

(S7) Abstract: A multi-layer cover tape construction includes a polymeric substrate with a first major surface and a second major surface; an adhesive layer disposed on the first major surface of the first substrate; and an antistatic layer disposed on the first major surface of the first substrate. The polymeric substrate has a surface energy of between 5 and 500 mN/m, and a surface roughness of between 0.1 and 5 μm .

MULTI-LAYER COVER TAPES

Field of the Disclosure

This disclosure relates to multi-layer cover tapes and the use of such cover tapes in carrier tape assemblies.

Background

Various cover tapes have been introduced for use in sealing electronic components within a carrier tape assembly. Such cover tapes are described in, for example, U.S. Pat. App. Pub. 2003/0049437, U.S. Pat. 4,963,405, and U.S. Pat. 4,964,405.

Summary

Disclosed herein are multi-layer cover tape constructions, carrier tape assemblies that include multi-layer cover tape constructions, and methods of making multi-layer cover tape constructions. In some embodiments, a multi-layer cover tape construction includes a first substrate with a first major surface and a second major surface; an adhesive layer disposed on the first major surface of the first substrate; and an antistatic construction disposed on the first major surface of the first substrate. The antistatic construction includes a second polymeric substrate with a first major surface and a second major surface; and an antistatic layer disposed on the second major surface of the second substrate. The second polymeric substrate has a surface energy of between wherein the second polymeric substrate has a surface energy of between 5 and 500 mN/m, and a surface roughness of between 0.1 and 5 μ m.

In some embodiments, a multi-layer cover tape construction includes a polymeric substrate with a first major surface and a second major surface; an adhesive layer disposed on the first major surface of the first substrate; and an antistatic layer disposed on the first major surface of the first substrate. The polymeric substrate has a surface energy of between 5 and 500 mN/m, and a surface roughness of between 0.1 and 5 μ m.

The above summary of the present disclosure is not intended to describe each embodiment of the present invention. The details of one or more embodiments of the disclosure are also set forth in the description below. Other features, objects, and advantages of the invention will be apparent from the description and from the claims.

Brief Description of the Drawings

The present application may be more completely understood in consideration of the following detailed description of various embodiments of the disclosure in connection with the accompanying drawings.

5 Figure 1 shows a cross-sectional view of an exemplary embodiment of a multi-layer cover tape of this disclosure.

 Figure 2 shows a cross-sectional view of an exemplary embodiment of a multi-layer cover tape of this disclosure.

10 Figure 3 shows a cross-sectional view of an exemplary embodiment of a multi-layer carrier tape construction of this disclosure.

 Figure 4 is a graph showing the effect of FC4400 content on the surface resistivity of coatings formed with SR740A dimethacrylate.

 Figure 5 is a graph showing the surface resistivity of the (1) as obtained anti-static coating and (2) after a tape peel test.

15 Figure 6 is a graph showing the effect of FC5000i content on surface resistivity of cellulose acetate and BOPP films.

 Figure 7 is a graph showing the effect of ZnO loading on the surface resistivity of a cellulose acetate substrate.

20 Figure 8 is a graph showing the effect of FC4400 loading on the surface resistivity of matte and super matte PET surfaces.

 Figure 9 is a contour plot showing the surface energy and surface roughness ranges on die-stick issue.

 Figure 10 are photos showing the testing of a matte BOPP substrate as a cover tape over a carrier with silicone encapsulated LED dies.

25 Figures 11A and 11B are photos showing the surface morphology of a cover tape without and with microstructures, respectively.

 Figure 12 is a graph showing the peel force required for each of the tested cover tapes with a tacky silicone component.

30 In the following description of the illustrated embodiments, reference is made to the accompanying drawings, in which is shown by way of illustration, various embodiments in which the disclosure may be practiced. It is to be understood that the embodiments may be utilized and structural changes may be made without departing from

the scope of the present disclosure. The figures are not necessarily to scale. Like numbers used in the figures refer to like components. However, it will be understood that the use of a number to refer to a component in a given figure is not intended to limit the component in another figure labeled with the same number.

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Detailed Description

Background

As electronic parts have become more miniature, storage, transportation and handling of such components has become more difficult, and specialized methods have evolved. One such method is use of a carrier tape. A carrier tape can be formed of a variety of materials, but is typically formed of a plastic material formed in a strip which has multiple longitudinal recesses or indentions meant to hold individual components to prevent them from touching each other or being otherwise exposed to trauma or contamination. Such indented segments typically include an upper opening by which the component is placed into the recess, and then the opening is sealed, generally by means of a cover tape.

Encapsulated LED dies are an electronic part frequently transported in carrier tapes. The encapsulation of LED dies is typically carried out to give protection against mechanical and thermal shock, chemical degradation, and humidity and temperature cycles. Furthermore, the encapsulation process is intended to promote the light emission and thermal transfer characteristics.

A variety of encapsulant materials, including polyurethanes, epoxies, silicones and other polymers are often employed with LED dies. Among these common encapsulants, silicones are most prevalent due to their high refractive index and light transmittance, optical clarity, and thermal and photo stability. This is particularly evident in encapsulants for high power LEDs.

