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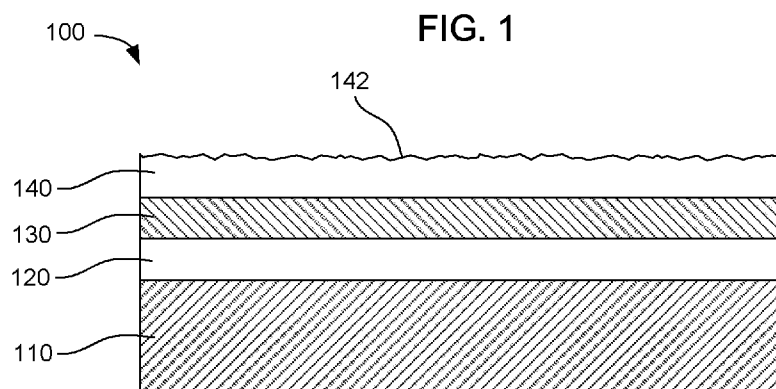
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(54) Title: DECORATIVE FILMS FOR COVERS OF ELECTRONIC DEVICES



(57) Abstract: The present disclosure is drawn to decorative films for covers of electronic devices. In one example, a decorative film for a cover for an electronic device can include a polymeric film adherable to the cover. A primer layer can be located over a top surface of the polymeric film. The primer layer can include a transparent polymer. A base coat layer can be over the primer layer. The base coat layer can include a filler dispersed in a polymeric resin. A clear top coat layer can be over the base coat layer. The clear top coat layer can have a three dimensional pattern molded into a top surface of the clear top coat layer.

5 **DECORATIVE FILMS FOR COVERS OF ELECTRONIC DEVICES**

 BACKGROUND

 [0001] The use of personal electronic devices of all types continues to
10 increase. Cellular phones, including smartphones, have become nearly
 ubiquitous. Tablet computers have also become widely used in recent years.
 Portable laptop computers continue to be used by many for personal,
 entertainment, and business purposes. For portable electronic devices in
 particular, much effort has been expended to make these devices more useful
15 and more powerful while at the same time making the devices smaller, lighter,
 and more durable. The aesthetic design of personal electronic devices is also of
 concern in this competitive market.

 BRIEF DESCRIPTION OF THE DRAWING

20 [0002] FIG. 1 is a cross-sectional view illustrating an example decorative
 film for a cover for an electronic device in accordance with examples of the
 present disclosure;

 [0003] FIG. 2 is a cross-sectional view illustrating another example
25 decorative film for a cover for an electronic device in accordance with examples
 of the present disclosure;

 [0004] FIG. 3 is a cross-sectional view illustrating yet another example
 decorative film for a cover for an electronic device in accordance with examples
 of the present disclosure;

30 [0005] FIG. 4 is a cross-sectional view illustrating an example cover for
 an electronic device in accordance with examples of the present disclosure;

[0006] FIG. 5 is a cross-sectional view illustrating another example cover for an electronic device in accordance with examples of the present disclosure;

[0007] FIG. 6 is a cross-sectional view illustrating yet another example cover for an electronic device in accordance with examples of the present disclosure;

[0008] FIG. 7 is a flowchart illustrating an example method of making a decorative film for a cover for an electronic device in accordance with examples of the present disclosure;

[0009] FIG. 8 is a top-down view of an example three dimensional pattern on a decorative film in accordance with examples of the present disclosure;

[0010] FIG. 9 is a top-down view of another example three dimensional pattern on a decorative film in accordance with examples of the present disclosure;

[0011] FIG. 10 is a top-down view of yet another example three dimensional pattern on a decorative film in accordance with examples of the present disclosure; and

[0012] FIG. 11 is a top-down view of another example three dimensional pattern on a decorative film in accordance with examples of the present disclosure.

DETAILED DESCRIPTION

[0013] The present disclosure describes decorative films for covers of electronic devices. In some examples, a decorative film for a cover of an electronic device can include a polymeric film that is adherable to the cover, a primer layer over a top surface of the polymeric film, a base coat layer over the primer layer, and a clear top coat layer over the base coat layer. The clear top coat layer can have a three dimensional pattern molded into a top surface thereof. The base coat layer can include a filler dispersed in a polymeric resin. The primer layer can include a transparent polymer. In further examples, the polymer film can include polyacrylic, polymethacrylic, polyethylene terephthalate, polyimide, polyurethane, polycarbonate, polyvinyl chloride, or a

combination thereof. In still further examples, the transparent polymer of the primer layer can include polyacrylic, polymethacrylic, polycarbonate, polyester, cyclic olefin copolymer, or a combination thereof. In another example, the primer layer can also include a sparkling pigment or metal nanoparticles in an amount
5 from about 0.01 wt% to about 0.1 wt%. In yet another example, the polymeric resin of the base coat layer can include polyurethane, polyester, polyacrylic, polymethacrylic, epoxy, or a combination thereof, and the filler of the base coat layer can include carbon black, titanium dioxide, clay, mica, talc, barium sulfate, calcium carbonate, synthetic pigment, metallic powder, aluminum flakes,
10 aluminum oxide, graphene, or a combination thereof. In another example, the clear top coat layer can include a radiation-curable resin that includes poly(meth)acrylic, polyurethane, urethane (meth)acrylate, (meth)acrylic (meth)acrylate, epoxy (meth)acrylate, or a combination thereof. In a particular example, the decorative film can also include a non-conductive vacuum
15 metallized layer between the primer layer and the base coat layer. In another particular example, the decorative film can also include an adhesive layer on a bottom surface of the polymeric film.

[0014] The present disclosure also extends to covers for electronic devices. In one example, a cover for an electronic device can include a rigid
20 substrate, a polymeric film adhered over the rigid substrate, a primer layer over the polymeric film, a base coat layer over the primer layer, and a clear top coat layer over the base coat layer. The clear top coat layer can have a three dimensional pattern molded into a top surface thereof. The base coat layer can include a filler dispersed in a polymeric resin. The primer layer can include a
25 transparent polymer. In another example, the rigid substrate can include plastic, carbon fiber, glass, metal, a composite, or a combination thereof. In a particular example, the rigid substrate can include metal and insert molded plastic, and the cover can further include a substrate primer layer between the substrate and the polymeric film. In yet another particular example, the rigid substrate can
30 include metal having a micro-arc oxidation layer on a surface thereof.

[0015] The present disclosure also extends to methods of making decorative films for electronic devices. In one example, a method of making a

decorative film for an electronic device can include applying a primer layer to a top surface of a polymeric film. The primer layer can include a transparent polymer. A base coat layer can be applied over the primer layer. The base coat layer can include a filler dispersed in a polymeric resin. A clear top coat layer
5 can be applied over the base layer. The clear top surface can be contacted with a mold to form a three dimensional molded pattern in the top surface. In another example, the clear top coat layer can include a radiation-curable resin and the method can also include applying radiation energy to the clear top coat layer to cure the radiation-curable resin. In further examples, contacting the top surface
10 of the clear top coat layer with a mold can be performed using an out-molding process or the method can be a roll-to-roll process and the mold can be a three dimensional patterned roller.

Decorative Films for Covers for Electronic Devices

15 [0016] The decorative films described herein can be adhered to covers for electronic devices to give the devices a particular decorative appearance and/or tactile texture. In some examples, the decorative films can be designed to have a sparkling or metallic appearance. In various examples the appearance can be partially obtained by using sparkling pigments, metal powders, non-
20 conductive vacuum metallization, or other such materials in the decorative films. Additionally, the decorative films can include a clear top coat layer with a molded three dimensional pattern on the top surface. The molded three dimensional pattern can provide a specific tactile texture to the film and can also contribute to the decorative appearance of the film. In some examples, the three
25 dimensional pattern can be designed to utilize the reflection and refraction of light by the clear top coat to contribute to the sparkling or metallic appearance of the film. For example, the three dimensional pattern can include multiple facets oriented at different angles to reflect and refract light to create a specific desired appearance.

30 [0017] In further examples, the decorative films can provide a desired appearance to a cover for an electronic device without interfering with radio wave transmission to or from the electronic device. Many electronic devices

include transceivers for sending and receiving radio waves to cellular networks, Wi-Fi routers, wireless accessories, and so on. Some materials can block or interfere with these radio waves. In particular, metal enclosures can often block incoming and outgoing radio waves. The decorative films described herein can
5 provide a desired appearance, including a metallic appearance, without blocking radio waves. In some examples, the decorative film can include a non-conductive vacuum metallized layer that has a metallic appearance, but which does not block the radio waves.

