(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
30 December 2009 (30.12.2009)

PCT

(10) International Publication Number
WO 2009/158354 A1

(51) International Patent Classification:
G02B 26/00 (2006.01) *G09G 3/34* (2006.01)
B81B 3/00 (2006.01) *G01J 3/26* (2006.01)

(21) International Application Number:
PCT/US2009/048323

(22) International Filing Date:
23 June 2009 (23.06.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
12/146,402 25 June 2008 (25.06.2008) US

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(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, 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, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, 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, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (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, SE, SI, SK, 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))*

WO 2009/158354 A1

(54) **Title**: BACKLIGHT DISPLAYS

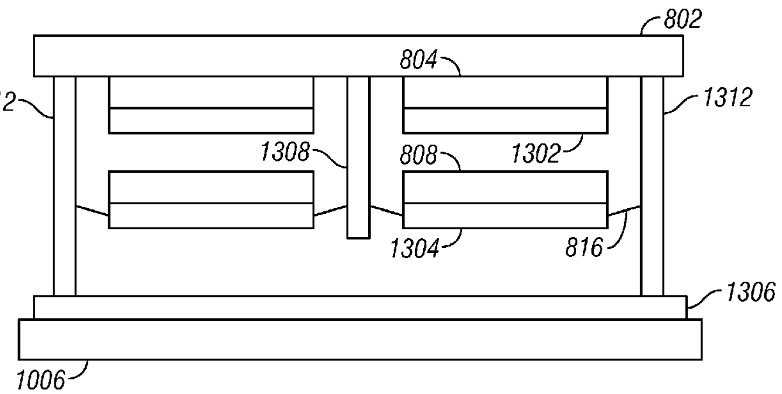

FIG. 13

(57) **Abstract**: A transmissive backlit display is disclosed. In one aspect, the backlit display comprises a backlight and an array of transmissive interferometric modulators. Each interferometric modulator is formed on a substrate and comprises a fixed and moving dielectric mirror stack. The interferometric modulators cause light within the desired wavelength range to be transmitted while reflecting at least a portion of the remaining light. A back plate is coupled to the substrate and comprises at least one bus line configured to connect one or more electrodes of the interferometric modulators, the bus line comprising solid metal.

BACKLIGHT DISPLAYS

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The field of the invention relates to microelectromechanical systems (MEMS).

Description of the Related Technology

[0002] Microelectromechanical systems (MEMS) include micro mechanical elements, actuators, and electronics. Micromechanical elements may be created using deposition, etching, and/or other micromachining processes that etch away parts of substrates and/or deposited material layers or that add layers to form electrical and electromechanical devices. One type of MEMS device is called an interferometric modulator. As used herein, the term interferometric modulator or interferometric light modulator refers to a device that interferometrically modulates light using the principles of optical interference. The interferometric modulator could be a reflective device that selectively absorbs and/or reflects light, or a transmissive device that selectively absorbs and/or transmits light. In certain embodiments, an interferometric modulator may comprise a pair of conductive plates, one or both of which may be transparent and/or reflective in whole or part and capable of relative motion upon application of an appropriate electrical signal. In a particular embodiment, one plate may comprise a stationary layer deposited on a substrate and the other plate may comprise a metallic membrane separated from the stationary layer by an air gap. As described herein in more detail, the position of one plate in relation to another can change the optical interference of light incident on the interferometric modulator. Such devices have a wide range of applications, and it would be beneficial in the art to utilize and/or modify the characteristics of these types of devices so that their features can be exploited in improving existing products and creating new products that have not yet been developed.

Summary of Certain Inventive Aspects

[0003] The system, method, and devices of the invention each have several aspects, no single one of which is solely responsible for its desirable attributes. Without limiting the scope of this invention, its more prominent features will now be discussed briefly. After considering this discussion, and particularly after reading the section entitled "Detailed Description of Certain Embodiments" one will understand how the features of this invention provide advantages over other display devices.

[0004] In one aspect, a transmissive display device is disclosed. The display device comprises an array of interferometric modulators deposited on the back side of a substrate, a back plate sealed to the back side of the substrate, and a reflective black mask located between the front side of the back plate and the substrate and patterned to cover at least the non-active areas of the array of interferometric modulators.

[0005] In another aspect, a transmissive display device is disclosed. The display device comprises an array of interferometric modulators deposited on the back side of a substrate, and a collimated light source located on the back side of the substrate and configured to illuminate through the array.

[0006] In another aspect, a transmissive display device is disclosed. The display device comprises an array of interferometric modulators positioned on the back side of a substrate, and an angle converter, positioned on the front side of the substrate, for changing angular distribution of light based on the direction of light.

[0007] In another aspect, a transmissive display device is disclosed. The device comprises means for transmissively and interferometrically modulating light, the modulating means being deposited on a first side of a substrate distal from a viewer, means for enclosing the modulating means, the enclosing means being sealed to the first side of the substrate, and means for covering at least the non-active areas of the modulating means and reflecting light coming from the back of the display, the covering means being located between the enclosing means and the substrate.

[0008] In another aspect, a transmissive display device is disclosed. The device comprises means for transmissively and interferometrically modulating light, the modulating means being deposited on the back side of a substrate, and means for illuminating the modulating means with substantially collimated light.

[0009] In another aspect, a transmissive display device is disclosed. The device comprises means for transmissively and interferometrically modulating light, the modulating means being deposited on the back side of a substrate, and means for changing angular distribution of light based on the direction of light, the changing means being positioned on the front side of the substrate.

[0010] In another aspect, a transmissive display device is disclosed. The device comprises a cavity defined by a first layer deposited on a substantially transparent substrate and a second layer connected to the substrate, the first and second layers being at least partially transparent; a ring-shaped first electrode operatively connected to the first layer and a ring-shaped second electrode operatively connected to the second layer, wherein light incident to the display device is interferometrically modulated by the first and second layer.

[0011] In another aspect, a transmissive display device is disclosed. The device comprises means for interferometrically modulating light and means for actuating the interferometrically modulating means, the actuating means being ring-shaped. .

[0012] In another aspect, a method of making a transmissive display device is disclosed. The method comprises forming a cavity defined by a first layer deposited on a substantially transparent substrate and a second layer connected to the substrate, the first and second layers being at least partially transparent; and forming a ring-shaped first electrode operatively connected to the first layer and a ring-shaped second electrode operatively connected to the second layer.

[0013] In another aspect, a transmissive display device is disclosed. The device comprises an array of interferometric modulators formed on a substantially transparent substrate. Each interferometric modulator comprises a cavity defined by a first layer deposited on the substrate and a second layer connected to the substrate, the first and second layers being at least partially transparent, wherein light incident to the display device is interferometrically modulated by the first and second layer; a substantially transparent first electrode operatively connected to the first layer, and a substantially transparent second electrode operatively connected to the second layer. The device further comprises a back plate coupled to the substrate and comprising at least one bus line configured to connect one or more electrodes of the interferometric modulators, the at least one bus line comprising substantially solid metal.

[0014] In another aspect, a transmissive display device is disclosed. The device comprises means for transmissively and interferometrically modulating light, the modulating means formed on a substantially transparent substrate; means for actuating the modulating means, the actuating means being substantially transparent; and means for enclosing the modulating means, the enclosing means being coupled to the substrate and further comprises means for electrically connecting at least one of the actuating means.

[0015] In another aspect, a method of making a transmissive display device is disclosed. The method comprises forming an array of interferometric modulators on a substantially transparent substrate. Each interferometric modulator comprises a cavity defined by a first layer deposited on the substrate and a second layer connected to the substrate, the first and second layers being at least partially transparent, wherein light incident to the display device is interferometrically modulated by the first and second layer; a substantially transparent first electrode operatively connected to the first layer; and a substantially transparent second electrode operatively connected to the second layer. The method further comprises forming a back plate coupled to the substrate and comprising at least one bus line configured to connect one or more electrodes of the interferometric modulators, the at least one bus line comprising substantially solid metal.

Brief Description of the Drawings

[0016] FIG. 1 is an isometric view depicting a portion of one embodiment of an interferometric modulator display in which a movable reflective layer of a first reflective interferometric modulator is in a relaxed position and a movable reflective layer of a second reflective interferometric modulator is in an actuated position.

[0017] FIG. 2 is a system block diagram illustrating one embodiment of an electronic device incorporating a 3x3 interferometric modulator display.

[0018] FIG. 3 is a diagram of movable mirror position versus applied voltage for one exemplary embodiment of an interferometric modulator of FIG. 1.

[0019] FIG. 4 is an illustration of a set of row and column voltages that may be used to drive an interferometric modulator display.

[0020] FIG. 5A illustrates one exemplary frame of display data in the 3x3 interferometric modulator display of FIG. 2.

[0021] FIG. 5B illustrates one exemplary timing diagram for row and column signals that may be used to write the frame of FIG. 5A.

[0022] FIGS. 6A and 6B are system block diagrams illustrating an embodiment of a visual display device comprising a plurality of interferometric modulators.

[0023] FIG. 7A is a cross section of the device of FIG. 1.

[0024] FIG. 7B is a cross section of an alternative embodiment of an interferometric modulator.

[0025] FIG. 7C is a cross section of another alternative embodiment of an interferometric modulator.

[0026] FIG. 7D is a cross section of yet another alternative embodiment of an interferometric modulator.

[0027] FIG. 7E is a cross section of an additional alternative embodiment of an interferometric modulator.

[0028] FIG. 8 is a cross section of one embodiment of a transmissive interferometric display.

[0029] FIG. 9 is a top view of the display embodiment in FIG. 8.

[0030] FIG. 10 illustrates another embodiment of a transmissive interferometric modulator display comprising black masks on the front and/or back of the display covering non-active areas.

[0031] FIG. 11 illustrates another embodiment of a transmissive interferometric modulator display comprising an angle converter on the front of the display.

[0032] FIG. 12 illustrates another embodiment of a transmissive interferometric modulator display comprising a lenslet array converging backlight into the pixels.

[0033] FIG. 13 illustrates another embodiment of a transmissive interferometric modulator display.

Detailed Description of Certain Embodiments

[0034] The following detailed description is directed to certain specific embodiments of the invention. However, the invention can be embodied in a multitude of different ways. In this description, reference is made to the drawings wherein like parts are designated with like numerals throughout. As will be apparent from the following description, the embodiments may be implemented in any device that is configured to display an image, whether in motion (e.g., video) or stationary (e.g., still image), and whether textual or pictorial. More particularly, it is contemplated that the embodiments may be implemented in or associated with a variety of electronic devices such as, but not limited to, mobile telephones, wireless devices, personal data assistants (PDAs), hand-held or portable computers, GPS receivers/navigators, cameras, MP3 players, camcorders, game consoles, wrist watches, clocks, calculators, television monitors, flat panel displays, computer monitors, auto displays (e.g., odometer display, etc.), cockpit controls and/or displays, display of camera views (e.g., display of a rear view camera in a vehicle), electronic photographs, electronic billboards or signs, projectors, architectural structures, packaging, and aesthetic structures (e.g., display of images on a piece of jewelry). MEMS devices of similar structure to those described herein can also be used in non-display applications such as in electronic switching devices.

