS AND APPARATUS  
FOR PROVIDING DISPLAY COMPONENTS**

**CROSS-REFERENCE TO RELATED APPLICATIONS**

**[0001]** This application claims the benefit of priority under 35 U.S.C. § 119 of U.S. Provisional Application Serial No. 61/620,677 filed on April 5, 2012, the content of which is relied upon and incorporated herein by reference in its entirety.

**FIELD OF THE DISCLOSURE**

**[0002]** The present disclosure relates to methods and apparatus for providing one or more components for a display system, particularly for producing diffused light.

**BACKGROUND**

**[0003]** Conventional components used to produce diffused light have included diffusive glass, which has been employed in a number of applications in the display industry. These applications include bezel-free television systems, liquid crystal displays (LCDs), electrophoretic displays (EPD), organic light emitting diode displays (OLEDs), plasma display panels (PDPs), micro-electromechanical structures (MEMS) displays, electronic reader (e-reader) devices, and others.

**[0004]** It has been discovered, however, that commercially available diffusive glasses do not meet certain new and important requirements for the emerging display industry.

**[0005]** It has also been discovered that certain types of displays within the display industry, such as translucent

(semi-transparent) displays, suffer from some poor performance characteristics because conventional display components, particularly as concerns providing a source of backplane illumination, will not meet the performance requirements of the marketplace.

**SUMMARY**

**[0006]** It has been discovered that a commercially attractive display system includes a glass component as a foundation on which a plurality of electronically controllable display components are disposed. The glass component includes a generally planar sheet construction having a surface directed towards a viewer, and an opposing surface on which the plurality of display components (such as MEMS components, OLED components, or the like) are disposed. The collection of individual display components define a large number of pixel sites for manipulating light in accordance with electronic control signaling in order to provide desirable display resolution to the viewer.

**[0007]** The glass component provides a light diffusing characteristic, such that any light entering the glass sheet from one or more edges, from one or more borders, and/or from the viewing surface is diffused as it propagates toward the display elements. In this regard, the glass component includes one or more light diffusing features, such that the glass component operates as a diffusive glass component. The light diffusing features may include the provision of a plurality of light scattering sites in proximity to the surface of the glass sheet opposite to the viewing surface,

i.e., proximate to the surface on which the display elements are disposed.

**[0008]** Important attributes of the diffusive glass include a large forward-to-backward scattering ratio, high haze ratio, high light transmission ratio, and wide angular light scattering characteristics. In certain of the display system applications, the light scattering sites need to be near, but buried below, the surface on which the display elements are disposed. Indeed, they must enable light scattering within a few microns of the surface. This is especially the case when a transparent conductive oxide (TCO) layer is deposited above such surface, between the surface of the glass sheet and the display elements. In addition, there may be a significant flatness requirement for the surface on which the display elements are disposed, which is specified as a function of the pixel length (a measurement associated with the rather small dimensions of the individual display elements). Another important requirement is that the glass sheet with the light diffusing features (such as the light scattering elements and associated structures) must maintain their performance properties when subject to downstream processes, such as the deposition of the display elements thereon, which may subject the glass component to processing temperatures of about 400 degrees C or even higher.

**[0009]** Although it is possible to find commercially available diffusive glass, none of the available glass meets the above mentioned new and important requirements for the emerging display industry. For example, one can purchase from Edmund Optics a diffusive glass having a roughened surface designed to scatter light at wide angles. This glass, however, cannot be used for the aforementioned new display

application(s) because the scattering functionality relies on a roughened surface, where the scattering feature dimensions are significantly larger than is acceptable for the deposition of the display elements, such as the deposition of a TCO layer. Further, these large dimension features would cause undesirable high resistance or shunting of the electrical properties in a display system. Scattering in glass can also be achieved using phase separated glasses, glass ceramics or frits doped with crystals. None of these glasses, however, will enable scattering within a few microns of the glass surface.

**[00010]** In accordance with one or more embodiments herein, methods and apparatus have been developed to provide a diffusive glass structure, in which scattering elements (i.e., particles, agglomerates, or aggregates) are adsorbed onto a glass substrate and fixed there using a binder material. The elements may be on the order of hundreds of nanometers in size, such as about 250 nm. In some applications, the elements are characterized by a relatively high refractive index (such as about 2.0) as compared with the refractive index of the glass sheet and the binder, which may be on the order of about 1.4 - 1.6, or about 1.43 to about 1.56. In other applications, the elements need not be of high refractive index, but rather may be on the order of the same refractive index as the glass sheet and the binder material. The light scattering feature achieved by the elements may be formed via a single layer of particles, agglomerates, or aggregates, or it may be formed via multiple layers. Either implementation may result in a height dimension of the elements of between the sub-micron level to a micron or more. The binder may be employed to partially or fully fill the

voids between the elements to control the surface characteristics (such as the flatness) of the surface of the glass component. When sufficient binder is employed (which may include multiple layers), the binder may form a planarizing layer, extending from sub-microns to microns above the elements.

**[00011]** The above-described glass components provide high haze ratios, high transmission ratios, suitably flattened surfaces for downstream thin film deposition processes, desirable light scattering features (e.g., wide angular scattering) within microns of the surface of the glass component, and survival of downstream processing temperatures of about 400 degrees C and higher. Furthermore, the contemplated glass components may be produced using a wide variety of glass substrate types.

**[00012]** In accordance with one or more further embodiments herein, methods and apparatus have been developed to provide a backplane for a display system.

**[00013]** Commercial translucent display systems, such as translucent (semi-transparent) LCD televisions are commercially available for digital signage and advertising applications. These display systems are semi-transparent in the "off state" (i.e., when no image is being commanded by the associated electronics driving the LCD elements). In order to maintain the semi-transparent characteristics, these display systems do not employ an opaque optical backplane in order to produce light to excite the LCDs. Instead, the display systems use background, ambient light to excite the LCDs in the "on state" (i.e., when the associated electronics is commanding an image). Thus, one can see through the display system and view objects (such as merchandise, etc.) behind the

display screen. Concurrently, the viewer can also receive visual information on certain portions of the screen (or the entire screen), which in a commercial application would likely be related to the merchandise behind the screen.

**[00014]** A significant issue with the semi-transparent display systems, however, is that they are not particularly transparent. In fact, measurements have shown that they exhibit only about a 15% transmission ratio. Thus, one must often provide a relatively high level of ambient light in proximity to the screen, which might not always be feasible or even desirable for any number of reasons. The result is an array of problems in terms of uniformity of image quality across the display, such as non-uniformity in color, contrast ratio, etc.

**[00015]** Thus, in accordance with one or more further embodiments herein, a transparent backplane is provided for a transparent display system. The transparent backplane is formed using some or all of the components discussed above in connection with the diffusive glass structure. The diffusive glass structure is placed behind the translucent display system, and light is introduced into the glass sheet along one or more edges thereof, and/or along one or more borders thereof. The light propagates in a waveguide fashion within the glass sheet and is incident on the light scattering portion. Thus, the light scatters out of the transparent backplane and illuminates the LCDs of the translucent display system. The transparent backplane therefore improves the light source for the LCD elements of the translucent display system. The scattering elements are chosen and deployed in order to provide suitable refractive index characteristics and dimensions to achieve the proper light wavelength(s) and angle

independent excitation of the LCDs. In addition, the scattering elements produce a suitable haze ratio, which is low enough so as to achieve a high level of transparency of the backplane (one can visually see through it) when portions of the display system are in the off state.

**[00016]** Advantages of the transparent backplane include increased brightness, maintaining transparency (in the off state), improved light uniformity, improved light wavelength and incidence angle, improved color coordinates, and relatively simple and cost-effective input optics.

**[00017]** Other aspects, features, and advantages of the embodiments of the present disclosure will be apparent to one skilled in the art from the description herein taken in conjunction with the accompanying drawings.

#### **DESCRIPTION OF THE DRAWINGS**

**[00018]** For the purposes of illustration, there are forms shown in the drawings that are presently preferred, it being understood, however, that the embodiments are not limited to the precise arrangements and instrumentalities shown.

**[00019]** FIG. 1 is a side-sectional view of a light diffusing apparatus in accordance with one or more embodiments herein;

**[00020]** FIG. 2 is a front elevational view of the light diffusing apparatus of FIG. 1;

**[00021]** FIG. 3 is a graph of scattering cross-section and scattering angle for scattering particles of varying size;

**[00022]** FIGS. 4A, 4B, and 4C are side sectional views of intermediate structures for illustrating a method of producing the light diffusing apparatus of FIG. 1;

**[00023]** FIGS. 5A-5E are respective scanning electron microscope (SEM) images of light scattering elements disposed on a surface of the light diffusing apparatus, with each image showing differing binder characteristics;

**[00024]** FIGS. 6A-6B are graphs of a haze ratio and a transmission ratio (expressed as percentages), respectively, when a surfactant is added to the solution used for the deposition of scattering particles on the light diffusing apparatus of FIG. 1;

**[00025]** FIGS. 7A-7B are graphs of a haze ratio and a transmission ratio (expressed as percentages) as functions of open areas and roundness, respectively, when a surfactant is, and is not, added to the solution used for the deposition of scattering particles on the light diffusing apparatus of FIG. 1;

**[00026]** FIG. 8 is a histogram of plots for frequency versus perimeter - Feret (max) Ratio for a number of samples that were prepared using a surfactant added to the solution used for the deposition of scattering particles on the light diffusing apparatus of FIG. 1;

**[00027]** FIG. 9 is a side-sectional view of a display system employing a light diffusing apparatus and a plurality of electronic display elements in accordance with one or more embodiments herein;

**[00028]** FIG. 10 is a partial schematic diagram of a portion of the light diffusing embodiments disclosed herein including a light source;

**[00029]** FIG. 11 is a side schematic view of the light diffusing embodiments disclosed herein including a fiber light source;

[00030] FIG. 12 is a schematic view of a display system employing a light diffusing component in accordance with one or more embodiments herein;

[00031] FIG. 13 is a schematic view of further details of the display system of FIG. 12; and

[00032] FIG. 14 is a schematic sectional view of a light diffusing component suitable for use in connection with the display system of FIG. 13.

#### **DETAILED DESCRIPTION OF THE EMBODIMENTS**

[00033] With reference to the drawings wherein like numerals indicate like elements there are shown in the figures a number of features and methodologies suitable to use in connection providing various optical components for one or more display systems.

#### **Light Diffusing Structure/Methodology**

[00034] With reference to FIGS. 1-2, a diffusing apparatus 100 in accordance with one or more embodiments herein may be employed to process light for a display system. In general, the diffusing apparatus 100 operates to receive light from one or more edges or borders of the structure, propagate the light within a glass structure and diffuse and scatter the light out a front of the structure (as illustrated by the arrows in FIG. 2) for useful purposes.

[00035] The diffusing apparatus 100 includes a glass sheet 102 having first and second spaced apart, planar surfaces 104, 106. Any suitable commercially available glass sheet may be employed, which can withstand the processing parameters

expressly or inherently disclosed herein. The diffusing apparatus 100 also includes at least one scattering layer having a plurality of sub-micron sized light scattering elements 110 disposed on the first surface 104 of the glass sheet 102. A binder material 112 is disposed on the first surface 104 of the glass sheet 102 and at least partially fills voids between adjacent scattering elements 110.

