



(51) International Patent Classification:

G02B 5/22 (2006.01) B32B 38/18 (2006.01)
B32B 3/30 (2006.01) B82Y 30/00 (2011.01)

(21) International Application Number:

PCT/US2016/055597

(22) International Filing Date:

05 October 2016 (05.10.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P. [US/US]; 11445 Compaq Center Drive W, Houston, Texas 77070 (US).

(72) Inventors: WU, Kuan-Ting; 10F, No.66, Jing Mao 2 Rd., NanGang Dist, Taipei City, 11568 (TW). CHU, Wei-Kuang; 10F, No.66, Jing Mao 2 Rd., NanGang Dist, Taipei City, 11568 (TW).

(74) Agent: MAISAMI, Ceyda Azakli; 3390 E Harmony Road, Fort Collins, Colorado 80528 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD,

SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to the identity of the inventor (Rule 4.17(i))
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

Published:

- with international search report (Art. 21(3))

(54) Title: DISPLAY CONTROL FILMS

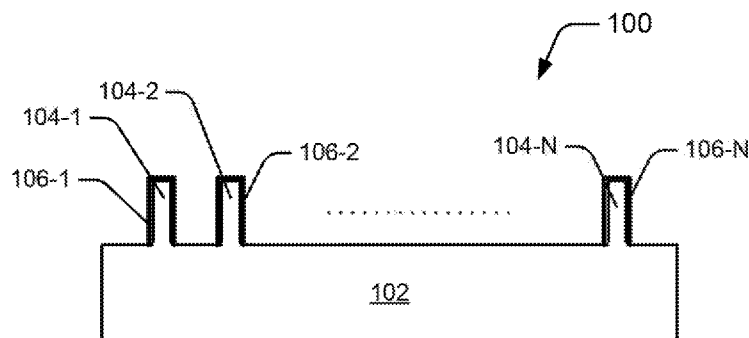


Fig. 1

(57) Abstract: The present subject matter relates to display control films. In an example implementation, a display control film comprises a transparent substrate including a first set of linear protrusions protruding from a face of the transparent substrate. The first set of linear protrusions is parallel to each other. The display control film also comprises a graphene coating on each linear protrusion of the first set.



DISPLAY CONTROL FILMS

BACKGROUND

[0001] Electronic devices, such as laptops, tablets, and mobile phones, may have a display screen for displaying contents to users. The display screen of such devices may include a liquid crystal display (LCD) screen, a light emitting diode (LED) display screen, an organic LED display screen, a polymer LED display screen, a plasma display screen, and the like.

BRIEF DESCRIPTION OF DRAWINGS

[0002] The following detailed description references the drawings, wherein:

[0003] Fig. 1 illustrates a sectional view of a display control film, according to an example implementation of the present subject matter;

[0004] Fig. 2 illustrates a perspective view of the display control film of Fig. 1, according to an example implementation of the present subject matter;

[0005] Figs. 3(a)-3(b) illustrate display control films, according to example implementations of the present subject matter;

[0006] Figs. 4(a) illustrates a sectional view of a display control film, according to an example implementation of the present subject matter;

[0007] Figs. 4(b) illustrates a sectional view of a display control film, according to an example implementation of the present subject matter;

[0008] Fig. 5 illustrates a top view of a transparent substrate for a display control film, according to an example implementation of the present subject matter;

[0009] Fig. 6 illustrates a sectional view of a display control film, according to an example implementation of the present subject matter;

[0010] Fig. 7 illustrates a sectional view of a display control film, according to an example implementation of the present subject matter;

[0011] Fig. 8 illustrates a sectional view of a display device, according to an example implementation of the present subject matter; and

[0012] Fig. 9 illustrates a method of fabricating a display control film, according to an example implementation of the present subject matter.

DETAILED DESCRIPTION

[0013] Electronic devices, for example, laptops, tablets, and smartphones, are often utilized by users for performing activities which involve accessing personal data of users. The accessed data may be displayed on a display screen of a display device associated with the electronic device. The activities that involve accessing of personal data may, for example, include online banking, online trading, insurance, finance, writing exams, accessing medical records, etc. The personal data, displayed on a display screen of a display device, may be sensitive to be viewed by others who are in the vicinity of the display device.

[0014] The display devices generally display contents with wide view angles. A view angle for a display device may be an angle subtended by a direction with respect to a perpendicular to the plane of a display screen of the display device up to which the display from the display screen is visible. With wide view angles, displayed contents are visible almost from all directions in front of the display device. The wide view angles of the display device may affect security of personal data of users. Such data may have to be protected from prying eyes in the vicinity of the display device.

[0015] The present subject matter relates to controlling view angles of displays from display devices to protect and maintain privacy of displayed contents from prying eyes. The present subject matter describes display control films which when affixed on a display screen of a display device enable view angle control for displays from the display screen. The present subject matter also describes display devices which are enabled for view angle control. The present subject matter further describes methods of fabrication of display control films for controlling the view angles.

[0016] In accordance with an example implementation of the present subject matter, a display control film may include a transparent substrate having

a set of protrusions protruding from a face of the transparent substrate. The protrusions of the set are linear structures that are along the same direction and parallel to each other. The display control film includes a graphene coating on each of the protrusions of the set.

[0017] In accordance with an example implementation of the present subject matter, a display control film may include a transparent substrate having two sets of protrusions protruding from a face of the transparent substrate in the form of a matrix of rows and columns of protrusions. The protrusions of a first set are linear structures that are parallel each other. The protrusions of a second set are linear structures that are parallel to each other and perpendicular to the first set of protrusions. Each protrusion of the first set and the second set of protrusions has a graphene coating.

[0018] The display control films of the present subject matter, when pasted or affixed on a display screen of a display device, control or restrict a view angle of displays from the display device. The display control films of the present subject matter having a set of graphene coated protrusions in one direction on a transparent substrate enable a view angle control about an axis along the direction of the set of graphene coated protrusions. Such a view angle control may be referred to as 2-way view angle control. Further, the display control films of the present subject matter having a first set of graphene coated protrusions that are parallel to each other and a second set of graphene coated protrusions that are parallel to each other but perpendicular to the first set enable a view angle control about an axis along the direction of the first set of protrusions and also about an axis along the direction of the second set of protrusions. Such a view angle control may be referred to as 4-way view angle control. It may be noted that to return to the unrestricted view angle of displays, the display control film may have to be removed from the display screen of the display device.