[0035] Certain embodiments as will be described below provide a transmissive backlit display. In one embodiment, the backlit display comprises a backlight and an array of transmissive interferometric modulators, wherein each interferometric modulator comprises a fixed and moving dielectric mirror stack. The interferometric modulators cause light within the desired wavelength range to be transmitted while reflecting at least a portion of the remaining light.

[0036] Figures 1-7E describe a display comprising an interferometric modulator. In the exemplary embodiments, reflective interferometric modulators are used for illustration. However, it should be noted that the principle described in Figures 1-7E may be equally applied to transmissive interferometric modulators and a display comprising transmissive interferometric modulators as will be described below with regard to Figures 8-13.

[0037] One interferometric modulator display embodiment comprising an interferometric MEMS display element is illustrated in Figure 1. In these devices, the pixels are in either a bright or dark state. In the bright ("on" or "open") state, the display element reflects a large portion of incident visible light to a user. When in the dark ("off" or "closed") state, the display element reflects little incident visible light to the user. Depending on the embodiment, the light reflectance properties of the "on" and "off" states may be reversed. MEMS pixels can be configured to reflect predominantly at selected colors, allowing for a color display in addition to black and white.

[0038] Figure 1 is an isometric view depicting two adjacent pixels in a series of pixels of a visual display, wherein each pixel comprises a MEMS interferometric modulator. In some embodiments, an interferometric modulator display comprises a row/column array of these interferometric modulators. Each interferometric modulator includes a pair of reflective layers positioned at a variable and controllable distance from each other to form a resonant optical gap with at least one variable dimension. In one embodiment, one of the reflective layers may be moved between two positions. In the first position, referred to herein as the relaxed position, the movable reflective layer is positioned at a relatively large distance from a fixed partially reflective layer. In the second position, referred to herein as the actuated position, the movable reflective layer is positioned more closely adjacent to the partially reflective layer. Incident light that reflects from the two layers interferes constructively or destructively depending on the position of the movable reflective layer, producing either an overall reflective or non-reflective state for each pixel.

[0039] The depicted portion of the pixel array in Figure 1 includes two adjacent interferometric modulators **12a** and **12b**. In the interferometric modulator **12a** on the left, a movable reflective layer **14a** is illustrated in a relaxed position at a predetermined distance from an optical stack **16a**, which includes a partially reflective layer. In the interferometric modulator **12b** on the right, the movable reflective layer **14b** is illustrated in an actuated position adjacent to the optical stack **16b**.

[0040] The optical stacks **16a** and **16b** (collectively referred to as optical stack **16**), as referenced herein, typically comprise several fused layers, which can include an electrode layer, such as indium tin oxide (ITO), a partially reflective layer, such as chromium, and a transparent dielectric. The optical stack **16** is thus electrically conductive, partially transparent, and partially reflective, and may be fabricated, for example, by depositing one or more of the above layers onto a transparent substrate **20**. The partially reflective layer can be formed from a variety of materials that are partially reflective such as various metals, semiconductors, and dielectrics. The partially reflective layer can be formed of one or more layers of materials, and each of the layers can be formed of a single material or a combination of materials.

[0041] In some embodiments, the layers of the optical stack **16** are patterned into parallel strips, and may form row electrodes in a display device as described further below. The movable reflective layers **14a**, **14b** may be formed as a series of parallel strips of a deposited metal layer or layers (orthogonal to the row electrodes of **16a**, **16b**) deposited on top of posts **18** and an intervening sacrificial material deposited between the posts **18**. When the sacrificial material is etched away, the movable reflective layers **14a**, **14b** are separated from the optical stacks **16a**, **16b** by a defined gap **19**. A highly conductive and reflective material such as aluminum may be used for the reflective layers **14**, and these strips may form column electrodes in a display device.

[0042] With no applied voltage, the gap **19** remains between the movable reflective layer **14a** and optical stack **16a**, with the movable reflective layer **14a** in a mechanically relaxed state, as illustrated by the pixel **12a** in Figure 1. However, when a potential difference is applied to a selected row and column, the capacitor formed at the intersection of the row and column electrodes at the corresponding pixel becomes charged, and electrostatic forces pull the electrodes together. If the voltage is high enough, the movable reflective layer **14** is deformed and is forced against the optical stack **16**. A dielectric layer (not illustrated in this Figure) within the optical stack **16** may prevent shorting and control the separation distance between layers **14** and **16**, as illustrated by pixel **12b** on the right in Figure 1. The behavior is the same regardless of the polarity of the applied potential difference. In this way, row/column actuation that can control the reflective vs. non-reflective pixel states is analogous in many ways to that used in conventional LCD and other display technologies.

[0043] Figures 2 through 5B illustrate one exemplary process and system for using an array of interferometric modulators in a display application. As mentioned above, though reflective interferometric modulators are used for illustration, the principle described in Figures 2-5B may be equally applied to transmissive interferometric modulators as will be described below with regard to Figures 8-13.

[0044] Figure 2 is a system block diagram illustrating one embodiment of an electronic device that may incorporate aspects of the invention. In the exemplary embodiment, the electronic device includes a processor **21** which may be any general purpose single- or multi-chip microprocessor such as an ARM, Pentium®, Pentium II®, Pentium III®, Pentium IV®, Pentium® Pro, an 8051, a MIPS®, a Power PC®, an ALPHA®, or any special purpose microprocessor such as a digital signal processor, microcontroller, or a programmable gate array. As is conventional in the art, the processor **21** may be configured to execute one or more software modules. In addition to executing an operating system, the processor may be configured to execute one or more software applications, including a web browser, a telephone application, an email program, or any other software application.

[0045] In one embodiment, the processor **21** is also configured to communicate with an array driver **22**. In one embodiment, the array driver **22** includes a row driver circuit **24** and a column driver circuit **26** that provide signals to a display array or panel **30**. The cross section of the array illustrated in Figure 1 is shown by the lines 1-1 in Figure 2. For MEMS interferometric modulators, the row/column actuation protocol may take advantage of a hysteresis property of these devices illustrated in Figure 3. It may require, for example, a 10 volt potential difference to cause a movable layer to deform from the relaxed state to the actuated state. However, when the voltage is reduced from that value, the movable layer maintains its state as the voltage drops back below 10 volts. In the exemplary embodiment of Figure 3, the movable layer does not relax completely until the voltage drops below 2 volts. Thus, there exists a window of applied voltage, about 3 to 7 V in the example illustrated in Figure 3, within which the device is stable in either the relaxed or actuated state. This is referred to herein as the "hysteresis window" or "stability window." For a display array having the hysteresis characteristics of Figure 3, the row/column actuation protocol can be designed such that during row strobing, pixels in the strobed row that are to be actuated are exposed to a voltage difference of about 10 volts, and pixels that are to be relaxed are exposed to a voltage difference of close to zero volts. After the strobe, the pixels are exposed to a steady state voltage difference of about 5 volts such that they remain in whatever state the row strobe put them in. After being written, each pixel sees a potential difference within the "stability window" of 3-7 volts in this example. This feature makes the pixel design illustrated in Figure 1 stable under the same applied voltage conditions in either an actuated or relaxed pre-existing state. Since each pixel of the interferometric modulator, whether in the actuated or relaxed state, is essentially a capacitor formed by the fixed and moving reflective layers, this stable state can be held at a voltage within the hysteresis window with almost no power dissipation. Essentially no current flows into the pixel if the applied potential is fixed.

[0046] In typical applications, a display frame may be created by asserting the set of column electrodes in accordance with the desired set of actuated pixels in the first row. A row pulse is then applied to the row 1 electrode, actuating the pixels corresponding to the asserted column lines. The asserted set of column electrodes is then changed to correspond to the desired set of actuated pixels in the second row. A pulse is then applied to the row 2 electrode, actuating the appropriate pixels in row 2 in accordance with the asserted column electrodes. The row 1 pixels are unaffected by the row 2 pulse, and remain in the state they were set to during the row 1 pulse. This may be repeated for the entire series of rows in a sequential fashion to produce the frame. Generally, the frames are refreshed and/or updated with new display data by continually repeating this process at some desired number of frames per second. A wide variety of protocols for driving row and column electrodes of pixel arrays to produce display frames are also well known and may be used in conjunction with the present invention.

[0047] Figures 4, 5A, and 5B illustrate one possible actuation protocol for creating a display frame on the 3x3 array of Figure 2. Figure 4 illustrates a possible set of column and row voltage levels that may be used for pixels exhibiting the hysteresis curves of Figure 3. In the Figure 4 embodiment, actuating a pixel involves setting the appropriate column to $-V_{bias}$, and the appropriate row to $+\Delta V$, which may correspond to -5 volts and +5 volts, respectively. Relaxing the pixel is accomplished by setting the appropriate column to

$+V_{bias}$, and the appropriate row to the same $+\Delta V$, producing a zero volt potential difference across the pixel. In those rows where the row voltage is held at zero volts, the pixels are stable in whatever state they were originally in, regardless of whether the column is at $+V_{bias}$, or $-V_{bias}$. As is also illustrated in Figure 4, it will be appreciated that voltages of opposite polarity than those described above can be used, e.g., actuating a pixel can involve setting the appropriate column to $+V_{bias}$, and the appropriate row to $-\Delta V$. In this embodiment, releasing the pixel is accomplished by setting the appropriate column to $-V_{bias}$, and the appropriate row to the same $-\Delta V$, producing a zero volt potential difference across the pixel.

[0048] Figure 5B is a timing diagram showing a series of row and column signals applied to the 3x3 array of Figure 2 which will result in the display arrangement illustrated in Figure 5A, where actuated pixels are non-reflective. Prior to writing the frame illustrated in Figure 5A, the pixels can be in any state, and in this example, all the rows are at 0 volts, and all the columns are at +5 volts. With these applied voltages, all pixels are stable in their existing actuated or relaxed states.

[0049] In the Figure 5A frame, pixels (1,1), (1,2), (2,2), (3,2) and (3,3) are actuated. To accomplish this, during a "line time" for row 1, columns 1 and 2 are set to -5 volts, and column 3 is set to +5 volts. This does not change the state of any pixels, because all the pixels remain in the 3-7 volt stability window. Row 1 is then strobed with a pulse that goes from 0, up to 5 volts, and back to zero. This actuates the (1,1) and (1,2) pixels and relaxes the (1,3) pixel. No other pixels in the array are affected. To set row 2 as desired, column 2 is set to -5 volts, and columns 1 and 3 are set to +5 volts. The same strobe applied to row 2 will then actuate pixel (2,2) and relax pixels (2,1) and (2,3). Again, no other pixels of the array are affected. Row 3 is similarly set by setting columns 2 and 3 to -5 volts, and column 1 to +5 volts. The row 3 strobe sets the row 3 pixels as shown in Figure 5A. After writing the frame, the row potentials are zero, and the column potentials can remain at either +5 or -5 volts, and the display is then stable in the arrangement of Figure 5A. It will be appreciated that the same procedure can be employed for arrays of dozens or hundreds of rows and columns. It will also be appreciated that the timing, sequence, and levels of voltages used to perform row and column actuation can be varied widely within the general principles outlined above, and the above example is exemplary only, and any actuation voltage method can be used with the systems and methods described herein.