[0018] The decorative films described herein can be produced by efficient
10 manufacturing processes such as roll-to-roll process, out molding process, or combinations thereof. In certain examples, a roll-to-roll process can be used to add the various layers of materials to the film. The three dimensional molded pattern can be molded into the clear top coat layer by a patterned roller, for example.

[0019] As used herein, “cover” refers to the exterior shell or housing of an
15 electronic device. In other words, the cover contains the internal electronic components of the electronic device. The cover is an integral part of the electronic device. The decorative films described here are adherable to a cover of electronic devices, but in some examples, they are actually adhered to the
20 cover of the electronic device. The term “cover” is not meant to refer to the type of removable protective cases that are often purchased separately from an electronic device (especially smartphones and tablets) and placed around the exterior of the electronic device. However, the decorative films described herein may be adhered to other surfaces besides covers for electronic devices, e.g., to
25 removable protective cases or other surfaces.

[0020] With the above description in mind, FIG. 1 shows a cross-sectional
view of an example decorative film 100 for a cover for an electronic device in
accordance with an example of the present disclosure. The decorative film
includes a polymeric film 110, a primer layer 120 over a top surface of the
30 polymeric film, a base coat layer 130 over the primer layer, and a clear top coat layer 140 over the base coat layer. The clear top coat layer has a three dimensional pattern 142 molded into the top surface of the clear top coat layer.

As mentioned above, the primer layer can include a transparent polymer and the base coat layer can include a filler dispersed in a polymeric resin.

[0021] FIG. 2 shows a cross-sectional view of another example decorative film 200 for a cover for an electronic device in accordance with an example of the present disclosure. The film includes a polymeric film 210 with a primer layer 220 over the top surface of the polymeric film. In this example, a non-conductive vacuum metallized layer 250 is applied over the primer layer. A base coat layer 230 is applied over the non-conductive vacuum metallized layer and a clear top coat layer 240 is applied over the base coat layer. The clear top coat layer includes a molded three dimensional pattern 242 on the top surface. In this example, the non-conductive vacuum metallized layer can have a reflective metallic appearance. The three dimensional pattern of the clear top coat layer can be designed to enhance the metallic appearance of the film if desired.

[0022] FIG. 3 shows a cross-sectional view of yet another example decorative film 300 for a cover for an electronic device in accordance with an example of the present disclosure. The film includes a polymeric film 310, a primer layer 320 over the top surface of the polymeric film, a base coat layer 330 over the primer layer, and a clear top coat layer 340 over the base coat layer. The clear top coat layer includes a three dimensional molded pattern 342 on the top surface. This example also includes an adhesive layer 360 on the bottom surface of the polymeric film. A release liner 362 is adhered on the other side of the adhesive layer. Thus, the release liner can be peeled off the adhesive layer and the decorative film can be adhered to the surface of a cover for an electronic device.

[0023] It is noted that when discussing decorative films, covers for electronic devices, or methods of making the decorative films for covers for electronic devices, such discussions can be considered applicable to one another whether or not they are explicitly discussed in the context of that example. Thus, for example, when discussing the polymeric film in the context of one of the example decorative films, such disclosure is also relevant to and directly supported in the context of covers for electronic devices that include a

polymeric film. It is also understood that terms used herein will take on their ordinary meaning in the relevant technical field unless specified otherwise. In some instances, there are terms defined more specifically throughout or included at the end of the present disclosure, and thus, these terms are
5 supplemented as having a meaning described herein.

[0024] In further detail, it is noted that the spatial relationship between layers is often described herein as positioned or applied “on” or “over” another layer. These terms do not infer that this layer is positioned directly in contact with the layer to which it refers, but could have intervening layers therebetween.

10 That being stated, a layer described as being positioned on or over another layer can be positioned directly on that other layer, and thus such a description finds support herein for being positioned directly on the referenced layer.

Polymeric Film

15 [0025] The decorative films described herein can include a polymeric film to which the other layers are applied. In some examples, the decorative film can be made by beginning with the polymeric film as a base and then the primer layer, base coat layer, clear top coat layer, and any other layers can be applied to the polymeric film. The decorative film may derive a majority of its strength
20 and structural integrity from the polymeric film.

[0026] In some examples, the polymeric film can include polyacrylic, polymethacrylic, polyethylene terephthalate, polyimide, polyurethane, polycarbonate, polyvinyl chloride, or a combination thereof. In various examples, the polymeric film can be extruded, cast, spin coated, or prepared by any other
25 method. In further examples, the polymeric film can have a thickness from about 10 μm to about 150 μm . In still further examples, the polymeric film can have a thickness from about 25 μm to about 100 μm or from about 30 μm to about 75 μm .

30 *Primer Layer*

[0027] A primer layer can be placed over the polymeric film. In some examples, the primer layer can include a transparent polymer. Non-limiting

examples of the transparent polymer can include polyacrylic, polymethacrylic, polycarbonate, polyester, cyclic olefin copolymer, or a combination thereof. In certain examples, the primer layer can consist of the transparent polymer, and thus the primer layer can be transparent.

5 [0028] In various examples, the primer layer can be applied to the polymeric film by co-extrusion, lamination, or as a liquid polymer or slurry that can be dried and/or cured after being applied to the polymeric film. Liquid or slurry primers can be applied by any suitable coating method, such as by spray coating, rod coating, blade coating, and so on. In some examples, the thickness
10 of the primer layer can be from about 5 μm to about 60 μm or from about 10 μm to about 40 μm .

[0029] The primer layer can also include additional ingredients to contribute to the decorative appearance of the decorative film. In certain examples, the primer layer can include a sparkling pigment, pearlescent
15 pigment, or metal nanoparticles dispersed in the transparent polymer of the primer layer. Sparkling and pearlescent pigments can include particles of materials such as mica, silica, glass, and alumina. These particles can be coated with a metal oxide coating. The metal oxide coating can include a variety of metals, such as titanium, chromium, iron, aluminum, cobalt, nickel, zinc, and
20 copper. In some cases, incident light can be partially reflected and partially transmitted by the metal oxide coating material and the pigment particle material. This can create a sparkling appearance. For example, a mica particle coated with a metal oxide coating can reflect light at four different interfaces. Some incident light can be reflected immediately from the surface of the metal
25 oxide coating. Some of the light can be transmitted through the metal oxide coating and then reflect off the interface between the metal oxide coating and the mica particle. Some light can transmit through the mica particle and then reflect off the interface between the mica and the metal oxide coating on the backside of the particle. Then, some light can also be transmitted all the way
30 through the particle and then reflect off the backside surface of the metal oxide coating. The amounts of light reflected may depend on the angle of incident light, and thus the pigment can sparkle when the angle of incident light changes.

[0030] Metal nanoparticles can also be included in the primer layer to reflect light. The average particle size of the metal nanoparticles, sparkling pigment particles, and/or pearlescent pigment particles can be from about 10 nm to about 10 μ m or from about 30 nm to about 8 μ m. In various examples, the primer layer can include the metal nanoparticles, sparkling pigment, and/or pearlescent pigment in an amount from about 0.01 wt% to about 0.5 wt% or from about 0.01 wt% to about 0.1 wt% with respect to the dry weight of the primer layer.

10 *Base Coat Layer*

[0031] A base coat layer can be applied over the primer layer on the polymeric film. This layer can include a filler dispersed in a polymeric resin. In certain examples, the filler can be present in the base coat in an amount from about 0.1 wt% to about 15 wt%, or from about 0.2 wt% to about 12 wt%, or from about 0.5 wt% to about 10 wt% with respect to the dry weight of the base coat layer. Non-limiting examples of fillers in the base coat can include carbon black, titanium dioxide, clay, mica, talc, barium sulfate, calcium carbonate, synthetic pigment, metallic powder, aluminum flakes, aluminum oxide, graphene, or a combination thereof. In some examples the base coat layer can include a sparkling pigment, pearlescent pigment, or metal nanoparticles similar to the primer layer. In a particular example, the primer layer and the base coat layer can both include the same type of sparkling pigment, pearlescent pigment, or metal nanoparticles.