[0019] The following detailed description refers to the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the following description to refer to the same or similar parts. While several examples are described in the description, modifications, adaptations, and other implementations are possible. Accordingly, the following

detailed description does not limit the disclosed examples. Instead, the proper scope of the disclosed examples may be defined by the appended claims.

[0020] Fig. 1 illustrates a sectional view of a display control film 100, according to an example implementation of the present subject matter. The display control film 100 includes a transparent substrate 102. The transparent substrate 102 may be like a thin film of a transparent material. The transparent substrate 102, as shown in Fig. 1, has a set of protrusions 104-1, 104-2, ... , 104-N protruding perpendicularly upwards from a face of the transparent substrate 102. The set of protrusions, collectively referred to as 104, are linear structures along a direction on the transparent substrate 102 and are parallel to each other, as illustrated in a perspective view of the display control film 100 in Fig. 2. The protrusions may hereinafter be referred to as linear protrusions.

[0021] The set of linear protrusions 104 may be preformed on a transparent substrate layer to form the transparent substrate 102. The linear protrusions may, for example, be preformed using a molding process. The linear protrusions may be of the same material as that of the transparent substrate layer. Thus, the transparent substrate 102 with the set of linear protrusions 104 may form a unified structure.

[0022] In an example implementation, the transparent substrate 104 with the set of linear protrusions 104 may be of a thermoplastic plastic material which can be molded. The thermoplastic plastic material may include, but is not restricted to, polycarbonate, cyclic olefin copolymer (COC), polyethylene terephthalate (PET), and polyacrylic, such as poly-methyl methacrylate (PMMA).

[0023] Further, as shown in Fig. 1, the display control film 100 has a graphene coating 106-1, 106-2, ... , 106-N, on each of the linear protrusions of the transparent substrate 102. The graphene coating, collectively referred to as 106, may be a multi-layer graphene coating of a thickness in a range of about 5 nm to about 100 nm. The graphene coating 106 may, for example, be coated using a physical vapour deposition (PVD) process. The graphene coating on the linear protrusions enables controlling the view angle of displays from a display device, when the display control film is pasted on a display screen of the display device.

[0024] In an example implementation, each linear protrusion of the transparent substrate may have a cross-sectional shape of a rectangle, as shown in Fig. 1. Figs. 3(a)-3(b) illustrate example display control films 300 and 310, respectively, having transparent substrates with linear protrusions of different shapes. Fig. 3(a) shows a display control film 300 having a transparent substrate 302 with linear protrusions 304 of triangular cross-sectional shape. The linear protrusions 304 of the transparent substrate 302 are coated with a graphene coating 306. Fig. 3(b) shows a display control film 310 having a transparent substrate 312 with linear protrusions 314 of a cross-sectional shape of a portion of an oval. The linear protrusions 314 of the transparent substrate 312 are coated with a graphene coating 316. In an example implementation, the linear protrusions may have another cross-sectional shape, and is not restricted to the shapes shown herein.

[0025] In an example implementation, each pair of adjacent protrusions of the set of protrusions on the transparent substrate is separated by a distance in a range of about 75 μm to about 300 μm . The smaller the distance between the adjacent pair protrusions, the lower is the maximum limit of the view angle of displays from a display device when the display control film is pasted thereon.

[0026] In an example implementation, each protrusion of the set of protrusions on the transparent substrate has a width in a range of about 5 μm to about 100 μm . It may be noted that the width of a protrusion herein refers to the thickness of the protrusion at an end interfacing with the face of the transparent substrate. The wider the protrusions, the lower is the maximum limit of the view angle of displays from a display device when the display control film is pasted thereon.

[0027] Further, in an example implementation, each protrusion of the set of protrusions on the transparent substrate has a height in a range of about 100 μm to about 375 μm . The taller the protrusions, the lower is the maximum limit of the view angle of displays from a display device when the display control film is pasted thereon.

[0028] Tables 1 and 2 illustrate variations in view angle values for display control films with different heights of protrusions and with different distance

between adjacent protrusions, respectively, according to example implementations of the present subject matter. Table 1 shows that the maximum limit of the view angle reduces with an increase in the height of protrusions. Table 2 shows that the maximum limit of the view angle reduces with an increase in the distance between the adjacent protrusions. It may be noted that for a display control film with the view angle of $\pm 45^\circ$, the display from a display screen having the display control film is visible from directions within 45° on either side of a perpendicular to the display screen and about an axis along the direction of the set of protrusions of the transparent substrate in the display control film.

Table 1

Film #	Distance between adjacent protrusions	Height of protrusions	View angle
1	150 μm	125 μm	$\pm 45^\circ$
2	150 μm	250 μm	$\pm 30^\circ$
3	150 μm	375 μm	$\pm 15^\circ$

Table 2

Film #	Distance between adjacent protrusions	Height of protrusions	View angle
4	300 μm	250 μm	$\pm 45^\circ$
5	150 μm	250 μm	$\pm 30^\circ$
6	75 μm	250 μm	$\pm 15^\circ$

[0029] Further, the set of linear protrusions of the transparent substrate in the display control film may have a variable height. In an example implementation, the set of linear protrusions may have a negative height gradient from an edge of the transparent substrate towards the center of the transparent substrate. Figs. 4(a) illustrates a sectional view of an example display control film 400 including a transparent substrate 402 with a set of linear protrusions 404 having a negative height gradient from an edge of the transparent substrate 402 towards the center of the transparent substrate 402.

In an example implementation, a linear protrusion, of the set 404, at an edge of the transparent substrate 402 has a height in a range of about 100 μm to about 375 μm , and each adjacent linear protrusion, of the set 404, from the edge towards the center of the transparent substrate 402 has a height lower by a value in a range of about 10 μm to about 250 μm . The set of linear protrusions 404 are coated with a graphene coating 406.