It has been discovered that during the use of carrier tapes for the transport of encapsulated LED dies (e.g., silicone encapsulated LED dies) the encapsulated parts have a tendency to come out of the carrier tape pockets and adhere to the cover tape (herein referred to as “die stick”). The die stick phenomenon, in turn, leads to problems with the pick and place operations commonly employed in surface mount processes and, therefore,

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results in high yield loss by the end user of the LED dies. Consequently, cover tape materials or constructions that could reduce or eliminate die stick are desirable.

Generally, the present disclosure is directed to cover tapes, carrier tape constructions and methods of making them, which incorporate a polymeric film and an antistatic layer.

Definitions

The term "adhesive" as used herein refers to polymeric compositions useful to adhere together two adherends. Examples of adhesives are heat activated adhesives and pressure sensitive adhesives.

Heat activated adhesives are non-tacky at room temperature but become tacky and capable of bonding to a substrate at elevated temperatures. These adhesives usually have a T_g (glass transition temperature) or melting point (T_m) above room temperature. When the temperature is elevated above the T_g or T_m , the storage modulus usually decreases and the adhesive becomes tacky.

Pressure sensitive adhesive compositions are well known to those of ordinary skill in the art to possess properties including the following: (1) aggressive and permanent tack, (2) adherence with no more than finger pressure, (3) sufficient ability to hold onto an adherend, and (4) sufficient cohesive strength to be cleanly removable from the adherend. Materials that have been found to function well as pressure sensitive adhesives are polymers designed and formulated to exhibit the requisite viscoelastic properties resulting in a desired balance of tack, peel adhesion, and shear holding power. Obtaining the proper balance of properties is not a simple process.

Unless otherwise indicated, "optically transparent" refers to an article, film or adhesive composition that has a high light transmittance over at least a portion of the visible light spectrum (about 400 to about 700 nm).

Unless otherwise indicated, "optically clear" refers to an adhesive or article that has a high light transmittance over at least a portion of the visible light spectrum (about 400 to about 700 nm), and that exhibits low haze. The term "haze" refers to that percentage of transmitted light that deviates from the incident beam by more than 2.5° on the average.

As used herein, the term "conductivity" means a measure of the ability of electrical charge to move within a material. "Resistivity" is the reciprocal of conductivity.

As used herein, the term "cover tape" means a tape useful for sticking to the surface of a carrier tape, which has indented segments for accommodating and transporting chips and other sensitive electronic components.

As used herein, the term "indented segments" refers to individual carriers, e.g., pockets or cups formed in the carrier tape to hold typically a single unit of some product. Such segments are typically formed by vacuum forming, thermoforming, molding or other known process.

As used herein, the term "strip portion" refers to that portion of the carrier tape along each longitudinal edge, which may or may not have sprocket holes for winding.

The term "adjacent" as used herein when referring to two layers means that the two layers are in proximity with one another with no intervening open space between them. They may be in direct contact with one another (e.g. laminated together) or there may be intervening layers.

The term "directly adjacent" as used herein when referring to two layers means that the two layers are in direct contact with one another and there are no intervening layers between the two layers.

As used herein, the singular forms "a", "an", and "the" include plural referents unless the content clearly dictates otherwise. As used in this specification and the appended embodiments, the term "or" is generally employed in its sense including "and/or" unless the content clearly dictates otherwise.

As used herein, the recitation of numerical ranges by endpoints includes all numbers subsumed within that range (e.g. 1 to 5 includes 1, 1.5, 2, 2.75, 3, 3.8, 4, and 5). Unless otherwise indicated, all numbers expressing quantities or ingredients, measurement of properties and so forth used in the specification and embodiments are to be understood as being modified in all instances by the term "about." Accordingly, unless indicated to the contrary, the numerical parameters set forth in the foregoing specification and attached listing of embodiments can vary depending upon the desired properties sought to be obtained by those skilled in the art utilizing the teachings of the present disclosure. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claimed embodiments, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques

Referring to FIG. 1, in some embodiments, the present disclosure is directed to a multi-layer cover tape construction 10 having a top surface 11A and a bottom surface 11B (the bottom surface 11B intended to be nearest an electronic component positioned in a carrier tape). The cover tape construction 10 may include a first substrate 12 having a first major surface 12A and a second major surface 12B, and an adhesive layer 14 and an antistatic construction 18 disposed on the first major surface 12A. As shown, the adhesive layer 14 may be disposed between the first major surface 12A and the antistatic construction 18. The antistatic construction 18 may be sized and shaped such that it overlaps only a portion of the adhesive layer 14 (i.e., portions of the adhesive layer 14 remain exposed). For example, as shown, two longitudinal edges of the adhesive layer 14 may remain exposed. The multi-layer construction 10 may also include a low adhesion backsize coating 16 disposed on the second major surface 12B, and a primer layer 13 disposed between the first major surface 12A and the adhesive layer 14.

In some embodiments, the antistatic construction 18 may include a second substrate 22 with a first major surface 22A and a second major surface 22B, the first major surface 22A being positioned adjacent the adhesive layer 14. The antistatic construction 18 may further include an antistatic layer 24 disposed on the second major surface 22B of the second substrate 22.

