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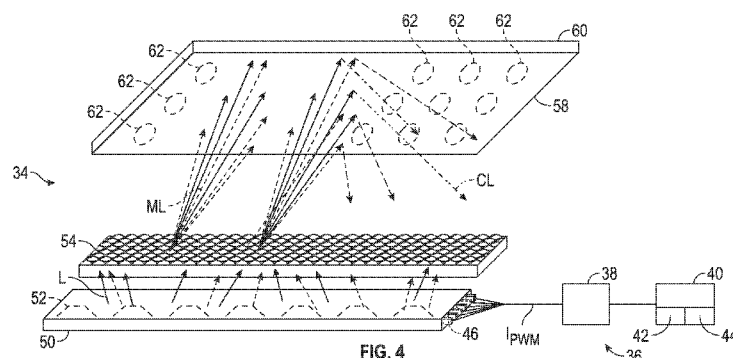
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(54) Title: AMBIENT DISPLAY



(57) **Abstract:** A windshield includes a windshield body and an ambient display coupled to the windshield body. The ambient display includes a light guide plate and a light source optically coupled to the light source. Aside from the light source, the ambient display includes a transparent phosphor film and an optic array. The transparent phosphor film includes at least one phosphor. The optic array includes a plurality of lenses and is disposed between the light guide plate and the transparent phosphor film. The light guide plate is positioned relative to the optic array such that light emitted from the light source is directed toward the optic array. The chromaticity and luminance of the light emitted by the transparent phosphor film can be adjusted based on the electrical current received by the light source.

AMBIENT DISPLAY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/816,089, filed April 25, 2013, which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to ambient displays for use in a vehicle.

BACKGROUND

[0003] Vehicles, such as cars, typically include displays or indicators to provide information to the vehicle operator. Such displays or indicators may, for example, provide information regarding mileage, fuel consumption, and vehicle speed. The vehicle operator can observe an in-vehicle display in order to visually process the information presented by these displays or indicators.

SUMMARY

[0004] It is therefore useful to develop an ambient display that allows the vehicle operator to visually process the information presented by the ambient displays. Specifically, it is useful to develop substantially transparent ambient displays that are coupled to the windshield of the vehicle and are optimally located relative to the windshield in the forward field of view (FOV) of the vehicle operator to encourage the vehicle operator to look forward through the windshield. It is also useful to minimize the cost of these ambient displays. To this end, the present disclosure describes an ambient display capable of being coupled to a vehicle windshield, as well as a windshield including at least one ambient display.

[0005] In an embodiment, the windshield includes a first glass layer, a second glass layer, and an interlayer disposed between the first and second glass layers. At least the first glass layer, the second glass layer, and the interlayer collectively form a windshield body. The windshield further includes at least one ambient display coupled to the windshield body. The ambient display includes a light guide plate and a light source optically coupled to the light guide plate such that the light emitted

from the light source is received by the light guide plate. Aside from the light source, the ambient display includes a transparent phosphor film and a micro-optic array. The transparent phosphor film includes at least one phosphor. The micro-optic array includes a plurality of lenses and is disposed between the light source and the transparent phosphor film such that the optic array shapes a distribution of light guided by the light guide plate according to the shape and size of the transparent phosphor film. The light guide plate is positioned relative to the optic array such that light emitted from the light source is directed toward the optic array. The chromaticity and luminance of the light emitted by the transparent phosphor film can be adjusted based on the electrical current received by the light source.

[0006] The present disclosure also relates to a vehicle including a vehicle body, a windshield coupled to the vehicle body, a power supply, a control module in communication with the power supply, and an ambient display as described above. The control module is specifically programmed to adjust the electrical current supplied to light source in order to adjust the chromaticity and luminance of the light emitted by the transparent phosphor film.

[0007] The present disclosure also relates to an ambient display system including the power supply, control module, and ambient display as described above. The ambient display can be coupled to a windshield as described above.

[0008] The above features and advantages and other features and advantages of the present invention are readily apparent from the following detailed description of the best modes for carrying out the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a schematic, side view of a vehicle including a windshield;

[0010] FIG. 2 is a schematic, front view of the windshield of the vehicle schematically shown in FIG. 1, wherein the windshield includes a plurality of ambient displays;

[0011] FIG. 3 is a schematic, sectional side view of the windshield of FIG. 1;

[0012] FIG. 4 is a schematic, perspective, exploded view of one of the ambient displays schematically illustrated in FIG. 2, wherein the ambient display is electrically connected to a power supply, and the power supply is in communication with a control module; and

[0013] FIG. 5 is a schematic, perspective, enlarged view of a micro-optic array of the ambient display shown in FIG. 4.