[0030] Figs. 4(b) illustrates a sectional view of an example display control film 410 including a transparent substrate 412 with a set of linear protrusions 414 having a negative height gradient from the center of the transparent substrate 412 towards an edge of the transparent substrate 412. In an example implementation, a linear protrusion, of the set 414, at the center of the transparent substrate 412 has a height in a range of about 100 μm to about 375 μm , and each adjacent linear protrusion, of the set 404, from the center towards the edge of the transparent substrate 402 has a height lower by a value in a range of about 10 μm to about 250 μm . The set of linear protrusions 414 are coated with a graphene coating 416.

[0031] It may be noted that although the linear protrusions in Figs 4(a) and 4(b) are shown to have a rectangular cross-sectional shape, in an example implementation, linear protrusions may have a cross-sectional shape of a triangle, a portion of a circle, or a portion of an oval. The width of the protrusions of the sets 404 and 414, and the distance between each pair of adjacent protrusions of the sets 404 and 414 may be in the ranges as described earlier.

[0032] The display control films described above have transparent substrates with one set of linear protrusions that are along one direction and parallel to each other. Such display control films enable 2-way view angle control, i.e., restricting the view angle of displays about an axis along the direction of the set of linear protrusions. In an example, 2-way view angle control can provide privacy of displays when viewed from the left and the right of the display screen, or when viewed from the top and the bottom of the display screen, depending on the orientation of the graphene coated linear protrusions of the display control film on the display screen.

[0033] In an example implementation, a display control film may have a transparent substrate with two sets of linear protrusions in the form of a matrix of rows and columns of linear protrusions in the plane of the transparent substrate. Fig. 5 illustrates a top view of a transparent substrate 500 for such a display control film, according to an example implementation of the present subject matter. The transparent substrate 500 includes a first set of linear protrusions 502 that are along one direction and are parallel to each other. The transparent substrate also includes a second set of linear protrusions 504 that are parallel to each other but are along a direction perpendicular to the direction of the first set of linear protrusions 502. The first set and the second set of linear protrusions 502 and 504 cross-mesh each other. Each of the first set and the second set of linear protrusions 502 and 504 may, individually, be similar to the set of linear protrusions as described above with reference to Figs. 1, 2, 3(a)-3(b), and 4(a)-4(b).

[0034] A display control film having the transparent substrate 500 and a graphene coating (not shown) on the linear protrusions of the transparent substrate 500 enable 4-way view angle control, i.e., restricting the view angle of displays about an axis along the direction of the first set of linear protrusions 502 and about an axis along the direction of the second set of linear protrusions 504. In an example, 4-way view angle control can provide privacy of displays when viewed from either of left, right, top and bottom of the display screen.

[0035] Fig. 6 illustrates a sectional view of a display control film 600, according to an example implementation of the present subject matter. The display control film 600 includes a transparent substrate 602 having linear protrusions 604. The linear protrusions 604 may include one set of linear protrusions along one direction or include two sets of linear protrusions along two directions that are perpendicular to each other. The cross-sectional shape and dimensions of the linear protrusions 604 may be the same as described earlier in accordance with implementations of the present subject matter.

[0036] The display control film 600 includes a graphene coating 606 on each of the linear protrusions 604 of the transparent substrate 602. The display control film 600 also includes an optically clear layer 608 over the transparent

substrate 602. The optically clear layer 608 covers the graphene coating 606 on the linear protrusions 604 and covers a surface of the transparent substrate 602 between the linear protrusions 604. The optically clear layer 608 provides durability to the graphene coating 606.

[0037] In an example implementation, the optically clear layer 608 has a thickness in a range of about 100 μm to about 400 μm . The optically clear layer 608 may be of a material including, but not restricted to, one of polyacrylic, polycarbonate, COC, and polyester. In an example implementation, the optically clear layer 608 may be in the form of a thin film which is laminated on the transparent substrate 602. In an example implementation, the optically clear layer 608 spray coated on the transparent substrate 602 followed by curing using ultraviolet (UV) light.

[0038] Fig. 7 illustrates a sectional view of a display control film 700, according to an example implementation of the present subject matter. The display control film 700 includes the transparent substrate 602 with the linear protrusions 604, the graphene coating 606 on each of the linear protrusions 604, and the optically clear layer 608 covering the graphene coating 606 and the surface of the transparent substrate 602 between the linear protrusions 604, similar to those of the display control film 600.

[0039] The display control film 700 also includes a cover layer 702 over the optically clear layer 608 to provide durability and structural strength to the display control film. The cover layer 702 may be one of a hard transparent layer and a plastic layer. The hard transparent layer may be of a material including, but not restricted to, one of polyacrylic and polycarbonate. The hard transparent layer may be spray coated on the optically clear layer 608 followed by curing using UV light. The hard transparent layer may have a thickness in a range of about 1 μm to about 10 μm . The plastic layer may be of a thickness in a range of about 100 μm to about 500 μm . The plastic layer may be spray coated on the optically clear layer 608.

[0040] In an example implementation, a display control film may be the display control film 600 and having a hard transparent layer on the optically clear layer 608 and a plastic layer on the hard transparent layer.

[0041] Fig. 8 illustrates a sectional view of a display device 800, according to an example implementation of the present subject matter. The display device 800 may be implemented in various ways. For example, the display device 800 may be implemented as monitors for desktop computers, and display units of laptops, mobile phones, tablets, electronic readers, televisions, etc. The display device 800 includes a display screen 802. The display screen 802 may, for example, include an LCD screen, an LED display screen, an organic LED display screen, a polymer LED display screen, a plasma display screen, and such.

[0042] The display device 800 includes a display control film 804 over the display screen 802. The display control film 804 includes a transparent substrate 806 interfacing with the display screen 802. The transparent substrate 806 includes a plurality of protrusions 808 protruding perpendicularly from a face of the transparent substrate 806 away from the display screen 802. The display control film 804 and the plurality of protrusions 808 may be arranged such that each protrusion is either along the length of the display screen 802 or along the breadth of the display screen 802. In an example, the plurality of protrusions 808 may include one set of linear protrusions or include two sets of linear protrusions as described earlier. The cross-sectional shape and dimensions of the plurality of protrusions 808 may be the same as described earlier, in accordance with implementations of the present subject matter.