In some embodiments, a wide range of materials are suitable for use in the first and second substrates 12 and 22 of the cover tape construction 10. Generally, the substrates 12, 22 may be a film prepared from polymeric materials, either a single polymeric material or a blend of polymeric materials. In some embodiments, the substrates 12, 22 may be optically transparent or optically clear. Suitable polymeric materials include a wide range of polymeric materials that are typically used in tape constructions as backing materials. Examples of suitable materials include: cellulose acetate, polyesters, such as for example polyethylene terephthalate (PET), and polyester copolymers; polyolefins, such as polyethylene (PE), including a wide range of grades of polyethylene such as low density polyethylene (LDPE) and polyethylene copolymers, polypropylene (PP), including biaxially oriented polypropylene (BOPP), and polyolefin copolymers; polyurethanes, including polyurethane copolymers; polyacrylate polymers and copolymers; polyvinyl polymers and copolymers; polymethylmethacrylate polymers and copolymers; polycarbonate polymers and copolymers; and combinations and mixtures thereof. The

substrates 12, 22 may be formed of the same material or different materials. In some embodiments, the substrates 12, 22 may include or be formed of PET, BOPP, or cellulose acetate. In some embodiments, the substrates 12, 22 may include or be formed of cellulose acetate.

5 The first and second substrates may be of any suitable thickness. Typically the substrates are in the range of from about 5 micrometers (0.2 mils) to about 100 micrometers (4 mils), more typically the substrates are in the range of from about 6 micrometers (0.25 mils) to about 32 micrometers (1.25 mils), or 13 micrometers (0.5 mils) to 25 micrometers (1.0 mils).

10 In some embodiments, the second substrate (and optionally the first substrate) may be selected to have a particular surface energy and/or surface roughness. In this regard, it has been discovered that the die stick issue may be eliminated or mitigated by the selection of certain combinations of surface energy and surface roughness. In some embodiments, the surface roughness of the second substrate 22 (and optionally the first
15 substrate 12) may be between 0.1 and 5 μ m, 0.1 and 1 μ m, or 0.2 and 0.5 μ m, or may be at least 0.5, 0.3, or 0.15 μ m; and the surface energy may be between 5 and 500 mN/m, 20 and 100 mN/m, or 20 and 50 mN/m or may be at least 40, 30, or 20mN/m. As used herein, surface energy values are as measured by ASTM D7490 – 13, Standard Test Method for Measurement of the Surface Tension of Solid Coatings, Substrates and
20 Pigments using Contact Angle Measurements; and surface roughness values are as measured by ASTM D7127 - 13 Standard Test Method for Measurement of Surface Roughness of Abrasive Blast Cleaned Metal Surfaces Using a Portable Stylus Instrument.

 In some embodiments, the adhesive layer 14 may be disposed upon any portion (up to all) of the first major surface 12A of the first polymeric substrate. In some
25 embodiments, the adhesive layer 14 may include a heat activated adhesive, a pressure sensitive adhesive, or combinations thereof.

 Heat activated adhesives are non-tacky at room temperature but become tacky and capable of bonding to a substrate at elevated temperatures. These adhesives usually have a T_g (glass transition temperature) or melting point (T_m) above room temperature. When
30 the temperature is elevated above the T_g or T_m , the storage modulus usually decreases and the adhesive becomes tacky.

Typically, because it is desirable that the cover tape construction be optically transparent or optically clear, the heat activated adhesive may be optically transparent or optically clear. A wide variety of optically clear heat activated adhesives may be used. Examples of suitable optically clear heat activated adhesives include polyacrylate hot melt
5 adhesives, polyvinyl butyrals, ethylene vinyl acetate, ionomers, polyolefins, or combinations thereof.

The optically clear heat activated adhesives may be (meth)acrylate-based hot melt adhesives. The hot melt adhesives typically are prepared from (meth)acrylate polymers that have a glass transition temperature (T_g) of greater than room temperature, more
10 typically greater than about 40°C, and are prepared from alkyl (meth)acrylate monomers. Useful alkyl (meth)acrylates (i.e., acrylic acid alkyl ester monomers) include linear or branched monofunctional unsaturated acrylates or methacrylates of non-tertiary alkyl alcohols, the alkyl groups of which have from 4 to 14 and, in particular, from 4 to 12 carbon atoms. Poly(meth)acrylic hot melt adhesives may also contain optional co-
15 monomer components such as, for example, (meth)acrylic acid, vinyl acetate, N-vinyl pyrrolidone, (meth)acrylamide, a vinyl ester, a fumarate, a styrene macromer, alkyl maleates and alkyl fumarates (based, respectively, on maleic and fumaric acid), or combinations thereof.

In some embodiments, the adhesive layer 14 may be at least partially formed of
20 polyvinyl butyral. The polyvinyl butyral layer may be formed via known aqueous or solvent-based acetalization process in which polyvinyl alcohol is reacted with butyraldehyde in the presence of an acidic catalyst. In some instances, the polyvinyl butyral layer may include or be formed from polyvinyl butyral that is commercially available from Solutia Incorporated, of St. Louis, MO, under the trade name "BUTVAR"
25 resin.