**[00036]** As illustrated by the dashed arrows, light may enter the glass sheet 102 and begin propagating therethrough until the rays of light impinge upon the scattering elements 110. Given the optical properties of the glass sheet 102, the scattering elements 110, and the binder material 112 (which will be discussed in greater detail below) the light scatters out of the diffusing apparatus 100. When a single layer of scattering elements 110 are employed, then the optical characteristics are generally of the surface scattering variety. On the other hand, when the scattering elements 110 are built up by a number of layers, then the optical characteristics are generally of the volumetric scattering variety.

**[00037]** Reference is now made to FIG. 3, which is a graph of scattering cross-section (on the Y-axis) and scattering angle (on the X-axis) for varying sized particles. The light scattering elements 110 are formed from one or more of individual particles, agglomerates, and/or aggregates of particles. When the individual particles are of a suitable size then agglomerating and/or aggregating such particles may not be necessary. On the other hand, when the individual particle sizes are too small, then it is desirable to agglomerate or aggregate the particles to form respective scattering elements 110 of suitable size. The graph of FIG. 3

shows four plots 30, 32, 34, 36, each representing the characteristics of four different particle sizes, specifically 50 nm, 100 nm, 150 nm, and 200 nm. The plots were generated using Mie scattering calculations derived for spherical scattering sites. Thus, the plots illustrate approximations of the optical characteristics of the individual particles or agglomerates of approximately spherical shapes forming the scattering elements 110.

**[00038]** The plots of FIG. 3 indicate that small particles scatter backwards as well as forwards, and particles of about 150 nm and larger scatter predominately forward, which is generally desirable in the diffusing apparatus 100. Indeed, as will be discussed in more detail below, scattering in predominantly the forward direction facilitates high transmission ratios and high haze ratios in the apparatus 100. More particularly, the plots show the calculated angular dependence of the normalized scattering cross section as a function of particle size. The results indicate that the general dimensions of the particles or agglomerates should be on the order of about 200 nm (assuming a generally spherical shape or approximated shape) in order to achieve a high transmission ratio. Indeed, as smaller particles tend to backscatter the light, the resultant transmission ratio would be adversely affected. Particles greater than about 500 nm scatter light forward, but the angular spread is small, which is less desirable.

**[00039]** Given the above optical scattering characteristics as a function of scattering element size, the approximate diameter of each scattering element 110 may be one of: (i) between about 100 nm to about 500 nm, (ii) between about 200 nm to about 300 nm, and (iii) about 250 nm.

**[00040]** The optical light scattering characteristics of the diffusing apparatus 100 are also affected by the refractive indices of the glass sheet 102, the scattering elements 110, and the binder material 112. In some applications, the scattering elements 110 are characterized by a relatively high refractive index as compared with the refractive index of the glass sheet 102 and the binder material 112. The glass sheet 102 and the binder material 112 will likely have refractive indices on the order of about 1.4 - 1.6, or about 1.43 to about 1.56. Thus, when the scattering elements 110 are characterized by a relatively high refractive index, then such refractive index may be one of: (i) between about 1.5 and about 4.0, (ii) between about 1.7 and about 2.5, and (iii) at least 2.0.

**[00041]** By way of example, the scattering elements may be formed from agglomerates of Titania (TiO<sub>2</sub>), Cerium oxide (Ce<sub>2</sub>O<sub>3</sub>), Zinc Oxide (ZnO), and/or Zirconium Dioxide (ZrO<sub>2</sub>). Skilled artisans will appreciate that other materials may also be found suitable for use in the apparatus 100 if a reasonable amount of investigation is performed. As mentioned above, the elements 110 may be on the order of about 250 nm in size, and therefore employing the listed oxides may require agglomeration and/or aggregation to achieve the desired size.

**[00042]** As mentioned above, the binder material 112 may have a refractive index substantially similar to the refractive index of the glass sheet, such as: (i) between about 1.2 and about 1.7, (ii) between about 1.3 and about 1.6, and (iii) about 1.5. By way of example, the binder material layer 112 may be formed from one or more of: polymerized or partially cured poly alkyl siloxane, poly-dimethyl-siloxane, poly-diphenyl-siloxane, polymerized alkyl or aryl silsesquioxane T-

resins, poly-methyl-silsesquioxane, poly-methyl-phenyl-silsesquioxane, poly-phenyl-silsesquioxane, and uv curable poly siloxanes or silsesquioxanes. Then the binder material 112 is cured to completion using a thermal or uv curable curing step

**[00043]** In addition to the refractive index, the binder material 112 may be chosen based on one or more of: solubility (organic solvent versus aqueous solvent), viscosity (ability to flow), ability to react with both the glass sheet 102 and itself so that the binder material 112 can be cured to completion, and ability to be stable up to process temperatures of about 400 C to 600 C.

**[00044]** Reference is now made to FIGS. 4A, 4B, and 4C, which are side sectional views of intermediate structures for illustrating a method of producing the diffusing apparatus 100 of FIG. 1. As illustrated in FIG. 4A, the first surface 104 of the glass sheet 102 is prepared in a way to promote its adsorption characteristics, which may involve surface cleaning and preparation.

**[00045]** Next, a plurality of sub-micron sized light scattering elements 110 is disposed onto the first surface 104 of the glass sheet 102 such that they adsorb thereto. The step of disposing the light scattering elements 110 may include employing a dip coating or spin coating process to apply a flowable phase (e.g., a slurry or solution) of the elements 110 onto the first surface 104. As there is a relationship between the quantity and spacing of the scattering elements 110 on the first surface 104 and the resultant transmission and haze ratios, care should be taken during the deposition step. Indeed, when the scattering elements 110 have a relatively high refractive index and the glass sheet 102 and binder material 112 have a lower refractive index, as

the spacing between elements 110 increases, the haze ratio also increases (at least within a particular range).

**[00046]** The spacing of the scattering elements 110 may be controlled by varying a concentration (e.g., characterized by a weight percentage) of the scattering elements 110 in the slurry applied to the surface 104 using the dip coating or spin coating process. It has been found that a concentration of about 10% by weight of the scattering elements 110 (formed from Titania) in the slurry will yield on the order of about a 40% haze ratio in the finished diffusing apparatus 100. Contrast that with a concentration of about 40% by weight of the scattering elements 110 (formed from Titania) in the slurry yielding on the order of about a 100% haze ratio.

**[00047]** Further, the characteristics of the quantity and spacing of the scattering elements 110 on the first surface 104 may also be controlled by varying the parameters of the spin coating process (such as the spin speed, ramp rate, duration, temperature, etc.), and/or the dip coating process (such as the withdrawal speed, concentration, temperature of the enclosure and dipping solution, etc.).

**[00048]** Once the scattering elements 110 have been disposed on the first surface 104 of the glass sheet 102, a heat treating process is carried out to drive off excess liquids. The heat treating process may include elevating the temperature of the intermediate structure (FIG. 4A) to about 120 degrees C for about 1-2 hours.

**[00049]** Next, as illustrated in FIG. 4B, a flowable binder material 112 is disposed onto the first surface 104 of the glass sheet 102 such that the binder material 112 at least partially fills voids between adjacent scattering elements

110. Thereafter, the binder material 112 is cured in accordance with the manufacturer's specifications. It is noted that varying the thicknesses of binder material 112 may be achieved by controlling the processing parameters of the deposition. By way of example, the flowable binder material 112 may be applied using a dip coating or spin coating process. Thus, the parameters of such processes (speed, duration, temperature, etc.) may be adjusted to achieve a desired thickness of binder material 112. Alternatively, a plurality of coats of binder material 112 may be applied in order to build up the thickness of the binder layer 112. As illustrated in FIG. 4B, the binder material layer 112 need not entirely cover the scattering elements 110. However, in the embodiment illustrated in FIG. 4C, the binder material layer 112 completely fills the voids and covers the scattering elements 110 to produce a planarization layer 114. In connection with the embodiment of FIG. 4C, the extent to which the binder material layer 112 extends above the scattering elements 110 may vary depending on the application, from sub-microns to a micron or more.

**[00050]** In accordance with one or more further embodiments, the number of coats of the binder material 112 may be different on different areas of the glass sheet 102 to produce differing transmission ratios, haze ratios, and/or scattering at one or more of such areas. For example, the number of coats may be increased in one or more central areas of the glass sheet 102 to produce higher scattering at one or more of such central areas as compared to one or more peripheral areas (surrounding the central areas) of the glass sheet 102.

**[00051]** Reference is now made to FIGS. 5A-5E, which are SEM images of the intermediate structure of FIGS. 4A-C employing

differing binder material 112 thicknesses. FIG. 5A is an image of the apparatus 100 employing 20% rutile Titania agglomerate elements 110, which have been adsorbed onto the first surface 104 of the glass sheet 102 using a dip coating process. In FIG. 5A, no binder material 112 has been applied. FIG. 5B shows an image of the diffusing apparatus 100 after a binder material layer 112 of 25% concentration HardSil™ in isopropanol AM (Gelest, PP1-HSAM 19-21 wt% of solids, 25% concentration has about 5% solids) has been applied using a dip coating process at a withdrawal speed of 50 mm/minute. FIG. 5C shows an image of the diffusing apparatus 100 after a binder material layer 112 of 25% concentration HardSil™ AM has been applied using a dip coating process at a withdrawal speed of 70 mm/minute. FIG. 5D shows an image of the diffusing apparatus 100 after a binder material layer 112 of 50% concentration HardSil™ AM (about 10 wt% solids) has been applied using a dip coating process at a withdrawal speed of 25 mm/minute. FIG. 5E shows an image of the diffusing apparatus 110 after a binder material layer 112 has been almost completely covered the scattering elements 110.

**[00052]** It has been discovered that application of the binder material layer 112 will have an effect on the resultant transmission ratio and haze ratio. For example, seven (7) diffusing apparatus 100 were produced, each representing a respective sample A-G for evaluation. Each sample was prepared by applying 20% rutile Titania agglomerate to a glass sheet 102 using a dip coating process at 40 degrees C and a withdrawal rate of 125 mm/minute. The samples were then subject to a heat treatment process at 120 degrees C for sufficient time to drive off excess water and/or other liquids.

**[00053]** The first two samples (A, B) were not subject to application of a binder layer 112 but were subject to a sintering step at 600 degrees C for about 1 hour to establish a basis for the transmission ratio of between 79% - 82.6%, and a basis for the haze ratio of between 52.7% and 53.9%.

**[00054]** Sample C was subject to application of a binder layer 112 of 50% concentration HardSil™ AM at a dip coating withdrawal rate of 25 mm/minute and sintering at 600 degrees C for about 1 hour - resulting in a transmission ratio of 73.3%, and a haze ratio of 65.4%.

**[00055]** Sample D was subject to application of a binder layer 112 of 50% concentration HardSil™ AM at a dip coating withdrawal rate of 50 mm/minute sintering at 600 degrees C for about 1 hour - resulting in a transmission ratio of 86.2%, and a haze ratio of 46.8%.

**[00056]** Sample E was subject to application of a binder layer 112 of 25% concentration HardSil™ AM at a dip coating withdrawal rate of 50 mm/minute and sintering at 600 degrees C for about 1 hour - resulting in a transmission ratio of 81.7%, and a haze ratio of 68.7%.

**[00057]** Sample F was subject to application of a binder layer 112 of 25% concentration HardSil™ AM at a dip coating withdrawal rate of 70 mm/minute and sintering at 600 degrees C for about 1 hour - resulting in a transmission ratio of 81.0%, and a haze ratio of 69.1%.