[0043] The display control film 804 includes a graphene coating 810 on each of the plurality of protrusions 808. The graphene coating 810 may be of a thickness in a range of about 5 nm to about 100 nm. The display control film 804 also includes an optically clear layer 812 over the transparent substrate 806, such the optically clear layer 812 covers the graphene coating 810 on the plurality of protrusions 808 and covers a surface of the transparent substrate 806 between the plurality of protrusions 808. In an example implementation, the optically clear layer 812 may be the same as described earlier with reference to Fig. 6.

[0044] In an example implementation, the display control film 806 may also include a cover layer (not shown) over the optically clear layer 812 to provide

durability and structural strength to the display control film. The cover layer may be one of a hard transparent layer and a plastic layer as described earlier with reference to Fig. 7. In an example implementation, the display control film 806 may include a hard transparent layer on the optically clear layer 812 and a plastic layer on the hard transparent layer.

[0045] It may be noted that the display control film 806 has to be affixed on the display screen 802 of the display device 800 to enable view angle control of displays from the display screen 802 in accordance with the present subject matter. In an example implementation, the display control film 806 may be pasted on the display screen 802 using silicon rubber, such that the display control film 806 is detachable from the display screen 802. In an example implementation, the display control film 806 may be permanently pasted on the display screen 802 using a UV curable adhesive. The UV curable adhesive may include, but is not restricted to, an isocyanate based polymer, epoxy, acrylic, hot melt adhesive, ethylene-vinyl acetate copolymer, polyamide, polyolefin, styrene copolymer, polyester, and polyurethane.

[0046] In an example implementation, the display control film 806 may include one set of graphene coated protrusions that are in one direction. The display control film 806 can be pasted on the display screen 802, such that the graphene coated protrusions are positioned row-wise or column-wise on the display screen 802. If the graphene coated protrusions are positioned column-wise on the display screen 802, the view angle of displays is restricted when viewed from the left and the right of the display screen 802. If the graphene coated protrusions are positioned row-wise on the display screen 802, the view angle of displays is restricted when viewed from the top and the bottom of the display screen 802.

[0047] In an example implementation, the display control film 806 may include two sets of graphene coated protrusions arranged along direction perpendicular to each other. The display control film 806 can be pasted on the display screen 802, such that the graphene coated protrusions are positioned row-wise and column-wise on the display screen 802. With such an

arrangement, the view angle of displays is restricted when viewed from the left, the right, the top, and the bottom, of the display screen 802.

[0048] Fig. 9 illustrates a method 900 of fabricating a display control film, according to an example implementation of the present subject matter. For fabricating the display control film, a transparent substrate having a plurality of linear protrusions is prepared. The transparent substrate may be prepared by a molding a transparent thermoplastic plastic material. The transparent thermoplastic plastic material may be poured in a mold having linear channels of a suitable shape that lead to formation of the plurality of linear protrusions. The linear channels may be along one direction and parallel to each other to obtain a transparent substrate with one set of linear protrusions. The linear channels may be along two directions perpendicular to each other in the form of a cross-mesh to obtain a transparent substrate with two sets of linear protrusions as described earlier.

[0049] At block 902, a detachable film is pasted on a face of the transparent substrate having the plurality of linear protrusions. The detachable film is pasted such that the linear protrusions pass through the detachable film and the detachable film couples with a surface of the transparent substrate between the plurality of linear protrusions. The detachable film may be of silicon rubber and of a thickness in a range of about 3 μm to about 30 μm . For pasting the detachable film, the transparent substrate may be maintained at a temperature higher than that of the detachable film. The higher temperature of the transparent substrate enables passing of the linear protrusions through the detachable film.

[0050] At block 904, a graphene coat is deposited on the detachable film and the plurality of linear protrusions of the transparent substrate. The graphene coat may be deposited through a PVD process at a pressure of about 10 mTorr and a temperature in a range of about 80 $^{\circ}\text{C}$ to about 150 $^{\circ}\text{C}$ maintained for 7 to 10 minutes.

[0051] After the graphene coat is deposited, the detachable film is removed, at block 906. By removing the detachable film, the display control film with the transparent substrate having graphene coat on the linear protrusions is

obtained. Surfaces of the transparent substrate between the linear protrusions and surrounding the linear protrusions have no graphene coating.

[0052] In an example implementation, an optically clear layer may be provided on the transparent substrate, such that the optically clear layer covers the graphene coat on the linear protrusions and covers the surface of the transparent substrate between the linear protrusions. The optically clear layer may be laminated on the transparent substrate or spray or slit coated on the transparent substrate. If spray or slit coated, the optically clear layer is cured using UV light of energy in a range of about 600 mJ to about 1000 mJ and a temperature in a range of about 50 °C to about 55 °C for about 10 minutes.

[0053] Further, in an example implementation, a hard transparent layer or a plastic layer may be coated as a cover layer of the optically clear layer. The hard transparent layer or the plastic layer may be spray coated in the optically clear layer. The hard transparent layer may be made of polyacrylic or polycarbonate, and cured using UV light of energy in a range of about 750 mJ to about 950 mJ and a temperature in a range of about 50 °C to about 55 °C for about 8 to 12 minutes.

[0054] Although implementations for display control films, display devices, and methods of fabrication of display control films have been described in language specific to structural and functional features, it is to be understood that the present subject matter is not limited to the specific features described. Rather, the specific features are disclosed and explained as example implementations for display control films, display devices, and methods of fabrication of display control films.

We claim:

1. A display control film for a display device, comprising:
 - a transparent substrate including a first set of linear protrusions protruding from a face of the transparent substrate, the first set of linear protrusions being parallel to each other; and
 - a graphene coating on each linear protrusion of the first set to control a view angle of a display from the display device.
2. The display control film as claimed in claim 1, further comprising an optically clear layer over the transparent substrate, wherein the optically clear layer covers the graphene coating on the first set of linear protrusions and a surface of the transparent substrate between linear protrusions of the first set.
3. The display control film as claimed in claim 2, further comprising a cover layer over the optically clear layer, wherein the cover layer is one of a hard transparent layer and a plastic layer.
4. The display control film as claimed in claim 1, wherein the transparent substrate includes a second set of linear protrusions protruding from the face of the transparent substrate, the second set of linear protrusions being parallel to each other and perpendicular to the first set of linear protrusions, and the display control film includes a graphene coating on each protrusion of the second set to control a view angle of the display from the display device.
5. A display device comprising:
 - a display screen; and
 - a display control film over the display screen, the display control film comprising:
 - a transparent substrate interfacing with the display screen, the transparent substrate including a plurality of protrusions protruding from a face of the transparent substrate away from the display screen,

each of the plurality of protrusions is along one of length and breadth of the display screen;

a graphene coating on each of the plurality of protrusions to control a view angle of a display from the display screen; and

an optically clear layer over the transparent substrate, the optically clear layer covering the graphene coating on the plurality of protrusions and covering a surface of the transparent substrate between the plurality of protrusions.