[0050] Figures 6A and 6B are system block diagrams illustrating an embodiment of a display device **40**. The display device **40** can be, for example, a cellular or mobile telephone. However, the same components of display device **40** or slight variations thereof are also illustrative of various types of display devices such as televisions and portable media players.

[0051] The display device **40** includes a housing **41**, a display **30**, an antenna **43**, a speaker **45**, an input device **48**, and a microphone **46**. The housing **41** is generally formed from any of a variety of manufacturing processes as are well known to those of skill in the art, including injection molding and vacuum forming. In addition, the housing **41** may be made from any of a variety of materials, including, but not limited to, plastic, metal, glass, rubber, and ceramic, or a combination thereof. In one embodiment, the housing **41** includes removable portions (not shown) that may be interchanged with other removable portions of different color, or containing different logos, pictures, or symbols.

[0052] The display **30** of exemplary display device **40** may be any of a variety of displays, including a bi-stable display, as described herein. In other embodiments, the display **30** includes a flat-panel display, such as plasma, EL, OLED, STN LCD, or TFT LCD as described above, or a non-flat-panel display, such as a CRT or other tube device, as is well known to those of skill in the art. However, for purposes of describing the present embodiment, the display **30** includes an interferometric modulator display, as described herein.

[0053] The components of one embodiment of exemplary display device **40** are schematically illustrated in Figure 6B. The illustrated exemplary display device **40** includes a housing **41** and can include additional components at least partially enclosed therein. For example, in one embodiment, the exemplary display device **40** includes a network interface **27** that includes an antenna **43**, which is coupled to a transceiver **47**. The transceiver **47** is connected to a processor **21**, which is connected to conditioning hardware **52**. The conditioning hardware **52** may be configured to condition a signal (e.g., filter a signal). The conditioning hardware **52** is connected to a speaker **45** and a microphone **46**. The processor

21 is also connected to an input device **48** and a driver controller **29**. The driver controller **29** is coupled to a frame buffer **28** and to an array driver **22**, which in turn is coupled to a display array **30**. A power supply **50** provides power to all components as required by the particular exemplary display device **40** design.

[0054] The network interface **27** includes the antenna **43** and the transceiver **47** so that the exemplary display device **40** can communicate with one or more devices over a network. In one embodiment, the network interface **27** may also have some processing capabilities to relieve requirements of the processor **21**. The antenna **43** is any antenna known to those of skill in the art for transmitting and receiving signals. In one embodiment, the antenna transmits and receives RF signals according to the IEEE 802.11 standard, including IEEE 802.11(a), (b), or (g). In another embodiment, the antenna transmits and receives RF signals according to the BLUETOOTH standard. In the case of a cellular telephone, the antenna is designed to receive CDMA, GSM, AMPS, or other known signals that are used to communicate within a wireless cell phone network. The transceiver **47** pre-processes the signals received from the antenna **43** so that they may be received by and further manipulated by the processor **21**. The transceiver **47** also processes signals received from the processor **21** so that they may be transmitted from the exemplary display device **40** via the antenna **43**.

[0055] In an alternative embodiment, the transceiver **47** can be replaced by a receiver. In yet another alternative embodiment, network interface **27** can be replaced by an image source, which can store or generate image data to be sent to the processor **21**. For example, the image source can be a digital video disc (DVD) or a hard-disc drive that contains image data, or a software module that generates image data.

[0056] Processor **21** generally controls the overall operation of the exemplary display device **40**. The processor **21** receives data, such as compressed image data from the network interface **27** or an image source, and processes the data into raw image data or into a format that is readily processed into raw image data. The processor **21** then sends the processed data to the driver controller **29** or to frame buffer **28** for storage. Raw data typically refers to the information that identifies the image characteristics at each location within an image. For example, such image characteristics can include color, saturation, and gray-scale level.

[0057] In one embodiment, the processor **21** includes a microcontroller, CPU, or logic unit to control operation of the exemplary display device **40**. Conditioning hardware **52** generally includes amplifiers and filters for transmitting signals to the speaker **45**, and for receiving signals from the microphone **46**. Conditioning hardware **52** may be discrete components within the exemplary display device **40**, or may be incorporated within the processor **21** or other components.

[0058] The driver controller **29** takes the raw image data generated by the processor **21** either directly from the processor **21** or from the frame buffer **28** and reformats the raw image data appropriately for high speed transmission to the array driver **22**. Specifically, the driver controller **29** reformats the raw image data into a data flow having a raster-like format, such that it has a time order suitable for scanning across the display array **30**. Then the driver controller **29** sends the formatted information to the array driver **22**. Although a driver controller **29**, such as a LCD controller, is often associated with the system processor **21** as a stand-alone Integrated Circuit (IC), such controllers may be implemented in many ways. They may be embedded in the processor **21** as hardware, embedded in the processor **21** as software, or fully integrated in hardware with the array driver **22**.

[0059] Typically, the array driver **22** receives the formatted information from the driver controller **29** and reformats the video data into a parallel set of waveforms that are applied many times per second to the hundreds and sometimes thousands of leads coming from the display's x-y matrix of pixels.

[0060] In one embodiment, the driver controller **29**, array driver **22**, and display array **30** are appropriate for any of the types of displays described herein. For example, in one embodiment, driver controller **29** is a conventional display controller or a bi-stable display controller (e.g., an interferometric modulator controller). In another embodiment, array driver **22** is a conventional driver or a bi-stable display driver (e.g., an interferometric modulator display). In one embodiment, a driver controller **29** is integrated with the array driver **22**. Such an embodiment is common in highly integrated systems such as cellular phones, watches, and other small area displays. In yet another embodiment, display array **30**

is a typical display array or a bi-stable display array (e.g., a display including an array of interferometric modulators).

[0061] The input device **48** allows a user to control the operation of the exemplary display device **40**. In one embodiment, input device **48** includes a keypad, such as a QWERTY keyboard or a telephone keypad, a button, a switch, a touch-sensitive screen, or a pressure- or heat-sensitive membrane. In one embodiment, the microphone **46** is an input device for the exemplary display device **40**. When the microphone **46** is used to input data to the device, voice commands may be provided by a user for controlling operations of the exemplary display device **40**.

[0062] Power supply **50** can include a variety of energy storage devices as are well known in the art. For example, in one embodiment, power supply **50** is a rechargeable battery, such as a nickel-cadmium battery or a lithium ion battery. In another embodiment, power supply **50** is a renewable energy source, a capacitor, or a solar cell including a plastic solar cell, and solar-cell paint. In another embodiment, power supply **50** is configured to receive power from a wall outlet.

[0063] In some embodiments, control programmability resides, as described above, in a driver controller which can be located in several places in the electronic display system. In some embodiments, control programmability resides in the array driver **22**. Those of skill in the art will recognize that the above-described optimizations may be implemented in any number of hardware and/or software components and in various configurations.

[0064] The details of the structure of interferometric modulators that operate in accordance with the principles set forth above may vary widely. For example, Figures 7A-7E illustrate five different embodiments of the movable reflective layer **14** and its supporting structures. These embodiments may be equally applied to a movable transmissive layer and its supporting structures in a transmissive interferometric modulator as will be described below with regard to Figures 8-13.

[0065] Figure 7A is a cross section of the embodiment of Figure 1, where a strip of metal material **14** is deposited on orthogonally extending supports **18**. In Figure 7B, the moveable reflective layer **14** is attached to supports at the corners only, on tethers 32. In Figure 7C, the moveable reflective layer **14** is suspended from a deformable layer **34**, which may comprise a flexible metal. The deformable layer **34** connects, directly or indirectly, to the substrate **20** around the perimeter of the deformable layer **34**. These connections are herein referred to as support posts. The embodiment illustrated in Figure 7D has support post plugs 42 upon which the deformable layer **34** rests. The movable reflective layer **14** remains suspended over the gap, as in Figures 7A-7C, but the deformable layer **34** does not form the support posts by filling holes between the deformable layer **34** and the optical stack **16**. Rather, the support posts are formed of a planarization material, which is used to form support post plugs 42. The embodiment illustrated in Figure 7E is based on the embodiment shown in Figure 7D, but may also be adapted to work with any of the embodiments illustrated in Figures 7A-7C, as well as additional embodiments not shown. In the embodiment shown in Figure 7E, an extra layer of metal or other conductive material has been used to form a bus structure **44**. This allows signal routing along the back of the interferometric modulators, eliminating a number of electrodes that may otherwise have had to be formed on the substrate **20**.

[0066] In embodiments such as those shown in Figure 7, the interferometric modulators function as direct-view devices, in which images are viewed from the front side of the transparent substrate **20**, the side opposite to that upon which the modulator is arranged. In these embodiments, the reflective layer **14** optically shields the portions of the interferometric modulator on the side of the reflective layer opposite the substrate **20**, including the deformable layer **34**. This allows the shielded areas to be configured and operated upon without negatively affecting the image quality. Such shielding allows the bus structure **44** in Figure 7E, which provides the ability to separate the optical properties of the modulator from the electromechanical properties of the modulator, such as addressing and the movements that result from that addressing. This separable modulator architecture allows the structural design and materials used for the electromechanical aspects and the optical aspects of the modulator to be selected and to function independently of each other. Moreover, the embodiments shown in Figures 7C-7E have additional benefits deriving from the decoupling of the optical properties of the reflective layer **14** from its mechanical properties, which are carried out by the deformable layer **34**. This allows the structural design and materials used for the reflective layer **14** to be optimized with respect to the optical properties, and the structural design and materials used for the deformable layer **34** to be optimized with respect to desired mechanical properties.

[0067] Some applications require a large display which may be viewed well in conditions of reduced ambient illumination. For such applications, reflective displays generally do not work well because reflective displays usually require frontlight and the frontlight performance of reflective displays suffers when applied to large diagonal screens. There are currently various ways to apply backlight to a reflective-type interferometric modulator display. However, these ways tend to be inefficient and diminish the perceived performance of the display.

[0068] Certain embodiments as will be described below provide a transmissive backlit display. In one embodiment, the backlit display comprises a backlight and an array of transmissive interferometric modulators, wherein each interferometric modulator comprises a fixed and moving dielectric mirror stack. The interferometric modulators cause light within the desired wavelength range to be transmitted while reflecting at least a portion of the remaining light. Each of these embodiments relating to a transmissive interferometric modulator display may be incorporated in a display application such as the application described above with regard to Figures 2 through 6B.

[0069] One transmissive interferometric modulator display embodiment comprising an interferometric MEMS display element is illustrated in Figures 8 and 9. Figure 8 is a cross section of the display embodiment, while Figure 9 is a top view of the display embodiment.

[0070] A pixel of the display is in either a bright or dark state. A light source illuminating the display element and a user of the display element (not shown) are typically located on different sides of the display element. In the bright ("on" or "open") state, the display element transmits a large portion of incident visible light to the user. When in the dark ("off" or "closed") state, the display element transmits little incident visible light to the user. Depending on the embodiment, the light transmission properties of the "on" and "off" states may be reversed. MEMS pixels can be configured to transmit predominantly at selected colors, allowing for a color display in addition to black and white.

