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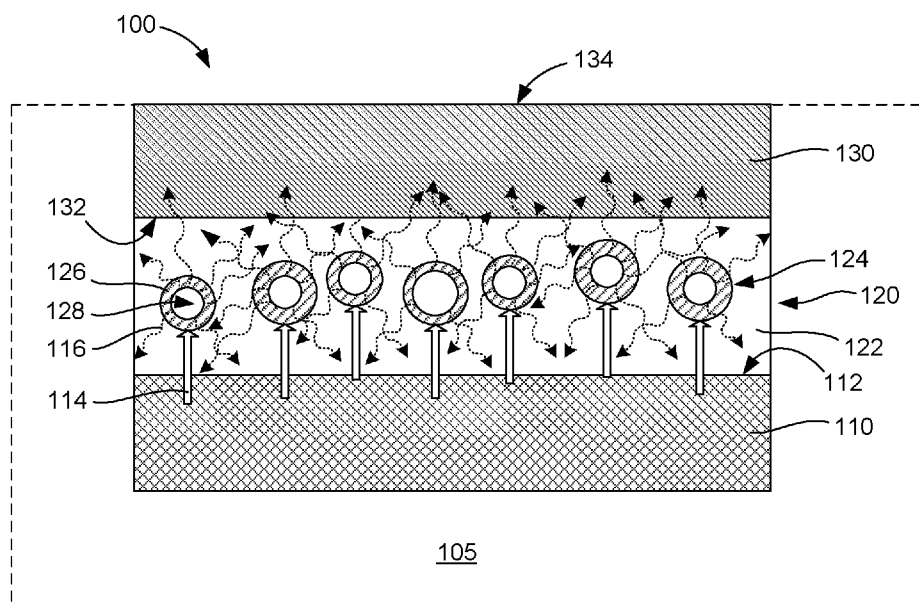


FIG. 1

(57) Abstract: The present disclosure is drawn to an optical assembly for an electronic device. The optical assembly can include an optical light-emitter, an optical light-transmission component, and an adhesive layer between the optical light-emitter and the optical light-transmission component. The adhesive layer can include an optically clear adhesive and hollow optical nanospheres dispersed in the optically clear adhesive. The hollow optical nanospheres can include an outer shell and a hollow inner portion.



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OPTICAL ASSEMBLIES FOR ELECTRONIC DEVICES

BACKGROUND

[0001] The use of personal electronic devices, computing devices, or any
10 other type of device that uses an optical display continues to increase.
Televisions, desktop computers, laptops, tablets, smartphones, and the like, with
optical display screens have become more and more common. Touchscreen
tablet computers and particularly touchscreen smartphones have become
ubiquitous in many countries. Portable laptop computers continue to be used by
15 many for personal, entertainment, and business purposes, and there is
continuing to be more and more need for the use of a touchscreen and/or other
type of display screen that provides clarity and good resolution.

BRIEF DESCRIPTION OF THE DRAWING

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[0002] FIG. 1 is a schematic view of an optical assembly for an electronic
device in accordance with examples of the present disclosure;

[0003] FIG. 2 is a schematic view of a touchscreen optical assembly for an
electronic device in accordance with examples of the present disclosure;

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[0004] FIG. 3 is a schematic view of an alternative optical assembly for an
electronic device in accordance with examples of the present disclosure; and

[0005] FIG. 4 is a flowchart depicting an example method of making an
optical assembly in accordance with examples of the present disclosure.

DETAILED DESCRIPTION

[0006] The present disclosure relates to optical displays and methods of making optical displays, and in examples herein, can include an adhesive layer positioned between an optical light-emitter, e.g., electronic visual display, and an optical light-transmission component, e.g. a lens, an optically transparent cover, a touch sensor, etc. In particular, by using an adhesive described herein, in some examples, an optical sparkle effect sometimes generated by coupling an optical light-emitter with an optical light-transmission component can be ameliorated.

[0007] In accordance with this, an optical assembly for an electronic device can include an optical light-emitter, an optical light-transmission component, and an adhesive layer between the optical light-emitter and the optical light-transmission component. The adhesive layer can include an optically clear adhesive and hollow optical nanospheres dispersed in the optically clear adhesive. The hollow optical nanospheres can include an outer shell and a hollow inner portion. In one example, the optical light-emitter can be an electronic visual display, such as a backlit display device. The optical light-transmission component can include a touch sensor, a lens, or an optically transparent cover, for example. The hollow optical nanospheres can be present in the adhesive layer in an amount from about 0.1 wt% to about 3 wt% based on a total weight of the adhesive layer. The hollow optical nanospheres can include polyacrylic nanospheres, polycarbonate nanospheres, cyclic olefin copolymer nanospheres, or glass nanospheres, for example. The hollow optical nanospheres can have a D50 particle size from about 100 nm to about 1.25 μm . In one example, the optically clear adhesive can have a refractive index from about 1.48 to about 1.7, the outer shell of the hollow optical nanospheres can have a refractive index from about 1.48 to about 1.7, and the hollow inner portion can have a refractive index from about 0.48 to about 0.7 different than the refractive index of the optically clear adhesive, the outer shell, or both. The optically clear adhesive can include polyacrylic, e.g., polymethyl methacrylate (PMMA); cyclic olefin copolymer; polycarbonate; epoxy; or a combination thereof.