[0032] The polymeric resin of the base coat layer can include polyurethane, polyester, polyacrylic, polymethacrylic, epoxy, or combinations thereof. In certain examples, the polymeric resin of the base coat layer can have a weight-average molecular weight from about 100 g/mol to about 6,000 g/mol. In further examples, the filler can be dispersed in the polymeric resin and the mixture can be coated over the primer layer on the polymeric film by any suitable coating method.

[0033] The thickness of the base coat layer can be from about 1 μ m to about 100 μ m in some examples. In further examples, the thickness can be

from about 5 μm to about 20 μm . In certain examples, the base coat layer can be a layer including a filler dispersed in polyacrylic with a thickness from about 1 μm to about 50 μm , from about 2 μm to about 30 μm , or from about 5 μm to about 15 μm . In other examples, the base coat layer can include a filler
5 dispersed in polyurethane with a thickness from about 5 μm to about 100 μm , from about 10 μm to about 75 μm , or from about 10 μm to about 50 μm .

Clear Top Coat Layer

[0034] The clear top coat layer can be a layer of a transparent resin with
10 a three dimensional pattern molded into the top surface of the layer. In some examples, the clear top coat layer can be a radiation-curable resin such as poly(meth)acrylic, polyurethane, urethane (meth)acrylate, (meth)acrylic (meth)acrylate, epoxy (meth)acrylate, or a combination thereof. In certain examples, the clear coat layer can be a layer of polyacrylic with a thickness from
15 about 1 μm to about 50 μm , from about 2 μm to about 30 μm , or from about 5 μm to about 25 μm . In other examples, the clear coat layer can be a polyurethane with a thickness from about 20 μm to about 100 μm , from about 30 μm to about 75 μm , or from about 40 μm to about 50 μm .

[0035] In various examples, the three dimensional pattern molded into the
20 top surface of the clear coat layer can contribute to the decorative appearance of the decorative film and/or provide a particular tactile texture to be felt by a user. In some examples, the three dimensional pattern can be designed to contribute to a sparkling or metallic appearance of the decorative film. In certain examples, the three dimensional pattern can include multiple small facets that
25 are angled at different orientations to reflect light in different directions, similar to facets of a cut gemstone. Incident light can be reflected and refracted by these facets in such a way that the film can have a sparkling appearance due to the three dimensional molded pattern of the clear top coat layer. This sparkling effect can in some cases be in addition to the sparkling appearance provided by
30 sparkling pigments or metallic particles in the primer layer and/or base coat layer of the decorative film. A wide variety of designs can be used for the three dimensional molded pattern. The three dimensional pattern can be designed to

provide a sparkling appearance, an appearance similar to brushed metal, an appearance of a color gradient, and others.

Additional Layers

5 [0036] The decorative films described herein can include additional layers in some examples. In a particular example, the decorative film can include a non-conductive vacuum metallized layer between the primer layer and the base coat layer. "Non-conductive vacuum metallization" is a process that can form a film that appears to be a continuous, shiny metallic film, but is in fact a layer of
10 isolated metallic spots or islands on the surface. Because the metallized layer is not a continuous metallic film, the layer is not electrically conductive. The use of this type of film can provide a shiny, metallic appearance in some examples, but can still be useful in electronic devices that send and receive wireless signals, such as radio, Wi-Fi, Satellite (GPS), Bluetooth®, and cellular signals.
15 Conversely, conductive metal films can interfere with these types of electromagnetic signals.

 [0037] In some examples, the non-conductive vacuum metallized layer can have a film thickness from about 30 nm to about 500 nm, from about 40 nm to about 300 nm, or from about 50 nm to about 200 nm. Materials that can be
20 used in non-conductive vacuum metallization can include titanium, chromium, nickel, zinc, zirconium, manganese, copper, aluminum, tin, molybdenum, tantalum, tungsten, hafnium, gold, vanadium, silver, platinum, graphite, and alloys thereof.

 [0038] In further examples, the decorative film can include an adhesive
25 layer on a bottom surface of the polymeric film. The adhesive layer can be used to adhere the decorative film to a surface such as the surface of a cover of an electronic device. In some examples, the adhesive layer can have a thickness from about 1 μm to about 100 μm , from about 2 μm to about 50 μm , or from about 5 μm to about 30 μm . Non-limiting examples of adhesive materials that
30 can be used include ethylene vinyl acetate copolymers, ethylene ethyl acrylate copolymers, ionomers, poly(ethyl acrylate), phenoxy resins, polyamides, polyesters, polyvinyl acetate, polyvinyl butyral, polyvinyl ethers, and others

[0039] In some examples, the decorated panel can include a removable release liner on the bottom face of the adhesive layer. The release liner can be peeled off before adhering the decorative film to a surface. In some examples, the release liner can include a transparent plastic film, such as a polyethylene terephthalate (PET) film or a polycarbonate (PC) film, for example. In some examples, the release liner can be siliconized by coating a surface of the film with a silicone compound. In another example, the release liner can be siliconized paper.

10 *Covers for Electronic Devices*

[0040] The present disclosure also extends to covers for electronic devices that include the decorative films described above. FIG. 4 shows a cross-sectional view of an example cover 400 for an electronic device that incorporates one of the decorative films described herein. The cover includes a rigid substrate 470, which can be the solid material of the cover of the electronic device. A polymeric film 410 is adhered over the rigid substrate by way of an adhesive layer 460. A primer layer 420 is over the polymeric film. The primer layer can include a transparent polymer. A base coat layer 430 is located over the primer layer. The base coat layer can include a filler dispersed in a polymeric resin. A clear top coat layer 440 is over the base coat layer. The clear top coat layer includes a three dimensional pattern 442 molded into the top surface.

[0041] FIG. 5 shows a cross-sectional view of another example cover 500 for an electronic device in accordance with an example of the present disclosure. This example has a rigid substrate made up of a metal portion 570 and an insert-molded plastic portion 572. A substrate primer layer 580 is applied over the substrate. A polymeric film 510 is adhered to the primer layer by way of an adhesive layer 560. A primer layer 520, base coat layer 530, and clear top coat layer 540 are placed over the polymeric film. A three dimensional pattern 542 is molded into the top surface of the clear top coat layer.

[0042] FIG. 6 shows a cross-sectional view of yet another example cover 600 for an electronic device in accordance with an example of the present

disclosure. In this example, the substrate is made up of a light metal 770 having micro-arc oxidation layers 674 on the top and bottom surfaces. A substrate primer layer 680 is again placed on the top surface of the substrate, and a polymeric film 610 is adhered to the primer layer by an adhesive layer 660. A primer layer 620, base coat layer 630, and clear top coat layer 640 are placed over the polymeric film. A three dimensional pattern 642 is molded into the top surface of the clear top coat layer.

Rigid Substrate

[0043] In some examples, the rigid substrate of the cover for an electronic device can include plastic, carbon fiber, glass, metal, a composite, or a combination thereof. In certain examples, the substrate can include a light metal such as aluminum, magnesium, titanium, lithium, niobium, or an alloy thereof. In some examples, alloys of these metals can include additional metals, such as bismuth, copper, cadmium, iron, thorium, strontium, zirconium, manganese, nickel, lead, silver, chromium, silicon, tin, gadolinium, yttrium, calcium, antimony, zinc, cerium, lanthanum, or others. In a particular example, the substrate can be pure magnesium or an alloy including 99% magnesium or greater. In another particular example, the substrate can be made of an alloy including magnesium and aluminum. In a particular example, the substrate can be made from AZ31 alloy or AZ91 alloy.

[0044] In further examples, the substrate can include carbon fiber. In particular, the substrate can be a carbon fiber composite. The carbon fiber composite can include carbon fibers in a plastic material such as a thermoset resin or a thermoplastic polymer. Non-limiting examples of the polymer can include epoxies, polyesters, vinyl esters, and polyamides.

[0045] In various examples, the substrate can be formed by molding, casting, machining, bending, working, or another process. In certain examples, the substrate can be a chassis for an electronic device that is milled from a single block of metal or metal alloy. In other examples, an electronic device chassis can be made from multiple panels. As an example, laptops sometimes include four separate pieces forming the chassis or cover of the laptop, with the

electronic components of the laptop protected inside the chassis. The four separate pieces of the laptop chassis are often designated as cover A (back cover of the monitor portion of the laptop), cover B (front cover of the monitor portion), cover C (top cover of the keyboard portion) and cover D (bottom cover of the keyboard portion). In certain examples, one of these covers or more than one of these covers can include metal, metal alloy, carbon fiber, glass, plastic, and so on. These covers can be made by machining, casting, molding, bending, or by other forming methods. Other types of electronic device covers can also be the substrate referred to above, such as a smartphone, tablet, or television cover. These substrates can be made using the same forming methods.