DETAILED DESCRIPTION

[0014] Referring now to the drawings, wherein the like numerals indicate corresponding parts throughout the several views, FIG. 1 schematically illustrates a vehicle 10 including a vehicle body 12. The vehicle 10 may be a land vehicle, such as a car, or any other type of vehicle such as an airplane or a boat. Regardless of the specific kind of vehicle, the vehicle 10 includes a windshield 14 coupled to the vehicle body 12. The windshield 14 is wholly or partly made of a substantially transparent material. Accordingly, a vehicle operator can see through the windshield 14.

[0015] With respect to FIGS. 2 and 3, the windshield 14 includes a first glass layer 16, a second glass layer 18, and an interlayer 20 disposed between the first and second glass layers 16, 18. In the depicted embodiment, the interlayer 20 is wholly or partly made of polyvinyl butyral (PVB) and interconnects the first and second glass layers 16, 18. The first glass layer 16, the second glass layer 18, and the interlayer 20 collectively form a windshield body 22 and are substantially transparent in order to allow a vehicle operator to see through the windshield body 22. The interlayer 20 is disposed between the first and second glass layers 16, 18. In the depicted embodiment, the interlayer 20 interconnects the first and second glass layers 16, 18.

[0016] With continued reference to FIGS. 2 and 3, the windshield 14 defines a top edge 24, a bottom edge 26 opposite the top edge 24, a first lateral edge 28 located between the top edge 24 and the bottom edge 26, and second lateral edge 30 opposite the first lateral edge 28. A rearview mirror 32 is coupled to the windshield 14 between the first lateral edge 28 and the second lateral edge 30.

[0017] The vehicle 10 further includes at least one ambient display 34 coupled to the windshield 14. In the depicted embodiment, the vehicle 10 includes three ambient displays 34 coupled to the windshield body 22. It is nevertheless contemplated that the vehicle 10 may include more or fewer ambient displays 34. Irrespective of the quantity, the ambient displays 34 are located relative to the windshield 14 along the peripheral visual field of the vehicle operator (i.e. the driver). In particular, the location of the ambient displays 34 relative to the windshield 14 allows the vehicle operator to visually process the indications in the ambient displays

34 without foveation. In the present disclosure, the term “foveation” means the act of angling the eyes to center the visual field of view on an object to focus and maximize visual acuity. Thus, the ambient displays 34 are optimally located relative to the windshield 14 in the edge of the forward field of view (FOV) of the vehicle operator to encourage the vehicle operator to look forward through the windshield 14. To this end, in the depicted embodiment, two ambient displays 34 are adjacent to the top edge 24 of the windshield 14 and another ambient display 34 is adjacent the bottom edge 26 of the windshield 14. One ambient display 34 is positioned closer the first lateral edge 28 than to the second lateral edge 30. Another ambient display 34 is disposed closer to the second lateral edge 30 than to the first lateral edge 28. Yet another ambient display 34 is positioned substantially equidistant from the first and second lateral edges 28, 30.

[0018] Each ambient display 34 is substantially transparent such that the visible internal light transmission through the ambient display 34 is greater than ninety (90) percent, thereby allowing the vehicle operator to see through the ambient display 34. In other words, each ambient display 34 is wholly or partly made of one or more substantially transparent materials in order to allow a vehicle operator to see through the ambient display 34. Further, each ambient display 34 can present information through color. For instance, the ambient displays 34 may change colors along the red-green-blue color spectrum or the red-green color spectrum to indicate particular information to the vehicle operator. As a non-limiting example, at least one ambient display 34 may change colors to red in order to indicate that another vehicle is close to the vehicle 10. Aside from changing colors, the ambient displays 34 can change its luminance at a constant rate to indicate other types of information to the vehicle operator. For example, at least one ambient display 34 can increase its luminance as another vehicle gets closer to the vehicle 10. In addition to changing its luminance at a constant rate, each ambient display 34 can modulate its luminance at a predetermined constant or variable frequency to indicate other types of information to the vehicle operator. For example, each ambient display 34 can modulate its luminance at an increasing frequency to indicate to the vehicle operator the rate at which another vehicle is approaching the vehicle 10.