[0008] In another example, a touchscreen optical assembly for an electronic device can include an electronic visual display, a touch sensor, and an adhesive layer between the electronic visual display and the touch sensor. The adhesive layer can include an optically clear adhesive and hollow optical nanospheres dispersed in the optically clear adhesive. The hollow optical nanospheres can include an outer shell and a hollow inner portion. The hollow optical nanospheres can be present in the adhesive layer in an amount from about 0.1 wt% to about 3 wt% based on a total weight of the adhesive layer. The optically clear adhesive can have a refractive index from about 1.48 to about 1.7, the outer shell of the hollow optical nanospheres can have a refractive index from about 1.48 to about 1.7, and the hollow inner portion can have a refractive index from about 0.48 to about 0.7 different than the refractive index of the optically clear adhesive, the outer shell, or both. The touchscreen optical assembly can further include a lens and a second adhesive layer between the touch sensor and the lens on a touch sensor surface opposite the electronic visual display and adhesive layer.

[0009] In another example, a method of making an optical assembly of an electronic device can include admixing hollow optical nanospheres into an optically clear adhesive to form an adhesive layer composition. The hollow optical nanospheres can include an outer shell and a hollow inner portion. The method can also include adhering a light-emitting surface of an optical light-emitter to a surface of a light-transmission component to form an adhesive layer therebetween. The adhesive layer can have a thickness from about 10 μm to about 100 μm , and the hollow optical nanospheres can be present in the adhesive layer in an amount from about 0.1 wt% to about 3 wt% based on a total weight of the adhesive layer. In one example, the optically clear adhesive can have a refractive index from about 1.48 to about 1.7, the outer shell of the hollow optical nanospheres can have a refractive index from about 1.48 to about 1.7, and the hollow inner portion can have a refractive index from about 0.48 to about 0.7 different than the refractive index of the optically clear adhesive, the outer shell, or both.

[0010] It is noted that when discussing either the optical assembly, the touchscreen optical assembly, or the methods herein, such discussions can be considered applicable to one another whether or not they are explicitly discussed in the context of that example. Thus, for example, when discussing adhesive
5 layer in the context of one of the optical assembly examples, such disclosure is also relevant to and directly supported in the context of the touchscreen optical assembly and/or method, and *vice versa*. It is also understood that terms used herein will take on their ordinary meaning in the relevant technical field unless specified otherwise. In some instances, there are terms defined more specifically
10 throughout or included at the end of the present disclosure, and thus, these terms are supplemented as having a meaning described herein.

[0011] In further detail, it is noted that the spatial relationship between layers is often described herein as positioned “on” or applied “on” another layer, or a layer may be described as being “between” other layers, or simply
15 “therebetween.” These terms do not infer that the particular layer being discussed is positioned directly adjacent to the layer(s) or structure(s) to which it refers, but could have intervening layers or structures therebetween. That being stated, a layer described as being positioned on another layer or structure, or between two other layers or structures, can be positioned directly adjacent to or thereon the
20 other layer(s)/structure(s) referred to, and thus such a description finds support herein for being positioned directly on the referenced layer or structure, or immediately between two layers or structures.

[0012] *Optical Assemblies*

25 [0013] In accordance with examples of the present disclosure, various optical assemblies for electronic devices can be formed, including a touchscreen optical assembly, a non-touchscreen optical assembly, or other optical assemblies for use with electronic devices. As shown by example in FIG. 1, an optical assembly 100 for an electronic device 105 can include an optical
30 light-emitter 110, an optical light-transmission component 130, and an adhesive layer 120 between a light-emitting surface 112 of the optical light-emitter and an inner surface 132 of the optical light-transmission component. In this instance, the

adhesive layer directly adheres the optical light-emitter and the optical light-transmission component together, but in some examples, there may be intervening layers therebetween. The adhesive layer can include an optically clear adhesive 122 and hollow optical nanospheres 124 dispersed in the optically clear adhesive. The hollow optical nanospheres can include an outer shell 126 and a hollow inner portion 128. Thus, in one example, when light 114 is emitted from the optical-light-emitter (through the light-emitting surface) and into the adhesive layer, the light can become scattered light 116. In this instance, “scattered light” is defined as light that is scattered to a greater degree than when introduced at the same intensity into the same optically clear adhesive without the presence of the hollow optical nanospheres. Once the light is scattered, typically in a relatively uniformly distributed matter due to the presence of the hollow optical nanospheres admixed homogenously throughout the optically clear adhesive, the light can enter the optical-light-emitter to be viewed through a viewing surface 134, which may be the outermost surface of the optical assembly. In this instance, the viewing surface is an outermost surface of the optical light-transmission component, but if there are other layers or components applied to the optical light-transmission component, the viewing surface may be associated with a different layer or structure, e.g., a lens, touch screen, protective optically clear cover, etc., applied with other adhesive layers, for example.

[0014] Turning now to FIG. 2, a touchscreen optical assembly 200 for an electronic device 205 is shown, and can include an electronic visual display 210 as the optical light-emitter, a touch sensor 230 as the optical light-transmission component, and an adhesive layer 220 between the electronic visual display and the touch sensor. The other details of this touchscreen optical assembly can be as described previously with respect to FIG. 1 and hereinafter.

