A METHOD OF MAKING AN ELECTRONIC APPARATUS INCORPORATING A CONTOURED FUNCTIONAL FILM

FIELD OF THE INVENTION

[0001] The present invention relates generally to forming contoured functional films, and more particularly to a method of making a contoured functional film and an electronic apparatus having a 3-dimensional shape and incorporating a contoured functional film.

BACKGROUND

[0002] Electronic interfaces are commonly used in a wide range of applications from consumer products including computer systems, game consoles, electrical appliances, in-vehicle systems including automotive consoles or central stacks and wheel mounted controls, portable devices including audio devices, multimedia players, cellular phones or the like, to industrial control consoles, switches, or the like. While mechanical buttons, switches, contacts and the like have typically been used in connection with conventional electronic input devices, there has been a shift away from the use of mechanical buttons, switches and the like toward low activation pressure technologies such as touch sensitive switches. Integrating touch sensor technologies into input devices in connection with products such as touch panels, touch screens, and capacitive keypads and the like has increased due to the development in capacitive sensing technologies. Such technologies generally locate the area of touch sensitivity within the bounds of a flat region on a panel of a device such as a display or the like, which can be glass, plastic, film or the like, and is often located over a display.

[0003] It will be appreciated however that, while advantages can be gained by the use of touch sensitive controls on computer screens and flat panel input areas, certain limitations exist for integrating touch sensitive technology into molded articles. Currently, regardless of the desired shape of the device, the design is predominated by the need for a flat area into which or onto which a touch sensitive input device can be mounted. The electronics and plastic parts

are generally then assembled to form a product requiring multiple steps of subassembly integration, test, final assembly, final test and the like. Touch sensitive areas are required to be flat because there are generally no known touch sensor switches and or other film based technology that can be readily integrated into a shaped structure having contours within the touch sensitive areas.

[0004] In recent years, due to the development of better printing methodologies and inks with special functions such as conductive inks, and the like, in mold labeling (IML) processes have been used to manufacture touch sensor devices and lighting devices which make use of electroluminescent (EL) technologies in connection with film articles. Further, IML process has been used to incorporate elements such as a switches and the like into film articles. After the IML process is completed and a film article is produced, the printed film articles can be further subjected to molding processes including: injection molding or thermoforming processes.

[0005] For example, in-molded resistive and shielded elements are disclosed in International Application Publication Number WO 2009/128856, while an in-molded capacitive switch is disclosed in International Application Publication Number WO 2008/131305 A1 to Haag, et al. While Haag describes various configurations in which films using conductive inks can be formed, the problem of cracking during formation is acknowledged and vacuum or pressure forming are described as being suitable to avoid cracking provided that process parameters are adjusted to avoid cracking or stretching. While Haag describes manufacturing variables such as cycle times, temperatures, vacuums or pressures that can be adjusted to ensure that inks do not crack during forming, there is no specific description in Haag regarding what variables associated with the ink can be address to avoid cracking regardless of the manufacturing process. Still further, the forming in Haag is described in connection with contoured regions, that notably avoid spanning across sensing zones so as to avoid subjecting the inks within the sensing zones to the acknowledged problems associated with cracking and the like.

[0006] Still further, while capacitive switches and EL lighting materials have been used in electronic devices, integrating known touch sensitive elements and EL lighting into film structures has posed challenges, although conventional IML capacitive touch panels are available in 2-dimensional form. FIG. 1 shows an assembly of parts that make up a prior art touch panel 100. In particular, touch panel 100 can include a formable film 105, a graphic layer 104, and a plurality of layers 101, 102, 103. The plurality of layers 101, 102, 103 may consist of conductive ink printed on the graphic layer 104 to form a touch sensor zone. However, layers formed from such conductive inks are generally brittle and are susceptible to cracking during forming processes as is acknowledged in the art.

[0007] Therefore, in view of the above described and other disadvantages associated with the prior art, it would be desirable to provide a shaped film that can be used in touch sensor and lighting applications. Such a shaped film could be formed in conventional forming tools without undue consideration to manufacturing variables such as temperature or pressure and could be suitable for further molding and additional surface treatments or the like.

SUMMARY OF THE INVENTION

[0008] According to an embodiment, a method is provided for manufacturing a shaped film. A functional ink layer can be applied on one of a plurality of film layers. The functional ink layer has an associated function. The functional ink layer and the plurality of film layers can be formed into a 3-dimensional shape having a contoured portion. An "acceptable" value of the conductivity can be advantageously maintained in the contoured portion after the forming, unlike the prior art, wherein bending of a functional layer in a contoured portion would lead to cracking or the like. This "acceptable" value of the conductivity is one that allows the functional ink layer to still perform its function even after the forming into a contoured portion.

[0009] In an embodiment, the functional ink layer is a conductive ink layer which is printed and cured to form a touch sensor layer and the function of the functional ink layer is to detect a change in capacitance when a conductive object comes into contact with it.