[0071] In some embodiments, an interferometric modulator display comprises a row/column array of these interferometric modulators. Each interferometric modulator includes a pair of transmissive layers positioned at a variable and controllable distance from each other to form a resonant optical gap with at least one variable dimension. In one embodiment, one of the transmissive layers may be moved between two positions. In the first position, referred to herein as the relaxed position, the movable transmissive layer is positioned at a relatively large distance from a fixed transmissive layer. In the second position, referred to herein as the actuated position, the movable transmissive layer is positioned more closely adjacent to the fixed transmissive layer. Incident light that transmits through the two layers interferes constructively or destructively depending on the position of the movable transmissive layer, producing either an overall transmissive or non-transmissive state for each pixel. A pixel passes through light of a particular wavelength range in an overall transmissive state, and blocks out a substantial amount of light in an overall non-transmissive state. In certain embodiments, the movable transmissive layer may move to a third position other than the relaxed position and the actuated position.

[0072] In the interferometric modulator, a movable transmissive layer 808 is illustrated in a relaxed position at a predetermined distance from a fixed transmissive layer 804. The transmissive layers 804 and 808, as referenced herein, may be formed from a variety of materials that are partially transparent such as various dielectrics. In one embodiment, the transmissive layers 804 and 808 are formed from a transparent dielectric.

[0073] The transmissive layers 804 and 808 are operatively connected to ring-shaped electrodes 806 and 812 respectively. The electrodes 806 and 812 may comprise electrically conductive material, e.g., metal or metal oxide. The electrodes 806 and 812 are typically shaped similarly and aligned with each other such that the electrodes attract each other under electrostatic forces.

[0074] In one embodiment, the electrodes 806 and 812 comprise absorbing metal or metal oxide. The electrodes 806 and 812 are ring-shaped such that light transmitted through the transmissive layers 804 and 812 can pass through the center hole surrounded by the electrodes as shown in Figure 9. The center hole defines the active area of the exemplary interferometric modulator, which is the area of an interferometric modulator where incident light is interferometrically modulated by the movable and fixed transmissive layers. The rest of the area of the interferometric modulator display is referred to as a non-active area. It should be noted that shapes other than ring may also be used for electrodes 806 and 812.

[0075] The transmissive layers 804 and 808 and the electrodes 806 and 812 may be fabricated, for example, by depositing one or more of the above layers onto a transparent substrate 802. Each layer can be formed of one or more layers of materials, and can be formed of a single material or a combination of materials.

[0076] The movable electrode 812 may be connected to a supporting structure in various ways as illustrated in Figures 7A-7E. For example, corners of the electrode 812 may be attached to supports 814 on tethers 816 as shown in Figure 9.

[0077] With no applied voltage differential across the electrodes 806 and 812, a gap remains between the movable transmissive layer 808 and fixed transmissive layer 804, with the tether 816 in a mechanically relaxed state, as illustrated in Figure 9. However, when a potential difference is applied across the electrodes 806 an 812, the capacitor becomes charged, and electrostatic forces pull the electrodes together. If the voltage is high enough, the tether 816 is deformed and the moveable electrode 812 is forced against the fixed electrode 806. The movable transmissive layer 808 which moves along with the electrode 812 is thus forced against the fixed transmissive layer 804. The behavior is the same regardless of the polarity of the applied potential difference. Therefore, the combination of two partially transmissive layers separated by an air gap may be used to pass light within a wavelength range while reflecting light outside the range.

[0078] Figure 10 illustrates another embodiment of a transmissive interferometric modulator display. The embodiment includes at least one black mask on the back and/or front of the display covering the non-active areas of an array of interferometric modulators, thereby offering an improved performance.

[0079] In the exemplary embodiment, the display comprises an array of interferometric modulators deposited on the back side of a substantially transparent substrate 802. Each interferometric modulator may be the same as described with regard to Figures 8 and 9.

[0080] In one embodiment, a light source 1002 is located behind the back side of a back plate 1006 to illuminate through the array of interferometric modulators. The light source 1002 may be, for example, a substantially collimated light source.

[0081] In one embodiment, a reflective black mask 1004 is located somewhere between the front side of the back plate 1006 and the substrate 802. The reflective black mask 1004 is patterned to cover the non-active areas of the array of interferometric modulators. The reflective black mask 1004 could be deposited on the front side of the back plate 1006. The reflective black mask 1004 keeps light, entering the back of the display, from reaching non-active areas of the pixel.

[0082] In one embodiment, the display is configured to recycle the backlight. Either light incident on non-active areas of the pixel from the back of the display which is reflected by the reflective black mask 1004, or light incident on active areas of the pixel from the back of the display which gets reflected by the two transmissive layers 804 and 808, may be reflected by, e.g., a reflective layer (not shown) behind the light source 1002, and enter the array of interferometric modulators for a second time. Eventually, the light has a chance of hitting a proper active area.

[0083] In one embodiment, the display further comprises an absorbing black mask 1008 deposited on the front side of the substrate 802. The absorbing black mask 1008 is also patterned to cover the non-active areas of the array of interferometric modulators. The absorbing black mask 1008 keeps light coming from the front side of the substrate from entering the non-active regions. The absorbing black mask 1008 further keeps light that has entered the non-active regions from exiting to the front side of the substrate 802. This reduces light reflecting off the front side of the substrate 802, thereby improving the contrast ratio of the display.

[0084] Figure 11 illustrates another embodiment of a transmissive interferometric modulator display. As shown, the display may comprise an angle converter 1102 as shown in Figure 11 on the front side of the array of interferometric modulators, instead of an absorbing black mask 1008 in Figure 10.

[0085] The angle converter 1102 is configured to change angular distribution of incident light based on the direction of light. The angle converter 1102 reduces reflection of light coming from the front side of the substrate. The angle converter 1102 also broadens angular distribution of light passing through the array of interferometric modulators. The collimated light coming from the back light is changed to wide-angle light that can be easily seen throughout a wide viewing area in front of the display.

[0086] In the exemplary embodiment, the angle converter 1102 includes an angle filter, which comprises a set of black masks separated by small gaps 1104 as shown in Figure 11. There is one black mask on each side of the pixel. The black masks have a substantially flat front side and a concave back side. The two black masks closest to a pixel therefore form an approximately semi-parabolic cavity over a pixel. The cavity may be of any suitable shape which causes light coming from the back side of the angle filter to be redirected. The front and back surfaces of the angle filter are made from different material. In one embodiment, the cavity of the angle filter may be filled with air or a solid transparent material.

[0087] With this structure, the front surface of the angle filter functions as an absorbing black mask. The absorbing black mask keeps light coming from the front side of the substrate 802 from entering the pixel. The absorbing black mask further keeps light that has entered the non-active regions from exiting to the front side of the substrate 802. This reduces light reflecting off the front side of the substrate 802, and thereby improving the contrast ratio of the display.

[0088] The back surface of the angle filter diffuses collimated light transmitted by the array of interferometric modulators to a user at the front side of the display. When a pixel is in a transmissive state, the pixel interferometrically modulates light coming from the light source 1002 and allows at least a portion of the incident light to pass through. The light passing though the pixel then gets diffused when passing through the approximately semispherical cavity, before reaching users located at the front side of the display. This improves the viewing experience of users.

[0089] Figure 12 illustrates another embodiment of a transmissive interferometric modulator display. The embodiment includes a lenslet array 1202 between the light source 1002 and the array of the interferometric modulators, due to the "bulls-eye" nature of the pixels. Each lenslet 1202 converges incident light from the light source 1002 into active areas of the interferometric modulator. The lenslet array 1202 may be deposited on the back side of a substantially transparent back plate 1006.

[0090] In one embodiment, a reflective film 1204 is located between the lenslet 1202 and the light source 1002 to cover areas between the lenslets 1202. The reflective film 1204 is used, for example, to ensure that light enters the lenslets 1202 at a desired angle. Light reaching the areas between the lenslets 1202 is reflected and may further be recycled.

[0091] Figure 13 illustrates another embodiment of a transmissive interferometric modulator display embodiment comprising an array of interferometric MEMS display elements. The transmissive interferometric modulator operates on the same principle as described with regard to Figures 8 and 9, but with a different structure.

[0092] In the interferometric modulator, a movable transmissive layer 808 is illustrated in a relaxed position at a predetermined distance from a fixed transmissive layer 804. The transmissive layers 804 and 808, as referenced herein, may be formed from a variety of materials that are partially transparent such as various dielectrics. In one embodiment, the transmissive layers 804 and 808 are formed from a transparent dielectric.

[0093] The transmissive layers 804 and 808 are operatively connected to electrodes 1302 and 1304 respectively. The electrodes 1302 and 1304 comprise electrically conductive material, e.g., metal or metal oxide. The electrodes 1302 and 1304 comprise substantially transparent metal or metal oxide, e.g., zinc oxide or ITO. The electrodes 1302 and 1304 are typically shaped similarly and aligned with each other such that the electrodes attract each other under electrostatic forces.

[0094] The transmissive layers 804 and 808 and the electrodes 1302 and 1304 may be fabricated, for example, by depositing one or more of the above layers onto a transparent substrate 802. Each layer can be formed of one or more layers of materials, and can be formed of a single material or a combination of materials.

[0095] The movable electrode 1304 may be connected to a supporting structure in various ways as illustrated in Figures 7A-7E. For example, the movable electrode 1304 may be attached to supports 1308 and 1312 on tethers 816 as shown in Figure 13.

[0096] In one embodiment, the display further comprises a backplate 1006 which is to be coupled to the substrate 802 upon assembly. In the exemplary embodiment, the backplate 1006 further comprises at least one bus line 1306. The bus line 1306 is configured to connect selected electrodes of the interferometric modulators and provides a high conductivity rating. The bus line 1306 may be formed by using a substantially solid metal. The backplate 1306 may be placed directly on the highest layer of posts 1312 on the substrate 802 used to support the bus line 1306.

[0097] The foregoing description details certain embodiments of the invention. It will be appreciated, however, that no matter how detailed the foregoing appears in text, the invention can be practiced in many ways. It should be noted that the use of particular terminology when describing certain features or aspects of the invention should not be taken to imply that the terminology is being re-defined herein to be restricted to including any specific characteristics of the features or aspects of the invention with which that terminology is associated.

WHAT IS CLAIMED IS:

1. A transmissive display device, comprising:

an array of interferometric modulators formed on a substantially transparent substrate, each interferometric modulator comprises:

a cavity defined by a first layer deposited on the substrate and a second layer connected to the substrate, the first and second layers being at least partially transparent, wherein light incident to the display device is interferometrically modulated by the first and second layer,

a substantially transparent first electrode operatively connected to the first layer,

a substantially transparent second electrode operatively connected to the second layer;

and

a back plate coupled to the substrate and comprising at least one bus line configured to connect one or more electrodes of the interferometric modulators, the at least one bus line comprising substantially solid metal.