In some instances, the polyvinyl butyral layer may be produced by mixing resin and (optionally) plasticizer and extruding the mixed formulation through a sheet die. If a plasticizer is included, the polyvinyl butyral resin may include about 20 to 80 or perhaps
30 about 25 to 60 parts of plasticizer per hundred parts of resin. Examples of suitable plasticizers include esters of a polybasic acid or a polyhydric alcohol. Suitable plasticizers are triethylene glycol bis(2-ethylbutyrate), triethylene glycol di-(2-ethylhexanoate), triethylene glycol diheptanoate, tetraethylene glycol diheptanoate, dihexyl adipate, dioctyl

adipate, hexyl cyclohexyl adipate, mixtures of heptyl and nonyl adipates, diisononyl adipate, heptylnonyl adipate, dibutyl sebacate, polymeric plasticizers such as the oil-modified sebacic alkyds, and mixtures of phosphates and adipates such as disclosed in U.S. Pat. No. 3,841,890 and adipates such as disclosed in U.S. Pat. No. 4,144,217.

5 Examples of suitable ethylene vinyl acetate (EVA) adhesives include a wide range of commercially available EVA hot melt adhesives. Typically these EVA hot melt adhesives have a vinyl acetate content of from about 18-29 % by weight of the polymer. The adhesives typically have high amounts of tackifiers and waxes. An exemplary composition is one with 30-40 % by weight of EVA polymer, 30-40 % by weight of
10 tackifier, 20-30 % by weight of wax, and 0.5-1 % by weight of stabilizers. Examples of suitable EVA hot melt adhesives are the BYNEL SERIES 3800 resins commercially available from DuPont, Wilmington, DE (including BYNEL 3810, BYNEL 3859, BYNEL 3860, and BYNEL 3861). A particularly suitable EVA hot melt adhesive is the material available from Bridgestone Corp. Tokyo, JP under the trade name "EVASAFE".

15 Examples of suitable ionomeric adhesives are the "ionoplast resins". Ionoplast resins are copolymers of ethylene and unsaturated carboxylic acids, wherein at least a portion of the acid groups in the copolymer have been neutralized to the salt form of the acid. Extruded sheets of ionoplast resins suitable for use in this disclosure are commercially available from DuPont Chemicals, Wilmington, DE, under the trade name
20 "SENTRYGLASS PLUS".

 Examples of suitable polyolefin adhesives include ethylene/ α -olefin copolymers. As used herein, the term "ethylene/ α -olefin copolymer" refers to polymers comprising a class of hydrocarbons manufactured by the catalytic oligomerization (*i.e.*, polymerization to low-molecular-weight products) of ethylene and linear α -olefin monomers. The
25 ethylene/ α -olefin copolymers may be made, for example, with a single site catalyst such as a metallocene catalyst or multi-site catalysts such as Ziegler-Natta and Phillips catalysts. The linear α -olefin monomers typically are 1-butene or 1-octene but may range from C3 to C20 linear, branched or cyclic α -olefin. The α -olefin may be branched but only if the branch is at least alpha to the double bond, such as 3-methyl-1-pentene. Examples of C3-
30 C20 α -olefins include propylene, 1-butene, 4-methyl-1-butene, 1-hexene, 1-octene, 1-dodecene, 1-tetradecene, 1-hexadecene and 1-octadecene. The α -olefins can also contain a cyclic structure such as cyclohexane or cyclopentane, resulting in an α -olefin such as 3-

cyclohexyl-1 propene (allyl cyclohexane) and vinyl cyclohexane. Although not α -olefins in the classical sense of the term, for purposes of this disclosure certain cyclic olefins, such as norbornene and related olefins, are α -olefins and can be used. Similarly, styrene and its related olefins (for example, α -methyl styrene) are α -olefins for the purposes of this disclosure. Acrylic and methacrylic acid and their respective ionomers, and acrylates and methacrylates, however are not α -olefins for the purposes of this disclosure. Illustrative ethylene/ α -olefin copolymers include ethylene/1-butene, ethylene/1-octene, ethylene/1-butene/1-octene, ethylene/styrene. The polymers can be block or random. Exemplary commercially available low crystalline ethylene/ α -olefin copolymers include resins sold under the tradenames "ENGAGE" ethylene/1-butene and ethylene/1-octene copolymers and "FLEXOMER" ethylene/1-hexene copolymer, available from Dow Chemical Co., and homogeneously branched, substantially linear ethylene/ α -olefin copolymers such as "TAFMER", available from Mitsui Petrochemicals Company Limited, and "EXACT", available from ExxonMobil Corp. As used herein, the term "copolymer" refers to polymers made from at least 2 monomers.

In some of these embodiments, the α -olefin moiety of the ethylene/ α -olefin copolymer includes four or more carbons. In some embodiments, the ethylene/ α -olefin copolymer is a low crystalline ethylene/ α -olefin copolymer. As used herein, the term "low crystalline" means crystallinity (according to method disclosed in ASTM F2625-07) of less than 50% by weight. In some embodiments, the low crystalline ethylene/ α -olefin copolymer is a butene α -olefin. In some embodiments the α -olefin of the low crystalline ethylene/ α -olefin copolymer has 4 or more carbons.