[0010] In an embodiment, the functional ink layer is an EL ink layer and the function of the functional ink layer is to emit light.

[0011] In an embodiment, the functional ink layer is a conductive ink layer which is printed and cured to form a touch sensor layer. An EL layer is printed and cured on one of the film layers. A dielectric layer is also applied and cured on one the film layers such that the dielectric layer separates the touch sensor layer from the EL layer. A transmissivity of the conductive ink can be set so as to allow a quantity of light from the EL layer to pass through.

[0012] In an embodiment, a surface characteristic can be applied to one of an outer surface and an inner surface of the 3-dimensional shape. The surface characteristic can include an antimicrobial characteristic, an oleo-phobic characteristic, a hydrophobic characteristic, or the like.

[0013] In an embodiment, a process for manufacturing a molded electronic article is provided. A plurality of film layers can be formed, including a functional ink layer applied on one of the plurality of film layers. The functional ink layer has an associated function. The article can be formed into a 3-dimensional shape that can have a curvature after forming, such as a non-zero curvature or a not substantially flat curvature. The plurality of film layers including the functional ink layer can then be inserted into an injection mold whereupon plastic resin can be injected over the functional ink and the plurality of film layers so as to form a molded plastic layer over the film layers. The functional ink layer in the contoured portion retains a level of conductivity such that the function can still be performed after the forming and the injection mold process.

[0014] In an embodiment, a multilayer film can be provided for forming into a 3-dimensional shape. The exemplary multilayer film can comprise a thermoplastic substrate, and a functional ink layer. The functional ink layer has an associated function. After the film is formed into a 3-dimensional shape with a contoured portion, the functional ink layer in the contoured portion retains a level of conductivity such that the function can still be performed.

[0015] In an embodiment, the functional ink layer on the multilayer film is a conductive ink layer which is printed and cured to form a touch sensor layer. The touch sensor layer comprises electrodes which are printed with PEDOT ink.

[0016] In another embodiment, an electronic apparatus can be provided having a 3-dimensional shape and can comprise a molded panel having a functional ink layer on a film layer. The functional ink layer has an associated function. The molded panel has a contoured portion. A connector assembly is configured to connect the functional ink layer to a printed circuit board. The functional ink layer in the contoured portion has a level of conductivity such that the function can be performed.

[0017] In an embodiment, a surface characteristic on the electronic apparatus can be applied by a film application or a spray application or a mixture integration application.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] In order that embodiments of the invention may be fully and more clearly understood by way of non-limitative examples, the following description is taken in conjunction with the accompanying drawings in which like reference numerals designate similar or corresponding elements, regions and portions, and in which:

[0019] FIG. 1 is a diagram illustrating a prior art touch panel;

[0020] FIG. 2A is a diagram illustrating a touch panel assembly having a 3-dimensional shape;

[0021] FIG. 2B is a diagram illustrating a part cut-out view of the touch panel assembly;

[0022] FIG. 2C is a diagram illustrating a cross-sectional view of the touch panel assembly;

[0023] FIG. 2D is a diagram illustrating an exploded view of the touch panel assembly having the various layers;

[0024] FIG. 2E is a diagram illustrating a perspective view of the touch panel assembly;

[0025] FIG. 3A is a diagram illustrating a perspective view of an electronic apparatus;

[0026] FIG. 3B is a diagram illustrating a perspective view of an electronic apparatus;

[0027] FIG. 4 is a diagram illustrating an exploded view of an electroluminescent layer;

[0028] FIG. 5 is a diagram illustrating an exploded view of an electronic apparatus in accordance with one or more embodiments;

[0029] FIG. 6 is a diagram illustrating an exploded view of a connector assembly;

[0030] FIG. 7A is a diagram illustrating an exploded view of an electronic apparatus in accordance with one or more embodiments including an electroluminescent layer and a touch sensor layer;

[0031] FIG. 7B is a diagram illustrating an exploded view of an electronic apparatus in accordance with one or more embodiments including a touch sensor layer;

[0032] FIG. 7C is a diagram illustrating an exploded view of an electronic apparatus in accordance with one or more embodiments including an electroluminescent layer;

[0033] FIG. 8 is a flow chart illustrating a process for manufacturing a 3-dimensional shaped film;

[0034] FIG. 9 is a flow chart illustrating an injection molding process for manufacturing a molded electronic article;

[0035] FIG. 10 is a flow chart illustrating a double molding process for manufacturing a molded electronic article.

DETAILED DESCRIPTION

[0036] While exemplary embodiments pertaining to the invention have been described and illustrated, it will be understood by those skilled in the technology concerned that many variations or modifications involving particular design, implementation or construction are possible and may be made without deviating from the inventive concepts described herein.