6. The display device as claimed in claim 5, wherein the graphene coating has a thickness in a range of about 5 nm to about 100 nm.

7. The display device as claimed in claim 5, wherein each of the plurality of protrusions has a height in a range of about 100 μm to about 375 μm .

8. The display device as claimed in claim 5, wherein the plurality of protrusions has a negative height gradient from an edge of the transparent substrate towards center of the transparent substrate.

9. The display device as claimed in claim 5, wherein the plurality of protrusions has a negative height gradient from center of the transparent substrate towards an edge of the transparent substrate.

10. The display device as claimed in claim 5, wherein each pair of adjacent protrusions of the plurality of protrusions is separated by a distance in a range of about 75 μm to about 300 μm .

11. The display device as claimed in claim 5, wherein each protrusion of the plurality of protrusions has a width, at an end interfacing with the face of the transparent substrate, in a range of about 5 μm to about 100 μm .

12. The display device as claimed in claim 5, wherein the plurality of protrusions is in the form of a matrix comprising rows and columns of protrusions.

13. The display device as claimed in claim 5, further comprising a cover layer over the optically clear layer, wherein the cover layer is one of a hard transparent layer and a plastic layer.

14. A method of fabricating a display control film, the method comprising:

pasting a detachable film on a face of a transparent substrate having a plurality of linear protrusions, the pasting is such that the plurality of linear protrusions pass through the detachable film and the detachable film couples with a surface of the transparent substrate between the plurality of linear protrusions;

depositing a graphene coat on the detachable film and the plurality of linear protrusions; and

removing the detachable film.

15. The method as claimed in claim 14, comprising:

providing an optically clear layer on the transparent substrate, the optically clear layer covering the graphene coat on the plurality of linear protrusions and the surface of the transparent substrate between the plurality of linear protrusions.

1/9

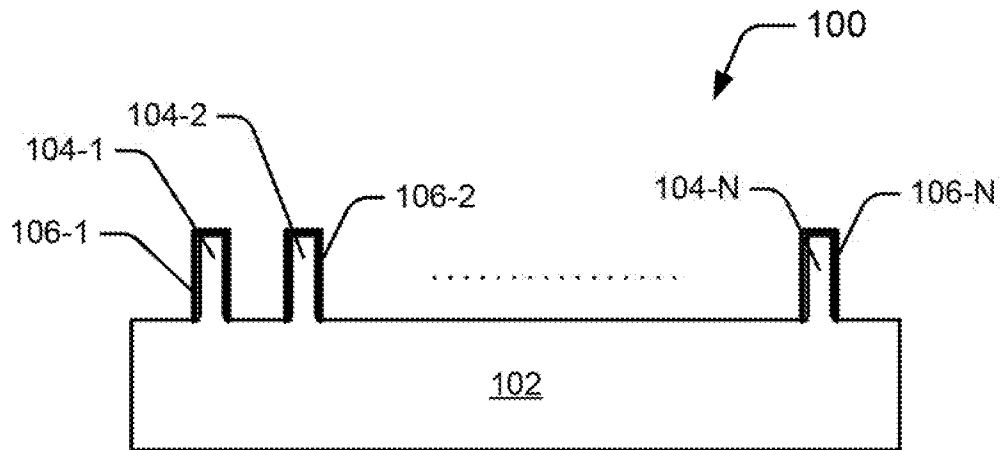


Fig. 1

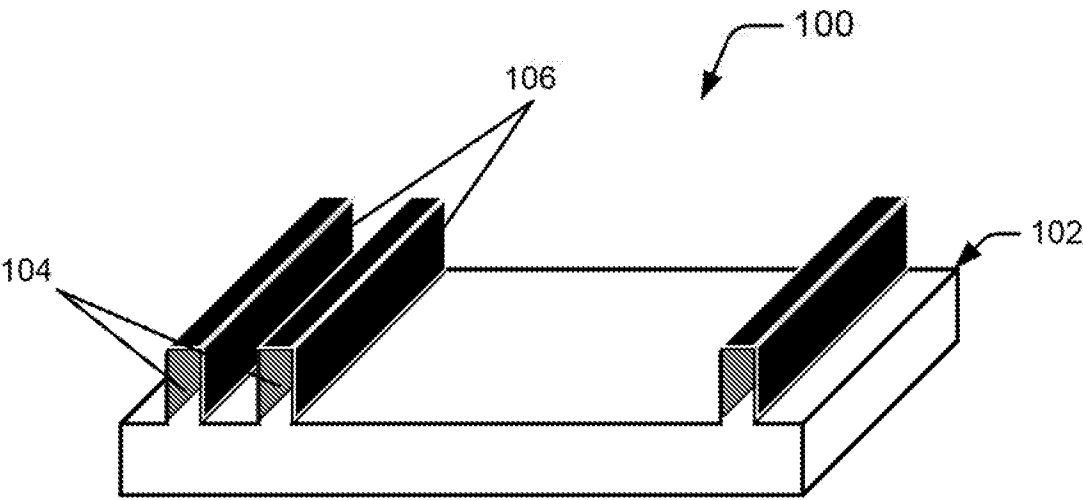


Fig. 2

3/9

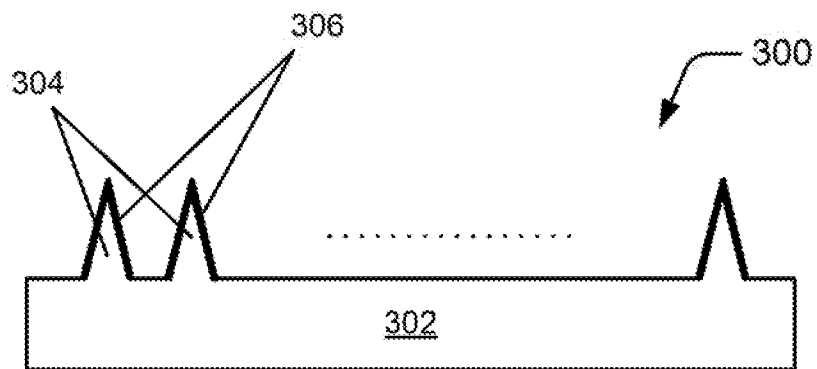


Fig. 3(a)