[0019] With specific reference to FIG. 3, the ambient displays 34 can be coupled to an outer surface 16A, 18A of the first glass layer 16 or the second glass layer 18. As a non-limiting example, the ambient displays 34 can be laminated to the

outer surface 16A, 18A of the first glass layer 16 or the second glass layer 18. Alternatively or additionally, the ambient displays 34 can be coupled to the interlayer 20. As a non-limiting example, the ambient displays 34 can be at least partially embedded inside the interlayer 20. In the depicted embodiment, the ambient displays 34 are completely embedded inside the interlayer 20.

[0020] With reference to FIGS. 4 and 5, each ambient display 34 is part of an ambient display system 36, which also includes a power supply 38 and a control module 40. The power supply 38 is electrically connected to the ambient display 34 and can therefore supply an electrical current to the ambient display 34. The control module 40 is in communication (e.g., electronic communication) with the power supply 38 and can regulate the electrical current supplied by the power supply 38. The terms “control module,” “control,” “controller,” “control unit,” “processor” and similar terms mean any one or various combinations of one or more of Application Specific Integrated Circuit(s) (ASIC), electronic circuit(s), central processing unit(s) (preferably microprocessor(s)) and associated memory and storage (read only, programmable read only, random access, hard drive, etc.) executing one or more software or firmware programs or routines, combinational logic circuit(s), sequential logic circuit(s), input/output circuit(s) and devices, appropriate signal conditioning and buffer circuitry, and other components to provide the described functionality. “Software,” “firmware,” “programs,” “instructions,” “routines,” “code,” “algorithms” and similar terms mean any controller executable instruction sets including calibrations and look-up tables. In the depicted embodiment, the control module 40 includes at least one processor 42 and at least one memory 44 (or any non-transitory, tangible computer readable storage medium). The memory 44 can store controller executable instruction sets, and the processor 42 can execute the controller executable instruction sets stored in the memory 44. In the depicted embodiment, the control module 40 is programmed to control the electrical current supplied by the power supply 38. The power supply 38 can then supply electrical current to the ambient display 34.

[0021] Each ambient display 34 includes at least one light source 46 electrically connected to the power supply 38. As such, the power supply 38 can supply electrical current to the light source 46. Upon receipt of the electrical current from the power supply 38, the light source 46 emits light. In the depicted embodiment, the light sources 46 are light-emitting diodes (LEDs). The light source

46 (e.g., LEDs) may ~~be~~ emit violet or near ultraviolet radiation at a specific wavelength to induce fluorescence by the phosphor 62. Depending on the chemical identity and spectral characteristics of the phosphor 62 it may emit (fluoresce) in the red, green or blue regions of the visible spectrum subsequent to absorption of the radiation produced by the LEDs. Accordingly, there is a specific LED whose emission is matched to the absorption spectrum of each specific red, green or blue phosphor 62.

[0022] The ambient display 34 further includes a frustrated total internal reflection light guide plate 50 optically coupled to the light sources 46. As such, light emitted by the light sources 46 is received by the light guide plate 50. In the depicted embodiment, the light source 46 (e.g., LEDs) are at least partially embedded in the light guide plate 50, thereby allowing the light emitted by the light source 46 (e.g., LEDs) to be received efficiently by the light guide plate 50. Light guide plate-LED optical coupling can be achieved with non-embedded LEDs, though with less coupling efficiency. The light guide plate 50 includes at least one frustration facet 52 for frustrating the total internal reflection in the light guide plate 50. In other words, the frustration facets 52 allow the light to escape from the light guide plate 50 and direct the light L toward an optic array 54 of the ambient display 34.

[0023] Each ambient display 34 also includes the optic array 54, which may be a micro-optic array. The optic array 54 includes a plurality of lenses 56 (FIG. 5) capable of magnifying the light L emitted by the light source 46. The lenses 56 may be spherical lenses (as shown in FIG. 5) or cylindrical lenses. Regardless of the shape of lenses 56, the optic array 54 can shape the distribution of light guided by the light guide plate 50 according to the shape and size of a transparent phosphor film 58 of the ambient display 34. Thus, the optic array 54 can receive light L from the light guide plate 50 and direct magnified light ML to the transparent phosphor film 58. To this end, the optic array 54 is disposed between the light guide plate 50 and the transparent phosphor film 58. Accordingly, the optic array 54 can shape the distribution of the light guided by the light guide plate 50 according to the shape and size of the transparent phosphor film 58. The light guide plate 50 is positioned relative to the optic array 54 such that light emitted from the light sources 46 is directed toward the optic array 54.