[0037] In accordance with embodiments discussed and described herein, true 3-D molded articles can be made, including contours that span sensitive areas unlike prior art processes that, while purporting to provide contoured articles, provide articles that are necessarily flat in areas where conductive ink constituting sensitive zones, such as touch sensitive zones are present. FIG. 2A illustrates a molded touch panel assembly 200 according to an embodiment. The touch panel assembly 200 includes a molded panel 201 having a functional ink layer 202, such as a conductive ink layer or the like as will be described in greater detail hereinafter. The functional ink layer 202 can be constituted of an ink configured so as to allow additional flexibility and workability while maintaining characteristics such conductive continuity and, for example, uniform resistivity. IML processes commonly used for printing decorative designs on an exterior surface can be used to apply the functional ink layer 202, such as by a printing process or the like. After the IML process for applying the functional ink layer 202 is completed, the functional ink layer 202 can be formed and otherwise worked, such as molded into the molded panel 201 to form the touch panel assembly 200. Forming of the functional ink layer 202 can include forming the film layer onto which functional ink, such as conductive ink, is printed.

[0038] It should be noted that initial forming can refer to processes that are used to shape the initial films and can include processes such as high pressure forming, thermoforming and the like. The formed articles can then be subject to additional molding such as injection molding and processes that can be used to cover substantially the formed films into a more conventional plastic package, while leaving, for example, connector areas that require exposure to touching in order to be operative, exposed or un-encapsulated. It will be appreciated that by integrating the IML process, total production costs can be advantageously reduced.

[0039] FIG. 2B shows a cut-away section of the touch panel assembly 200 of FIG. 2A. In an embodiment, the functional ink layer 202 can be printed with a plurality of electrodes 203, and a plurality of traces 204 connecting the electrodes 203 to form an electrical circuit. The functional ink layer 202 can be a touch sensor layer and/or EL layer. The functional ink on the functional ink layer 202 has an ink material characteristic which can be set by controlling an admixture of the ink and one or more additional constituents according to a specific ratio or ratios, so as to enable the functional ink layer to be shaped while maintaining an acceptable level of conductivity after the forming. If the functional ink layer is a touch sensor layer, this acceptable level of conductivity is a range in which the touch sensor retains its touch sensitive capability. If the functional ink layer is an EL layer, this acceptable level of conductivity is a range in which the EL layer can emit light. The ink material characteristic can be for example, viscosity of the functional ink or the composition of metal in the functional ink.

[0040] In one embodiment, the ink material characteristic can be set using a polymer material. The electrical circuit can have a connector for connection to a printed circuit board assembly. The electrical circuit can have a functional area which includes a touch sensitive function and/or lighting function. FIG. 2C shows a sectional view A-A from FIG. 2B, where the touch panel assembly 200 can include a film 205, a decorative layer 206 printed on the film 205, a functional ink layer 202 which can be a touch sensor layer 207 and/or

an EL layer 208. The touch sensor layer 207 can be configured and applied as an electrical circuit that includes, for example, capacitive switches capable of detecting a change in capacitance when an object such as a finger comes into contact or proximity thereto. Such a switch can perform functions of a mechanical switch such as a rotary switch, a slider switch, a push button switch, or the like, with greatly reduced friction and the elimination of moving parts, which can become an expensive liability. Such touch sensor switches can be widely used in home appliances, such as in touch panels for dishwashers, washing machines, coffee makers, and the like, photocopiers, space heaters, audio systems, and the like, portable devices such as Ipods, mobile phones, and the like, and automotive electronics systems such as audio systems, and controls located, for example within the central stack. In particular, the functional ink layer 202 (i.e. the touch sensor layer 207 and/or the electroluminescent layer 208) can be advantageously configured to be formed into a three-dimensional shape, including contours that span sensing zones, without cracking or otherwise losing its electrical integrity for the purposes of touch sensor, emitting light or the like.

[0041] To better illustrate contours spanning sensing zones, FIG. 2D shows an exploded view of a touch panel assembly 200 having a 3-dimensional shape. The touch panel assembly 200 has a thermoplastic substrate 209, a film 205 and a functional ink layer 202 on the thermoplastic substrate 209. The functional ink layer 202 can be configured with a material property such an elasticity, or a concentration of conductive particles within an ink matrix or a combination of material properties that can be used to control a characteristic such as an electrical conductivity, including continuity, resistivity or a uniformity of a resistivity per unit area. The material property can be set so as to enable the functional ink layer to be formed, including forming contours that span the sensing zone, without substantially altering the conductivity or maintaining an acceptable level of conductivity during the forming into the 3-dimensional shape. This acceptable level of conductivity is a range in which the touch sensor retains its touch sensitive capability.

[0042] It should be noted that, while the thermoplastic substrate 209 can include decorative graphics 210 printed on the film 205, the functional ink layer 202 can also be printed directly on the film 205. In some instances, the electrodes 203 are printed with PEDOT ink, such that they are transparent, and with conductive ink. The traces 204 are not transparent.