**[00058]** Sample G was subject to application of a binder layer 112 of 100% concentration HardSil AM (about 20 wt% solids) at a dip coating withdrawal rate of 50 mm/minute and sintering at 600 degrees C for about 1 hour - resulting in a transmission ratio of 76.7%, and a haze ratio of 59.9%.

**[00059]** The above experimentation revealed that the apparatus 100 exhibits at least one of the following optical characteristics: (i) a transmission ratio of between about 70% to about 90%; and (ii) a haze ratio of between about 50% to about 75%.

#### **Process Employing a Surfactant**

**[00060]** Reference is now made to FIGS. 6A-6B, 7A-7B, and 8, which relate to the use of a surfactant in the process of producing the light diffusing structure 100. In this regard, the details discussed in connection with the process of FIGS. 4A-4C are of consideration here. In particular, in accordance with one or more further embodiments, a surfactant is employed in the coating solution when the light scattering elements 110 are disposed onto the first surface 104 of the glass sheet 102. It has been discovered that the addition of the surfactant has an impact on at least one of (and often both) the haze ratio and transmission ratio of the resulting structure 100. In particular, higher transmission ratio and haze ratio (expressed as percentages) have been observed. For example, as discussed above with respect to FIGS. 5A-5E, values on the order of 80 % transmission and 70 % haze were achieved. However, with the use of a surfactant in the coating solution, even the initial values were found to be as high as 75-80% transmission and greater than about 90% haze. The increase in haze ratio may be due to the surfactant either dispersing the particles 110 better in solution and then acting as binding agent to the particles 110 (e.g., Titania nanoparticles) and agglomerating the particles more uniformly while being coated onto the substrate (via the dip or spin

process) to produce the resultant light scattering elements 110.

**[00061]** With specific reference to FIGS. 6A-6B, comparative samples were prepared in which disposing the light scattering elements 110 onto the top surface 104 of the glass sheet 102 was carried out using a dip coating process, which some samples including a surfactant in the coating solution and some not including a surfactant. The dip coating process was also conducted using differing withdrawal rates for different samples. In each case, 10% rutile Titania was employed to produce the light scattering elements 110. In the samples in which a surfactant was employed (the plots labeled 124), the surfactant was Pluronic™ P123 (specifically 5%), although other surfactants may be employed without departing from the contemplated embodiments. FIGS. 6A-6B are graphs of a haze ratio and a transmission ratio (on the Y-axis), expressed as percentages, versus a dip withdrawal speed (on the X-axis). FIGS. 6A-6B show that both the haze ratio and the transmission ratio were increased as a result of adding the surfactant, irrespective of dip withdrawal rate. It is believed that similar results would be obtained using a spin coating process, or other suitable process.

**[00062]** FIG. 7A is a graph of a haze ratio and a transmission ratio (on the Y-axis, expressed as a percentage) as functions of open areas (on the X-axis, expressed as a percentage) using the samples discussed above. FIG. 7B is a graph of a haze ratio and a transmission ratio (on the Y-axis, expressed as a percentage) as functions of roundness (on the X-axis) using the samples discussed above. The respective haze ratio values are shown as triangles, while the respective transmission values are shown as squares on the plots of FIGS.

7A-7B. The respective groups of values encircled on the left of FIGS. 7A and 7B represent results without a surfactant, while the respective groups of values encircled on the right of FIGS. 7A and 7B represent results where Pluronic™ P123 (specifically 5%) was employed. The straight line shown in each plot represents the linear percent haze.

**[00063]** FIG. 8 is a histogram of plots showing frequency (on the Y-axis) versus perimeter - Feret (max) Ratio (on the X-axis) for the number of samples that were prepared above. The plot labeled 80 represents sample(s) with no surfactant. The respective plots labeled 81, 82, 83, 84 represent sample(s) where Pluronic™ P123 (specifically 5%) was employed as a surfactant. These graphs show that the addition of the surfactant increases the percent open area in the Titania coating, increases the roundness value of the open spaces (i.e., a circle has a roundness value of 1), and shifts peak maxima and broadens the peak width of the ratio of the open space perimeter to maximum feret length (as indicated by the arrow). These results indicate that the surfactant is acting to roughen the boundary of the open spaces thereby increasing haze values while at least maintaining transmission (if not increasing transmission).

**[00064]** In one or more embodiments, more than one type of binder material 112 may be employed. For example, it has been discovered that application of different binder material layers 112 may lead to desirable transmission ratio, haze ratio, and surface roughness. For example, six (6) diffusing apparatus 100 were produced, each representing a respective sample A-F for evaluation. Each sample was prepared by applying two different binder material layers 112, each layer being spin coated onto the respective glass sheets 102. The

two specific binder materials were HardSil™ AM (HAM 100 wt% and HAM 50 wt%, each diluted using isopropanol) and HardSil™ AR (Gelest, PP1-HSAR, HAR 100%, or HAR 50 wt% diluted using IPA). Each binder material was spin coated onto the nanoparticles 110 of the glass sheet 102 using two spin cycles, a slow spin cycle to allow the first (dilute) binder to flow into the nanoparticle structure, and then a faster spin cycle used with the second (concentrated) binder material to form a planarizing layer. Many variations of these cycles are possible to create variations in the light diffusing characteristics of the resultant apparatus.

**[00065]** Sample A was subject to application of the first binder layer (HAR 50%) at a spin cycle speed of 5000 revolutions per minute (RPM), followed by application of the second binder layer (HAR 100%) at a spin cycle speed of 5000 RPM and a cure temperature of 250 degrees C for one hour. The resulting structure demonstrated a transmission ratio of 85.3%, a haze ratio of 67.4%, and a surface (Zygo) roughness of 0.05 um RMS with a standard deviation of 0.003 um.

**[00066]** Sample B was subject to application of the first binder layer (HAR 50%) at a spin cycle speed of 5000 revolutions per minute (RPM), followed by application of the second binder layer (HAR 100%) at a spin cycle speed of 3000 RPM and a cure temperature of 250 degrees C for one hour. The resulting structure demonstrated a transmission ratio of 85.1%, a haze ratio of 68.6%, and a surface (Zygo) roughness of 0.064 um RMS with a standard deviation of 0.004 um.

**[00067]** Sample C was subject to application of the first binder layer (HAR 50%) at a spin cycle speed of 5000 revolutions per minute (RPM), followed by application of the second binder layer (HAR 100%) at a spin cycle speed of 1000

RPM and a cure temperature of 250 degrees C for one hour. The resulting structure demonstrated a transmission ratio of 85.1%, a haze ratio of 66.4%, and a surface (Zygo) roughness of 0.026 um RMS with a standard deviation of 0.003 um.

**[00068]** Sample D was subject to application of the first binder layer (HAM 50%) at a spin cycle speed of 5000 revolutions per minute (RPM), followed by application of the second binder layer (HAM 100%) at a spin cycle speed of 5000 RPM and a cure temperature of 250 degrees C for one hour. The resulting structure demonstrated a transmission ratio of 85.6%, a haze ratio of 75.1%, and a surface (Zygo) roughness of 0.07 um RMS with a standard deviation of 0.006 um.

**[00069]** Sample E was subject to application of the first binder layer (HAM 50%) at a spin cycle speed of 5000 revolutions per minute (RPM), followed by application of the second binder layer (HAM 100%) at a spin cycle speed of 3000 RPM and a cure temperature of 250 degrees C for one hour. The resulting structure demonstrated a transmission ratio of 85.4%, a haze ratio of 75.8%, and a surface (Zygo) roughness of 0.07 um RMS with a standard deviation of 0.002 um.

**[00070]** Sample F was subject to application of the first binder layer (HAM 50%) at a spin cycle speed of 5000 revolutions per minute (RPM), followed by application of the second binder layer (HAM 100%) at a spin cycle speed of 1000 RPM and a cure temperature of 250 degrees C for one hour. The resulting structure demonstrated a transmission ratio of 85.8%, a haze ratio of 71.6%, and a surface (Zygo) roughness of 0.033 um RMS with a standard deviation of 0.002 um.

**[00071]** The light diffusing apparatus 100 discussed above will have some efficiency of scattering light, that propagates

through the glass sheet 102 in a waveguide fashion, due to the surface characteristics (or film). The efficiency of scattering as function of film characteristics will change, and in some cases the scattering will be lower than 100%, when the light reaches an opposite side of the glass sheet 102. In this case, one or more embodiments may employ reflectors (not shown) to redirect the light, thereby preventing (or at least reducing) light escaping out the edges of the glass sheet 102, and maintaining as much light propagating within the glass sheet 102 as possible so that such light may be scattered via the light scattering elements 110. Use of reflectors also helps uniformity of the panel lighting, when the scattering elements 110 are substantially uniform over the surface of the glass sheet 102.

#### **Light Diffusing Apparatus and Display System**

**[00072]** Reference is now made to FIG. 9, which is a side-sectional view of a display system 100A employing a light diffusing apparatus 100 and a plurality of electronic display elements in accordance with one or more embodiments herein. The display system 100A may employ any of the aforementioned aspects and/or features of the light diffusing apparatus 100 as a foundation on which a plurality of display components/elements 150 are disposed.

**[00073]** The glass sheet 102 provides a generally planar surface 106 directed towards a viewer of the display system 100A, and the opposing surface 104 on which the plurality of display components 150 are disposed. The collection of individual display components 150 define a large number of pixel sites for manipulating light in accordance with

electronic control signaling in order to provide desirable display resolution to the viewer. By way of example, the display components 150 may be individual MEMS components, OLED components, or the like, arranged in an array.

**[00074]** The light diffusing apparatus 100 provides a light diffusing characteristic, such that any light entering the glass sheet 102 from one or more edges, borders, and/or from the viewing surface 106 is diffused and scattered as it propagates toward the display elements 150. In addition, any light propagating back from the display components 150 will again be diffused as such light passes through the binder layer 112 and elements 110 on its way back to the viewer. Advantageously, such additional diffusion produces better angular emission of the light coming back from the display components 150 to the viewer.

**[00075]** Advantageously, the light diffusing apparatus 100 exhibits a suitably flat planarization surface 114 on which the array of display elements 150 may be disposed using modern and cost-effective manufacturing processes, which include temperatures of about 400 degrees C or higher. Further, the light diffusing apparatus 100 provides a high haze ratio, a high transmission ratio, and desirable light scattering features (e.g., wide angular scattering) within microns of the surface 104 of the glass sheet 102.

#### **Plastic substrate Embodiment**

**[00076]** It is noted that in various embodiments disclosed herein, the sheet 102 has been discussed as being formed from a glass material. It is noted, however, that in some applications a suitable transparent plastic material may be

substituted for the glass sheet 102. Skilled artisans will appreciate which plastic materials will be suitable and which will not when the particular details and exigencies of the application are considered in full and/or some reasonable level of experimentation is performed.

### **Light Diffusing Apparatus with Light Source**

**[00077]** Reference is now made to FIGS. 10 and 11, which are schematic diagrams of the light diffusing embodiments disclosed herein including at least one light source. In either case, the embodiment may be employed with or without the display components 150 of FIG. 9.

**[00078]** FIG. 10 illustrates a light diffusing apparatus 100B, which includes a light source 160 disposed proximate to the glass (or plastic) sheet 102. The particular location of the light source 160 may be established such that light therefrom is coupled into the glass sheet 102, propagates within the glass sheet 102 in a waveguide mode, and at least a portion of light is diffused and scattered by the scattering layer. For example, the light source 160 may be one or a plurality of LEDs, or other suitable light generating elements, disposed along one or more edges 162 or one or more borders 164 of the glass sheet 102. In one or more embodiments, the one or more edges 162 of the glass sheet 102 may be beveled (and may include a metalized reflective surface 166). The bevel angle is chosen to redirect any light propagating within the glass sheet 102 in one or more directions that reduce the escape of light out of the at least one edge 162.