In some embodiments, the low crystalline ethylene/ α -olefin copolymer has a DSC peak melting point of less than or equal to 50°C. As used herein, the term "DSC peak melting point" means a melting point determined by DSC (10°/min) under nitrogen purge as the peak with the largest area under the DSC curve.

In some embodiments, the adhesive layer 14 may include or be formed of a pressure sensitive adhesive. Pressure sensitive adhesive compositions are well known to those of ordinary skill in the art to possess properties including the following: (1) aggressive and permanent tack, (2) adherence with no more than finger pressure, (3) sufficient ability to hold onto an adherend, and (4) sufficient cohesive strength to be

cleanly removable from the adherend. A wide range of pressure sensitive adhesives are suitable for use in the cover tape constructions of the present disclosure.

Suitable pressure sensitive adhesives include those based on natural rubbers, synthetic rubbers, styrene block copolymers, polyvinyl ethers, (meth)acrylates, poly- α -olefins, silicones, urethanes or ureas. As with the heat activated adhesives described above, typically the pressure sensitive adhesive is optically transparent or optically clear.

Useful natural rubber pressure sensitive adhesives generally contain masticated natural rubber, from 25 parts to 300 parts of one or more tackifying resins to 100 parts of natural rubber, and typically from 0.5 to 2.0 parts of one or more antioxidants. Natural rubber may range in grade from a light pale crepe grade to a darker ribbed smoked sheet and includes such examples as CV-60, a controlled viscosity rubber grade and SMR-5, a ribbed smoked sheet rubber grade.

Tackifying resins used with natural rubbers generally include but are not limited to wood rosin and its hydrogenated derivatives; terpene resins of various softening points, and petroleum-based resins, such as, the "ESCOREZ 1300" series of C5 aliphatic olefin-derived resins from Exxon, and "PICCOLYTE S" series, polyterpenes from Hercules, Inc. Antioxidants are used to retard the oxidative attack on natural rubber, which can result in loss of the cohesive strength of the natural rubber adhesive. Useful antioxidants include but are not limited to amines, such as N-N' di- β -naphthyl-1,4-phenylenediamine, available as "AGERITE D"; phenolics, such as 2,5-di-(*t*-amyl) hydroquinone, available as "SANTOVAR A", available from Monsanto Chemical Co., tetrakis[methylene 3-(3',5'-di-*tert*-butyl-4'-hydroxyphenyl)propanate]methane, available as "IRGANOX 1010" from Ciba-Geigy Corp., and 2-2'-methylenebis(4-methyl-6-*tert* butyl phenol), available as Antioxidant 2246; and dithiocarbamates, such as zinc dithiodibutyl carbamate. Other materials can be added to natural rubber adhesives for special purposes, wherein the additions can include plasticizers, pigments, and curing agents to partially vulcanize the pressure sensitive adhesive.

Another useful class of pressure sensitive adhesives are those comprising synthetic rubber. Such adhesives are generally rubbery elastomers, which are either self-tacky or non tacky and require tackifiers.

Self-tacky synthetic rubber pressure sensitive adhesives include for example, butyl rubber, a copolymer of isobutylene with less than 3 percent isoprene, polyisobutylene, a

homopolymer of isoprene, polybutadiene, such as "TAKTENE 220 BAYER" or styrene/butadiene rubber. Butyl rubber pressure sensitive adhesives often contain an antioxidant such as zinc dibutyl dithiocarbamate. Polyisobutylene pressure sensitive adhesives do not usually contain antioxidants. Synthetic rubber pressure sensitive adhesives, which generally require tackifiers, are also generally easier to melt process. They comprise polybutadiene or styrene/butadiene rubber, from 10 parts to 200 parts of a tackifier, and generally from 0.5 to 2.0 parts per 100 parts rubber of an antioxidant such as "IRGANOX 1010". An example of a synthetic rubber is "AMERIPOL 1011A", a styrene/butadiene rubber available from BF Goodrich. Tackifiers that are useful include derivatives of rosins such as "FORAL 85", a stabilized rosin ester from Hercules, Inc., the "SNOWTACK" series of gum rosins from Tenneco, and the "AQUATAC" series of tall oil rosins from Sylvachem; and synthetic hydrocarbon resins such as the "PICCOLYTE A" series, polyterpenes from Hercules, Inc., the "ESCOREZ 1300" series of C₅ aliphatic olefin-derived resins, the "ESCOREZ 2000" Series of C₉ aromatic/aliphatic olefin-derived resins, and polyaromatic C₉ resins, such as the "PICCO 5000" series of aromatic hydrocarbon resins, from Hercules, Inc. Other materials can be added for special purposes, including hydrogenated butyl rubber, pigments, plasticizers, liquid rubbers, such as "VISTANEX LMMH" polyisobutylene liquid rubber available from Exxon, and curing agents to vulcanize the adhesive partially.