[0043] FIG. 2E illustrates the curvature of the touch panel assembly 200.

[0044] To better understand how various layers can be combined to form a functional article, FIG. 3A illustrates an electronic apparatus 300 having a 3-dimensional shape according to an embodiment. The electronic apparatus 300 has a molded panel 301 including a functional ink layer, which is not directly shown, on a film layer 302. The functional ink layer can be molded so as to have a functional area or a plurality of functional areas 303, 306. The functional areas 303, 306 may be spanned by a contoured portion associated with the 3-dimensional shape. Each of the functional areas 303 and 306 can include a backlighting area 304 and a graphic indicia 305. The film layer 302 may be formed by printing a decorative ink layer on a plastic film substrate. A material of the plastic film substrate may be a material suitable for molding processes, such as for example thermoplastic materials including polycarbonate, polyester, and the like. In-mold decorative inks can be used in the printing of the decorative ink layer.

[0045] In addition to various aspects associate with contoured functional ink layers, as described hereinabove, various embodiments are possible that contemplate the ability to provide for a functional surface layer. In, particular, as shown in FIG. 3B, the electronic apparatus 300 can be provided with a surface characteristic of a surface 307 in accordance with different applications such as anti-microbial, and the like. For example, the surface characteristic may be configured or modified by applying an independent film layer such as for example, through a spray application, film application and bonding, or by

integrating a chemical characteristic into the material itself as an admixture, on a molecular level, or by applying material inside the mold cavity or thermoforming equipment that can be used to infuse a chemical, such as an antimicrobial agent, hydrophilic or hydrophobic agent, or the like, into the material during forming.

[0046] A layer of material 311 may be applied on the surface 307 such as by spraying or the like, as shown in view 308, may be embedded within the surface 307 for example in a molecular infusion, as shown in view 309, or can be applied as a separate integrated film layer on the surface 307 as shown in view 310. Various modifications will be apparent to those skilled in the art. For example, instead of a spray application, an agent may be mixed into the resin that is used in the injection molding process of the electronic apparatus 300. Alternatively, the surface characteristic can be associated with a material characteristic of the independent film layer.

[0047] The above described functional surface layer can further include an anti-fingerprint property, an oleophobic property or the like, through surface modification. By treating the surface 307 of the electronic apparatus 300, such as by applying an oleophobic chemical, additional properties can be realized. For example, a coating can be used to create a hard surface on the electronic apparatus 300 thus increasing resistance to wear, scratches, and the like.

[0048] In some examples, as described, the surface 307 of the electronic apparatus 300 can be coated with a layer of antimicrobial agent. An agent, such as a silver based agent, a zinc pyrithione based agent, or the like can be applied so as to kill microbes, fungus, bacteria, or the like, greatly reducing the risk of cross contamination or infections for articles that are handled by multiple users. An antimicrobial effect can be achieved on the surface on the electronic apparatus 300 by mixing the antimicrobial agent into the resin used in the injection molding process of the electronic apparatus 300 or earlier in the manufacturing process by integrating the agent into films and the like. The surface can be further treated for easy cleaning by coating the surface 307 with a layer of

hydrophobic materials like perfluorinated polyether (PFPE) or the like. Hydrophobic surface characteristics cause water to easily roll off the surface of the article and by doing so carries away the dirt and other contaminant from the apparatus 300 surface.

[0049] It will be understood that in accordance with embodiments discussed and described herein, many different layers can be incorporated into a film that can be formed or molded. Various layers such as those enumerated in FIG. 4, which show an EL layer 400, can be formed into a 3-dimensional shape to be used in manufacturing of electronic products as described herein. The EL layer 400 can be configured with a conductive shielding layer 401, a dielectric ink layer 402, a transparent conductive ink layer 403, a phosphorous ink layer 404, an additional dielectric ink layers 405 and 406, a second conductive ink layer 407, and an additional dielectric ink layer 408. In accordance with the embodiments, an exemplary EL layer can be made up of at least 5 different ones of the functional ink layers illustrated in FIG. 4. An exemplary EL function can be achieved using, for example, the conductive shielding layer 401, the transparent conductive ink layer 403, the phosphorous ink layer 404, the dielectric ink layer 405 and/or 406 and the second conductive ink layer 407.

[0050] By configuring the layers as shown and described, the phosphorous ink layer 404 is sandwiched between the conductive ink layer 403 and the dielectric ink layer or layers 405 and 406, which, acting as electrodes cause the phosphorous ink layer 404 to release light when an oscillating current is applied. Still further, the conductive shielding layer 401, the dielectric ink layer 402, and the transparent conductive ink layer 403 can be configured to form an EL layer. An exemplary touch sensor layer can be further configured with electrodes and traces printed using conductive inks, such as silver conductive ink, PEDOT conductive ink, and the like. The conductive electrodes so formed, can act as a sensing zone whereby, for example, as in the case of capacitive touch sensor, an electric field can be applied there across that will experience a charge capacitance change when a finger for example is placed in the range of the electric field or in

direct contact with the sensing zone. The change in electric field will then be detected and interpreted by a micro-processor.