**[00079]** One or more alternative embodiments may employ one or more light sources and associated structures of the type(s) disclosed in U.S. Patent Application No. 61/407,698, filed October, 28, 2010, the entire disclosure of which is incorporated herein in its entirety.

**[00080]** FIG. 11 illustrates a light diffusing apparatus 100C, which includes at least one light diffusing fiber 170 extending along one or more edges of the glass sheet 102, and may optionally include a light redirecting or blocking border 172A, 172B to improve the optical appearance near the edges of the glass sheet 102. The light diffusing fiber 170 may be on the order of about 250-300 microns in diameter.

**[00081]** In a basic embodiment, one or more laser sources may produce white (or semi-white) light to couple into the fiber 170 and thereafter into the glass sheet 102 for diffusing. In one or more alternative embodiments, one or more laser sources, such a red laser source 180 (RED), a green laser source 182 (GREEN) and a blue laser source 184 (BLUE), may couple light energy of differing wavelengths into a single fiber 170, or multiple fibers, in a way that couples such light into the glass sheet 102 and causes diffusion and scattering as discussed previously. Using multiple laser sources permits the production of any number of colors by adjusting the power level of each laser source.

**[00082]** Further details concerning various structures and methodologies associated with modulating the laser sources (e.g., time sequential modulation) to achieve desirable color image functionality and other details concerning the use of the fiber 170 may be found in: U.S. Patent Application No. 13/094,221, filed April 26, 2011; U.S. Patent Application No. 61/545,713, filed October 11, 2011; and; U.S. Patent

Application No. 61/545,720, filed October 11, 2011, the entire disclosures of which are incorporated herein by reference.

### **Display System with Transparent Backplane**

**[00083]** As mentioned above, there are any number of applications in which the light scattering elements 110 need not be of high refractive index, but rather may be on the order of the same refractive index as the glass (or plastic) sheet 102 and the binder material 112. For example, with reference to FIGS. 12-14 and in accordance with one or more further embodiments herein, methods and apparatus have been developed to provide a backplane for a transparent or semi-transparent display system 200.

**[00084]** With reference to FIG. 12, the display system 200 operates to produce images 10, text 12, etc. on a display surface, which are viewable to a user. The display system 200 also exhibits transparent or semi-transparent characteristics such that one or more objects 14 behind the system 200 may be seen through the system 200, particularly (or possibly only) when no image is being commanded to exist in front of the object 14. In other words, the display system 200 is at least semi-transparent over one or more portions thereof when the associated display elements (e.g., LCD elements) in such portions are in an off-state. On the other hand, the same portions (or other portions) of the display system 200 may be semi-opaque or totally opaque when the associated display elements in such portions are in an on-state. Thus, one can see through the display system 200 and view the object 14 (such as merchandise, etc.) behind the display, while

concurrently receiving visual information (images 10, 12, etc.) on certain portions of the display.

**[00085]** Turning to FIGS. 13-14, the display system 200 includes a display layer 202 having first and second spaced apart major sides 204, 206, and a plurality of display elements (not shown) disposed within (or on) the display layer 202 in an array and operating to produce the images 10, 12, in response to electrical signaling for viewing at (or from) the first major side 204. The display system 200 also includes a light diffusing backplane 100D, having first and second spaced apart major sides 114, 106 and operating to produce diffused light out of the first major side thereof 114. It is noted that the light diffusing backplane 100D may be implemented using any of the light diffusing embodiments expressly or inherently disclosed or suggested herein, particularly those employing one or more light sources 160 or light diffusing fibers 170 to couple light into the diffusing apparatus. The light diffusing backplane 100D is oriented such that the first major side 114 thereof is directed toward the second major side 206 of the display layer 202 such that the diffused light is a source of light for the plurality of display elements.

**[00086]** As noted above, the light scattering elements 110 need not be of high refractive index in this application because of the proximity of the display layer 202 and the light diffusing backplane 100D, and also because the refractive index of air is sufficiently different from the refractive indices of the scattering elements 110 and the binder material 112. Instead, a suitable diffusion, scattering, transmission ratio, haze ratio, etc. may be achieved even though the light scattering elements 110 have a refractive index on the order of the same refractive index as

the glass sheet 102 (or plastic sheet) and the binder material 112. One suitable material for the light scattering elements 110 is silica (SiO<sub>2</sub>).

**[00087]** Although the disclosure herein has been characterized by reference to particular embodiments, it is to be understood that these embodiments are merely illustrative of the principles and applications of such embodiments. It is therefore to be understood that numerous modifications may be made to the illustrative embodiments and that other arrangements may be devised without departing from the spirit and scope of the combinations defined by the appended claims.

**CLAIMS:**

1. An apparatus, comprising:
  - a glass sheet having first and second spaced apart, planar surfaces;
  - at least one scattering layer having a plurality of sub-micron sized light scattering elements disposed on the first surface of the glass sheet; and
  - a binder disposed on the first surface of the glass sheet and at least partially filling voids between adjacent scattering elements.
  
2. The apparatus of claim 1, wherein:
  - the light scattering elements are formed from one or more of individual particles, agglomerates, and aggregates of particles; and
  - an approximate diameter of each scattering element is one of: (i) between about 100 nm to about 500 nm, (ii) between about 200 nm to about 300 nm, and (iii) about 250 nm.
  
3. The apparatus of claim 1, wherein at least one of:
  - the light scattering elements have a refractive index substantially higher than a refractive index of the glass sheet; and
  - the light scattering elements have a refractive index of one of: (i) between about 1.5 and about 4.0, (ii) between about 1.7 and about 2.5, and (iii) at least 2.0.
  
4. The apparatus of claim 1, wherein the light scattering elements are one or more of: agglomerates of Titania (TiO<sub>2</sub>), Cerium oxide (Ce<sub>2</sub>O<sub>3</sub>), Zinc Oxide (ZnO), and Zirconium Dioxide (ZrO<sub>2</sub>).

5. The apparatus of claim 1, wherein at least one of:  
the binder has a refractive index substantially similar  
than a refractive index of the glass sheet; and

the binder has a refractive index of one of: (i) between  
about 1.2 and about 1.7, (ii) between about 1.3 and about 1.6,  
and (iii) about 1.5.

6. The apparatus of claim 1, wherein the binding  
material is taken from one or more of: polymerized or  
partially cured poly alkyl siloxane, poly-dimethyl-siloxane,  
poly-diphenyl-siloxane, polymerized alkyl or aryl  
silsesquioxane T-resins, poly-methyl-silsesquioxane, poly-  
methyl-phenyl-silsesquioxane, poly-phenyl-silsesquioxane, and  
uv curable poly siloxanes or silsesquioxanes.

7. The apparatus of claim 1, wherein the binder  
completely fills the voids and covers the scattering elements  
to produce a planarization layer.

8. The apparatus of claim 1, wherein the apparatus  
exhibits at least one of the following optical  
characteristics: (i) a transmission ratio of between about 70%  
to about 90%; and (ii) a haze ratio of between about 50% to  
about 80%.

9. The apparatus of claim 1, further comprising a  
plurality of electronic display elements disposed in an array  
on or above the binder and operating to produce an image for  
viewing at the first surface of the glass sheet.

10. The apparatus of claim 9, wherein any light entering the glass sheet from one or more edges and/or borders of the second surface thereof is diffused and scattered as it propagates toward the display elements.

11. The apparatus of claim 9, wherein at least one of:  
the collection of individual display elements define a large number of pixel sites for manipulating light in accordance with electronic control signaling in order to produce the image; and

each display element is an individual MEMS component, or an individual OLED component.

12. The apparatus of claims 1 or 9, further comprising at least one light source disposed proximate to the glass sheet such that light therefrom is coupled into the glass sheet, propagates within the glass sheet in a waveguide mode, and at least a portion of light is diffused and scattered by the scattering layer toward the display elements.

13. The apparatus of claim 12, wherein the light source includes one or more light generating elements disposed along one or more edges or one or more borders of the glass sheet.

14. The apparatus of claim 13, wherein the light source includes at least one light diffusing fiber extending along one or more edges of the glass sheet.

15. The apparatus of claim 12, further comprising one or more reflectors at one or more edges of the glass sheet to redirect any light propagating within the glass sheet in one

or more directions that reduce the escape of light out of the at least one edge.

16. A method of producing a light diffusing component, comprising:

providing a glass sheet having first and second spaced apart, planar surfaces;

disposing a plurality of sub-micron sized light scattering elements on the first surface of the glass sheet such that they adsorb to the first surface of the glass sheet;

disposing a viscous binder material onto the first surface of the glass sheet such that the binder material at least partially fills voids between adjacent scattering elements; and

curing the binder material.

17. The method of claim 1, wherein:

the step of disposing the light scattering elements includes: (i) employing a dip coating or spin coating process to apply a slurry of the light scattering elements onto the first surface of the glass sheet, and (ii) heat treating the glass sheet to drive off excess liquids; and

the step of disposing the viscous binder material includes employing a dip coating or spin coating process to apply the binder material onto the first surface of the glass sheet.

18. The method of claim 17, wherein a plurality of coats of binder material are applied in order to build up a thickness of the binder layer.

19. The method of claim 18, wherein the number of coats varies in different areas of the glass sheet to produce higher scattering at one or more central areas and lower scattering at one or more peripheral areas of the glass sheet.

20. The method of claim 17, wherein: the step of disposing the light scattering elements includes employing a surfactant to the slurry of the light scattering elements.

21. An apparatus comprising:

a display layer having first and second spaced apart major sides, a plurality of display elements disposed within the display layer in an array and operating to produce an image for viewing at the first major side thereof;

a light diffusing backplane having first and second spaced apart major sides and operating to produce diffused light out of the first major side thereof, wherein:

the light diffusing backplane is oriented such that the first major side thereof is directed toward the second major side of the display layer such that the diffused light is a source of light for the plurality of display elements,

the display layer is: (i) at least semi-transparent in one or more portions thereof when the display elements in such portions are in an off-state, and (ii) substantially opaque in such portions when the display elements in such portions are in an on-state, and

the light diffusing backplane is substantially transparent such that objects behind the apparatus are visible through both the display layer and the light diffusing backplane.

22. The apparatus of claim 21, wherein the light diffusing backplane comprises:

a glass sheet having first and second spaced apart, planar surfaces;

at least one scattering layer having a plurality of sub-micron sized light scattering elements disposed on the first surface of the glass sheet; and

a binder disposed on the first surface of the glass sheet and at least partially filling voids between adjacent scattering elements.

23. The apparatus of claim 22, further comprising any one or more of the claims under the section labeled "Glass Diffusing Structure."

24. The apparatus of claim 22, wherein the light scattering elements are formed from silica (SiO<sub>2</sub>).

25. The apparatus of claim 22, wherein the light diffusing backplane further comprises at least one light source disposed proximate to the glass sheet such that light therefrom is coupled into the glass sheet, propagates within the glass sheet in a waveguide mode, and at least a portion of light is diffused and scattered by the scattering layer toward the display layer.

26. The apparatus of claim 25, wherein the light source includes one or more light generating elements disposed along one or more edges or one or more borders of the glass sheet.