[0046] The substrate is not particularly limited with respect to thickness. However, when used as a panel for an electronic device, such as for a housing or chassis, the thickness of the substrate chosen, the density of the material (for purposes of controlling weight, for example), the hardness of the material, the malleability of the material, the material aesthetic, etc., can be selected as appropriate for a specific type of electronics device, e.g., lightweight materials and thickness chosen for housings where lightweight properties may be commercially competitive, heavier more durable materials chosen for housings where more protection may be useful, etc. To provide some examples, the thickness of the substrate can be from about 0.5 mm to about 2 cm, from about 1 mm to about 1.5 cm, from about 1.5 mm to about 1.5 cm, from about 2 mm to about 1 cm, from about 3 mm to about 1 cm, from about 4 mm to about 1 cm, or from about 1 mm to about 5 mm, though thicknesses outside of these ranges can be used.

[0047] In further examples, a rigid substrate may include more than one type of material. In certain examples, a substrate can include a plastic portion formed by insert molding. For example, a substrate can have a metal portion or a carbon fiber portion or a glass portion and an insert molded plastic portion. Insert molding involves placing the substrate portion into a mold, where a plastic material is then injection molded in the mold around the metal, carbon fiber, or glass. In some cases, the metal, carbon fiber, or glass substrate can include an undercut shape and the molten plastic can flow into the undercut during

injection molding. When the plastic hardens, the undercut can provide a strong connection between the plastic and the other portion of the substrate.

[0048] In still further examples, the rigid substrate can include a metal having a micro-arc oxidation layer on a surface thereof. Micro-arc oxidation, also known as plasma electrolytic oxidation, is an electrochemical process where the surface of a metal is oxidized using micro-discharges of compounds on the surface of the substrate when immersed in a chemical or electrolytic bath, for example. The electrolytic bath may include predominantly water with about 1 wt% to about 5 wt% electrolytic compound(s), e.g., alkali metal silicates, alkali metal hydroxide, alkali metal fluorides, alkali metal phosphates, alkali metal aluminates, the like, and combinations thereof. The electrolytic compounds may likewise be included at from about 1.5 wt% to about 3.5 wt%, or from about 2 wt% to about 3 wt%, though these ranges are not considered limiting. In one example, a high-voltage alternating current can be applied to the substrate to create plasma on the surface of the substrate. In this process, the substrate can act as one electrode immersed in the electrolyte solution, and the counter electrode can be any other electrode that is also in contact with the electrolyte. In some examples, the counter electrode can be an inert metal such as stainless steel. In certain examples, the bath holding the electrolyte solution can be conductive and the bath itself can be used as the counter electrode. A high direct current or alternating voltage can be applied to the substrate and the counter electrode. In some examples, the voltage can be 200 V or higher, such as about 200 V to about 600 V, about 250 V to about 600 V, about 250 V to about 500 V, or about 200 V to about 300 V. Temperatures can be from about 20 °C to about 40 °C, or from about 25 °C to about 35 °C, for example, though temperatures outside of these ranges can be used. This process can oxidize the surface to form an oxide layer from the substrate material. Various metal or metal alloy substrates can be used, including aluminium, titanium, lithium, magnesium, and/or alloys thereof, for example. The oxidation can extend below the surface to form thick layers, as thick as 30 µm or more. In some examples the oxide layer can have a thickness from about 1 µm to about 25 µm, from about 1 µm to about 22 µm, or from about 2 µm to about 20 µm. Thickness can

likewise be from about 2 μm to about 15 μm , from about 3 μm to about 10 μm , or from about 4 μm to about 7 μm . The oxide layer can, in some instances, enhance the mechanical, wear, thermal, dielectric, and corrosion properties of the substrate. The electrolyte solution can include a variety of electrolytes, such as a solution of potassium hydroxide. In some examples, the rigid substrate can include a micro-arc oxidation layer on one side, or on both sides.

[0049] In some examples, a decorative film as described above can be adhered directly to a rigid substrate using an adhesive layer. In further examples, a substrate primer layer can be added to the surface of the rigid substrate before adhering the decorative film. The substrate primer layer can increase adhesion of the decorative film to the substrate. In a particular example, a substrate primer can be applied over a micro-arc oxidation layer on a metal substrate to increase the adhesion between the decorative film and the micro-arc oxidation layer. In another example, a substrate primer can be applied over a substrate that includes a metal portion and an insert molded plastic portion. The primer can increase adhesion and also fill in any gaps or uneven surfaces at the junction between the metal and the plastic. In some examples, the substrate primer layer can include a polyurethane or polyurethane copolymer. In certain examples, the polyurethane or polyurethane copolymer can be formed by polymerizing a polyisocyanate and a polyol. Non-limiting examples of polyisocyanates that can be used include toluene diisocyanate, methylene diphenyl diisocyanate, 1,6-hexamethylene diisocyanate, isophorone diisocyanate, 4,4'-diisocyanato dicyclohexylmethane, trimethylhexamethylene diisocyanate, and others. The polyol can, in some examples, be a polyether polyol or a polyester polyol having a weight average molecular weight from about 100 to about 10,000 or from about 200 to about 5,000. In certain examples, the polyol can be a diol that includes two hydroxyl groups. In further examples, the primer layer can have a thickness from about 1 μm to about 50 μm , from about 2 μm to about 25 μm , or from about 5 μm to about 15 μm .

[0050] In certain examples, the substrate primer can include a moisture-cured polyurethane. Moisture-cured polyurethanes can include isocyanate-terminated prepolymers that can be cured with ambient water. In a particular

example, the primer can include Airethane™ 1204 polyurethane or other Airethane™ 1000 series polyurethanes (Fairmont Industries).

[0051] In other examples, the substrate primer can include an alkyd resin. Alkyd resins are thermoplastic resins made from polyhydric alcohols and
5 polybasic acids or their anhydrides. In some examples, alkyd resins can be made by a polycondensation reaction of a polyol with a dicarboxylic acid or its anhydride. Non-limiting examples of other polybasic acids that can be used in alkyd resins include phthalic anhydride, isophthalic anhydride, maleic anhydride, fumaric acid, and others. Non-limiting examples of polyols that can be used in
10 alkyd resins include glycerol, trimethylolethane, trimethylolpropane, pentaerythritol, ethylene glycol, and neopentyl glycol. In some examples, a monobasic acid can also be included in the reaction to modify the alkyd resin. In specific examples, the primer can include a resin from the DOMALKYD™ line of resins, such as DOMALKYD™ 4161 (Helios).

15

Methods of Making Decorative Films for Covers for Electronic Devices

[0052] The present disclosure also extends to methods of making decorative films for covers for electronic devices. FIG. 7 is a flowchart showing an example method 700 of making a decorative film for a cover for an electronic
20 device. The method includes: applying 710 a primer layer to a top surface of a polymeric film, wherein the primer layer includes a transparent polymer; applying 720 a base coat layer over the primer layer, wherein the base coat layer includes a filler dispersed in a polymeric resin; applying 730 a clear top coat layer over the base coat layer; and contacting 740 a top surface of the
25 clear top coat layer with a mold to form a three dimensional molded pattern in the top surface.

[0053] As mentioned above, the clear top coat layer can in some examples include a radiation-curable resin. As such, in some examples the method of making the decorative film can include applying radiation energy to
30 the clear top coat layer to cure the radiation-curable resin. In certain examples, the clear top coat layer can include a UV-curable poly(meth)acrylic, polyurethane, urethane (meth)acrylate, (meth)acrylic (meth)acrylate, or epoxy

(meth)acrylate. In further examples, the clear top coat layer can be cured by applying UV radiation. Curing can include exposing the layer to radiation energy at an intensity from about 500 mJ/cm² to about 2,000 mJ/cm² or from about 700 mJ/cm² to about 1,300 mJ/cm². The layer can be exposed to the radiation
5 energy for a curing time from about 5 seconds to about 30 seconds, or from about 10 seconds to about 30 seconds. In other examples, curing can include heating the protective coating layer at a temperature from about 50 °C to about 80°C or from about 50 °C to about 60 °C or from about 60 °C to about 80 °C. The layer can be heated for a curing time from about 5 minutes to about 40
10 minutes, or from about 5 minutes to about 10 minutes, or from about 20 minutes to about 40 minutes.