2. The device of Claim 1, wherein each of the first and second layers comprises dielectric material.

3. The device of Claim 1, wherein each of the first and second electrodes comprises metal or metal oxide.

4. The device of Claim 1, wherein each of the first and second electrodes comprises zinc oxide or ITO.

5. The device of Claim 1, wherein the second layer is movable between a first and a second position.

6. The device of Claim 5, wherein each interferometric modulator is configured to block out a substantial amount of visible light while the second layer is in a second position.

7. The device of Claim 5, wherein each interferometric modulator is configured to pass through light of a particular wavelength range while the second layer is in a first position.

8. The device of Claim 5, wherein the second layer is further movable to a third position.

9. The device of Claim 1, further comprising:

a display;

a processor that is configured to communicate with said display, said processor being configured to process image data; and

a memory device that is configured to communicate with said processor.

10. The device of Claim 9, further comprising a driver circuit configured to send at least one signal to the display.

11. The device of Claim 10, further comprising a controller configured to send at least a portion of the image data to the driver circuit.

12. The device of Claim 9, further comprising an image source module configured to send said image data to said processor.

13. The device of Claim 12, wherein the image source module comprises at least one of a receiver, transceiver, and transmitter.

14. The device of Claim 9, further comprising an input device configured to receive input data and to communicate said input data to said processor.

15. A transmissive display device, comprising:

means for transmissively and interferometrically modulating light, the modulating means formed on a substantially transparent substrate;

means for actuating the modulating means, the actuating means being substantially transparent;

and

means for enclosing the modulating means, the enclosing means being coupled to the substrate and further comprises means for electrically connecting at least one of the actuating means.

16. The device of Claim 15, wherein the device comprises an array of interferometric modulators formed on a substantially transparent substrate, each interferometric modulator comprises:

a cavity defined by a first layer deposited on the substrate and a second layer connected to the substrate, the first and second layers being at least partially transparent, wherein light incident to the display device is interferometrically modulated by the first and second layer,

a substantially transparent first electrode operatively connected to the first layer, and

a substantially transparent second electrode operatively connected to the second layer,

and wherein the modulating means comprise the first and second layers of the interferometric modulators and the actuating means comprises the first and second electrodes of the interferometric modulators.

17. The device of Claim 16, wherein the enclosing means comprises a back plate coupled to the substrate and comprising at least one bus line configured to connect one or more electrodes of the interferometric modulators, the at least one bus line comprising substantially solid metal.

18. A method of making a transmissive display device, comprising:

forming an array of interferometric modulators on a substantially transparent substrate, each interferometric modulator comprises:

a cavity defined by a first layer deposited on the substrate and a second layer connected to the substrate, the first and second layers being at least partially transparent, wherein light incident to the display device is interferometrically modulated by the first and second layer,

a substantially transparent first electrode operatively connected to the first layer,

a substantially transparent second electrode operatively connected to the second layer;

and

forming a back plate coupled to the substrate and comprising at least one bus line configured to connect one or more electrodes of the interferometric modulators, the at least one bus line comprising substantially solid metal.

19. The method of Claim 18, wherein each of the first and second layers comprises dielectric material.

20. The method of Claim 18, wherein each of the first and second electrodes comprises metal or metal oxide.

21. The method of Claim 18, wherein each of the first and second electrodes comprises zinc oxide or ITO.

22. The method of Claim 18, wherein each of the first and second electrodes comprises absorbing metal or absorbing metal oxide.

23. The method of Claim 18, wherein the second layer is movable between a first and a second position.

24. The method of Claim 23, wherein the display device blocks out a substantial amount of visible light while the second layer is in a second position.

25. The method of Claim 23, wherein the display device passes through light of a particular wavelength range while the second layer is in a first position.

26. The method of Claim 23, wherein the second layer is further movable to a third position.

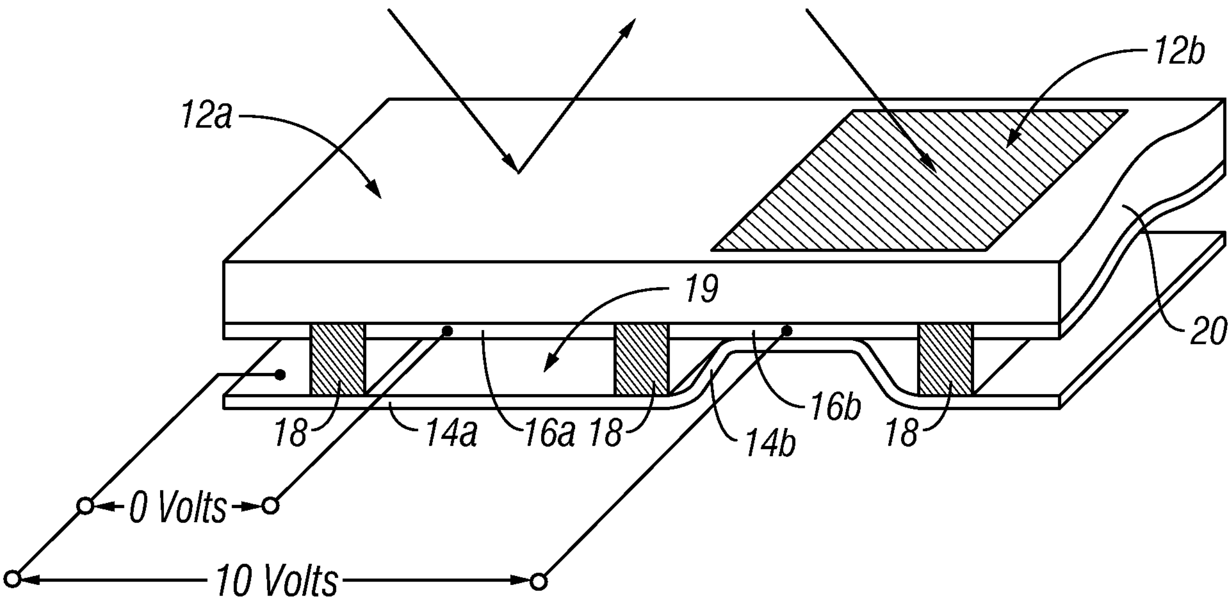

FIG. 1

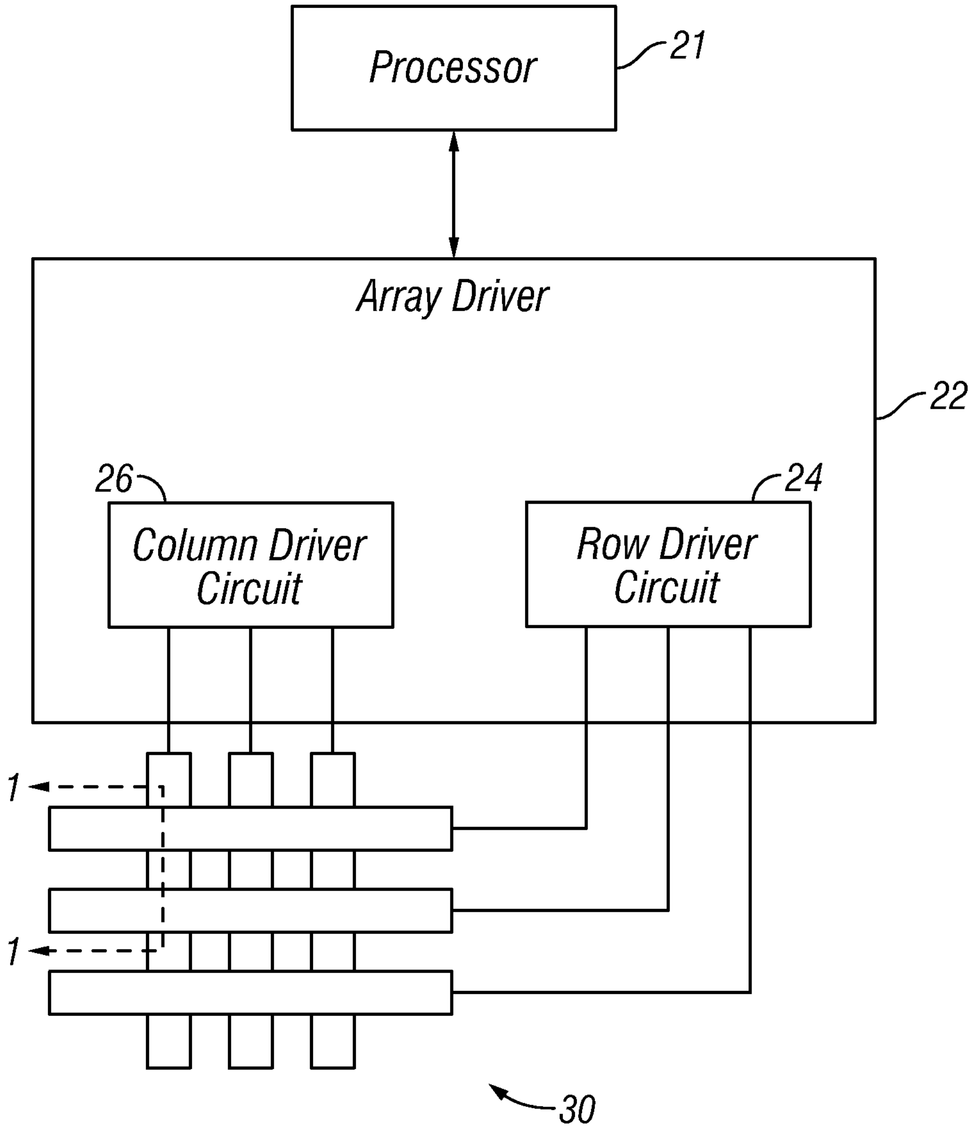
Processor
21
Array Driver
22
26
Column Driver Circuit
24
Row Driver Circuit
1
1
30

FIG. 2

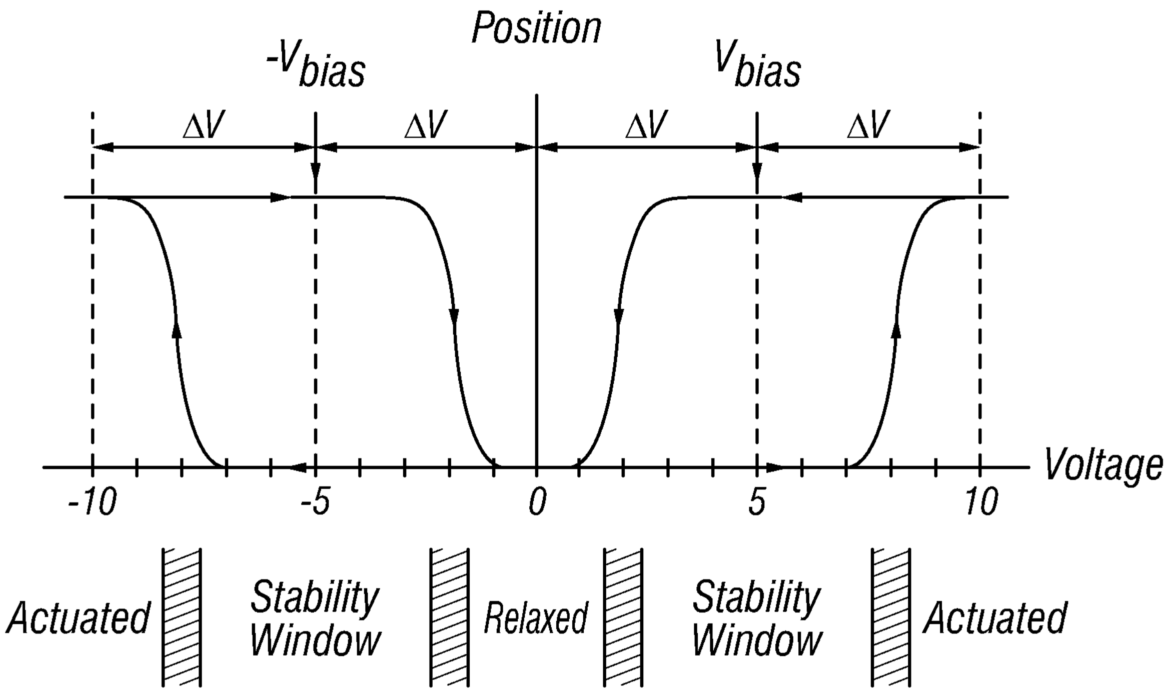

FIG. 3

Row Output Signals	Column Output Signals: $+V_{bias}$	Column Output Signals: $-V_{bias}$
0	Stable	Stable
$+\Delta V$	Relax	Actuate
$-\Delta V$	Actuate	Relax