Styrene block copolymer pressure sensitive adhesives generally comprise elastomers of the A-B or A-B-A type, where A represents a thermoplastic polystyrene block and B represents a rubbery block of polyisoprene, polybutadiene, or poly(ethylene/butylene), and resins. Examples of the various block copolymers useful in block copolymer pressure sensitive adhesives include linear, radial, star and tapered styrene-isoprene block copolymers such as "KRATON D1107P", available from Shell Chemical Co., and "EUOPRENE SOL TE 9110", available from EniChem Elastomers Americas, Inc.; linear styrene-(ethylene-butylene) block copolymers such as "KRATON G1657", available from Shell Chemical Co.; linear styrene-(ethylene-propylene) block copolymers such as "KRATON G1750X", available from Shell Chemical Co.; and linear, radial, and star styrene-butadiene block copolymers such as "KRATON D1118X", available from Shell Chemical Co., and "EUOPRENE SOL TE 6205", available from EniChem Elastomers Americas, Inc. The polystyrene blocks tend to form domains in the

shape of spheroids, cylinders, or plates that causes the block copolymer pressure sensitive adhesives to have two phase structures. Resins that associate with the rubber phase generally develop tack in the pressure sensitive adhesive. Examples of rubber phase associating resins include aliphatic olefin-derived resins, such as the “ESCOREZ 1300” series and the “WINGTACK” series, available from Goodyear; rosin esters, such as the “FORAL” series and the “STAYBELITE” Ester 10, both available from Hercules, Inc.; hydrogenated hydrocarbons, such as the “ESCOREZ 5000” series, available from Exxon; polyterpenes, such as the “PICCOLYTE A” series; and terpene phenolic resins derived from petroleum or turpentine sources, such as “PICCOFYN A100”, available from Hercules, Inc. Resins that associate with the thermoplastic phase tend to stiffen the pressure sensitive adhesive. Thermoplastic phase associating resins include polyaromatics, such as the “PICCO 6000” series of aromatic hydrocarbon resins, available from Hercules, Inc.; coumarone-indene resins, such as the “CUMAR” series, available from Neville; and other high-solubility parameter resins derived from coal tar or petroleum and having softening points above about 85° C, such as the “AMOCO 18” series of alphas-methyl styrene resins, available from Amoco, “PICCOVAR 130” alkyl aromatic polyindene resin, available from Hercules, Inc., and the “PICCOTEX” series of alphas-methyl styrene/vinyl toluene resins, available from Hercules. Other materials can be added for special purposes, including rubber phase plasticizing hydrocarbon oils, such as, “TUFFLO 6056”, available from Lydondell Petrochemical Co., Polybutene-8 from Chevron, “KAYDOL”, available from Witco, and “SHELLFLEX 371”, available from Shell Chemical Co.; pigments; antioxidants, such as “IRGANOX 1010” and “IRGANOX 1076”, both available from Ciba-Geigy Corp., “BUTAZATE”, available from Uniroyal Chemical Co., “CYANOX LDTP”, available from American Cyanamid, and “BUTASAN”, available from Monsanto Co.; antiozonants, such as “NBC”, a nickel dibutyldithiocarbamate, available from DuPont; liquid rubbers such as “VISTANEX LMMH” polyisobutylene rubber; and ultraviolet light inhibitors, such as “IRGANOX 1010” and “TINUVIN P”, available from Ciba-Geigy Corp.

Polyvinyl ether pressure sensitive adhesives are generally blends of homopolymers of vinyl methyl ether, vinyl ethyl ether or vinyl iso-butyl ether, or blends of homopolymers of vinyl ethers and copolymers of vinyl ethers and acrylates to achieve desired pressure sensitive properties. Depending on the degree of polymerization,

homopolymers may be viscous oils, tacky soft resins or rubber-like substances. Polyvinyl ethers used as raw materials in polyvinyl ether adhesives include polymers based on: vinyl methyl ether such as "LUTANOL M 40", available from BASF, and "GANTREZ M 574" and "GANTREZ 555", available from ISP Technologies, Inc.; vinyl ethyl ether such as
5 "LUTANOL A 25", "LUTANOL A 50" and "LUTANOL A 100"; vinyl isobutyl ether such as "LUTANOL I30", "LUTANOL I60", "LUTANOL IC", "LUTANOL I60D" and "LUTANOL I 65D"; methacrylate/vinyl isobutyl ether/acrylic acid such as "ACRONAL 550 D", available from BASF. Antioxidants useful to stabilize the polyvinylether pressure sensitive adhesive include, for example, "IONOX 30" available from Shell, "IRGANOX
10 1010" available from Ciba-Geigy, and antioxidant "ZKF" available from Bayer Leverkusen. Other materials can be added for special purposes as described in BASF literature including tackifier, plasticizer and pigments.