[0054] In further examples, the methods of making decorative films can be continuous methods, such as roll-to-roll methods. In one such example, a roller of polymeric film can be fed from a roll through equipment suitable to add
15 the other layers to the polymeric film, such as coating devices, drying devices, curing devices, molds, and so on. In such a roll-to-roll process, the three dimensional pattern of the clear top coat layer can be formed by pressing a three dimensional pattern roller onto the clear top coat layer. In some examples, this can be done prior to curing the clear top coat layer.

[0055] In other examples, the three dimensional pattern can be formed by
20 out molding. "Out molding" as used herein refers to a process in which an individual decorative film, such as a sheet, is placed in a stationary mold to mold the three dimensional pattern into the clear top coat layer. Thus, this is more of a batch process than a continuous process as a single sheet is molded at one
25 time.

[0056] A wide variety of different three dimensional patterns can be molded into the clear top coat of the decorative films. In some examples, the three dimensional patterns can contribute to the sparkling or metallic appearance of the film. In further examples, the three dimensional pattern can
30 give the film a specific tactile texture to be felt by the user. In certain examples, the three dimensional pattern can mimic the texture of another material, such as leather, wood, stone, and so on.

[0057] In some examples, the three dimensional pattern can include multiple facets of the surface that are oriented at different angles. Because of the reflection and refraction of light by the clear top coat layer, the facets may reflect different amounts of light depending on the angle of incident light. The light reflected by the facets can therefore change when the incident angle of light is changed, either by tilting the film or moving the light source. In some cases, this can result in a sparkling appearance.

[0058] FIGs. 8-11 show several examples of three dimensional patterns that include multiple facets for reflecting light. FIG. 8 is a top-down view of a decorative film having a three dimensional molded pattern made up of square-shaped facets. The facets can be slanted in slightly different directions so that light reflects off of the facets at differing intensities. Thus, some facets appear light and some appear dark, while still other facets have tones in between.

[0059] FIG. 9 shows a top-down view of another decorative film. The three dimensional pattern of this film includes facets shaped as vertical and horizontal lines. The facets can be slanted at different angles so that the facets reflect light at different intensities. Thus, when the facets reflect light the film can appear to have light and/or dark colored vertical and horizontal lines that can shift in tone when the film is tilted or when the light source moves.

[0060] FIG. 10 shows a top-down view of yet another decorative film. This film has a three dimensional pattern made up of square-shaped facets, similar to FIG. 8. In this example, the facets are oriented in such a way as to make a color gradient appear with darker squares toward the top end of the film and lighter squares toward the bottom end of the film. The orientation of the square-shaped facets is still partially randomized so that some light squares appear near the dark end and some dark squares appear near the light end. However, in other examples the color gradient can be made more exact and continuous by making the orientation of the facets more uniform across the width of the film.

[0061] FIG. 11 shows a top-down view of another decorative film. This example has a three dimensional pattern with facets shaped like random triangles and polygons. The facets can be slanted in different directions to reflect light in different amounts. In one example, these facets can be oriented

randomly to create a random sparkling appearance, similar to a sparkling crystal or ice. A variety of other three dimensional patterns can also be used on the decorative films described herein.

5 *Definitions*

[0062] It is noted that, as used in this specification and the appended claims, the singular forms "a," "an," and "the" include plural referents unless the content clearly dictates otherwise.

[0063] The term "about" as used herein, when referring to a numerical
10 value or range, allows for a degree of variability in the value or range, for example, within 5% or other reasonable added range breadth of a stated value or of a stated limit of a range. The term "about" when modifying a numerical range is also understood to include the exact numerical value indicated, e.g., the range of about 1 wt% to about 5 wt% includes 1 wt% to 5 wt% as an
15 explicitly supported sub-range.

[0064] As used herein, "average particle size" refers to a number average of the diameter of the particles for spherical particles, or a number average of the volume equivalent sphere diameter for non-spherical particles. The volume equivalent sphere diameter is the diameter of a sphere having the same volume
20 as the particle. Average particle size can be measured using a particle analyzer such as the Mastersizer™ 3000 available from Malvern Panalytical. The particle analyzer can measure particle size using laser diffraction. A laser beam can pass through a sample of particles and the angular variation in intensity of light scattered by the particles can be measured. Larger particles scatter light at
25 smaller angles, while small particles scatter light at larger angles. The particle analyzer can then analyze the angular scattering data to calculate the size of the particles using the Mie theory of light scattering. The particle size can be reported as a volume equivalent sphere diameter.

[0065] As used herein, a plurality of items, structural elements,
30 compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though the individual members of the list are individually identified as a separate and unique member.

Thus, no individual member of such list should be construed as a *de facto* equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary.

[0066] Concentrations, dimensions, amounts, and other numerical data may be presented herein in a range format. It is to be understood that such range format is used merely for convenience and brevity and should be interpreted flexibly to include the numerical values explicitly recited as the limits of the range, and also to include all the individual numerical values or sub-ranges encompassed within that range as if individual numerical values and sub-ranges are explicitly recited. For example, a layer thickness from about 0.1 μm to about 0.5 μm should be interpreted to include the explicitly recited limits of 0.1 μm to 0.5 μm , and to include thicknesses such as about 0.1 μm and about 0.5 μm , as well as subranges such as about 0.2 μm to about 0.4 μm , about 0.2 μm to about 0.5 μm , about 0.1 μm to about 0.4 μm etc.

[0067] The following illustrates an example of the present disclosure. However, it is to be understood that the following is illustrative of the application of the principles of the present disclosure. Numerous modifications and alternative compositions, methods, and systems may be devised without departing from the spirit and scope of the present disclosure. The appended claims are intended to cover such modifications and arrangements.

EXAMPLE

Example 1 - *Making a Decorative Film and Adhering to a Cover for an Electronic Device*

[0068] An example decorative film is prepared as follows:

- 1) A polyethylene terephthalate film is fed from a roller. A primer made up of polyacrylic polymer is applied to the polyethylene terephthalate film via a roll-to-roll process to make a primer layer about 8 μm thick.

- 2) A base coat layer is applied over the primer layer. The base coat layer is made up of 1 wt% aluminum flakes dispersed in a polyurethane polymer. The base coat layer is about 15 μm thick.
- 3) A clear top coat layer is applied by coating a UV-curable polyacrylic polymer resin over the base coat layer to make a clear top coat layer about 25 μm thick.
- 4) The film is fed between a three dimensional molded roller and a non-molded roller, with the molded roller contacting the top surface of the clear top coat layer. The molded roller imprints a three dimensional molded pattern into the clear top coat layer.
- 5) The clear top coat layer is heated at 50 °C for 10 minutes and then irradiated with ultraviolet radiation at an intensity of 700 mJ/cm^2 for 30 seconds to cure the layer.
- 6) An adhesive layer is applied to the bottom surface of the polymeric film. The film is cut to an appropriate size to fit a cover for an electronic device, and then adhered to the cover for an electronic device. The resulting cover has a sparkling appearance due to the aluminum flakes in the base coat layer and the molded facets of the three dimensional pattern in the clear top coat layer.

20

[0069] While the present technology has been described with reference to certain examples, it is appreciated that various modifications, changes, omissions, and substitutions can be made without departing from the disclosure. It is intended, therefore, that the disclosure be limited only by the scope of the following claims.

25

30

CLAIMS

What is claimed is:

- 5 1. A decorative film for a cover of an electronic device comprising:
a polymeric film adherable to the cover;
a primer layer over a top surface of the polymeric film, wherein the primer
layer comprises a transparent polymer;
a base coat layer over the primer layer, wherein the base coat layer
10 comprises a filler dispersed in a polymeric resin; and
a clear top coat layer over the base coat layer,
wherein the clear top coat layer has a three dimensional pattern molded
into a top surface thereof.
- 15 2. The decorative film of claim 1, wherein the polymeric film comprises
polyacrylic, polymethacrylic, polyethylene terephthalate, polyimide,
polyurethane, polycarbonate, polyvinyl chloride, or a combination thereof.
- 20 3. The decorative film of claim 1, wherein the transparent polymer of the
primer layer comprises polyacrylic, polymethacrylic, polycarbonate, polyester,
cyclic olefin copolymer, or a combination thereof.
- 25 4. The decorative film of claim 1, wherein the primer layer further
comprises a sparkling pigment or metal nanoparticles in an amount from about
0.01 wt% to about 0.1 wt%.
- 30 5. The decorative film of claim 1, wherein the polymeric resin of the base
coat layer comprises polyurethane, polyester, polyacrylic, polymethacrylic,
epoxy, or combinations thereof and wherein the filler of the base coat layer
comprises carbon black, titanium dioxide, clay, mica, talc, barium sulfate,
calcium carbonate, synthetic pigment, metallic powder, aluminum flakes,
aluminum oxide, graphene, or a combination thereof.