FIG. 4

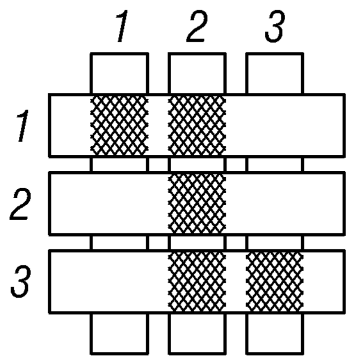
1
2
3
1
2
3

FIG. 5A

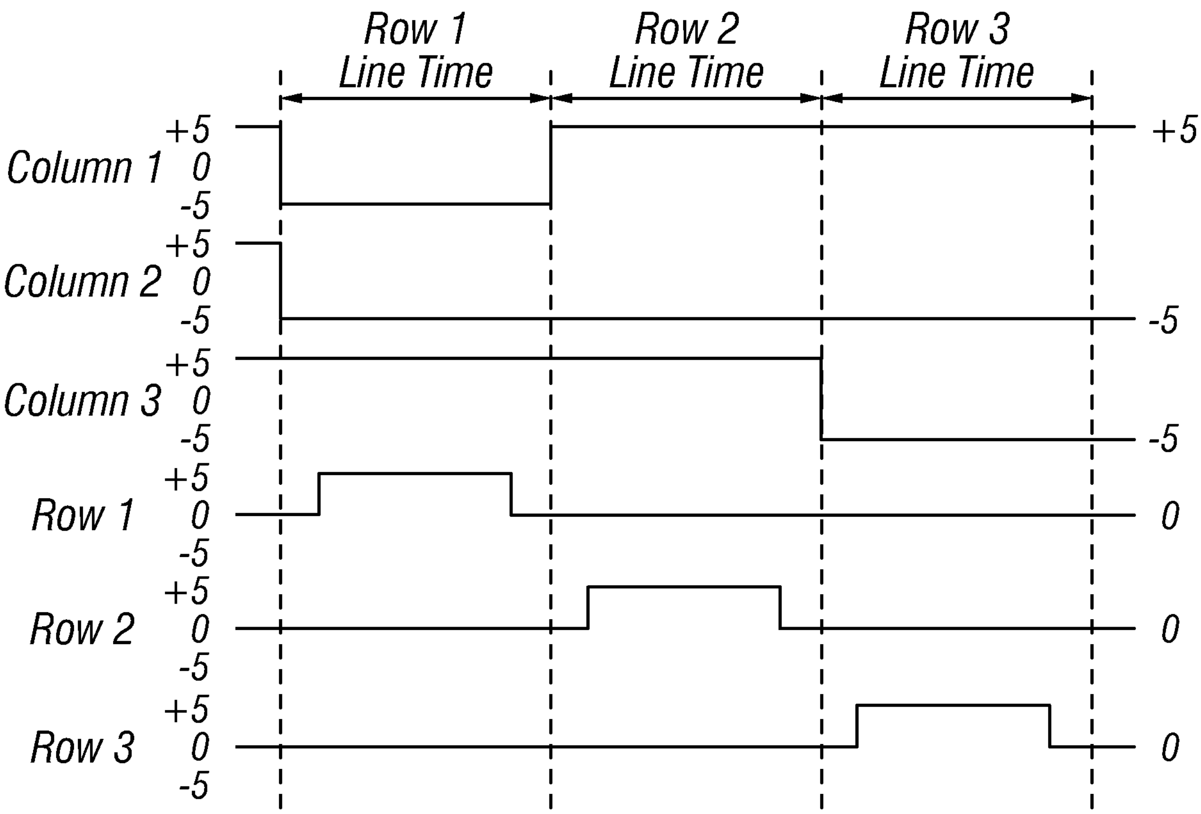
Row 1 Line Time
Row 2 Line Time
Row 3 Line Time
Column 1
Column 2
Column 3
Row 1
Row 2
Row 3
+5
0
-5

FIG. 5B

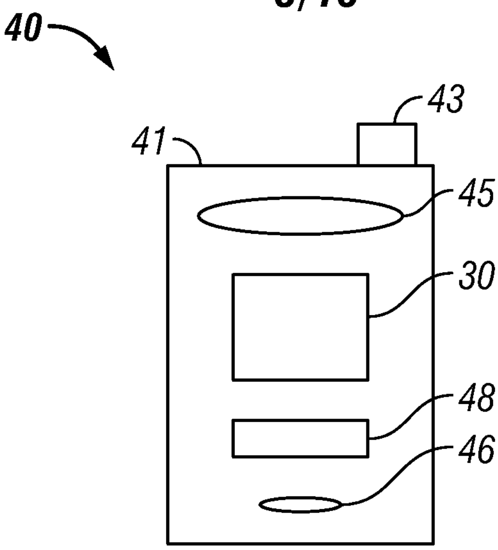
40
41
43
45
30
48
46

FIG. 6A

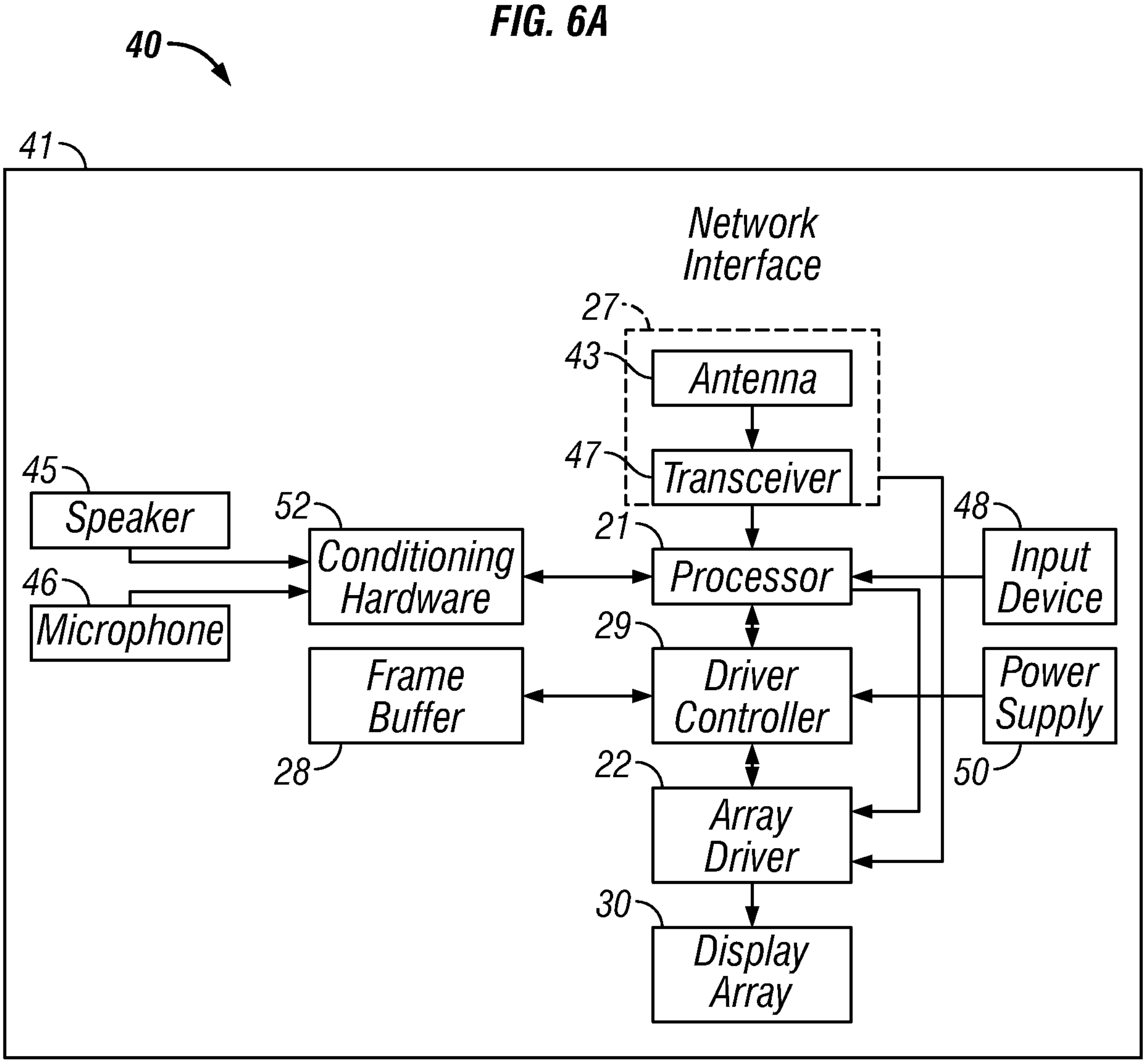
40
41
Network Interface
27
43
Antenna
47
Transceiver
45
Speaker
52
Conditioning Hardware
21
Processor
48
Input Device
46
Microphone
29
Frame Buffer
Driver Controller
Power Supply
28
22
50
Array Driver
30
Display Array