[0024] The substantially transparent phosphor film 58 includes a substantially transparent substrate 60 in order to allow the vehicle operator to see through the transparent phosphor film 58. As a non-limiting example, the substantially transparent

substrate 60 may be partly or wholly made of amorphous polyethylene terephthalate (PET). The visible light internal transmission through the transparent phosphor film 58 is greater than ninety percent (90) percent in order to allow the vehicle operator to see through the ambient display 34. The transparent phosphor film 58 includes at least one phosphor 62 at least partially embedded in the substantially transparent substrate 60. As used herein, the term “phosphor” refers to a substance that exhibits the phenomenon of luminescence and includes both phosphorescent materials and fluorescent materials. The phosphors 62 may be organic or inorganic and, in the depicted embodiment, exhibit fluorescence. The phosphors 62 of the substantially transparent phosphor film 58 green phosphor, red phosphor, blue phosphor, or any combination thereof. For example, the green phosphor may be a copper and aluminum activated zinc sulfide (ZnS:Cu, Al). The red phosphor may be, for example, an europium activated yttrium oxide-sulfide ($\text{Y}_2\text{O}_2\text{S:Eu}$). The europium activated yttrium oxide-sulfide may be coated with nanosized particles of iron oxide (Fe_2O_3). The blue phosphor may be, for example, a zinc sulfide silver (ZnS:Ag). In the substantially transparent phosphor film 58, the phosphor 62 may be distributed evenly along the substantially transparent substrate 60 and each phosphor 62 has a diameter that is less than 100 nanometers in order to enhance visible light transmission through the ambient display 34. In FIG. 4, the phosphors 62 are illustrated quite large with respect to the transparent substrate 60 for illustration purposes only. The phosphors 62 may have specific patterns in order to present icons on the ambient displays 34. The substantially transparent phosphor film 58 may alternatively include quantum dot phosphors.

[0025] In operation, the power supply 38 provides electrical current to the light sources 46. In response, the light sources 46 emit ultraviolet or violet light, which is captured by the light guide plate 50. The light guide plate 50 then directs the light toward the optic array 54. Next, the optic array 54 magnifies the light L in accordance with the shape and size of the transparent phosphor film 58 and directs the magnified light ML toward the transparent phosphor film 58. The substantially transparent phosphor film 58 then absorbs the magnified light ML and, depending on the excitation wavelengths of the magnified light ML, emits a colored light CL along the red-green-blue color spectrum. Thus, the ambient display 34 can be color-tuned based, at least in part, on the excitation wavelengths of the light L emitted by the light sources 46.

[0026] The control module 40 can control the power supply 38 in order to adjust the electrical current supplied to the light sources 46. In doing so, the control module 40 can adjust the chromaticity or luminance of the colored light CL emitted by the transparent phosphor film 58. By adjusting the electrical current supplied to the light sources 46, the control module 40 can change the color of the colored light CL. In addition, the control module 40 can adjust the luminance of the colored light CL at a constant rate or modulate the luminance of the colored light CL at a constant or variable frequency. To adjust the luminance of the colored light CL emitted by the transparent phosphor film 58, the control module 40 can command the power supply 38 to adjust the magnitude of the electrical current supplied to the light sources 46 at a constant rate. In other words, the control module 40 is programmed to adjust the magnitude of the electrical current supplied by the power supply 38 in order to adjust the luminance of the colored light CL emitted by the substantially transparent phosphor film 58.

[0027] The power supply 38 can emit a pulse modulated current I_{PWM} , and the control module 40 can control the duty cycle of the pulse modulated current I_{PWM} . By adjusting the duty cycle of the pulse modulated current I_{PW} , the excitation wavelengths of the light L emitted by the light source 46 (and eventually the magnified light ML) can be adjusted in accordance with instructions stored in the control module 40. As a consequence, the chromaticity of the colored light CL emitted by the substantially transparent phosphor film 58 can be adjusted by adjusting the duty cycle of the pulse modulated current I_{PWM} . In summary, the control module 40 can command the power supply 38 to adjust the electrical current supplied to the light sources 46 (e.g., LEDs) in order to adjust luminance, temporal nature of the luminance, the chromaticity, and spatial characteristics of the luminance (patterns) of the ambient display 34. The luminance and chromaticity of the colored light CL emitted by the substantially transparent phosphor film 58 can be adjusted based on the electrical current received by the light sources 46.