[0015] In FIG. 3, an optical assembly 300 for an electronic device 305 is shown, and can include an optical light-emitter 310, an optical light-transmission component 330, and an adhesive layer 320 between the electronic visual display to the touch sensor, which in this instance is directly adhering the optical light-emitter and the optical light-transmission component together. The other details of this optical assembly with respect to these three structures or layers can

be the same as described in FIG. 1 or FIG. 2, and hereinafter. In this example, there is a second optical light-transmission component 350 that is adhered to the optical light-transmission component by a second adhesive layer 340. As a note, both the adhesive layer and the second adhesive layer can be as described

5 herein having hollow optical nanospheres dispersed in an optically clear adhesive. However, since the nanospheres can be included to provide light scattering, and as light scattering with one adhesive layer may be sufficient to ameliorate optical sparkle that may be undesirable, one of the two adhesive layers may be formulated without the hollow optical nanospheres. On the other

10 hand, both adhesives may likewise be formulated as described herein to include both the hollow optical nanospheres and the optically clear adhesive. Furthermore, it is noted that the term "second" relative to a structure, e.g., adhesive layer vs. second adhesive layer, can be viewed as arbitrary, as either layer can be considered the adhesive layer or the second adhesive layer,

15 depending on context. Using FIG. 3 as an example, the optical light-emitter may be the structure shown at 310 as previously described. However, the adhesive layer may be adhesive layer 340 and the optical light-transmission component may be the structure shown at 350, as adhesive layer 340 is between the optical light emitter 310 and the (second) optical light-transmission component 350.

20 Regardless, in this example, a viewing surface 334 is present on optical light-transmission component 350, described previously as the second optical light-transmission component. That stated, to provide one specific example, the optical light-emitter 310 can be an electronic visual display, the optical light-transmission component 330 can be a touchscreen (including a touch

25 sensor) that is touch-sensitive for user input, and the second optical light-transmission component can be a lens or an optically transparent cover. The adhesive layer 320 and/or the second adhesive layer 340 can include hollow optical nanospheres dispersed in an optically clear adhesive as described herein.

30 [0016] *Optical Light-emitters*

[0017] The optical light-emitters shown and described herein can include electrically produced visual displays that emit light, including simple static light

display boxes, but more typically, electronic visual displays which can present electronically transmitted images, text, video, etc. Examples of the electronic visual displays include light emitting components of desktop computer monitors, laptop monitors, tablet monitors, smartphone monitors, gaming system monitors, television monitors, digital signage monitors, etc. Optical light-emitters can include complete display systems, or can include just the backlight associated with the display system. Examples of optical light-emitters that can include backlight architecture or completed assemblies of a liquid crystal display (LCD) emitter; a thin film transistor (TFT) LCD; an electroluminescent emitter, e.g., electro-luminescence (EL), light-emitting diode (LED), organic light-emitting diode (OLED), etc.; a photoluminescent emitter, e.g., plasma display panel (PDP); or the like. In one specific example, the light-emitter can be an LED or an OLED.

[0018] An LED structure may include an LED backlight, diffuser and/or light guides, polarizing films, liquid crystals, color filters, etc. These LED assemblies, which can be referred to collectively as an optical light emitter, e.g., LED backlight with intervening layers prior to positioning of the adhesive layer and optical light-transmission component. An OLED structure may include, for example, a substrate, an anode layer or assembly of layers, a conductive layer (e.g., organic molecules or polymer), an emissive layer (e.g., organic molecules or polymer, and a cathode or assembly of cathodes. The adhesives described herein can be used between the OLED assembly and the optical light-transmission component(s) described herein that may be assembled with OLED optical light-emitter assembly. There may also be other layers as well including anti-reflective film(s), color refiners, endcaps, hole transport layers, electron transport layers, etc.

[0019] *Optical Light-transmission Components*

[0020] The optical light-transmission component can be a structural layer that allows the transmission of light emitted from the optical light-emitter through the adhesive layer. Specific examples of optical transmission components include output components, such as covers and/or lenses that may be optically

clear, transparent, or translucent, etc. For example, an optically transparent cover, such as glass, clear plastic film(s) or layer(s), or the like can be used as the optical light-transmission component. Likewise, a lens that provides some magnification or focusing, for example, can be used as the optical
5 light-transmission component. These components can be optically clear or transparent, but can likewise have a tint or color added, in some instances. There can also be privacy films or other layers associated with the optical transmission component. In other examples, the optical light-transmission component can likewise include a contrast coating or other coating that may be used with
10 electronic displays.

[0021] Another type of optical light-transmission component is an input/output component, such as a touchscreen including a touch sensor. With a touchscreen, a user can view information emitted therebeneath from the optical light-emitter, making the touchscreen in this instance an output component.
15 Additionally, however, a touchscreen can also be used to receive input or control to an electronic device, for example. Touchscreen touch sensors come in a wide variety of types, some which work with user finger input, others are designed for input using a stylus, and some allow for both types of input, e.g., finger, stylus, or other device.

[0022] As a note, many touchscreen technologies include multiple layers, but as shown and described herein, the optical light-transmission component is shown as a single layer, or as multiple single layers if more than one optical light-transmission component is present. Thus, no attempt has been made to show the various layers that may be present in various touchscreen technologies,
20 as it is understood that the component as a whole, as shown in the FIGS., is considered to be a touchscreen that may include multiple layers including a touch sensor.

[0023] Touchscreen technologies that can be used with the optical assemblies of the present disclosure include, without limitation, resistive
30 touchscreens; surface acoustic wave (SAW) touchscreens; capacitive touchscreens, e.g., surface capacitance, projected capacitance, mutual capacitance, self-capacitance, stylus capacitance, etc.; infrared grid; infrared

acrylic projection; optical imaging; dispersive signal technology; acoustic pulse recognition; or the like. In some examples, the touchscreen can be electrically coupled to an electronic device to provide touchscreen accuracy, learning, or logic; consider ergonomics; provide haptics such as vibratory feedback; receive security information such as fingerprint verification; etc. In one example, the touchscreen can include a capacitive touch sensor. In this example, a finger of a user, which is conductive, can be used to create a coupled capacitor with electronics components beneath an outer display surface when a touchscreen display surface is contacted. Thus, a capacitive touch screen can include an image processing controller that continuously images a touch profile of a user. The controller can thus pick up changes in the capacitive value between electronic nodes and drive lines to pinpoint the location or movement of a touch of a display surface. The coordinates detected can then be fed back to the operating system. Though touchscreens with capacitive touch sensors are described above, it is noted that other touchscreen/touch sensor technologies can likewise be used as listed above.