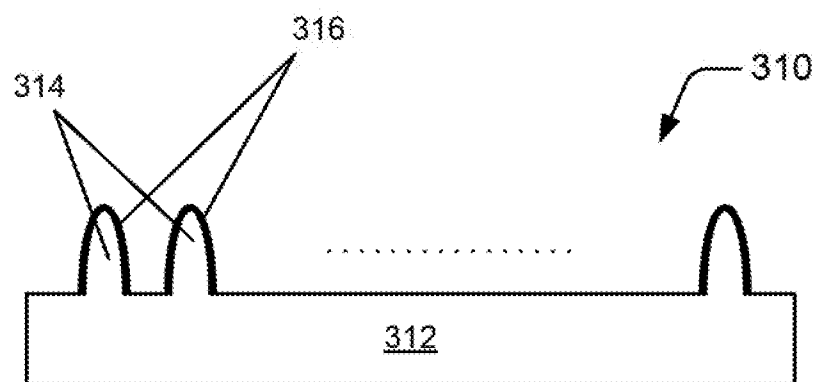


Fig. 3(b)

4/9

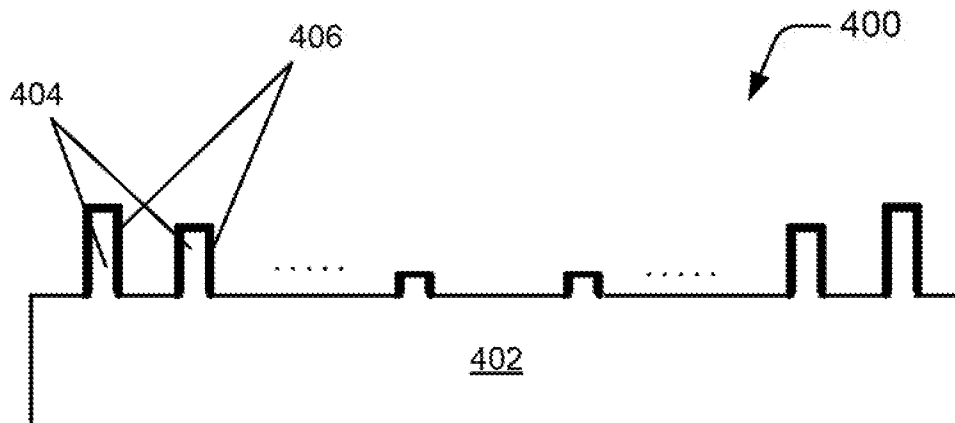


Fig. 4(a)

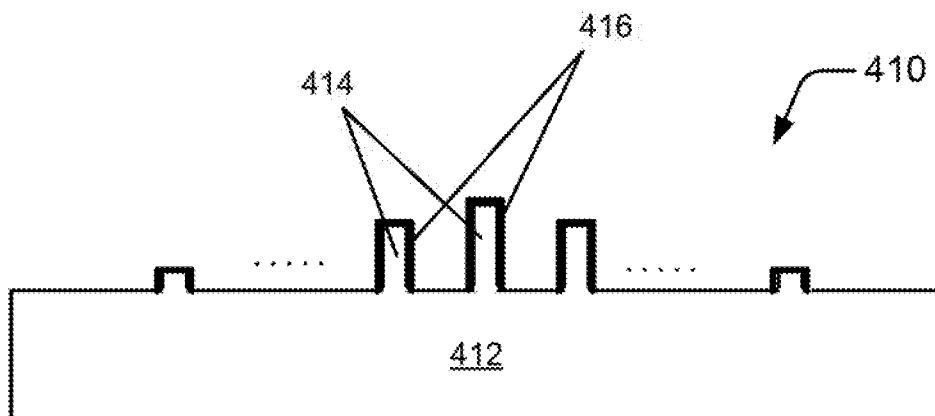


Fig. 4(b)