FIG. 6B

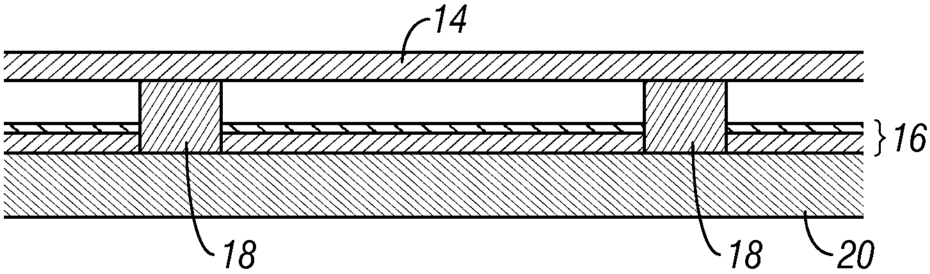

FIG. 7A

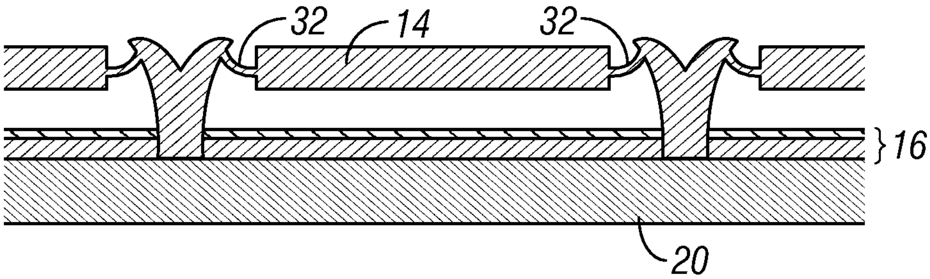

FIG. 7B

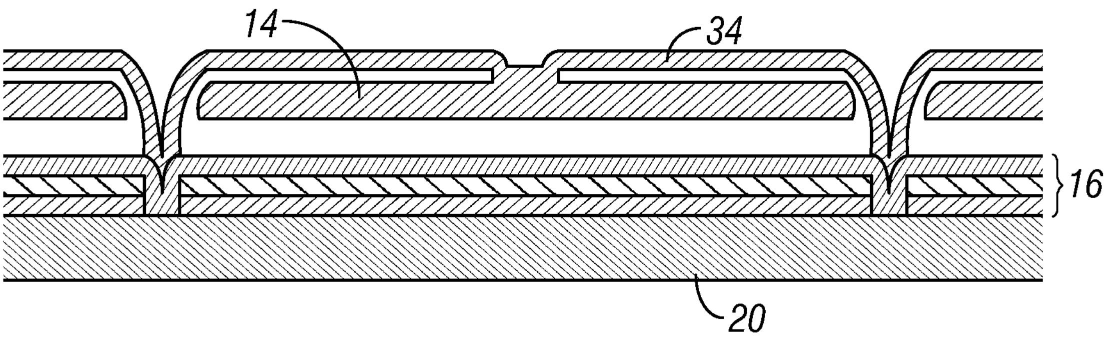

FIG. 7C

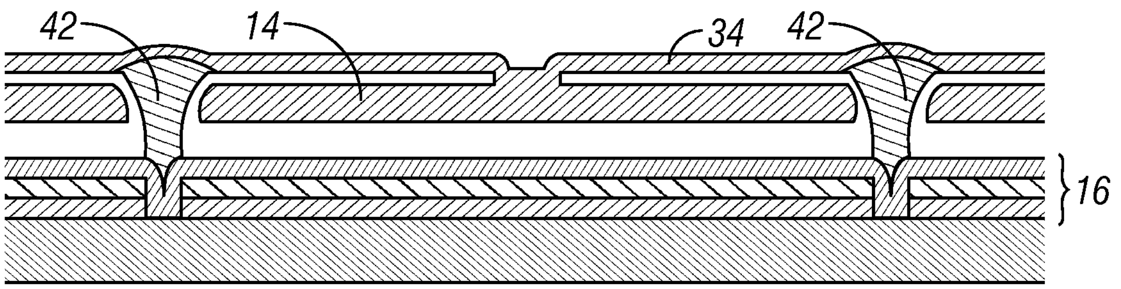

FIG. 7D

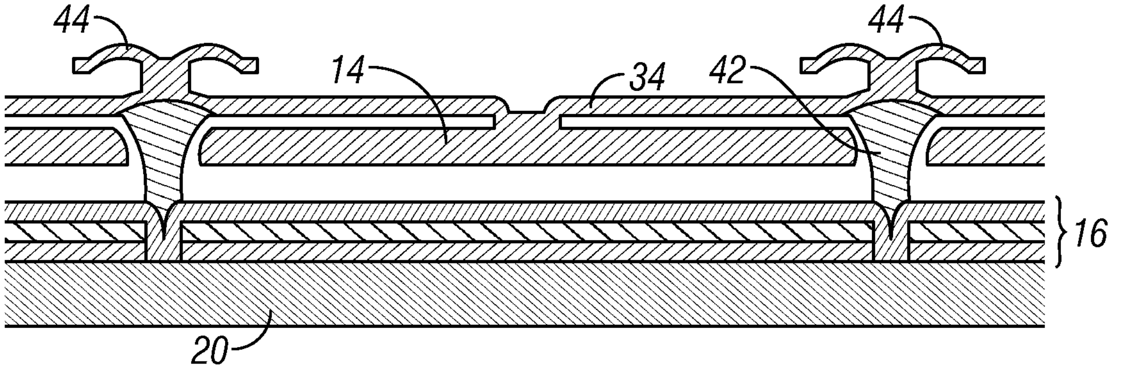

FIG. 7E

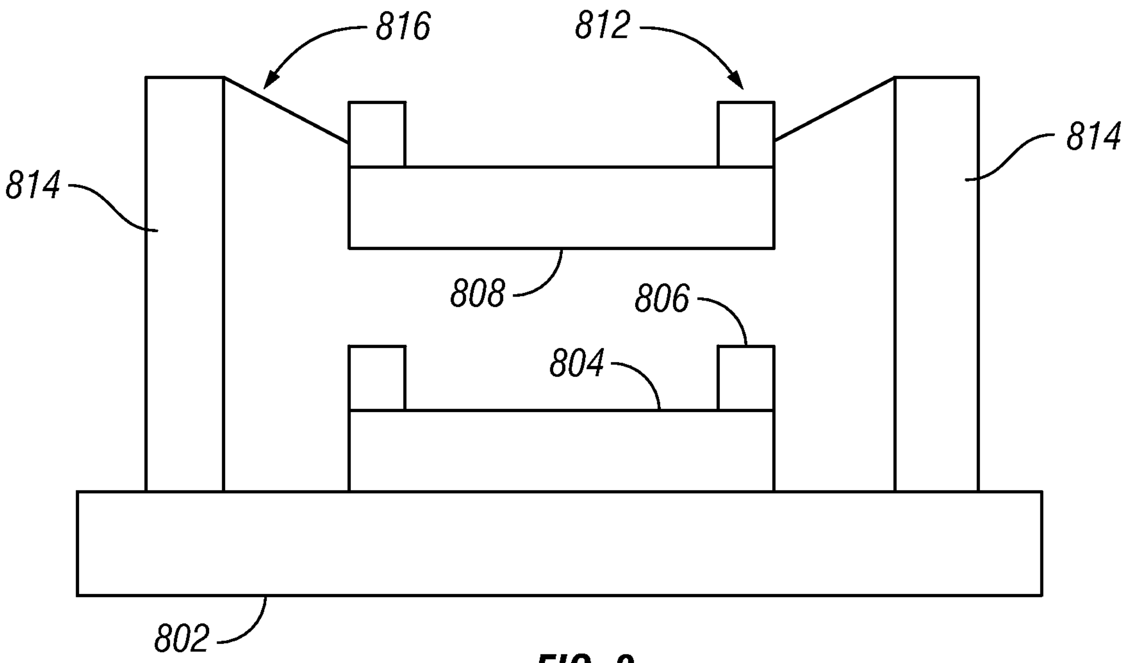

FIG. 8

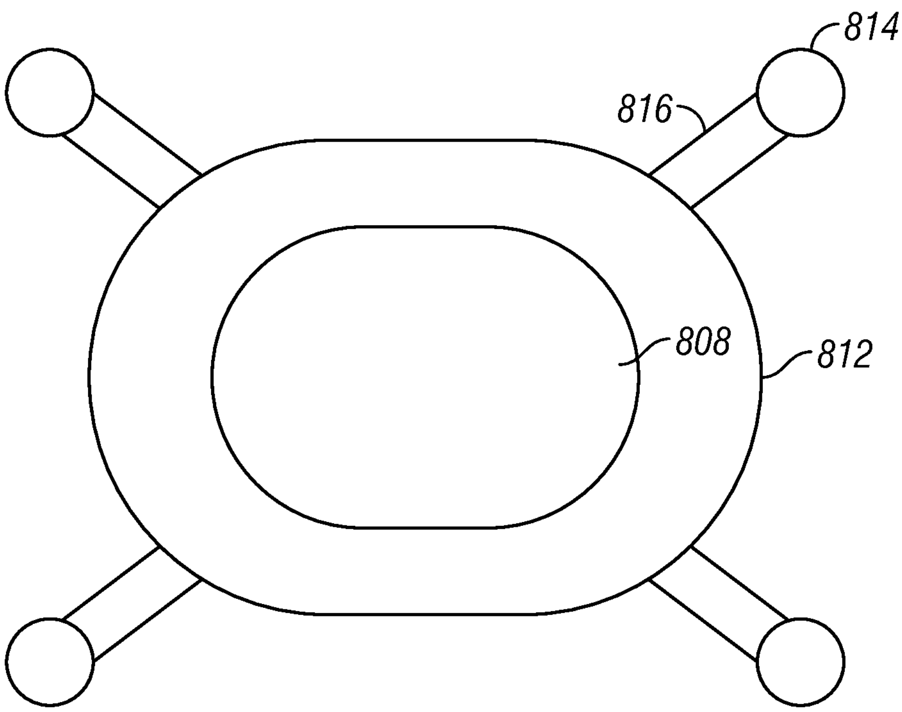

FIG. 9

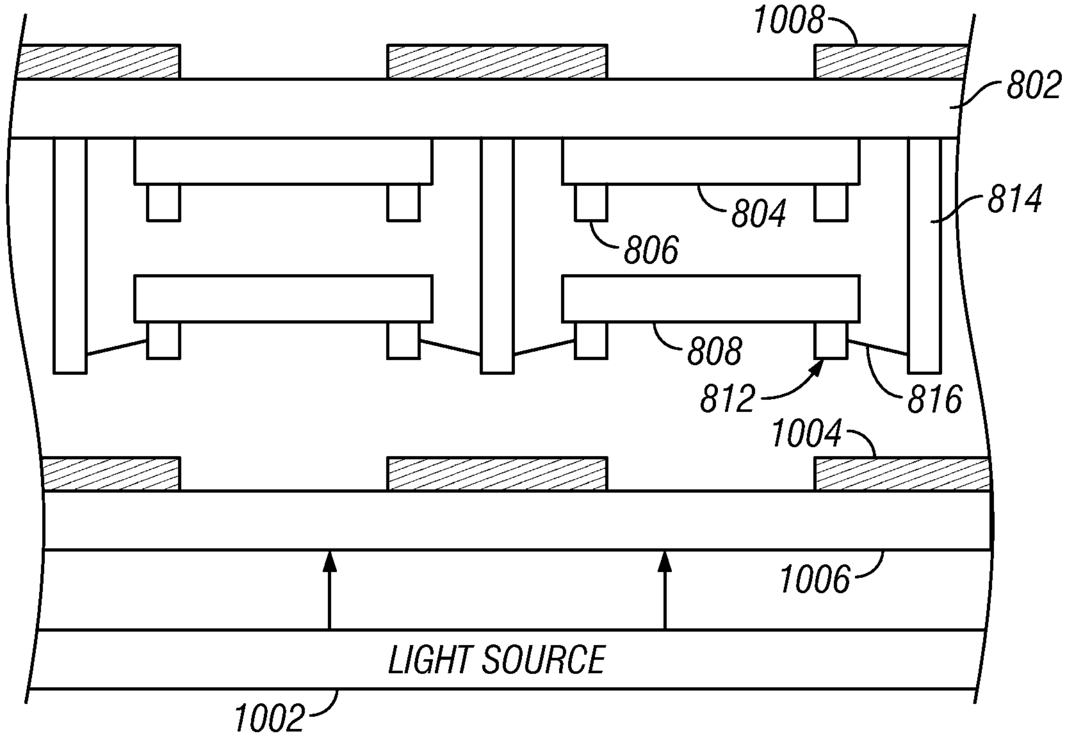
1008
802
804
814
806
808
812
816
1004
1006
LIGHT SOURCE
1002