[0024] *Adhesive Layers*

[0025] The adhesive layer of the present disclosure can be formulated, in one example, to ameliorate an optical sparkle effect that can occur with many optically clear adhesives. "Sparkle" is an optical phenomenon that occurs due to unwanted scattering that occurs with many different combinations of optical light-emitters and optical light-transmission components, and is often described as "visual noise" in the form of sparkle dots exhibiting varied intensities and colors, depending on the combination of optical elements. Intensity, color, and location of sparkle dots can change with the angle of observation of an optical assembly. The adhesive layer(s) described herein can ameliorate some of this sparkle effect, which can be distracting to a user. The adhesive layer, for example, can include an optically clear adhesive and hollow optical nanospheres dispersed in the optically clear adhesive. In some examples, the adhesive layer can have a thickness from about 10 μm to about 100 μm , from about 15 μm to about 50 μm , or from about 20 μm to about 40 μm .

[0026] The hollow optical nanospheres can be present in the adhesive layer in an amount from about 0.1 wt% to about 3 wt% based on a total weight of the adhesive layer. In other examples, they can be present at from about 0.2 wt% to about 3 wt%, from about 0.3 wt% to about 3 wt%, from about 0.4 wt% to about 2.5 wt%, from about 0.5 wt% to about 2.5 wt%, from about 0.5 wt% to about 2 wt%, from about 0.75 wt% to about 2 wt%, from about 1 wt% to about 2.5 wt%, or from about 1 wt% to about 2 wt%.

[0027] The hollow optical nanospheres, as mentioned, include an outer shell and an inner hollow portion. The inner hollow portion can include air, which has a refractive index of about 1 at standard temperature and pressure (0 °C and 760 mmHg). The outer shell can include a material that is considered to be an optical polymer or glass so that it is transparent or nearly transparent, at the same time having a refractive index that is different enough from the air that it can provide light scattering. Example materials that can be used in this regard include, for example, polyacrylic, e.g., polymethyl methacrylate (PMMA); polycarbonate; cyclic olefin copolymer (COC); cyclic olefin polymer (COP); polystyrene; polyetherimide; glass; etc. Other materials can also be used for the hollow optical nanospheres, such as other optical materials that have a refractive index different enough from air to provide light scattering sufficient to reduce the sparkle effect. Table 1 below provides the refractive index of the some example materials that can be used as an outer shell of hollow optical nanospheres.

Table 1

Hollow Optical Nanospheres	Refractive Index of Outer Shell
Polyacrylic	1.485 to 1.5
Polycarbonate	1.58 to 1.6
Cyclic Olefin Copolymer (COC)	1.53 to 1.54
Glass	1.5 to 1.7
Polystyrene	1.58 to 1.61
Cyclic Olefin Polymer (COP)	1.525 to 1.54
Polyetherimide	1.65 to 1.69

Refractive Index Ranges are Approximate

[0028] Based on the above refractive indices of Table 1, a range of refractive indices for the outer shell material can range from about 1.48 to about 1.7, from about 1.49 to about 1.66, from about 1.49 to about 1.62, or from about 1.5 to about 1.6. Outer shell materials within this refractive index range can be considered optical materials, but are different enough from the air or other similar gases that may be present in the hollow optical nanospheres and the hollow inner portion. Typically the difference can be the difference between the refractive index of the outer shell and the refractive index of air, e.g., a difference from about 0.48 to about 0.7.

[0029] In addition to the refractive index of the outer shell, and the concentration of hollow optical nanospheres in the adhesive layer, the particle size of the hollow optical nanospheres, as well as the size of the inner dimension of the outer shell (defining the hollow inner portion or air pocket) can be considered to promote light scattering. If the particle size is too small, or if the inner dimension of the hollow optical nanospheres is too small, then the hollow optical nanospheres may be optically less effective at scattering light. Good scattering can occur when the particle size is about half the wavelength of the light, which may be the visible light spectrum. As the visible light range is from about 380 nm to about 750 nm, hollow optical nanospheres with a D50 particle size from about 100 nm to about 1.25 μm can be effective for scattering light. Other particle size ranges can be from about 100 nm to about 1 μm , from about 150 nm to about 750 nm, from about 200 nm to about 700 nm, from about 250 nm to about 600 nm, from about 150 nm to about 500 nm, or from about 200 nm to about 500 nm. Below about 50 nm, visible light scattering is less effective, for example. In further detail, the inner size or dimension of the outer shell, e.g., average inner diameter or average length across the air pocket, can be from about 60 nm to about 750 nm, from about 100 nm to about 500 nm, or from about 150 nm to about 300 nm.

[0030] "D50 particle size" is defined as the particle size at which about half of the particles are larger than the D50 particle size and about half of the other particles are smaller than the D50 particle size (this value can be based on

weight). As used herein, particle size refers to the value of the diameter of spherical particles. If a particle is not uniformly spherical, an average diameter can be used. The same is true when determining the D50 value of the inner dimension of the outer shell of the hollow optical nanospheres.