6. The decorative film of claim 1, wherein the clear top coat layer comprises a radiation-curable resin that includes poly(meth)acrylic, polyurethane, urethane (meth)acrylate, (meth)acrylic (meth)acrylate, epoxy
5 (meth)acrylate, or a combination thereof.

7. The decorative film of claim 1, further comprises a non-conductive vacuum metallized layer between the primer layer and the base coat layer.

10 8. The decorative film of claim 1, further comprising an adhesive layer on a bottom surface of the polymeric film.

9. A cover for an electronic device comprising:
a rigid substrate;
15 a polymeric film adhered over the rigid substrate;
a primer layer over the polymeric film, wherein the primer layer comprises a transparent polymer;
a base coat layer over the primer layer, wherein the base coat layer comprises a filler dispersed in a polymeric resin; and
20 a clear top coat layer over the base coat layer,
wherein the clear top coat layer has a three dimensional pattern molded into a top surface thereof.

10. The cover of claim 9, wherein the rigid substrate comprises plastic,
25 carbon fiber, glass, metal, a composite, or a combination thereof.

11. The cover of claim 9, wherein the rigid substrate comprises metal and insert molded plastic, and wherein the cover further comprises a substrate primer layer between the substrate and the polymeric film.

30 12. The cover of claim 9, wherein the rigid substrate comprises metal having a micro-arc oxidation layer on a surface thereof.

13. A method of making a decorative film for a cover for an electronic device comprising:

- 5 applying a primer layer to a top surface of a polymeric film, wherein the primer layer comprises a transparent polymer;
- applying a base coat layer over the primer layer, wherein the base coat layer comprises a filler dispersed in a polymeric resin;
- applying a clear top coat layer over the base coat layer; and
- 10 contacting a top surface of the clear top coat layer with a mold to form a three dimensional molded pattern in the top surface.

14. The method of claim 13, wherein the clear top coat layer comprises a radiation-curable resin and the method further comprises applying radiation energy to the clear top coat layer to cure the radiation-curable resin.

15

15. The method of claim 13, wherein contacting the top surface of the clear top coat layer with a mold is performed using an out-molding process, or wherein the method is a roll-to-roll process and the mold is a three dimensional patterned roller.

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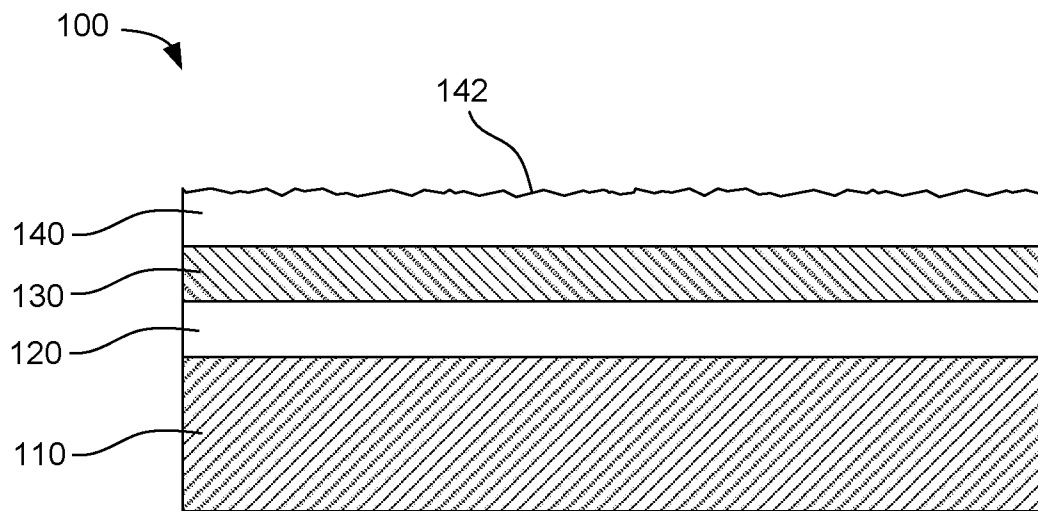


FIG. 1

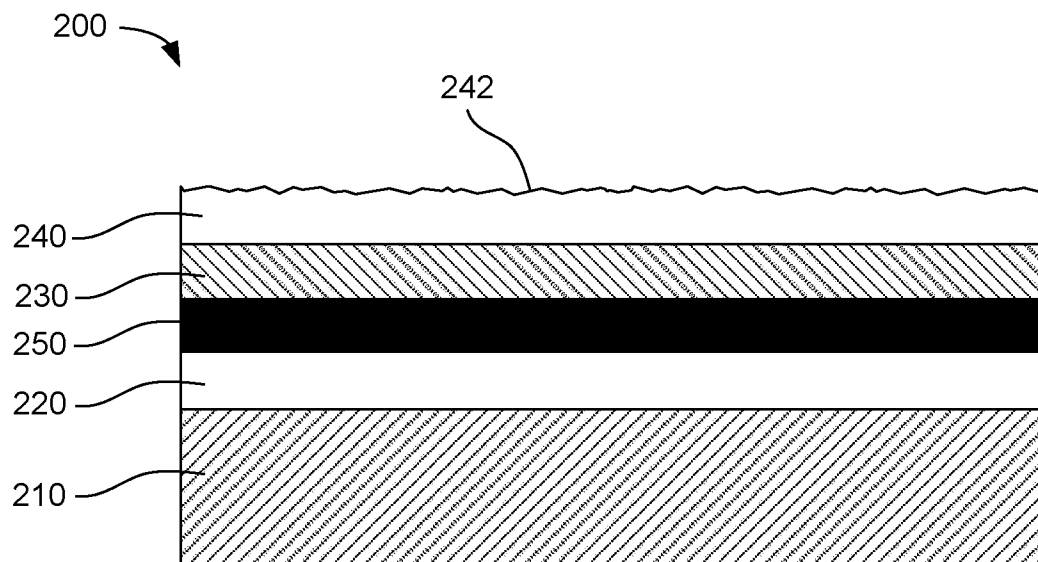


FIG. 2

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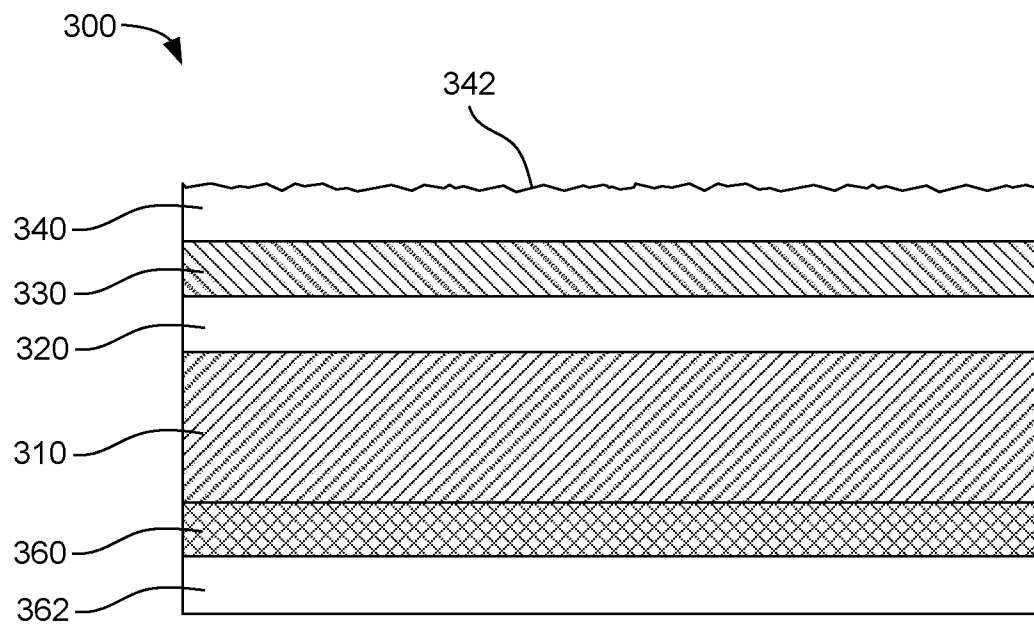