[0051] The high transmissivity of the transparent conductive ink layer will allow light from the EL layer to pass through the plastic films and provide a visible indication to a user, while the various dielectric layers separate the functional layers and prevent any short circuits between differently charged layers. It will be appreciated that the shielding conductive layer is printed with a transparent conductive ink that will not impair the transmissivity of light produced by the EL layer and yet shield the electrical field generated by the EL layer so as to prevent electric field interference being induced into the capacitive sensing zone.

[0052] The phosphorous ink layer can be printed with any phosphor material like zinc sulphide or the like, that will release light when an electrical current is applied. The dielectric layer is printed with any dielectric ink that is compatible with EL application. The silver conductive ink layer acts as the second or back electrode for the EL layer used for the conducting of electricity. The dielectric layer is printed over the silver conductive ink layer to protect the silver circuitry during injection molding and handling.

[0053] FIG. 5 illustrate an electronic apparatus 500 according to an embodiment. The electronic apparatus 500 comprises of an In-Mold-Technology (IMT) part and a connector assembly 507. The IMT part includes a thin wall molded plastic section 501, a film 502, a decorative layer 503, a touch sensor layer 504, an EL layer 505 and a molded plastic support structure 506. The connector assembly 507 can be configured to connect the touch sensor layer 504 to an external driver or a controller that is accessible through a physical platform such as a printed circuit board or the like, which can also accommodate other components such as a power inverter for providing power to an EL layer 505 or the like.

[0054] The thin wall molded plastic section 501 includes a layer of molded plastic, which in accordance with embodiments, can be provided, for example, with a thickness of less than 2mm over the film 502. The film 502 can be made of a plastic material including polycarbonate (PC), polyethylene terephthalate (PET), or any thermoplastic material that can withstand the processing parameters in a molding process that can include injection molding, thermoforming, high pressure forming, hydroforming, and in-mold processes. The processing parameters can include pressure, temperature, and cycle time.

[0055] The film 502 also acts as a substrate for the printing of decorative inks and functional inks such as conductive inks, EL inks or the like, which can be used to form the decorative layer 503. The decorative layer 503 consists of a plurality of decorative ink layers. The functional inks can be printed on either side or both sides of the film 502. The touch sensor layer 504 can include electrodes 508 and traces 509 printed using conductive inks as described herein above, to form capacitive switches, the operation of which is also described herein above.

[0056] The EL layer 505 can be made up of at least 4 different functional layers: conductive shielding layer, transparent conductive ink Layer, phosphorous ink Layer, dielectric ink layer and silver conductive ink layer. As described above in connection with FIG. 4, the phosphorous ink layer is sandwiched between the electrodes and the dielectric layer release light when an oscillating current is applied. The conductive shielding layer is printed with a transparent conductive ink that will not impair the transmissivity of light produced by the EL layer and yet will shield the electric field generated by energizing the EL layer so as to prevent interference from being induced into the capacitive sensing zone.

[0057] The touch sensor layer 504 is the front electrode for the electronic apparatus 500. The high transmissivity of the touch sensor layer 504 allows light from the EL layer 505 to be readily visible to a viewer. The phosphor ink layer of

EL layer 505 can be printed with any phosphor material including for example, zinc sulphide or the like, that will release light when an electrical current is applied. The dielectric layer can be printed with any dielectric ink that is compatible with an EL application. The silver conductive ink layer acts as the second or back electrode for the EL layer for conducting electricity used to drive the EL layer. The dielectric layer is printed over the silver conductive ink layer to protect the silver circuitry during injection molding and handling and to electrically isolate the conductive and EL layers from each other.

[0058] The molded plastic support structure 506 is a layer of plastic that provides structural strength to the IMT part. The molded plastic support structure 506 has a cavity 510 for connection to the connector assembly 507. The molded plastic support structure 506 also has openings 511 for the traces 509 to come out. The In Mold Decorative substrate, which usually in the form of a film as described herein above, has a front surface and a back surface, either the front surface or the back surface, can be printed with layers of decorative inks and cured to produce the designed graphic. Conductive ink can be printed over the graphic layer to produce the capacitive sensing zone. Layers of dielectric can be printed over the capacitive sensing zone and a layer of EL material printed over the dielectric layer. The EL layer along with the other layers where appropriate can be cured to create a light source to illuminate the region of the film switches or other area that required backlighting. A dielectric layer can be printed and cured over the EL layer. The functionalized film can then be die cut and formed into the desired shape via high pressure forming, blow forming, and the like, and injection molded to produce the final product. After which a connector such as a tail connector, zebra connector, or the like, can be attached.