FIG. 10

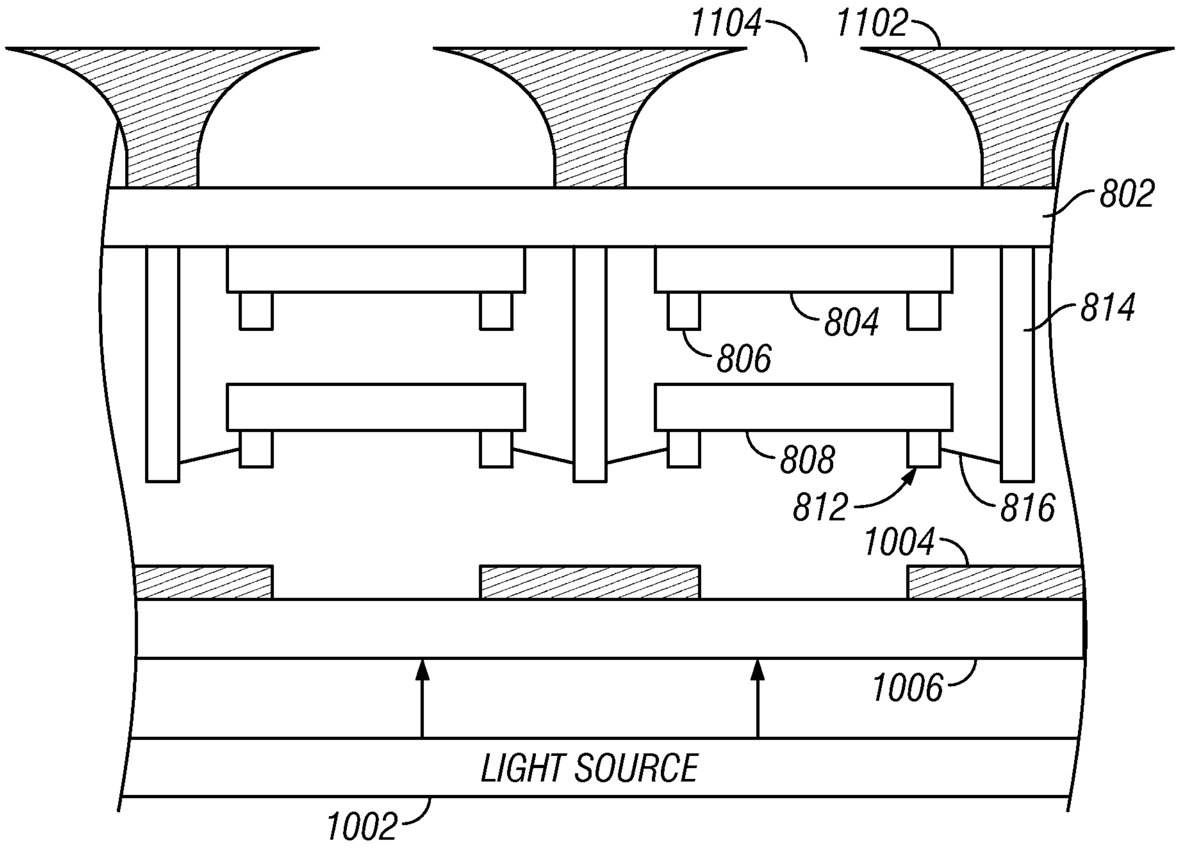
1104
1102
802
804
814
806
808
812
816
1004
1006
LIGHT SOURCE
1002

FIG. 11

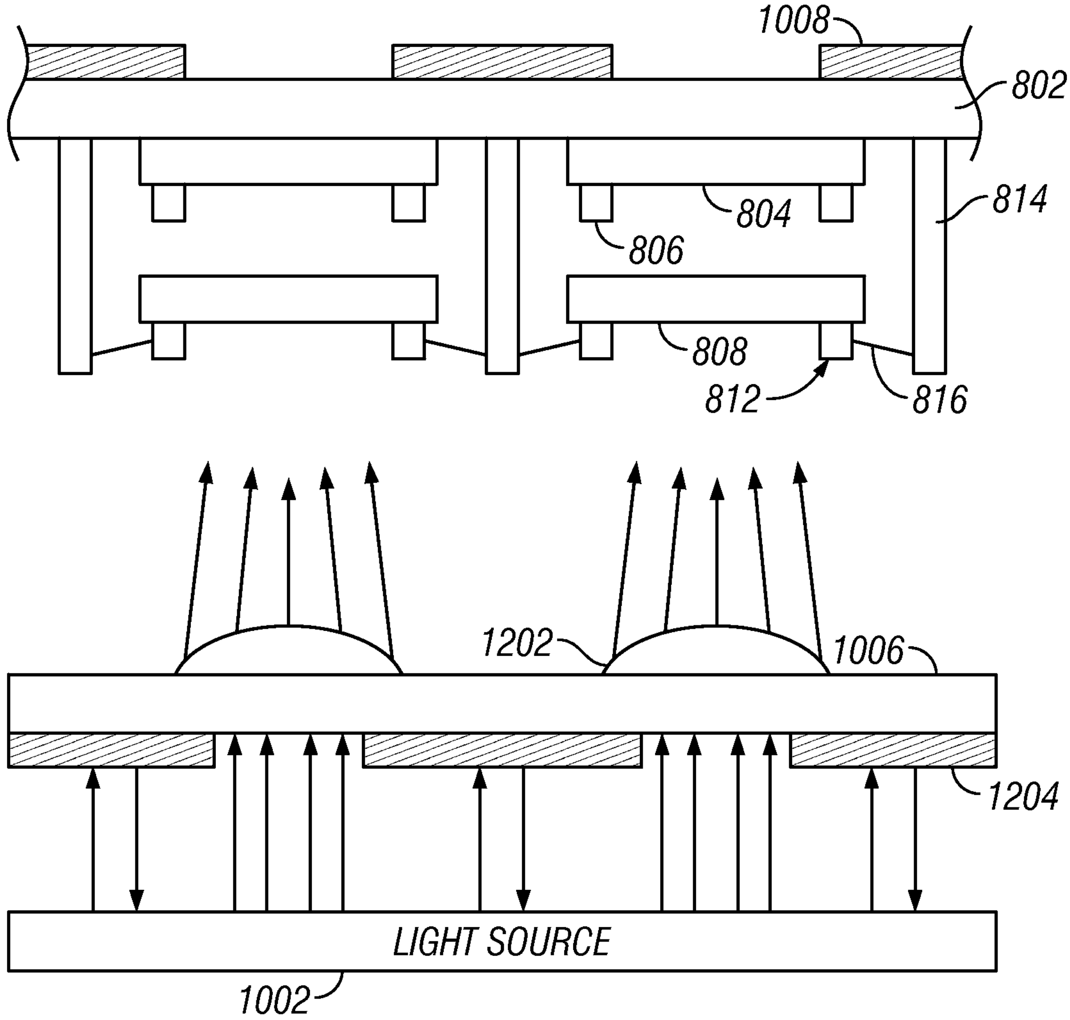
1008
802
814
804
806
808
812
816
1202
1006
1204
LIGHT SOURCE
1002

FIG. 12

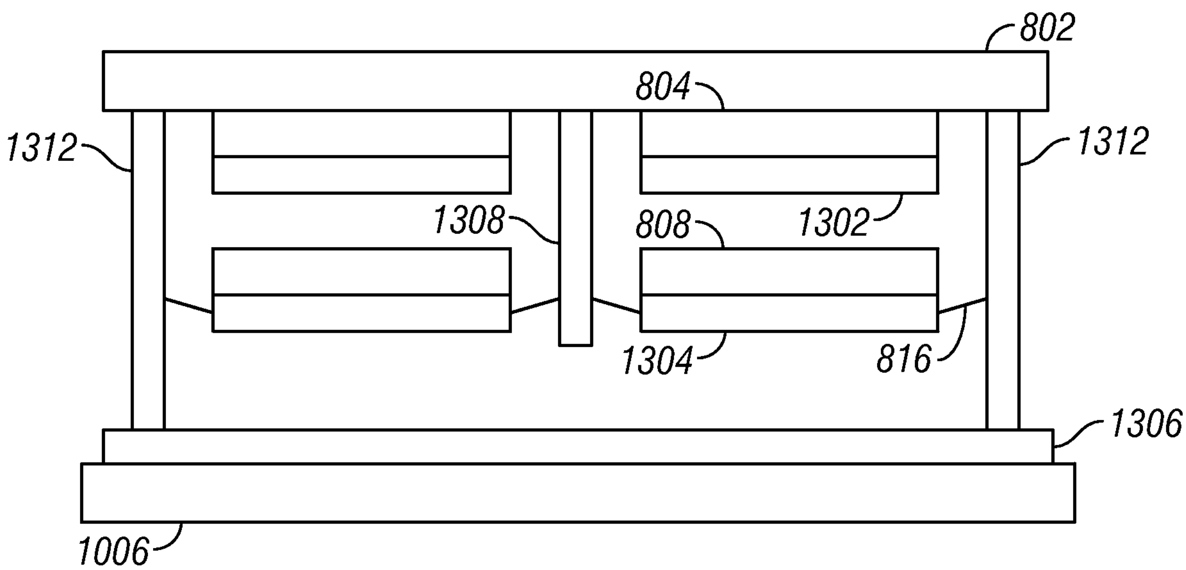
802
804
1312
1312
1308
808
1302
1304
816
1306
1006

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2009/048323

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B26/00 B81B3/00 G09G3/34 G01J3/26

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 B81B G09G G01J

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 practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 1 847 864 A (XEROX CORP [US]) 24 October 2007 (2007-10-24) abstract; figures	1-26
Y	US 2006/077533 A1 (MILES MARK W [US] ET AL) 13 April 2006 (2006-04-13) paragraph [0100] - paragraph [0113] figures 17a,17b	1-26
A	US 2005/212738 A1 (GALLY BRIAN [US]) 29 September 2005 (2005-09-29) abstract; figures	1-26
A	US 5 835 255 A (MILES MARK W [US]) 10 November 1998 (1998-11-10) abstract; figures	1-26

☐ 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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 October 2009	28/10/2009

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2009/048323

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