5 [0031] Regarding the optically clear adhesive, this adhesive can likewise have a refractive index from about 1.48 to about 1.7. Typically, the optically clear adhesive can be present in the adhesive layer at from about 90 wt% to about 99.7 wt%, meaning that there may be other components present in the adhesive layer than the optically clear adhesive and the hollow optical nanospheres. For
10 example, a surfactant can be added for wetting and dispersion of the hollow optical nanospheres in the optically clear adhesive. If added, the surfactant can include, for example, a polyethylene glycol ester, an anhydrosorbitol ester, a carboxylic amide, a polyoxyethylene fatty acid amide, the like, or a combination thereof. If present, the surfactant can be added at from about 0.05 wt% to about 5
15 wt%, from about 0.1 wt% to about 4 wt%, or from about 0.5 wt% to about 3 wt%, for example. In other examples, the optically clear adhesive can be present in the adhesive layer at from about 95 wt% to about 99.7 wt%, from about 97 wt% to about 99.7 wt%, from about 97 wt% to about 99 wt%, or from about 98 wt% to about 99.7 wt%, based on dry weight of the adhesive layer. Non-limiting
20 examples of optically clear adhesive materials that can be used include polyacrylic, e.g., polymethyl methacrylate (PMMA); cyclic olefin copolymer; polycarbonate; epoxies; or a combination thereof. PMMA, for example, can have a refractive index of about 1.49. Cyclic olefin copolymer can have a refractive index of about 1.53 to about 1.54. Polycarbonates can have a refractive index of
25 about 1.58 to about 1.6. Some types of epoxies may have a refractive index from about 1.5 to about 1.6.

[0032] *Electronic Devices with Optical Assemblies*

[0033] The present disclosure also extends to electronic devices that
30 include the optical assemblies described above. Thus, the details related to the optical assemblies described above are directly relevant to the electronic devices

shown and described herein. More specifically, FIGS. 1-3 show example electronic devices according to the present disclosure.

[0034] Electronic devices can include any of a number of components and features that can be electronically and optically associated with optical assemblies described above. Example electronic devices that can utilize the optical assemblies of the present disclosure include desktop computer monitors, laptops, tablets, smartphones, gaming system monitors, television monitors, digital signage, and the like. Furthermore, there are also utilitarian devices that provide functions that are independent of optical display, but can include an optical display for user display or interface enhancement, e.g., touch screen interface for appliances, security systems, printers, cameras, keypads, musical instrument, automobiles, aircraft, watercraft, etc.

[0035] *Method of Making Optical Assemblies for Electronic Devices*

[0036] The present disclosure also extends to methods of making optical assemblies for electronic devices. Thus, the details related to the optical assemblies described above are directly relevant to the present methods. Thus, in FIG. 4, a method 400 of making an optical assembly of an electronic device can include admixing 410 hollow optical nanospheres into an optically clear adhesive to form an adhesive layer composition. The hollow optical nanospheres can include an outer shell and a hollow inner portion. The method can also include adhering 420 a light-emitting surface of an optical light-emitter to a surface of a light-transmission component to form an adhesive layer therebetween. The adhesive layer can have a thickness from about 10 μm to about 100 μm , and the hollow optical nanospheres can be present in the adhesive layer in an amount from about 0.1 wt% to about 3 wt% based on a total weight of the adhesive layer. In one example, the optically clear adhesive can have a refractive index from about 1.48 to about 1.7, the outer shell of the hollow optical nanospheres can have a refractive index from about 1.48 to about 1.7, and the hollow inner portion can have a refractive index from about 0.48 to about 0.7 different than the refractive index of the optically clear adhesive, the outer shell, or both.

[0037] *Definitions*

[0038] It is noted that, as used in this specification and the appended claims, the singular forms "a," "an," and "the" include plural referents unless the content clearly dictates otherwise.

5 [0039] The term "about" as used herein, when referring to a numerical value or range, allows for a degree of variability in the value or range, for example, within 5% or other reasonable added range breadth of a stated value or of a stated limit of a range. The term "about" when modifying a numerical range is also understood to include the exact numerical value indicated, e.g., the range of
10 about 1 wt% to about 5 wt% includes 1 wt% to 5 wt% as an explicitly supported sub-range.

[0040] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member
15 of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a *de facto* equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary.

[0041] Concentrations, dimensions, amounts, and other numerical data
20 may be presented herein in a range format. It is to be understood that such range format is used merely for convenience and brevity and should be interpreted flexibly to include the numerical values explicitly recited as the limits of the range, and also to include all the individual numerical values or sub-ranges encompassed within that range as if each numerical value and sub-range is
25 explicitly recited. For example, a layer thickness from about 10 μm to about 100 μm should be interpreted to include the explicitly recited limits of 10 μm to 100 μm , and to include thicknesses such as about 10 μm and about 100 μm , as well as subranges such as about 20 μm to about 40 μm , about 50 μm to about 90 μm , about 10 μm to about 70 μm , etc.

30 [0042] The following illustrates an example of the present disclosure. However, it is to be understood that the following is illustrative of the application of the principles of the present disclosure. Numerous modifications and alternative

compositions, methods, and systems may be devised without departing from the spirit and scope of the present disclosure. The appended claims are intended to cover such modifications and arrangements.