(Meth)acrylate-based pressure sensitive adhesives generally have a glass transition temperature of about -20° C. or less and may comprise from 100 to 80 weight percent of a
15 C₃-C₁₂ alkyl ester component such as, for example, isooctyl acrylate, 2-ethyl-hexyl acrylate and n-butyl acrylate and from 0 to 20 weight percent of a polar component such as, for example, acrylic acid, methacrylic acid, ethylene vinyl acetate, N-vinyl pyrrolidone and styrene macromer. Generally, the (meth)acrylate-based pressure sensitive adhesives comprise from 0 to 20 weight percent of acrylic acid and from 100 to 80 weight percent of
20 isooctyl acrylate. The (meth)acrylate-based pressure sensitive adhesives may be self-tacky or tackified. Useful tackifiers for acrylics are rosin esters such as "FORAL 85", available from Hercules, Inc., aromatic resins such as "PICCOTEX LC-55WK", aliphatic resins such as "PICCOTAC 95", available from Hercules, Inc., and terpene resins such as α -pinene and β -pinene, available as "PICCOLYTE A-115" and "ZONAREZ B-100" from
25 Arizona Chemical Co. Other materials can be added for special purposes, including hydrogenated butyl rubber, pigments, and curing agents to vulcanize the adhesive partially.

Poly- α -olefin pressure sensitive adhesives, also called a poly(1-alkene) pressure sensitive adhesives, generally comprise either a substantially uncrosslinked polymer or a
30 uncrosslinked polymer that may have radiation activatable functional groups grafted thereon as described in U.S. Pat. No. 5,209,971 (Babu, et al) which is incorporated herein by reference. The poly- α -olefin polymer may be self tacky and/or include one or more

tackifying materials. If uncrosslinked, the inherent viscosity of the polymer is generally between about 0.7 and 5.0 dL/g as measured by ASTM D 2857-93, "Standard Practice for Dilute Solution Viscosity of Polymers". In addition, the polymer generally is predominantly amorphous. Useful poly- α -olefin polymers include, for example, C₃-C₁₈ poly(1-alkene) polymers, generally C₅-C₁₂ α -olefins and copolymers of those with C₃ or C₆-C₈ and copolymers of those with C₃. Tackifying materials are typically resins that are miscible in the poly- α -olefin polymer. The total amount of tackifying resin in the poly- α -olefin polymer ranges between 0 to 150 parts by weight per 100 parts of the poly- α -olefin polymer depending on the specific application. Useful tackifying resins include resins derived by polymerization of C₅ to C₉ unsaturated hydrocarbon monomers, polyterpenes, synthetic polyterpenes and the like. Examples of such commercially available resins based on a C₅ olefin fraction of this type are "WINGTACK 95" and "WINGTACK 15" tackifying resins available from Goodyear Tire and Rubber Co. Other hydrocarbon resins include "REGALREZ 1078" and "REGALREZ 1126" available from Hercules Chemical Co., and "ARKON P115" available from Arakawa Chemical Co. Other materials can be added for special purposes, including antioxidants, fillers, pigments, and radiation activated crosslinking agents.

Silicone pressure sensitive adhesives include two major components, a polymer or gum, and a tackifying resin. The polymer is typically a high molecular weight polydimethylsiloxane or polydimethyldiphenylsiloxane, that contains residual silanol functionality (SiOH) on the ends of the polymer chain, or a block copolymer comprising polydiorganosiloxane soft segments and urea terminated hard segments. The tackifying resin is generally a three-dimensional silicate structure that is endcapped with trimethylsiloxy groups (OSiMe₃) and also contains some residual silanol functionality. Examples of tackifying resins include SR 545, from General Electric Co., Silicone Resins Division, Waterford, N.Y., and MQD-32-2 from Shin-Etsu Silicones of America, Inc., Torrance, Calif. Manufacture of typical silicone pressure sensitive adhesives is described in U.S. Pat. No. 2,736,721 (Dexter). Manufacture of silicone urea block copolymer pressure sensitive adhesive is described in U.S. Pat. No. 5,214,119 (Leir, et al). Other materials can be added for special purposes, including, pigments, plasticizers, and fillers. Fillers are typically used in amounts from 0 parts to 10 parts per 100 parts of silicone

pressure sensitive adhesive. Examples of fillers that can be used include zinc oxide, silica, carbon black, pigments, metal powders and calcium carbonate. One suitable class of siloxane-containing pressure sensitive adhesives are those with oxamide terminated hard segments such as those described in US Patent No. 7,981,995 (Hays) and US Patent No. 7,371,464 (Sherman).

Useful polyurethane and polyurea pressure sensitive adhesives useful include, for example, those disclosed in WO 00/75210 (Kinning et al.) and in U.S. Patent Nos. 3,718,712 (Tushaus); 3,437,622 (Dahl); and 5,591,820 (Kydonieus et al.). Additionally, the urea-based pressure sensitive adhesives described in US Patent Publication No. 2011/0123800 (Sherman et al.) and the urethane-based pressure sensitive adhesives described in US Patent Publication No. 2012/0100326 (Sherman et al.) may be suitable.

One suitable class of optically clear pressure sensitive adhesives are (meth)acrylate-based pressure sensitive adhesives and may comprise either an acidic or basic copolymer. In many embodiments the (meth)acrylate-based pressure sensitive adhesive is an acidic copolymer. Generally, as the proportion of acidic monomers used in preparing the acidic copolymer increases, cohesive strength of the resulting adhesive increases. The proportion of acidic monomers is usually adjusted depending on the proportion of acidic copolymer present in the blends of the present disclosure.