[0059] FIG. 6 is an exploded view of a connector assembly 600 according to an embodiment. The connector assembly 600 has a connector 601, a connector holder 602, a printed circuit board 604, and a flexible cable 603 connected to the printed circuit board 604. Connector 601 can be a zebra connector or the like. The connector holder 602 has a pair of plate holes 607, each plate hole 607 for

receiving a screw 605. The printed circuit board 604 has four PCB holes 606, each PCB hole 606 for receiving a screw 605.

[0060] In an embodiment, conductive traces or the like, are formed by the conductive inks during printing. These conductive traces can be connected to outer mating connection points. A cavity 510 can be created in the molded plastic support structure 506 to fit in a connector 601, such as a zebra connector or the like. A conductive adhesive such as an anisotropic conductive adhesive tape, thermal bonding, silver epoxy, or the like, can be applied to the connector 601 to the IMT part so as to connect conductive traces with external connecting points. A series of conductive ink fingers can be printed on a flexible circuit material to form a flat flexible cable 603 such as a wraparound film switch or "pig tail," which can then be connected to an external connector. The printed circuit board 604 can be attached to the IMT part using a conventional fastening method such as by a screw 605 and the tail connector can be fastened by pressing with a piece of elastomer.

[0061] FIG. 7A shows an electronic apparatus 700 according to an embodiment. The electronic apparatus 700 can have six sections including a film 702, a decorative layer 703, a touch sensor layer 704, an EL layer 705 to form a lighting area, a molded plastic support structure 706, and a connector assembly 707 configured to connect to a external driver or controller mounted on a circuit plaform such as a printed circuit board (PCB), which can be provided with a power inverter or the like.

[0062] FIG. 7B shows an electronic apparatus 710 according to an embodiment. The electronic apparatus 710 has a thin wall molded plastic section 701, a film 702, a decorative layer 703, a touch sensor layer 704, a molded plastic support structure 706, and a connector assembly 707. Notably absent in electronic apparatus 710 is an EL layer 705. A backlighting function can still be provided in the electronic apparatus 710 using an external light source (not

shown) such as light emitting diodes (LEDs), fluorescence lighting, CCFL, or the like, as would be appreciated by one of ordinary skill in the art.

[0063] FIG. 7C shows still another electronic apparatus 720 according to an embodiment. The electronic apparatus 720 has a thin wall molded plastic section 701, a film 702, a decorative layer 703, an EL layer 705, a molded plastic support structure 706, and a connector assembly 707. Notably absent in electronic apparatus 720 is a touch sensor layer 704. Instead, an input function may be achieved through use of a mechanical switch, haptic input device, or the like. However, it will be noted that in accordance with embodiments, the EL layer 705 can still be contoured as described herein and used as a backlighting source for the mechanical switches or buttons.

[0064] In connection with embodiments, the film 702 can be provided with a first surface and a second surface, such as a front and a back surface. Either of the first surface and the second surfaces can be printed with layers of decorative inks and cured to produce the designed graphic. A layer of protective ink can be printed and cured after the decorative ink layers. A layer of EL material can be printed over the protective layer and cured to create a light source to illuminate the region of the film switches or other area that require a backlighting function. A dielectric layer can be printed and cured over the EL layer. The finished film can be die cut and formed into the desired shape via high pressure forming, blow forming and the like to produce a formed film. The formed film can be inserted into a mold and can undergo an injection molding step to produce the final product. A layer of conductive ink is printed and cured on the molded plastic support to produce the capacitive sensing zone and a layer of protective ink can be printed and cured over the silver conductive ink.

[0065] The various layers and sections mentioned above can be made up of only one layer of a particular film or ink, or can be made up of multiple layers of different inks or film materials. For example, as described, an EL layer may consist of the top and bottom electrode, top and bottom dielectric layer, with

phosphorus thin film or phosphorous luminescent centers. The dielectric layer is used to separate two functional layers so that short circuit can be avoided. In addition, a solvent resistant dielectric layer can also act as a protective layer.

[0066] In view of the above descriptions and in accordance with an embodiment or embodiments, exemplary method 800, as illustrated in FIG. 8, can be described as applying a functional ink layer onto a film layer, which can be included in a plurality of film layers at 801, so as to form a functional area thereon, such as a touch sensitive area. The functional ink layer can be a specially adapted conductive ink layer as described herein above, where the conductivity is generally determined, for example, by a concentration of conductive particles within a binding agent, or the like. In accordance with embodiments the functional ink layer can have a material property, such as a specific concentration of conductive particles, an elasticity, or a combination of material properties that correspond with a characteristic such as an electrical characteristic such as a resistivity per unit area, a conductivity or the like. The functional ink layer and the plurality of film layers can be formed into a 3-dimensional shape with contours of the shape spanning the functional area.