FIG. 3

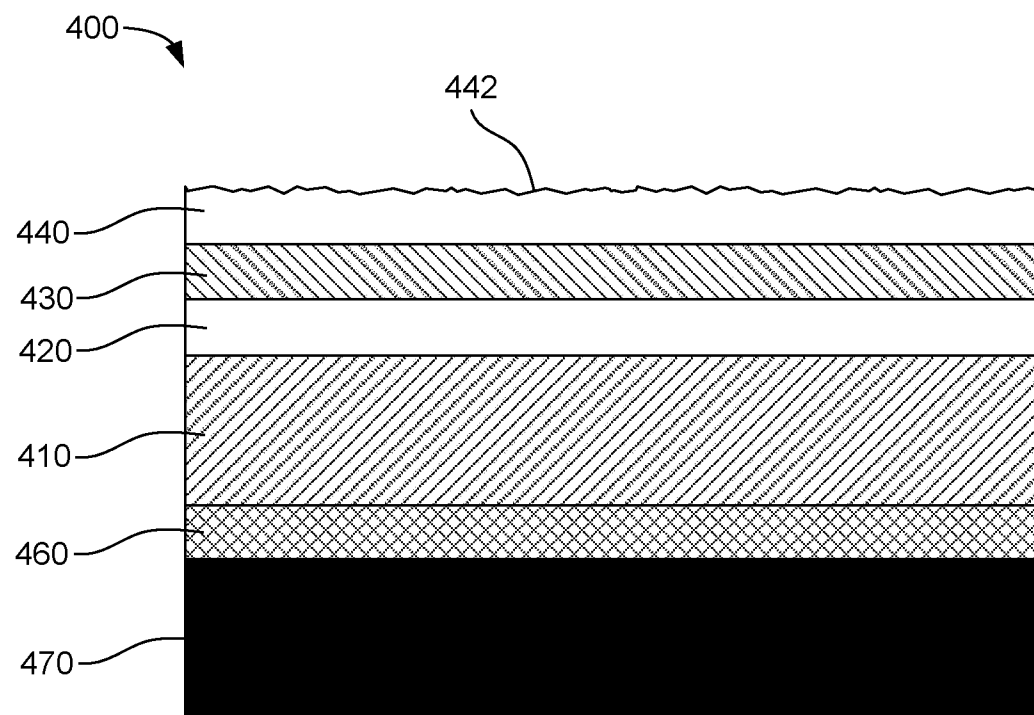


FIG. 4

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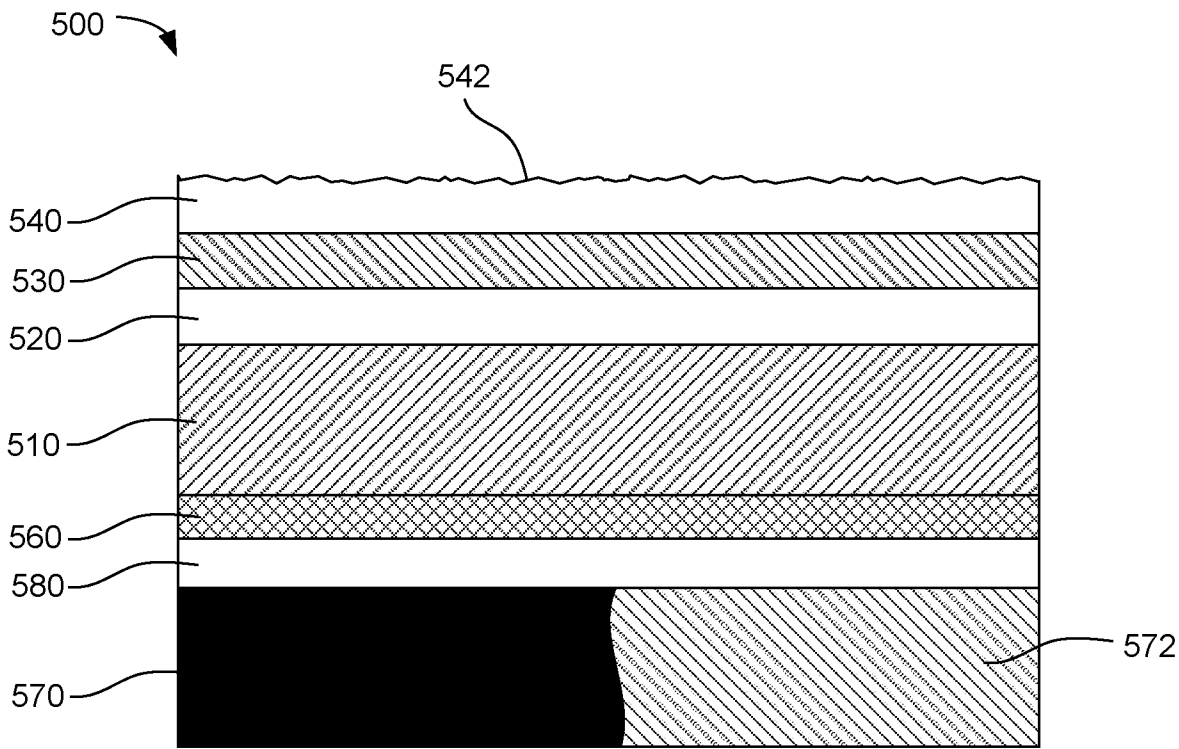