[0028] While the best modes for carrying out the invention have been described in detail, those familiar with the art to which this invention relates will recognize various alternative designs and embodiments for practicing the invention within the scope of the appended claims. For example, the ambient display 34 can be substituted with a transparent organic LED. The light guide plate 50 and the LEDs can be substituted with the red-green-blue pico (or pocket) projector with a micro-

optic projection screen. The light guide plate 50 and the LEDs can be substituted with the violet and near ultraviolet (UV) pico (or pocket) projector with a transparent phosphor screen. The ambient display 34 can be replaced with a transparent electroluminescent (EL) display. Also, a lens-of-lens design can be incorporated in the ambient display 34 in order to present fixed format images. Also, the ambient display 34 can be partly or entirely coupled to the portions of the vehicle body 12, such as the pillars.

CLAIMS

1. A windshield for a vehicle, comprising:
 - a first glass layer;
 - a second glass layer;
 - an interlayer disposed between the first and second glass layers,wherein at least the first glass layer, the second glass layer, and the interlayer collectively form a windshield body;
 - an ambient display coupled to the windshield body, wherein the ambient display includes:
 - a light guide plate;
 - a light source optically coupled to the light guide platesuch that light emitted from the light source is received by the light guide plate;
 - a substantially transparent phosphor film including at least one phosphor;
 - an optic array including a plurality of lenses, the optic array being disposed between the light guide plate and the transparent phosphor film such that the optic array shapes a distribution of light guided by the light guide plate according to a shape and size of the substantially transparent phosphor film, wherein the light guide plate is positioned relative to the optic array such that light emitted from the light source is directed toward the optic array; and
 - wherein a chromaticity and a luminance of light emitted by the substantially transparent phosphor film is adjustable based on the electrical current received by the light source.
2. The windshield of claim 1, wherein the substantially transparent phosphor film includes a green phosphor.
3. The windshield of claim 2, wherein the substantially transparent phosphor film includes a red phosphor.

4. The windshield of claim 3, wherein the substantially transparent phosphor film includes a blue phosphor.
5. The windshield of claim 4, wherein the luminance of light emitted by the substantially transparent phosphor film is adjustable based on a magnitude of the electrical current received by the light source.
6. The windshield of claim 4, wherein the chromaticity of the light emitted by the substantially transparent phosphor film is adjustable based on a duty cycle of a pulse modulated current received by the light source.
7. The windshield of claim 1, wherein the ambient display is laminated to an outer surface of the second glass layer.
8. The windshield of claim 1, wherein the ambient display is embedded inside the interlayer.
9. The windshield of claim 1, wherein the light source is a plurality of light emitting diodes (LEDs) that are coupled to the light guide plate.
10. A vehicle, comprising:
 - a vehicle body;
 - a windshield coupled to the vehicle body;
 - a power supply;
 - a control module in communication with the power supply,wherein the control module is programmed to control an electrical current supplied by the power supply;
 - an ambient display coupled to the windshield, wherein the ambient display includes:
 - a light guide plate;
 - a light source electrically connected to the power supply such that the power supply is capable of supplying electrical current to the light source, wherein the light source is optically coupled to the light guide plate such that light emitted from the light source is received by the light guide plate;

a substantially transparent phosphor film including at least one phosphor;

an optic array including a plurality of lenses, the optic array being disposed between the light guide plate and the substantially transparent phosphor film such that the optic array shapes a distribution of light guided by the light guide plate according to a shape and size of the substantially transparent phosphor film, wherein the light guide plate is positioned relative to the optic array such that light emitted from the light source is directed toward the optic array; and

wherein the control module is programmed to adjust the electrical current supplied by the power supply in order to adjust a chromaticity and a luminance of light emitted by the substantially transparent phosphor film.

11. The vehicle of claim 10, wherein the substantially transparent phosphor film includes a green phosphor.

12. The vehicle of claim 11, wherein the substantially transparent phosphor film includes a red phosphor.

13. The vehicle of claim 12, wherein the substantially transparent phosphor film includes a blue phosphor.

14. The vehicle of claim 13, wherein the control module is programmed to adjust a magnitude of the electrical current supplied by the power supply in order to adjust the luminance of the light emitted by the substantially transparent phosphor film.