27. The apparatus of claim 26, wherein at least one edge of the glass sheet includes a reflective surface, which is beveled at an angle sufficient to redirect any light propagating within the glass sheet in one or more directions that reduce the escape of light out of the at least one edge.

28. The apparatus of claim 27, wherein the reflective surface is metalized.

29. The apparatus of claim 26, wherein the light source includes at least one light diffusing fiber extending along one or more edges of the glass sheet.

FIG. 1

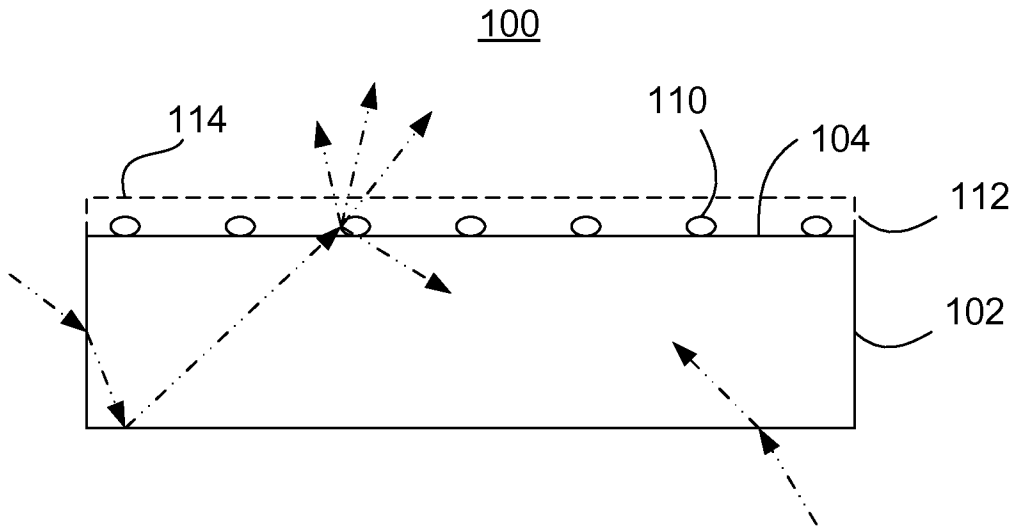


FIG. 2

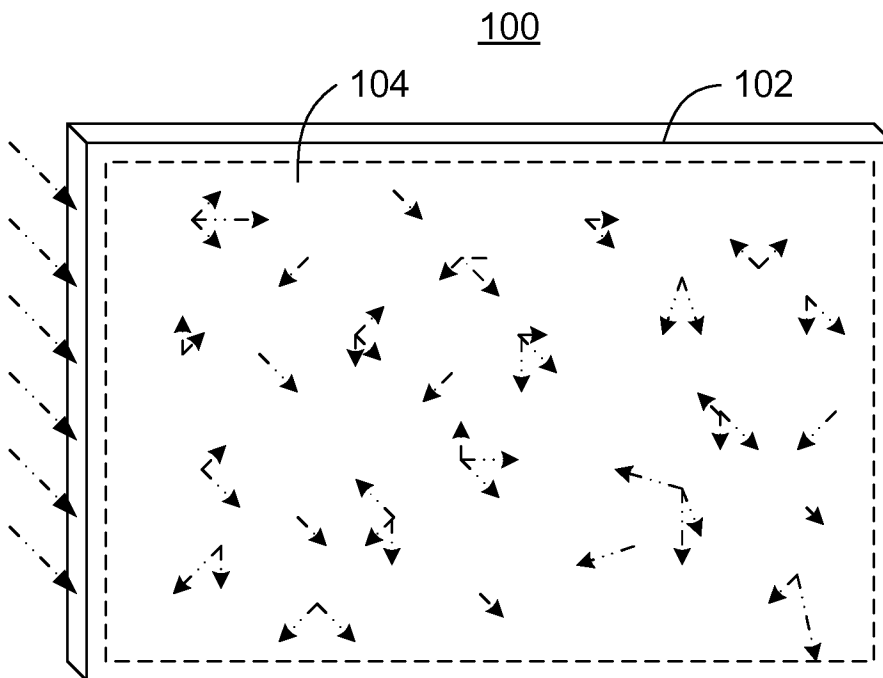


FIG. 3

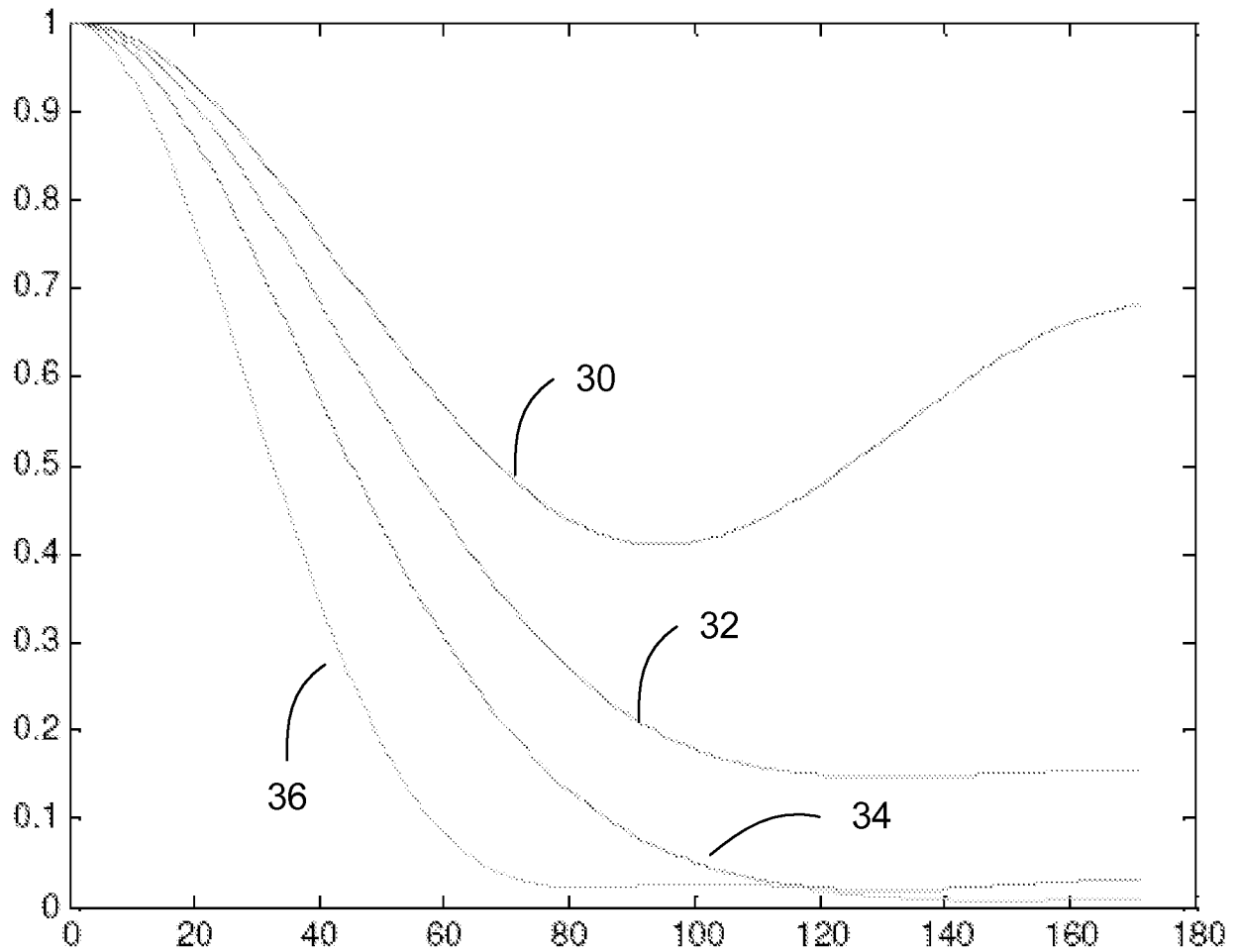


FIG. 4A

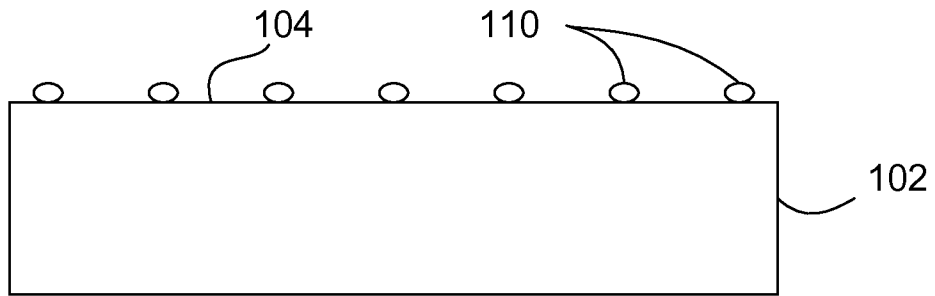


FIG. 4B

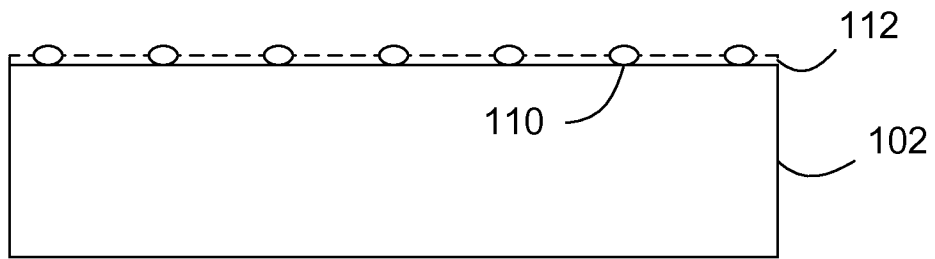


FIG. 4C

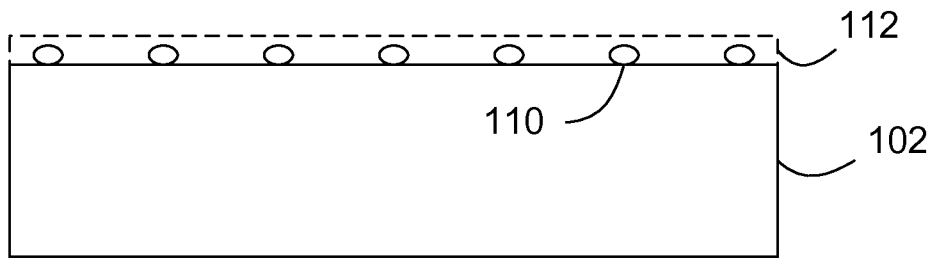


FIG. 5A

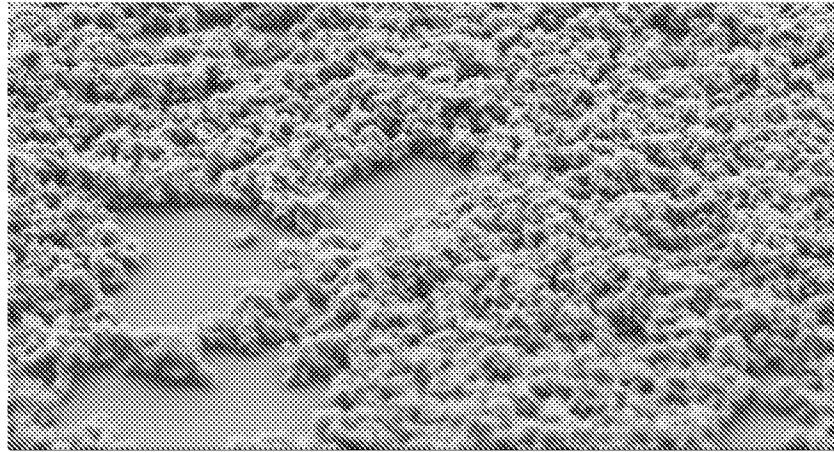


FIG. 5B

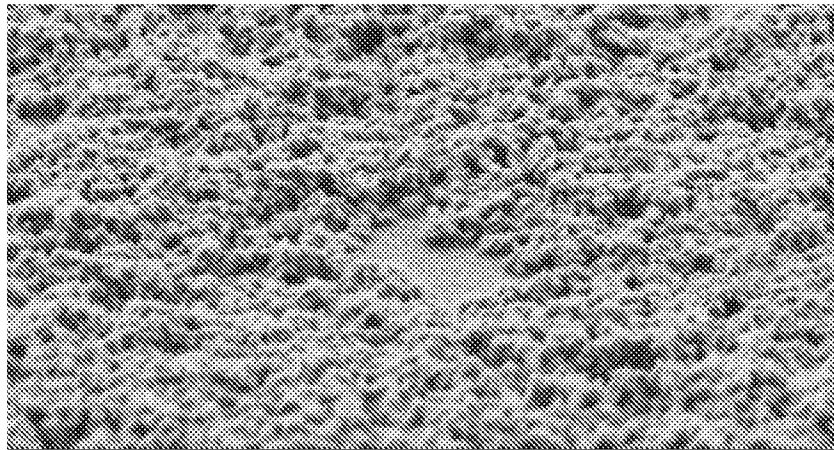


FIG. 5C

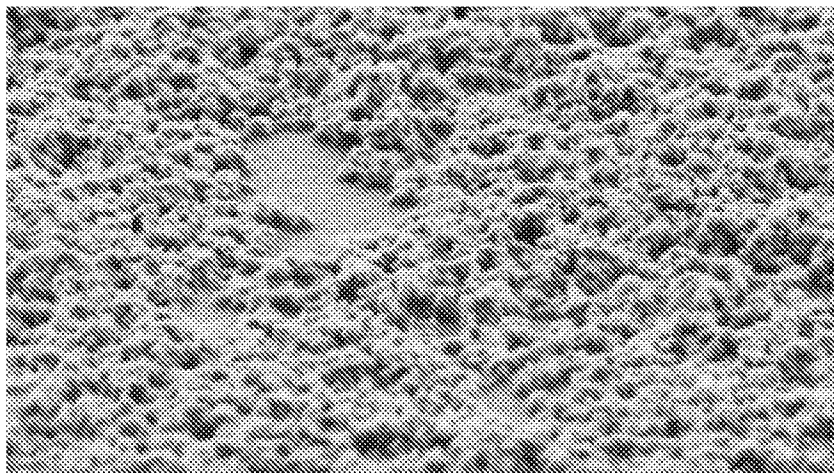


FIG. 5D

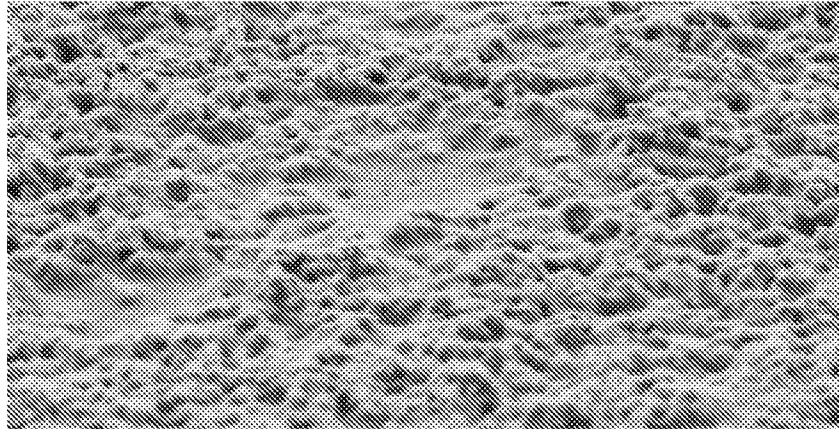
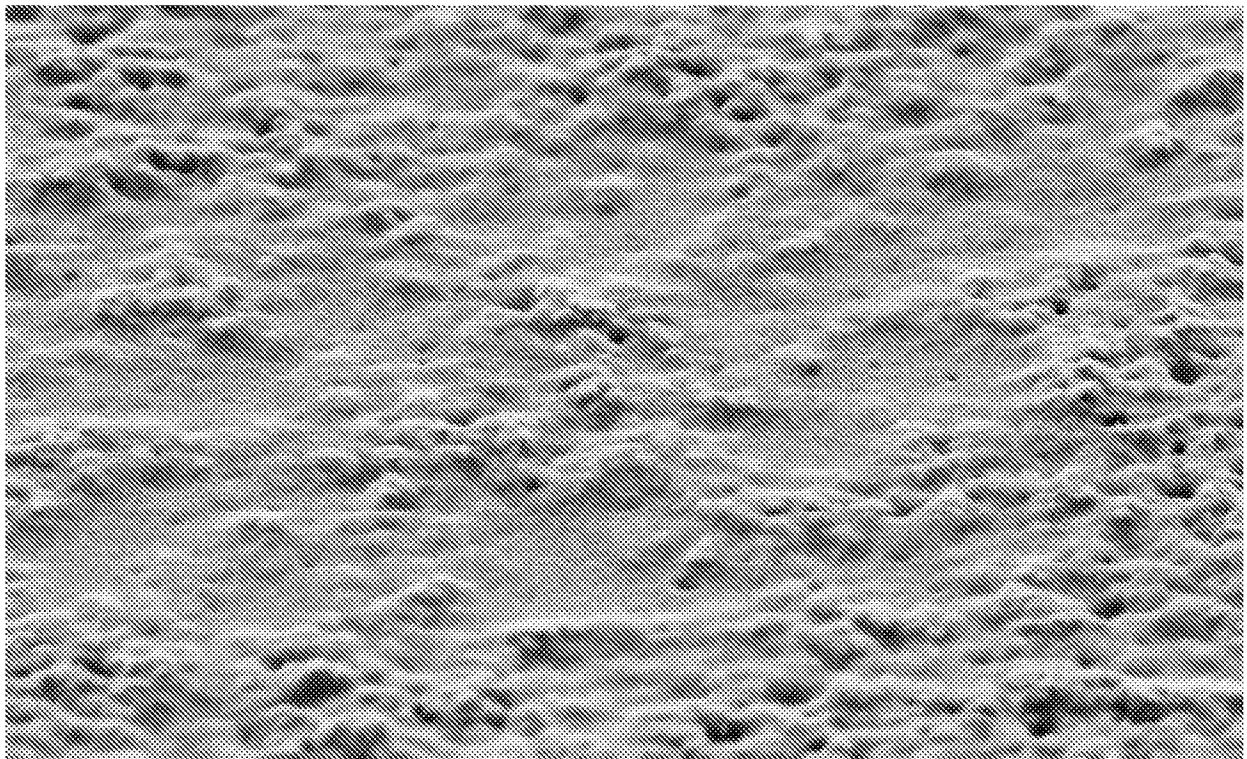