5

EXAMPLE

[0043] An example touchscreen optical assembly for an electronic device such as that shown in FIG. 3 is prepared as follows:

- 10 1) An adhesive layer composition is prepared by thoroughly admixing 98.5 wt% of polymethyl methacrylate (PMMA) optically clear adhesive (refractive index about 1.49) with 0.3 wt% glass nanospheres (refractive index about 1.65) in the form of hollow optical nanospheres having a D50 particle size of about 250 nm and an inner dimension (air pocket diameter) of about 90 nm. The admixture also includes 1.2 wt%
15 surfactant. If more glass nanospheres are included, e.g., 1 wt%, then less surfactant may be used, less optically clear adhesive used, and/or both. The admixture is blended using a mechanical mixer for 30 minutes at 30 °C until homogenous.
- 20 2) A first portion of the adhesive layer composition is applied to an optical light-emitter, namely a TFT LCD display, at a thickness of about 30 μm to form an adhesive layer that is optically clear.
- 3) An optical light-transmission component, namely a touchscreen including a capacitive touch sensor that allows for light output and user input, e.g., finger, is applied to the adhesive layer applied in 2) above.
- 25 4) A second portion of the adhesive layer composition is applied to the touchscreen surface at a thickness of about 30 μm to form a second adhesive layer.
- 5) A second optical light-transmission component, namely a protective optically clear cover, is then applied to the second adhesive layer.

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[0044] What has been described and illustrated herein is an example of the disclosure along with some of its variations. The terms, descriptions, and figures

used herein are set forth by way of illustration only and are not meant as limitations. Many variations are possible within the disclosure, which is intended to be defined by the following claims -- and their equivalents -- in which all terms are meant in their broadest reasonable sense unless otherwise indicated.

CLAIMS

What is claimed is:

- 5 1. An optical assembly for an electronic device comprising:
an optical light-emitter;
an optical light-transmission component; and
an adhesive layer between the optical light-emitter and the optical
light-transmission component, the adhesive layer including an optically clear
10 adhesive and hollow optical nanospheres dispersed in the optically clear
adhesive, wherein the hollow optical nanospheres include an outer shell and a
hollow inner portion.
- 15 2. The optical assembly of claim 1, wherein the optical light-emitter
includes an electronic visual display.
3. The optical assembly of claim 2, wherein the optical light-transmission
component includes a touch sensor.
- 20 4. The optical assembly of claim 2, wherein the optical light-transmission
component includes a lens or an optically transparent cover.
5. The optical assembly of claim 1, wherein the hollow optical nanospheres
are present in the adhesive layer in an amount from about 0.1 wt% to about 3 wt%
25 based on a total weight of the adhesive layer.
6. The optical assembly of claim 1, wherein the hollow optical nanospheres
include polyacrylic nanospheres, polycarbonate nanospheres, cyclic olefin
copolymer nanospheres, or glass nanospheres.
- 30 7. The optical assembly of claim 1, wherein the hollow optical nanospheres
have a D50 particle size from about 100 nm to about 1.25 μm .

8. The optical assembly of claim 1, wherein the optically clear adhesive has a refractive index from about 1.48 to about 1.7, the outer shell of the hollow optical nanospheres has a refractive index from about 1.48 to about 1.7, and the
5 hollow inner portion has a refractive index from about 0.48 to about 0.7 different than the refractive index of the optically clear adhesive, the outer shell, or both.

9. The optical assembly of claim 1, wherein the optically clear adhesive includes polyacrylic, cyclic olefin copolymer, polycarbonate, epoxy, or a
10 combination thereof.

10. A touchscreen optical assembly for an electronic device comprising:
an electronic visual display;
a touch sensor; and
15 an adhesive layer between the electronic visual display and the touch sensor, the adhesive layer including an optically clear adhesive and hollow optical nanospheres dispersed in the optically clear adhesive, wherein the hollow optical nanospheres include an outer shell and a hollow inner portion.

20 11. The touchscreen optical assembly of claim 10, wherein the hollow optical nanospheres are present in the adhesive layer in an amount from about 0.1 wt% to about 3 wt% based on a total weight of the adhesive layer.

25 12. The touchscreen optical assembly of claim 10, wherein the optically clear adhesive has a refractive index from about 1.48 to about 1.7, the outer shell of the hollow optical nanospheres has a refractive index from about 1.48 to about 1.7, and the hollow inner portion has a refractive index from about 0.48 to about 0.7 different than the refractive index of the optically clear adhesive, the outer shell, or both.

13. The touchscreen optical assembly of claim 10, further comprising a lens and a second adhesive layer adhering the touch sensor to the lens on a touch sensor surface opposite the electronic visual display and adhesive layer.

5 14. A method of making an optical assembly of an electronic device, comprising:

 admixing hollow optical nanospheres into an optically clear adhesive to form an adhesive layer composition, wherein the hollow optical nanospheres include an outer shell and a hollow inner portion; and

10 adhering a light-emitting surface of an optical light-emitter to an inner surface of a light-transmission component to form an adhesive layer therebetween, wherein the adhesive layer has a thickness from about 10 μm to about 100 μm , and wherein the hollow optical nanospheres are present in the adhesive layer in an amount from about 0.1 wt% to about 3 wt% based on a total
15 weight of the adhesive layer.

 15. The method of claim 14, wherein the optically clear adhesive has a refractive index from about 1.48 to about 1.7, the outer shell of the hollow optical nanospheres has a refractive index from about 1.48 to about 1.7, and the hollow
20 inner portion has a refractive index from about 0.48 to about 0.7 different than the refractive index of the optically clear adhesive, the outer shell, or both.