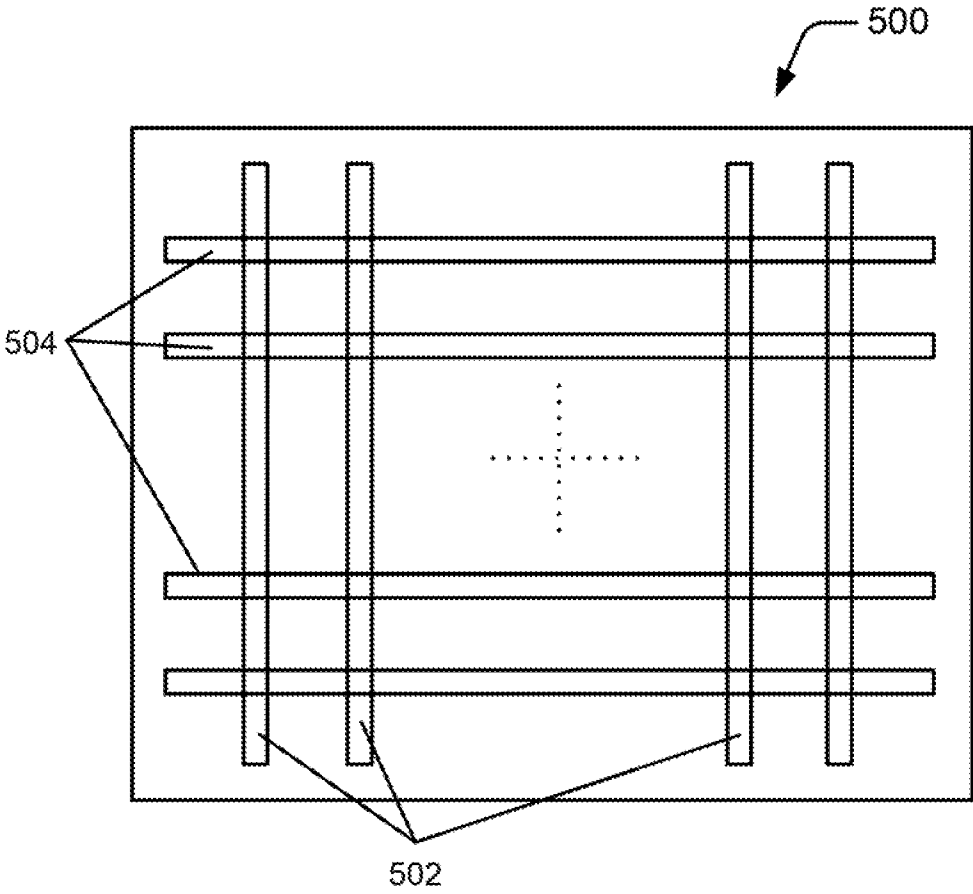


Fig. 5

6/9

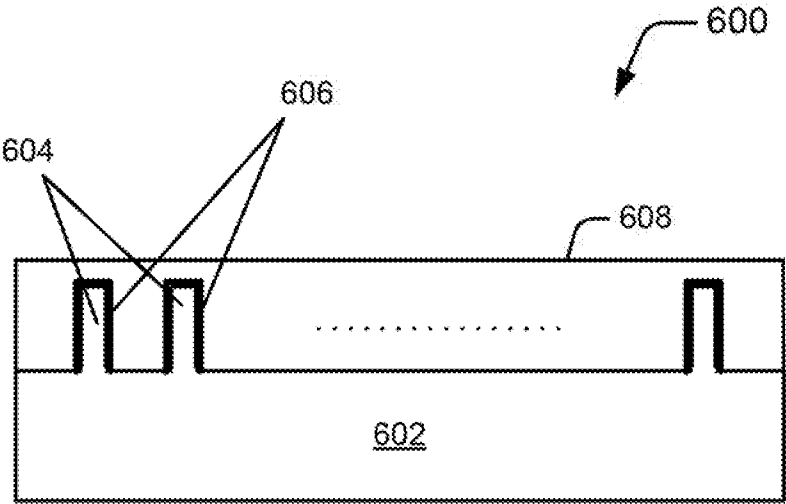


Fig. 6

7/9

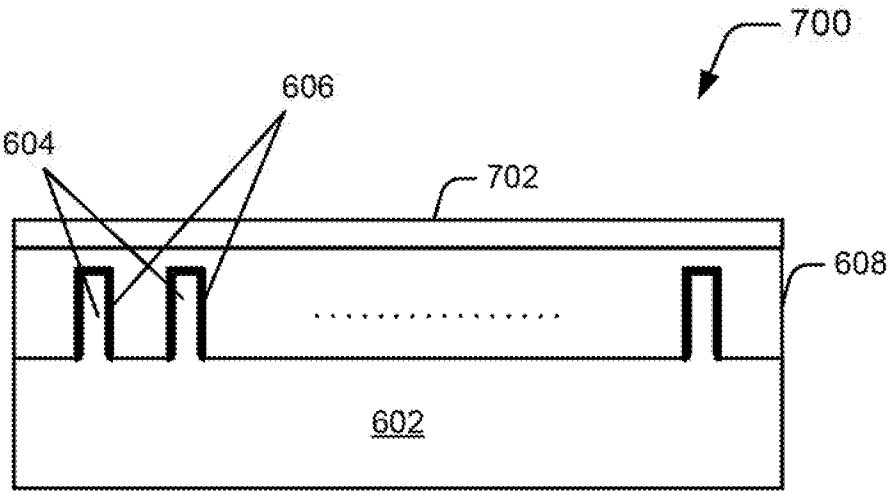


Fig. 7

8/9

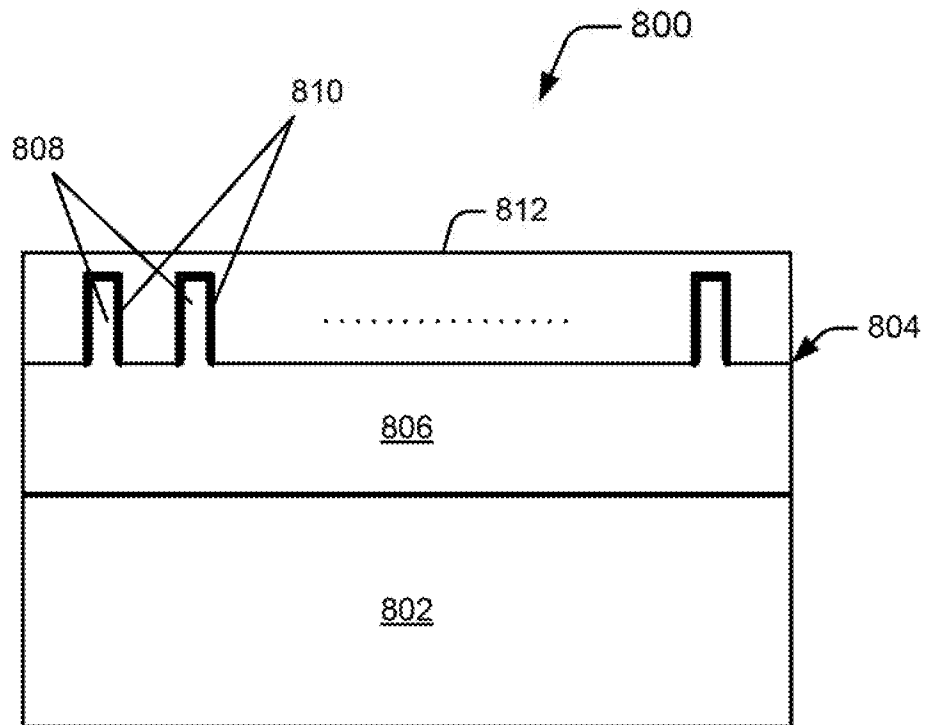
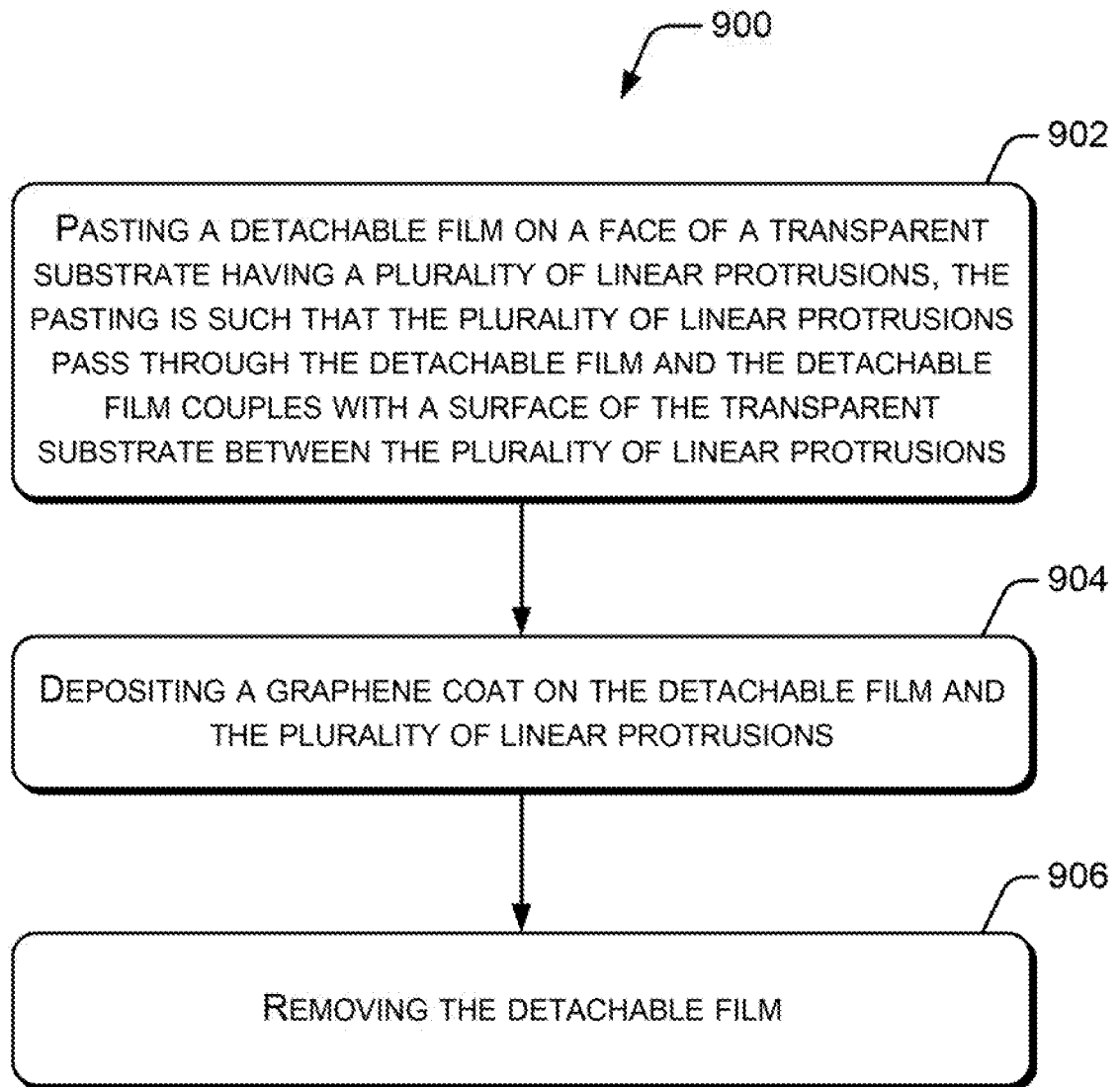


Fig. 8

9/9

**Fig. 9**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2016/055597

A. CLASSIFICATION OF SUBJECT MATTER		G02B 5/22 (2006.01) B32B 3/30 (2006.01) B32B 38/18 (2006.01) B82Y 30/00 (2011.01)	
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)			
B32B 3/00-3/30, 37/00-37/30, 38/00-38/18, G02B 5/00-5/32, G02F 1/00-1/39, B82Y 30/00			
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			
C. DOCUMENTS CONSIDERED TO BE RELEVANT			
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	
Y	US 2016/0011411 A1 (BOE TECHNOLOGY GROUP CO., LTD.) 14.01.2016, [0003], [0005], [0046], [0047], [0052], fig. 1-5	1-15	
Y	ANGUITA Jose V. et al. Graphene 'moth eyes' to power future smart technologies. SPIE, Newsroom, 18 July 2016 [online] [retrieved on 2017-07-05]. Retrieved from the Internet: <URL: http://spie.org/newsroom/6459-graphene-moth-eyes-to-power-future-smart-technologies , abstract, p. 1, col. 2, p. 2, col. 2, fig. 2	1-13	
Y	US 2011/0311722 A1 (SADEG M. FARIS) 22.12.2011, abstract, [0100], [0136]	14, 15	
Y	CN 203644041 U (YUE FANEN) 11.06.2014, fig. 1, [0056]-[0059]	4	
Y	CN 202357548 U (SHANGHAI EVERBRIGHT HIGH TECHNOLOGY CO LTD) 01.08.2012, [0025]	7, 10, 11	
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.			
* Special categories of cited documents:	"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 "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 "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		Date of mailing of the international search report	
05 July 2017 (05.07.2017)		14 August 2017 (14.08.2017)	
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 R. Artemiev Telephone No. 8-499-240-25-91	

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2016/055597

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2010/102643 A1 (MAXPLANCK-GESELLSCHAFT ZUR FORDERUNG DER WISSENSCHAFTEN et al.) 16.09.2010, p. 7, line 33-p. 8, line 35	8, 9
Y	CN 104730601 A (XIAMEN XICHENG TECHNOLOGY CO LTD) 24.06.2015, abstract, fig. 1	12