15. The vehicle of claim 14, wherein the control module is programmed to adjust a duty cycle of a pulse modulated current received by the light source in order to adjust the chromaticity of the light emitted by the substantially transparent phosphor film.

16. An ambient display system for a windshield of a vehicle, the ambient display system comprising:

a power supply;
a control module in communication with the power supply,
wherein the control module is programmed to control an electrical current supplied by the power supply;
an ambient display couplable to the windshield, wherein the ambient display includes:
a light guide plate;
a plurality of light emitting diodes (LEDs) electrically connected to the power supply such that the electrical current supplied by the power supply is received by the LEDs, wherein the LEDs are optically coupled to the light guide plate such that light emitted from the LEDs is received by the light guide plate;
a substantially transparent phosphor film;
an optic array including a plurality of lenses, the optic array being disposed between the light guide plate and the substantially transparent phosphor film such that the optic array shapes a distribution of light guided by the light guide plate according to a shape and size of the substantially transparent phosphor film, wherein the light guide plate is positioned relative to the optic array such that light emitted from the LEDs is directed toward the optic array; and
wherein the control module is programmed to adjust the electrical current supplied by the power supply in order to adjust a luminance and a chromaticity of light emitted by the substantially transparent phosphor film.

17. The ambient display system of claim 16, wherein the substantially transparent phosphor film includes a red phosphor and a green phosphor.

18. The ambient display system of claim 17, wherein the substantially transparent substantially phosphor film includes a blue phosphor.

19. The ambient display system of claim 15, wherein a visible light transmission of the substantially transparent phosphor film is greater than ninety percent.

20. The ambient display system of claim 1, wherein the substantially transparent phosphor film includes a transparent substrate and at least one phosphor at least partially embedded inside the transparent substrate.