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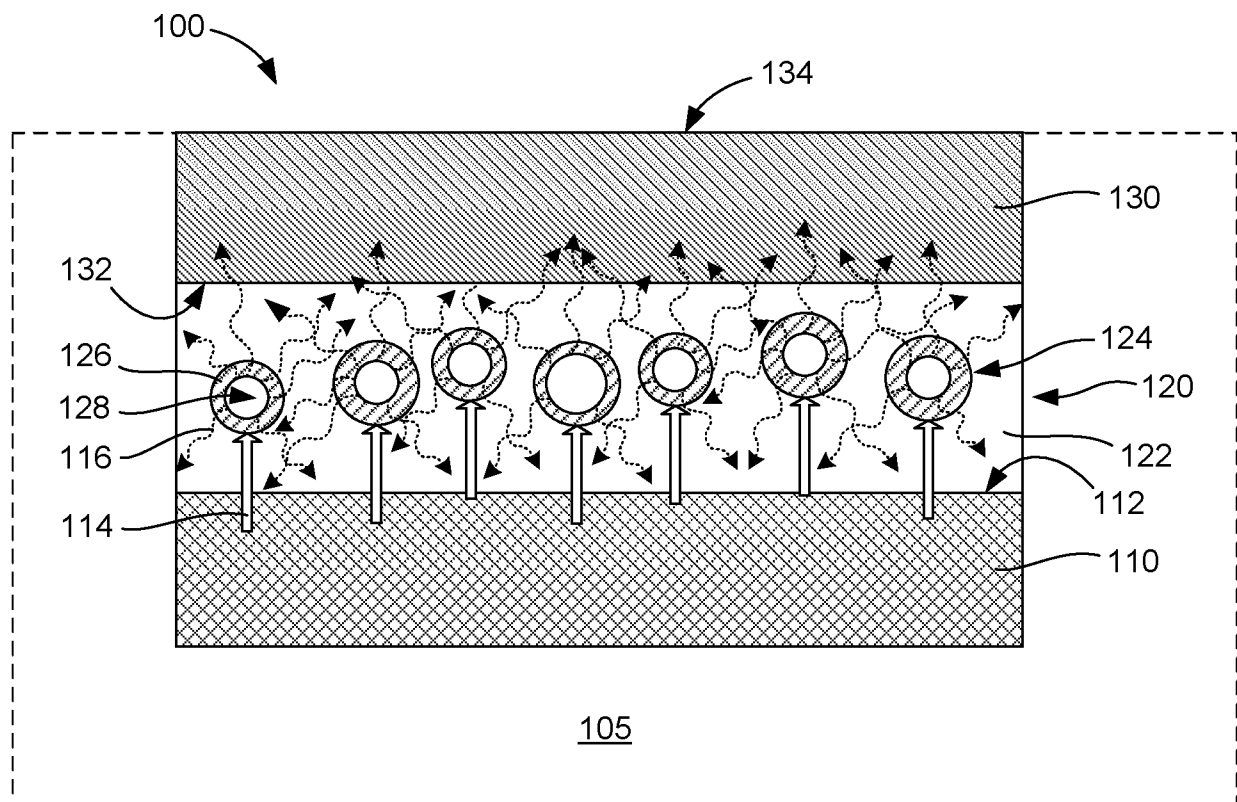