[0067] In order to appreciate the advantages associated with the ability to form contours that span the functional area, it should be noted that a particular radius of curvature or convexity or concavity not normally possible in accordance with conventional in-mold processing can be realized. For example, a radius of curvature of a contour that spans the functional area can be such that the local curvature for functional ink layer in the functional area is greater than an average curvature associated with the article, such as outside the functional area. In one example, where an article has a perfectly spherical or nearly perfectly spherical shape, the curvature of the functional area could be the same as the curvature of the article, although localized, "bumps" could be present on the surface of the sphere having a higher local curvature. In other cases, such as a generally flat article, the curvature of the functional area could exceed the curvature of the article itself so as to form areas where activation can be guided. In other words,

bumps or contoured surfaces in the functional areas would stand out from the background areas of the article, which would remain relatively flat. In this way the present disclosure can be distinguished from conventional formed structures that, while having some curvature at edges thereof away from the functional areas, for example, the curvature at or near the functional area is quite low and nearly flat as this approach has been favored in conventional configurations where cracking is to be avoided, by not excessively bending or stretching conventional conductive inks.

[0068] It should be noted that either prior to the application of the function ink layer, or after the formed article is produced and removed from the forming apparatus, the film layers may be cut according to methods known to a person skilled in the art of in-mold processing. Graphics may be created on one of a plurality of film layers by printing and curing a decorative ink on one of the plurality of film layers. Generally, an inkless area will define the graphic. White translucent ink printed on top of inkless area to give graphic indicia a white appearance. Other colours can be used to give a desired appearance for the graphic indicia. Thereafter, an EL layer can be printed and cured on the graphic layer. A dielectric layer can be printed over the EL layer and the dielectric layer is cured. A second functional layer including a conductive ink can be printed over the dielectric layer and cured. A function of the second functional layer can include a touch sensitive function. The film layers can then be cut into a desired size before undergoing forming into a desired 3-dimensional shape including contours.

[0069] It will be appreciated that applying the functional ink layer (i.e. the Touch Sensor Layer and EL layer) at 803 and 805 can include printing methods such as screen printing, roll to roll printing, ink jet printing, letter printing, or the like. Forming the functional ink layer and the plurality of film layers into a 3-dimensional shape may be performed by one of the forming methods including: Niebling HPF (high pressure forming), hydroforming, thermal forming or the like.

[0070] Still further as described herein, a formed article, formed as described herein above, can be further subjected to an exemplary molding process 900 to form a molded electronic article, as further illustrated in FIG. 9. A functional ink layer having the properties and characteristics as described above in connection with process 900, and a plurality of film layers are formed into a 3- dimensional shape at 901. The shaped plurality of film layers including the functional ink layer (EL layer and touch sensor layer) can be inserted into an injection mold at 902. Plastic resin is injected into the mold which will flow over the functional ink layer and the plurality of film layers at 903 to form the IMT part. The molded plastic can be in contact with the front surface or the back surface of the IML substrate or the film, depending on the type of IML process used. It will occur to a person skilled in the art of in mold processes whether a normal or reverse IML process is more desirable or both normal and reverse IML processes should be utilized. At step 904, a connector or a flexible cable can be applied to the conductive traces of the IMT part in a manner as previously described herein above, to link the IMT to a printed circuit board for its power supply. After the forming and the injection molding process, the functional ink in the contoured portion (EL layer and touch sensor layer) retains an acceptable level of conductivity such that is the touch sensor layer retains its touch sensitive capability and that the EL layer can emit light.

[0071] In an embodiment, a double molding process 110 for manufacturing a molded electronic article can be provided as shown in FIG 10. Prior to the molding process, the film is cut, and a graphic is created by printing and curing of decorative inks on the film. The layers are formed into a 3- dimensional shape at 111. The double molding process 110 is similar to the injection molding process 900 except that there are two injection molding steps involved; injection molding of a thin wall plastic support structure 112; and injection molding of a normal plastic support structure for backing 113.

[0072] While exemplary embodiments pertaining to the invention have been described and illustrated, it will be understood by those skilled in the technology concerned that many variations or modifications involving particular design, implementation or construction are possible and may be made without deviating from the inventive concepts described herein.

CLAIMS:

1. A method for manufacturing a shaped film, the method comprising:

applying a functional ink layer on one of a plurality of film layers; the functional ink layer having an associated function;

forming the plurality of film layers into a 3-dimensional shape with a contoured portion, wherein the functional ink layer in the contoured portion retains a level of conductivity such that the function can still be performed after the forming.

2. The method of claim 1 wherein applying the functional ink layer comprises:

printing the functional ink layer as a conductive ink layer on the one of the plurality of film layers; and

curing the conductive ink layer so as to form a touch sensor layer; wherein the function of the functional ink layer is to detect a change in capacitance when a conductive object comes into contact with it.

3. The method of claim 1 wherein applying the functional ink layer comprises:

printing the functional ink layer as an electroluminescent ink layer on the one of the plurality of film layers; and

curing the electroluminescent ink layer; wherein the function of the functional ink layer is to emit light.