FIG. 5

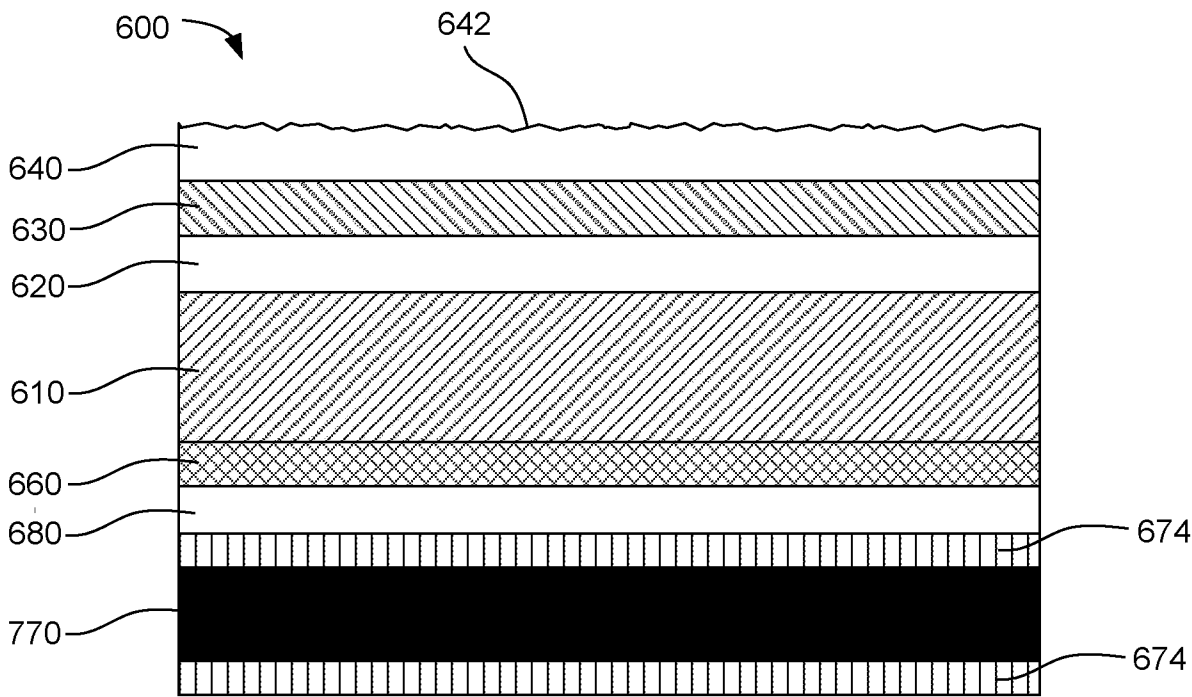


FIG. 6

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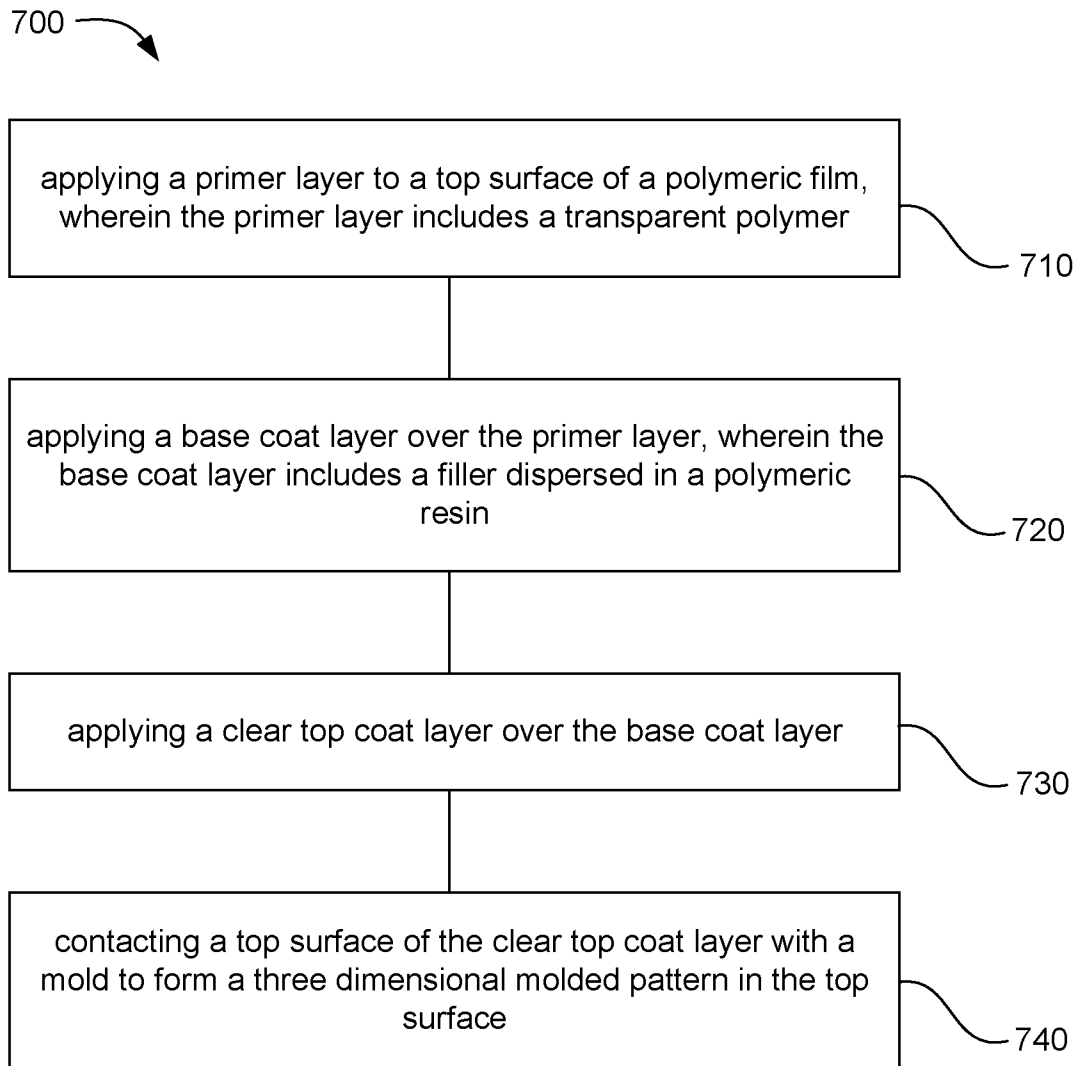


FIG. 7

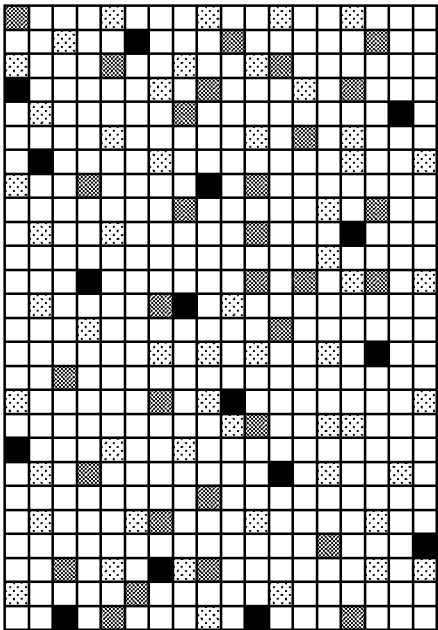


FIG. 8

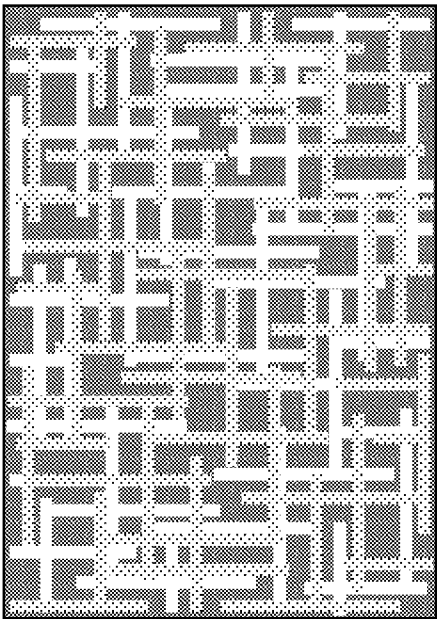


FIG. 9

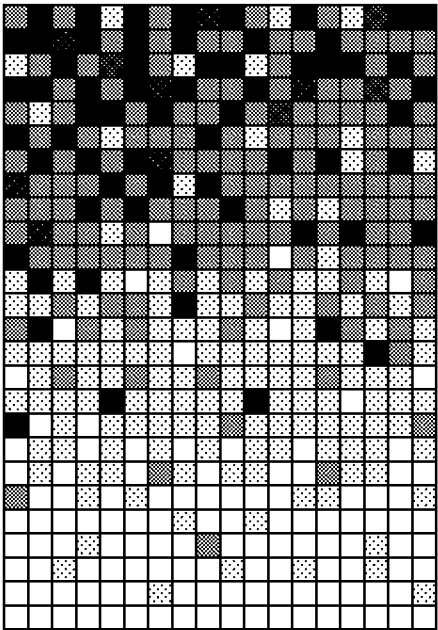


FIG. 10

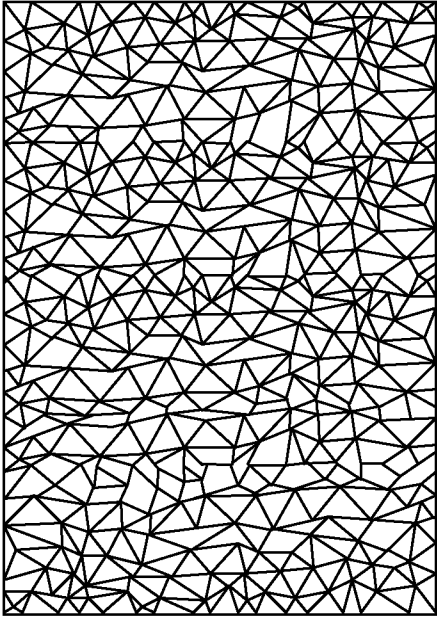


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2018/060673

A. CLASSIFICATION OF SUBJECT MATTER

B44C 5/04 (2006.01)**B32B 27/08 (2006.01)**

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)

B44C 5/00-5/04, 1/00-1/24, B32B 27/00-27/40, B32B 33/00, 37/00, B29C 43/00, H05K 5/00-5/06

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, Espacenet, Information Retrieval System of FIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008/0233326 A1 (DARRIN G. HEGEMIER et al.) 25.09.2008	1-15
A	WO 2011/060425 A1 (AVERY DENNISON CORPORATION et al.) 19.05.2011	1-15

☐

Further documents are listed in the continuation of Box C.

☐

See patent family annex.

* Special categories of cited documents:

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“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

03 July 2019 (03.07.2019)

Date of mailing of the international search report

08 August 2019 (08.08.2019)

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