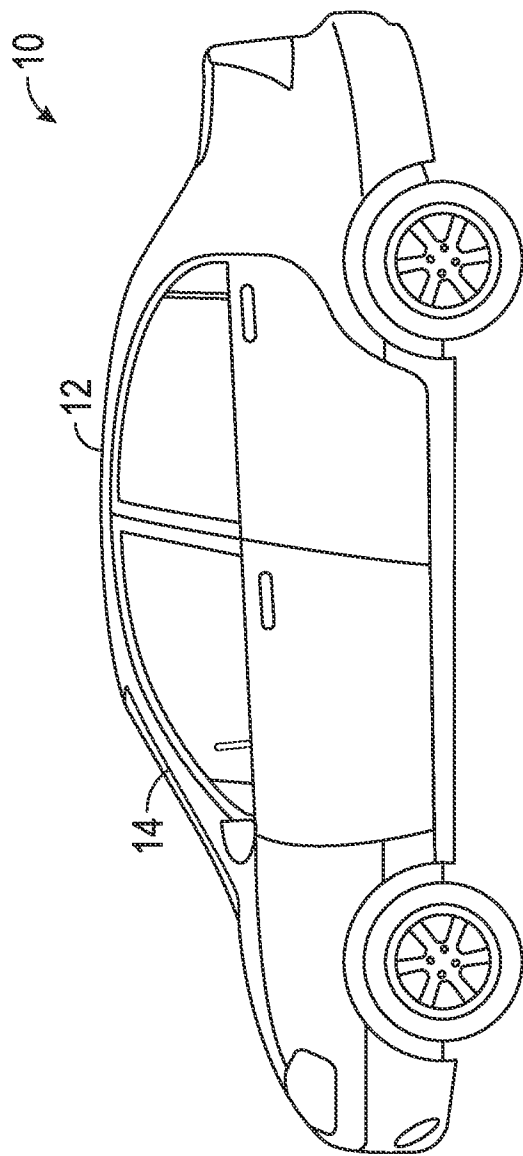


FIG. 1

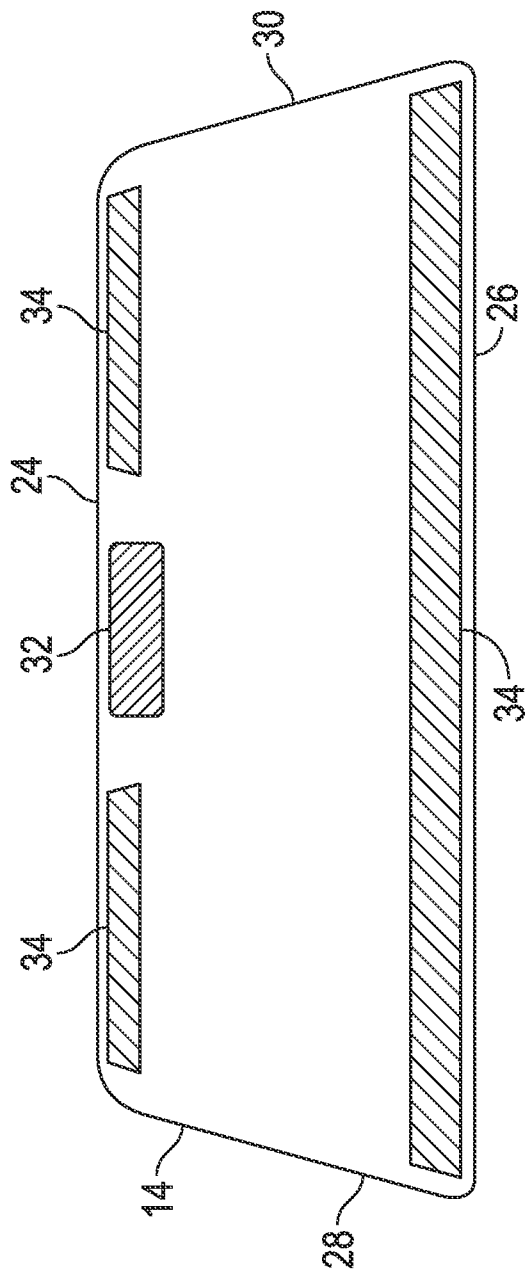


FIG. 2

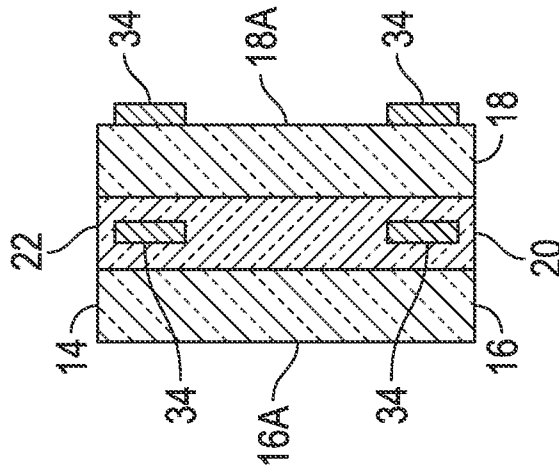
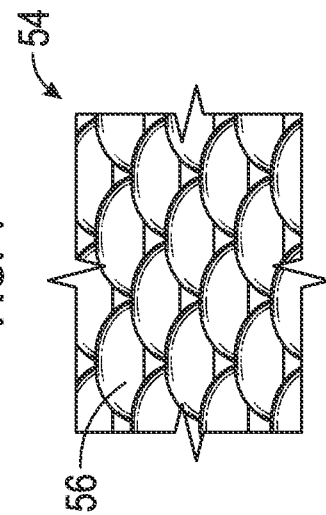
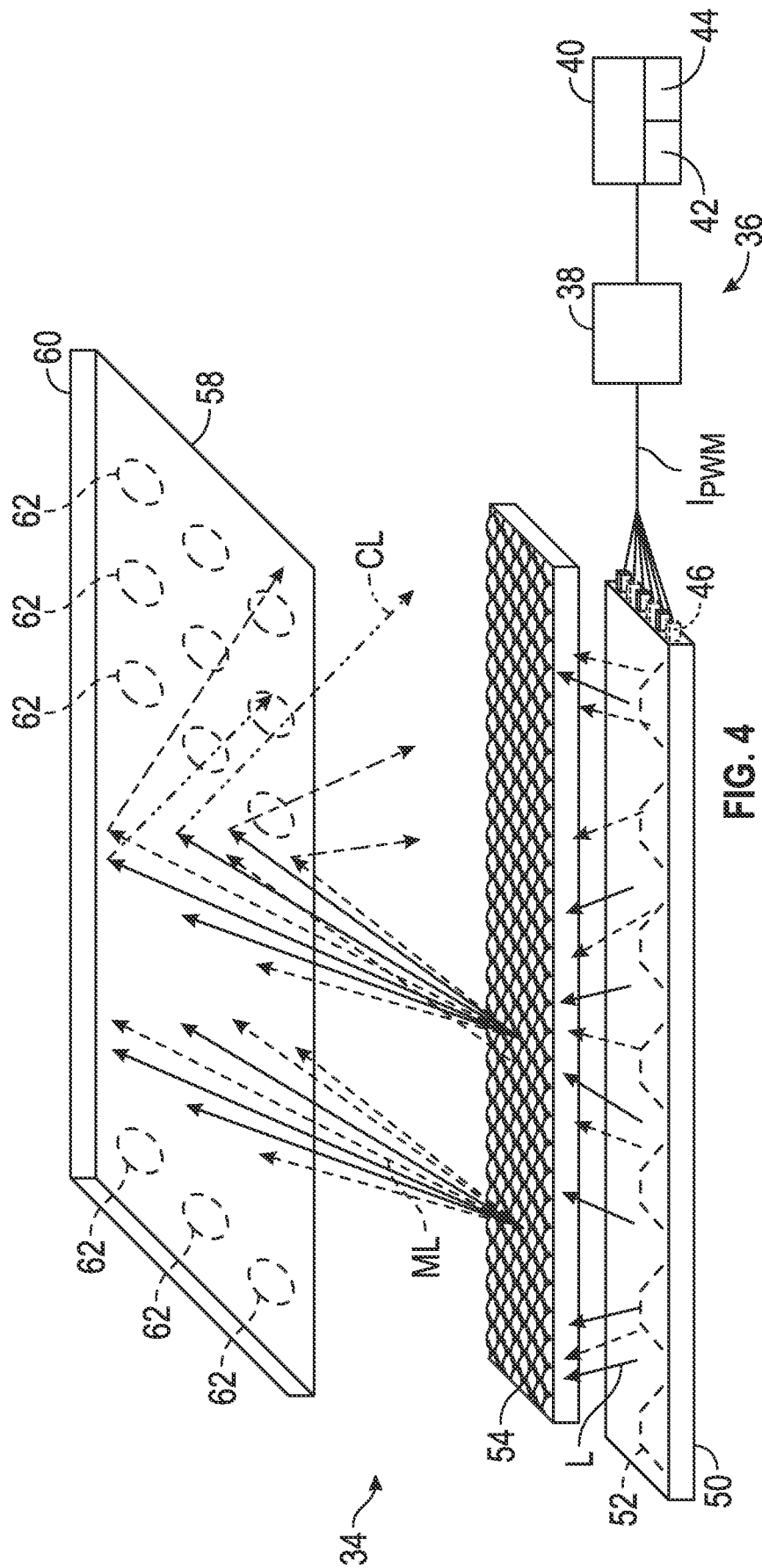


FIG. 3



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/035387**A. CLASSIFICATION OF SUBJECT MATTER****G02B 26/02(2006.01)i, G02F 1/1335(2006.01)i, B60K 35/00(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 26/02; G01N 21/64; B32B 27/40; G03B 21/60; G03B 21/00; G09G 3/30; G09F 9/46; B60Q 1/26; G02F 1/1335; B60K 35/00

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) & Keywords: vehicle, windshield, display, phosphor, lenses, current, adjust

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2011-0025584 A1 (NISHIGASAKO et al.) 03 February 2011 See paragraphs [0019], [0030], [0040], claims 1-2, 4, 8 and figures 1-2, 5.	1-20
Y	US 2009-0116107 A1 (KINDLER et al.) 07 May 2009 See abstract, paragraphs [0034], [0037], [0055], [0057]-[0059], [0065] and figures 1, 3A, 4-5.	1-20
A	JP 08-272321 A (TOYODA GOSEI CO., LTD.) 18 October 1996 See abstract, paragraphs [0012]-[0027] and figures 1-8.	1-20
A	US 2008-0158510 A1 (TANT et al.) 03 July 2008 See paragraphs [0022]-[0045] and figures 1-3.	1-20
A	US 2012-0068083 A1 (LABROT et al.) 22 March 2012 See abstract, paragraphs [0038]-[0047] and figure 1.	1-20



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INTERNATIONAL SEARCH REPORT

Information on patent family members

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