4. The method of claim 2 wherein prior to the step of forming the plurality of film layers into a 3-dimensional shape with a contoured portion; the following steps are carried out :-

applying a dielectric layer on the one of the plurality of film layers;

curing the dielectric layer;

printing an electroluminescent ink layer on the one of the plurality of film layers such that the dielectric layer separates the electroluminescent ink layer from the touch sensor layer;

curing the electroluminescent ink layer.

5. The method of claim 4 wherein a transmissivity of the conductive ink layer is set so as to allow a quantity of light from the electroluminescent ink layer to pass through.

6. The method of any one of the above claims, further comprising applying a surface characteristic to one of an outer surface and an inner surface of the 3-dimensional shape.

7. The method of claim 6, wherein the surface characteristic includes one of or a combination of: an antimicrobial characteristic, an oleophobic characteristic, and a hydrophobic characteristic.

8. A molding process for manufacturing a molded electronic article, the process comprising:

applying a functional ink layer on one of a plurality of film layers; the functional ink layer having an associated function;

forming the functional ink layer and the plurality of film layers into a 3-dimensional shape, the 3-dimensional shape having a contoured portion;

subjecting the plurality of film layers to an injection mold process by inserting the plurality of film layers into an injection mold after the forming, and injecting plastic resin over the plurality of film layers so as to form a molded plastic layer over the film layers;

wherein the functional ink layer in the contoured portion retains a level of conductivity such that the function can still be performed after the forming and the injection mold process.

9. The molding process of claim 8, wherein applying the functional ink layer comprises:

printing the functional ink layer as a conductive ink layer on the one of the plurality of film layers; and

curing the conductive ink layer so as to form a touch sensor layer; wherein the function of the functional ink layer is to detect a change in capacitance when a conductive object comes into contact with it.

10. The molding process of claim 8, wherein applying the functional ink layer comprises:

printing the functional ink layer as an electroluminescent ink layer on the one of the plurality of film layers; and

curing the electroluminescent ink layer; wherein the function of the functional ink layer is to emit light.

11. The molding process of claim 9 wherein prior to the step of forming the plurality of film layers into a 3-dimensional shape with a contoured portion; the following steps are carried out :-

applying a dielectric layer on the one of the plurality of film layers;
curing the dielectric layer;

printing an electroluminescent ink layer on the one of the plurality of film layers such that the dielectric layer separates the electroluminescent ink layer from the touch sensor layer;

curing the electroluminescent ink layer.

12. A multilayer film for forming into a 3-dimensional shape with a contoured portion comprising:

a thermoplastic substrate;

a functional ink layer on the thermoplastic substrate; the functional ink layer having an associated function; and wherein after the film is formed into a 3-dimensional shape with a contoured portion, the functional ink layer in the contoured portion retains a level of conductivity such that the function can still be performed.

13. The multilayer film of claim 12 wherein the functional ink layer is a conductive ink layer which has been cured to form a touch sensor layer and the

function of the functional ink layer is to detect a change in capacitance when a conductive object comes into contact with it.

14. The multilayer film of claim 12 wherein the functional ink layer is an electroluminescent ink layer and the function of the functional ink layer is to emit light.

15. The multilayer film of claim 13 further comprising a dielectric layer and an electroluminescent ink layer; wherein the dielectric layer separates the electroluminescent ink layer from the touch sensor layer.

16. The multilayer film of claim 13 or 15 wherein the touch sensor layer comprises electrodes which are printed with PEDOT ink.

17. An electronic apparatus comprising:

a 3-dimensional shaped molded panel with a contoured portion, the molded panel comprising a functional ink layer; the functional ink layer having an associated function;

a connector assembly configured to connect the functional ink layer to a printed circuit board;

wherein the functional ink layer in the contoured portion has a level of conductivity such that the function can be performed.

18. The electronic apparatus of claim 17 wherein the functional ink layer is a conductive ink layer which has been cured to form a touch sensor layer and the function of the functional ink layer is to detect a change in capacitance when a conductive object comes into contact with it.

19. The electronic apparatus of claim 17 wherein the functional ink layer is an electroluminescent ink layer and the function of the functional ink layer is to emit light.

20. The electronic apparatus of claim 18 wherein the molded panel further comprises a dielectric layer and an electroluminescent ink layer and the dielectric layer separates the electroluminescent ink layer from the touch sensor layer.

21. The electronic apparatus of any one of claims 17 to 20 wherein the molded panel includes a surface characteristic.

22. The electronic apparatus of claim 21 wherein the surface characteristic includes one of or a combination of: an antimicrobial characteristic, an oleophobic characteristic, and a hydrophobic characteristic.

23. The electronic apparatus of claim 21 or 22 wherein the surface characteristic is applied by one of the following: a film application, a spray application, and a mixture integration application.