FIG. 5E



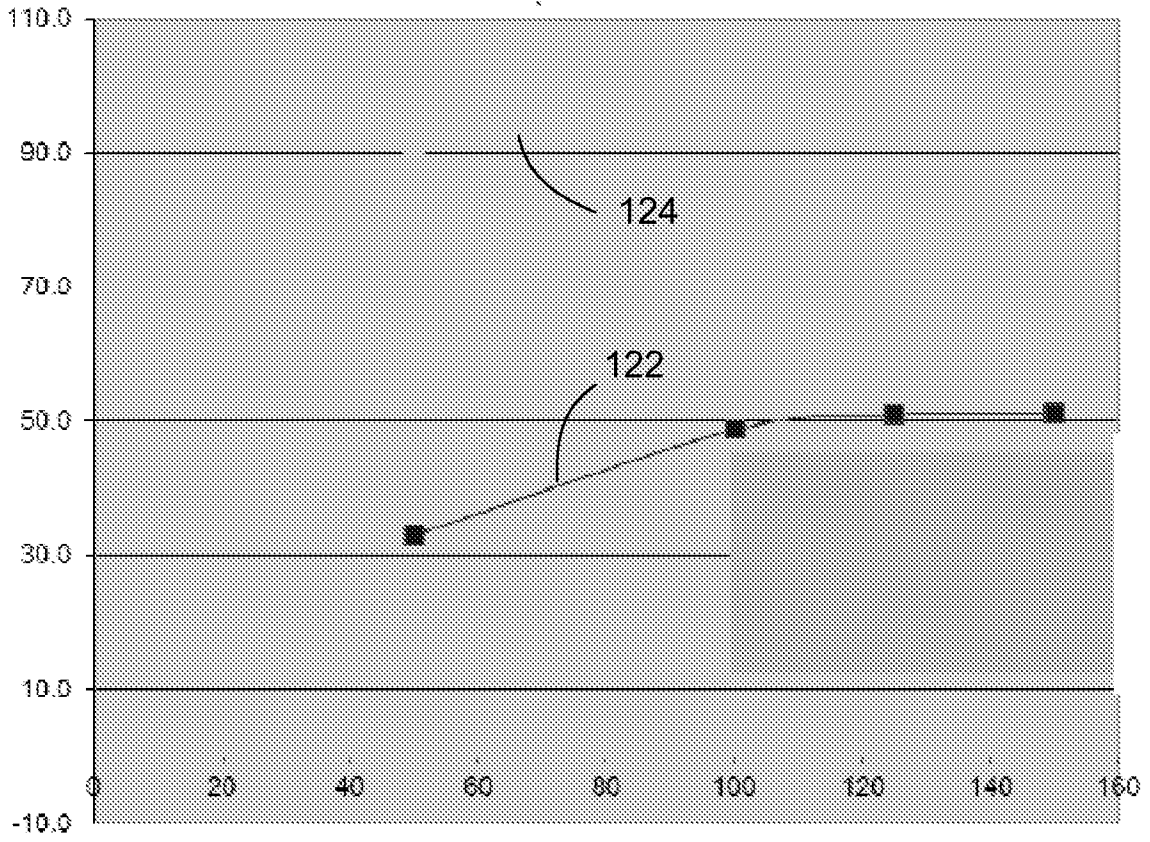


FIG. 6A

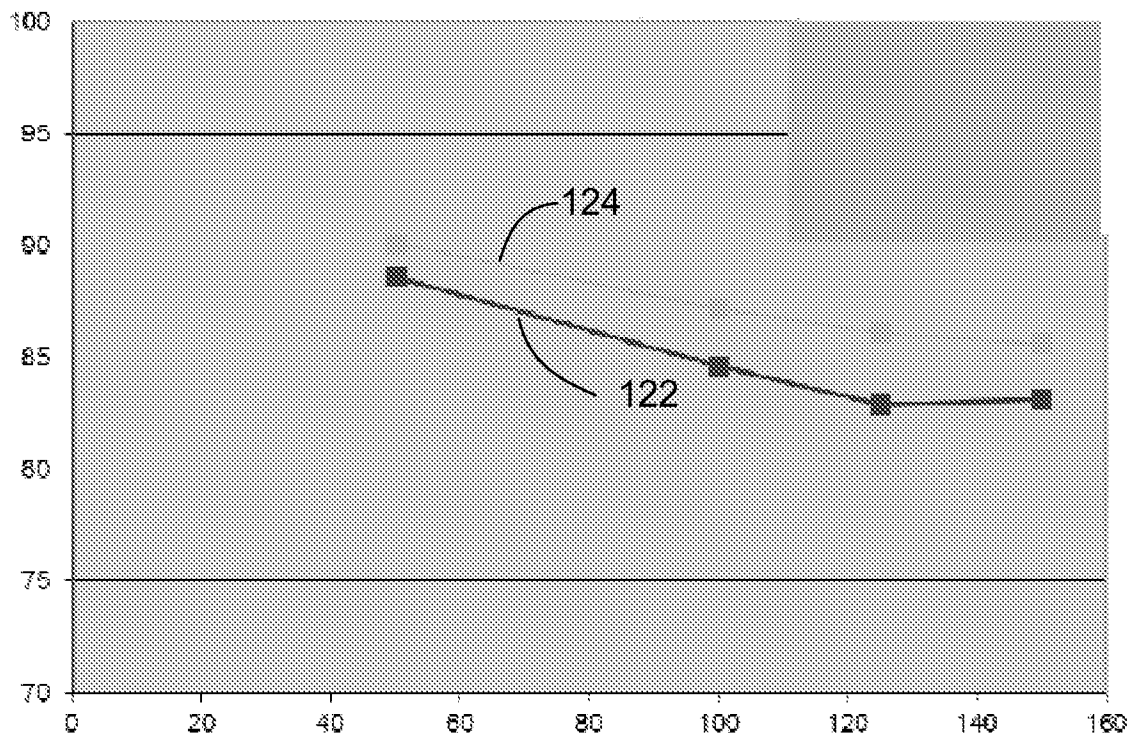


FIG. 6B

FIG. 7A

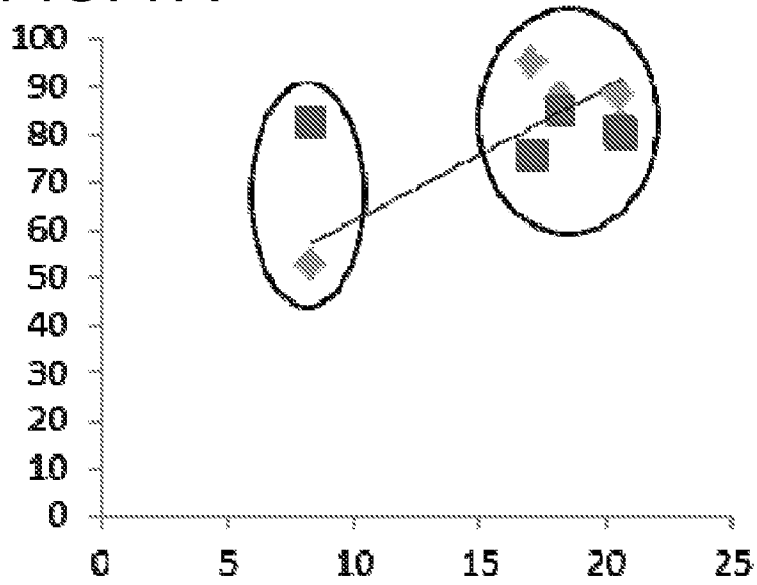


FIG. 7B

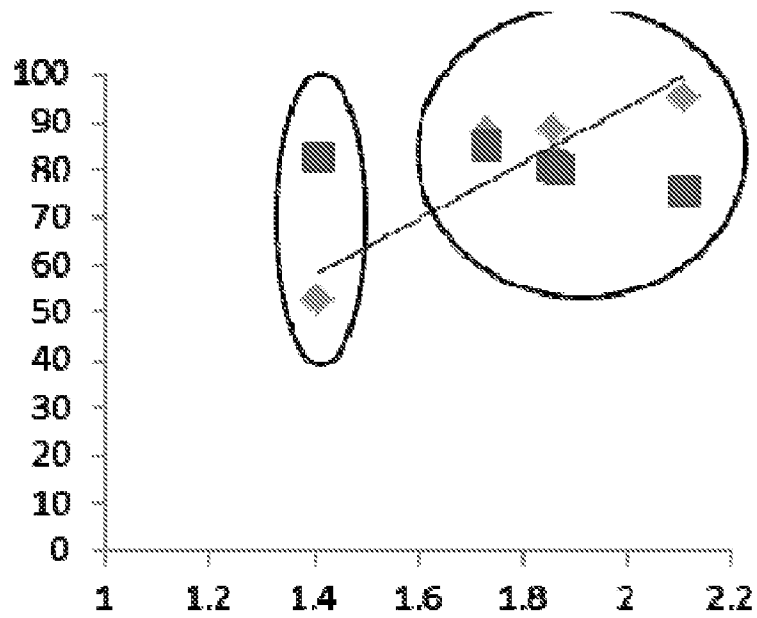


FIG. 8

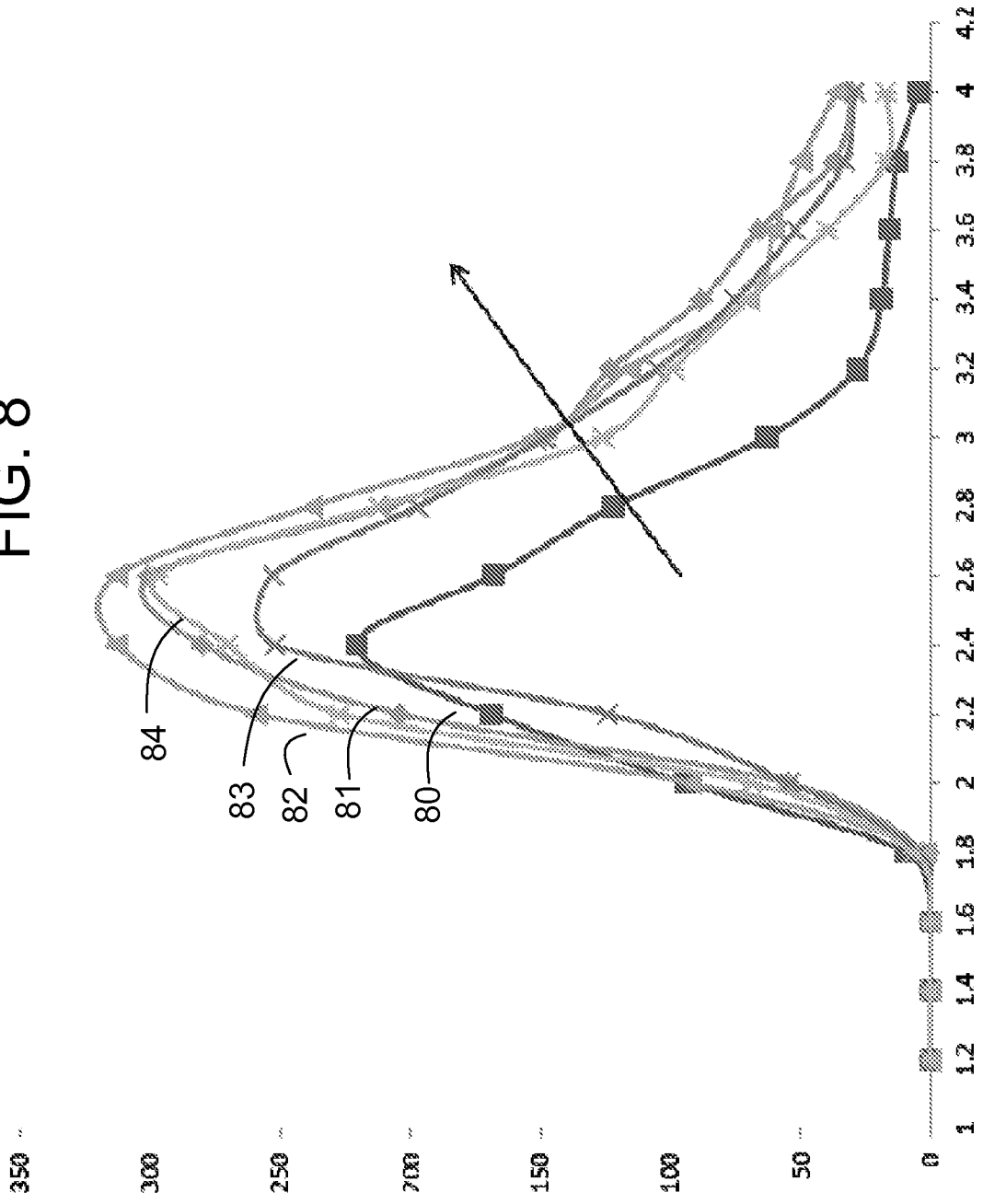


FIG. 9

100A

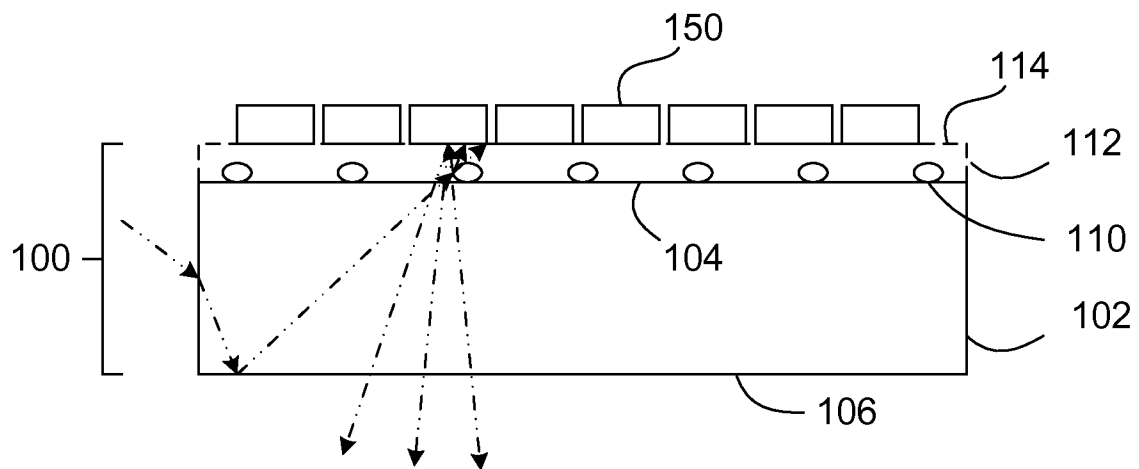


FIG. 10

100B

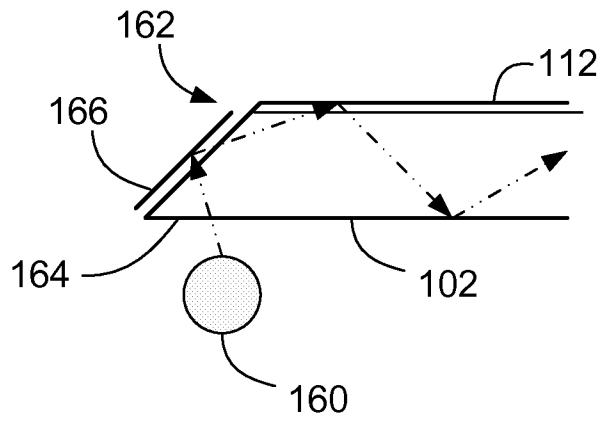


FIG. 11

100C

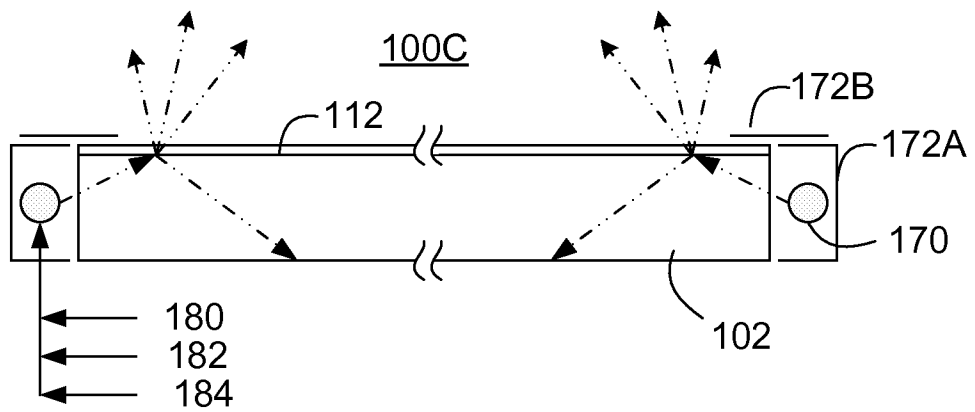


FIG. 12

200

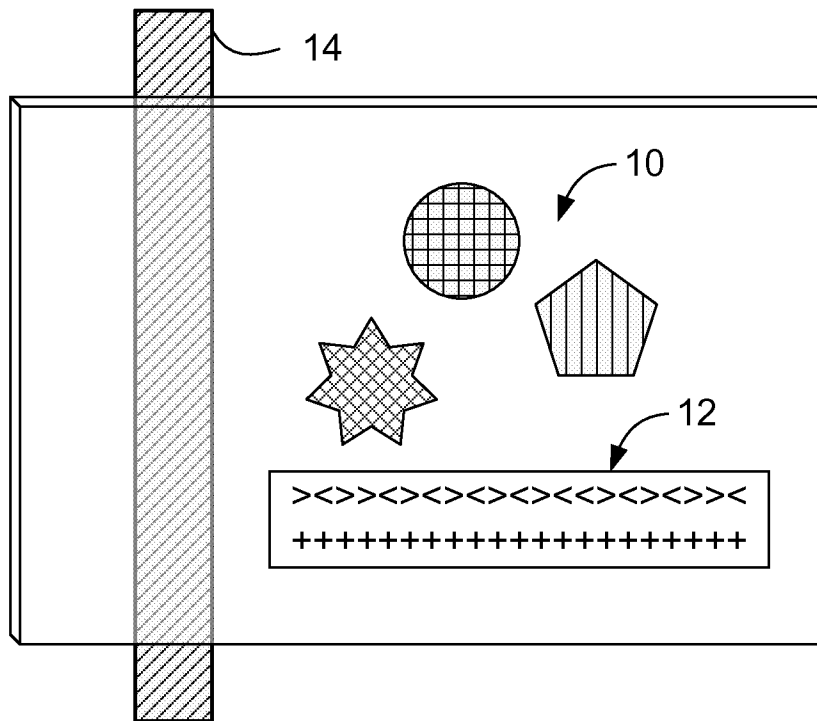


FIG. 13

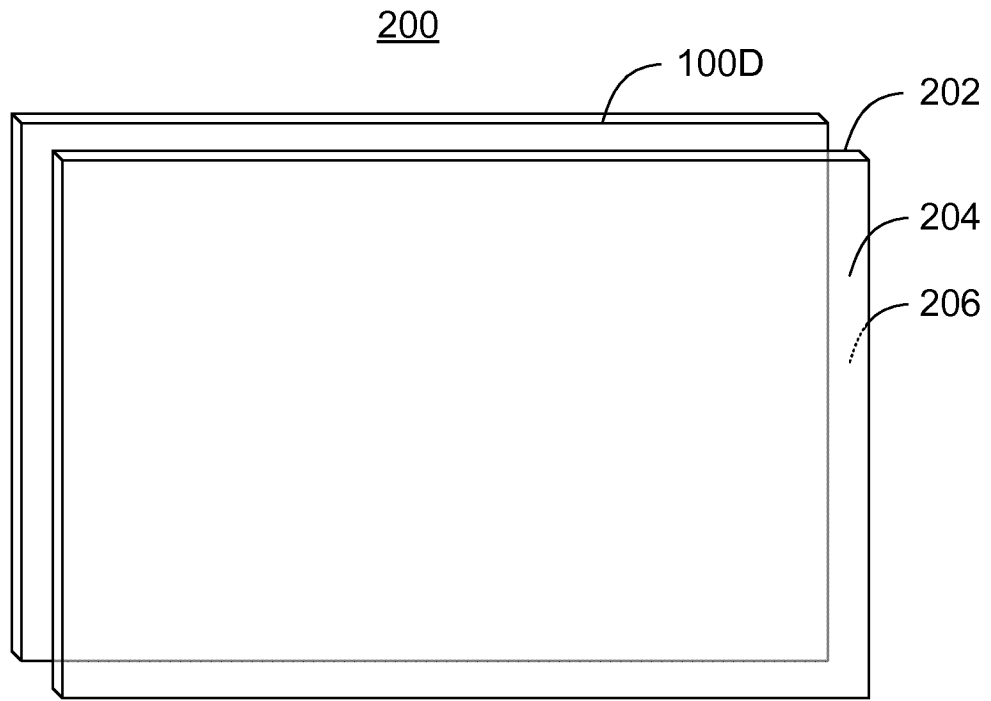
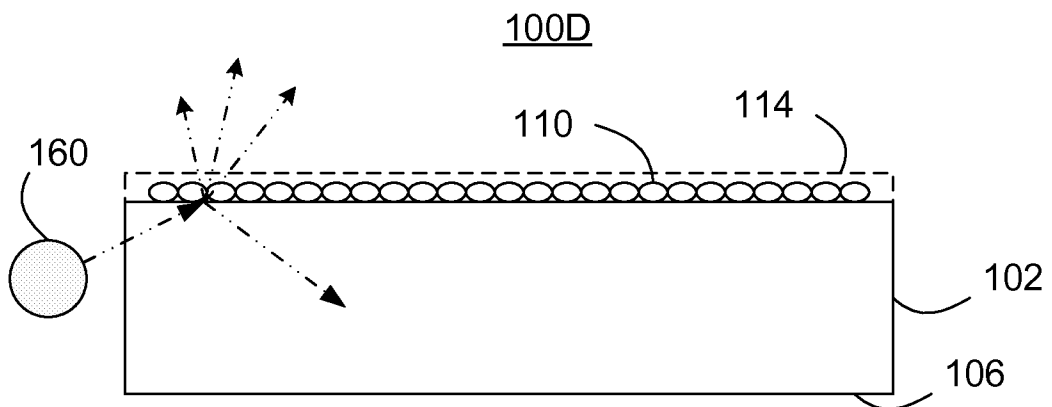


FIG. 14



**A. CLASSIFICATION OF SUBJECT MATTER****G02B 5/02(2006.01)i, G02F 1/13357(2006.01)i, G02B 26/00(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)

G02B 5/02; H05B 33/12; B32B 7/02; G02F 1/13357; C01G 9/02; H01L 33/00; G02F 1/133; G02B 13/20; G02B 26/00

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) &amp; Keywords: glass sheet, scattering element, sub-micron, binder, semi-transparent display, diffusing

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004-0253427 A1 (YOKOGAWA et al.) 16 December 2004 See abstract, paragraphs [0003], [0075], [0096], [0129], [0141], [0145]-[0146], [0149]-[0150], [0167] and figure 2.	1-9, 11-12, 16-20
Y		10, 13-15, 21-22, 24-29
Y	US 2006-0001036 A1 (JACOB et al.) 05 January 2006 See abstract, paragraph [0024], claim 1 and figures 2-3.	10, 13-15, 26-29
Y	US 2009-0244413 A1 (ISHIKAWA et al.) 01 October 2009 See abstract, paragraphs [0020]-[0021] and figures 1, 3-5.	21-22, 24-29
A	US 2006-0098288 A1 (PAN et al.) 11 May 2006 See abstract, paragraph [0019] and figure 3.	1-22, 24-29
A	EP 0893409 A1 (NIPPON SHOKUBAI CO., LTD.) 27 January 1999 See abstract, page 18, line 48 - page 19, line 5 and figure 3.	1-22, 24-29

 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 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

"&amp;" document member of the same patent family


Date of the actual completion of the international search

23 August 2013 (23.08.2013)

Date of mailing of the international search report

**24 August 2013 (24.08.2013)**

Name and mailing address of the ISA/KR