FIG. 1

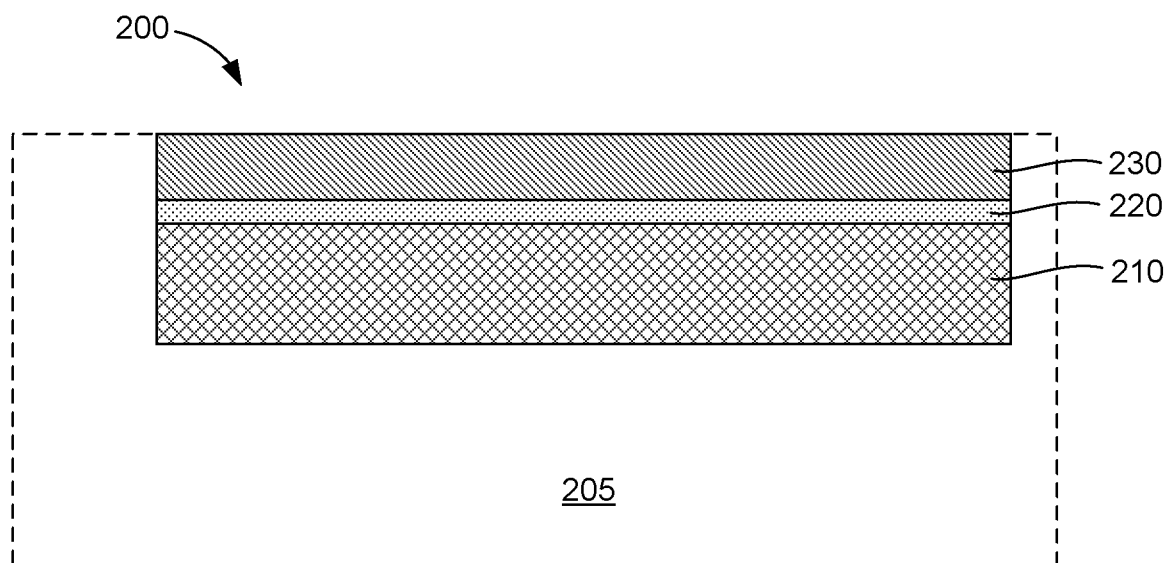


FIG. 2

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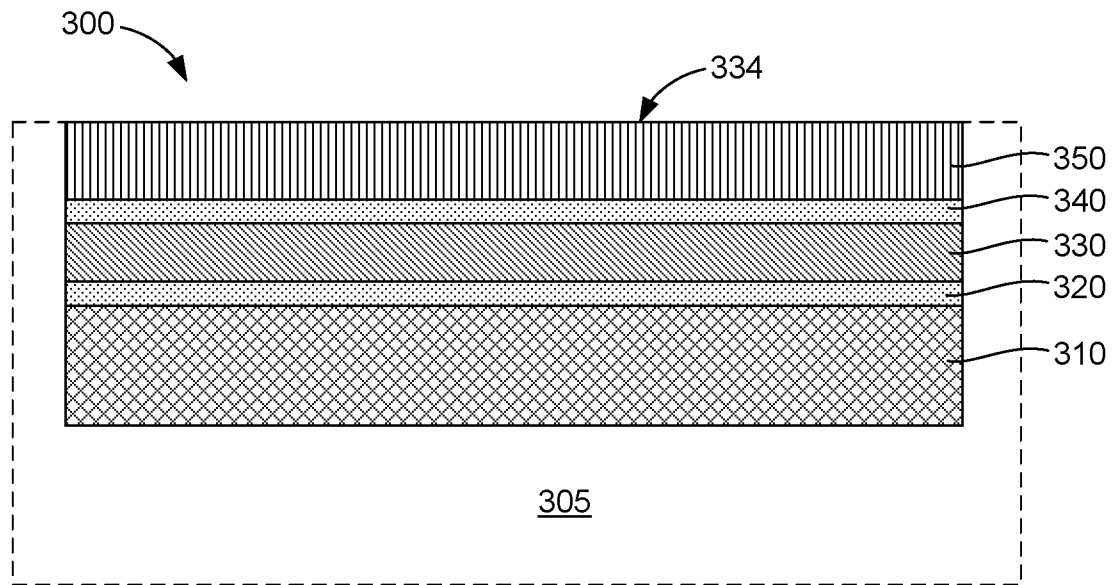


FIG. 3

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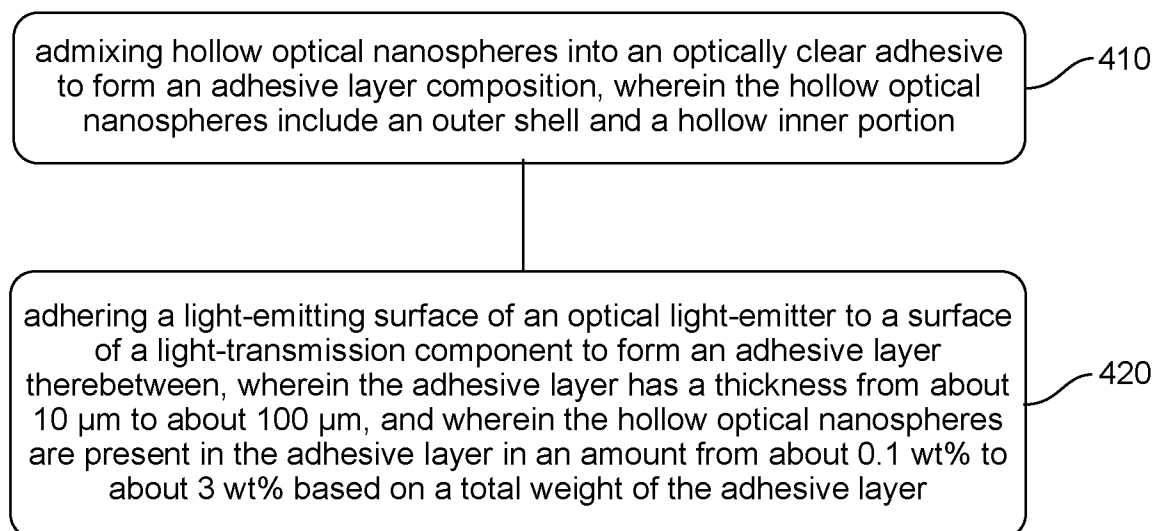


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2018/049840

A. CLASSIFICATION OF SUBJECT MATTER		
<i>G02B 5/02 (2006.01)</i> <i>G02B 1/10 (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)		
B82B, B82Y, G02B 3/00 - 6/54, 27/00, G02F 1/00 - 1/39, G06F 1/00 - 3/18, H01L, H04N		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE, Information Retrieval System of FIPS		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2010044269 A (TOPPAN PRINTING CO LTD) 25.02.2010, [0018], [0020], [0031], [0034], [0040], [0042], [0047], fig. 1	1-9, 11-12, 14-15
Y	KR 2015057474 A (DONGWOO FINE CHEM CO LTD) 28.05.2015 claim 1	1-15
Y	WO 2017/078448 A1 (MODA INNOCHIPS CO LTD) 11.05.2017, [0085], fig. 14	3, 10-13
Y	WO 2014/038160 A1 (SONY CORPORATION) 13.03.2014, [0037]	13
Y	JP 2002351343 A (SONY CORP) 06.12.2002, abstract	14-15
☐ 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 document but published on or after the international filing date	
“L”	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
“O”	document referring to an oral disclosure, use, exhibition or other means	
“P”	document published prior to the international filing date but later than the priority date claimed	
“T”	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	
“X”	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	
“Y”	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	
“&”	document member of the same patent family	
Date of the actual completion of the international search 27 May 2019 (27.05.2019)		Date of mailing of the international search report 06 June 2019 (06.06.2019)
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37		Authorized officer P. Aleksandrov Telephone No. (499) 240-25-91