 Korean Intellectual Property Office  
 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City,  
 302-701, Republic of Korea

Facsimile No. +82-42-472-7140

Authorized officer

KANG Sung Chul

Telephone No. +82-42-481-8405



**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.: 23  
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:  
Claim 23 is too broad to make meaningful search possible.
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

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 fee, this Authority did not invite payment of any additional fee.
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/US2013/035371**

Patent document cited in search report	Publication date	Patent family member(s)	Publication date		
US 2004-0253427 A1	16/12/2004	EP 1445095 A1	11/08/2004		
		EP 1445095 A4	30/05/2007		
		EP 1445095 B1	26/12/2012		
		EP 1447433 A1	18/08/2004		
		EP 1447433 B1	05/10/2011		
		EP 2226365 A1	08/09/2010		
		EP 2420539 A1	22/02/2012		
		JP 2003-201443 A	18/07/2003		
		JP 2003-202406 A	18/07/2003		
		JP 2003-202960 A	18/07/2003		
		JP 2003-216061 A	30/07/2003		
		JP 2007-134339 A	31/05/2007		
		JP 3899011 B2	28/03/2007		
		JP 4107050 B2	25/06/2008		
		KR 10-0671990 B1	24/01/2007		
		KR 10-0783714 B1	07/12/2007		
		KR 10-2007-0011650 A	24/01/2007		
		TW 574110 B	01/02/2004		
		US 2005-0109238 A1	26/05/2005		
		US 2007-0190305 A1	16/08/2007		
		US 7582351 B2	01/09/2009		
		WO 03-035389 A1	01/05/2003		
		US 2006-0001036 A1	05/01/2006	US 8324640 B2	04/12/2012
		US 2009-0244413 A1	01/10/2009	US 2012-268669 A1	25/10/2012
				US 8054391 B2	08/11/2011
				WO 2009-120474 A2	01/10/2009
				WO 2009-120474 A3	23/12/2009
		US 2006-0098288 A1	11/05/2006	KR 10-2006-0047789 A	18/05/2006
EP 0893409 A1	27/01/1999	DE 69528460 D1	07/11/2002		
		DE 69528460 T2	23/01/2003		
		DE 69531705 D1	09/10/2003		
		DE 69531705 T2	18/03/2004		
		EP 0768277 A1	16/04/1997		
		EP 0768277 A4	27/08/1997		
		EP 0768277 B1	02/10/2002		
		EP 0893409 B1	03/09/2003		
		JP 07-328421 A	19/12/1995		
		JP 08-060022 A	05/03/1996		
		JP 3554369 B2	18/08/2004		
		US 6200680 B1	13/03/2001		
		WO 95-33688 A1	14/12/1995		