To achieve pressure sensitive adhesive characteristics, the corresponding copolymer can be tailored to have a resultant glass transition temperature (T_g) of less than about 0°C. Suitable pressure sensitive adhesive copolymers are (meth)acrylate copolymers. Such copolymers typically are derived from monomers comprising about 40% by weight to about 98% by weight, often at least 70% by weight, or at least 85% by weight, or even about 90% by weight, of at least one alkyl (meth)acrylate monomer that, as a homopolymer, has a T_g of less than about 0°C.

Examples of such alkyl (meth)acrylate monomers are those in which the alkyl groups comprise from about 4 carbon atoms to about 12 carbon atoms and include, but are not limited to, n-butyl acrylate, 2-ethylhexyl acrylate, isooctyl acrylate, isononyl acrylate, isodecyl acrylate, and mixtures thereof. Optionally, other vinyl monomers and alkyl (meth)acrylate monomers which, as homopolymers, have a T_g greater than 0°C, such as methyl acrylate, methyl methacrylate, isobornyl acrylate, vinyl acetate, styrene, and the like, may be utilized in conjunction with one or more of the low T_g alkyl (meth)acrylate

monomers and copolymerizable basic or acidic monomers, provided that the Tg of the resultant (meth)acrylate copolymer is less than about 0°C.

In some embodiments, it may be desirable to use (meth)acrylate monomers that are free of alkoxy groups. Alkoxy groups are understood by those skilled in the art.

When used, basic (meth)acrylate copolymers useful as the pressure sensitive adhesive matrix typically are derived from basic monomers comprising about 2% by weight to about 50% by weight, or about 5% by weight to about 30% by weight, of a copolymerizable basic monomer. Exemplary basic monomers include N,N-dimethylaminopropyl methacrylamide (DMPMAm); N,N-diethylaminopropyl methacrylamide (DEAPMAm); N,N-dimethylaminoethyl acrylate (DMAEA); N,N-diethylaminoethyl acrylate (DEAEA); N,N-dimethylaminopropyl acrylate (DMPA); N,N-diethylaminopropyl acrylate (DEAPA); N,N-dimethylaminoethyl methacrylate (DMAEMA); N,N-diethylaminoethyl methacrylate (DEAEMA); N,N-dimethylaminoethyl acrylamide (DMAEAm); N,N-dimethylaminoethyl methacrylamide (DMAEMAm); N,N-diethylaminoethyl acrylamide (DEAEAm); N,N-diethylaminoethyl methacrylamide (DEAEMAm); N,N-diethylaminoethyl vinyl ether (DMAEVE); N,N-diethylaminoethyl vinyl ether (DEAEVE); and mixtures thereof. Other useful basic monomers include vinylpyridine, vinylimidazole, tertiary amino-functionalized styrene (e.g., 4-(N,N-dimethylamino)-styrene (DMAS), 4-(N,N-diethylamino)-styrene (DEAS)), N-vinylpyrrolidone, N-vinylcaprolactam, acrylonitrile, N-vinylformamide, (meth)acrylamide, and mixtures thereof.

When used to form the pressure sensitive adhesive matrix, acidic (meth)acrylate copolymers typically are derived from acidic monomers comprising about 2% by weight to about 30% by weight, or about 2% by weight to about 15% by weight, of a copolymerizable acidic monomer. Useful acidic monomers include, but are not limited to, those selected from ethylenically unsaturated carboxylic acids, ethylenically unsaturated sulfonic acids, ethylenically unsaturated phosphonic acids, and mixtures thereof. Examples of such compounds include those selected from acrylic acid, methacrylic acid, itaconic acid, fumaric acid, crotonic acid, citraconic acid, maleic acid, oleic acid, beta-carboxyethyl acrylate, 2-sulfoethyl methacrylate, styrenesulfonic acid, 2-acrylamido-2-methylpropanesulfonic acid, vinylphosphonic acid, and the like, and mixtures thereof. Due to their availability, typically ethylenically unsaturated carboxylic acids are used.

In certain embodiments, the poly(meth)acrylic pressure sensitive adhesive matrix is derived from between about 1 and about 20 weight percent of acrylic acid and between about 99 and about 80 weight percent of at least one of isooctyl acrylate, 2-ethylhexyl acrylate or n-butyl acrylate composition. In some embodiments, the pressure sensitive adhesive matrix is derived from between about 2 and about 10 weight percent acrylic acid and between about 90 and about 98 weight percent of at least one of isooctyl acrylate, 2-ethylhexyl acrylate or n-butyl acrylate composition.

Another useful class of optically clear (meth)acrylate-based pressure sensitive adhesives are those which are (meth)acrylic block copolymers. Such copolymers may contain only (meth)acrylate monomers or may contain other co-monomers such as styrenes. Examples of such pressure sensitive adhesives are described, for example in US Patent No. 7,255,920 (Everaerts et al.).

In some embodiments, the cover tape 10 may include an optional primer layer 13. The primer layer 13 may be disposed between the first major surface 12A of the first polymeric substrate and the adhesive layer 14. Generally, the primer layer may be any layer that is suitable for increasing the adhesion between layers. In this instance, the primer layer 13 may increase the adhesion between the polymeric substrate 12 and the adhesive layer 14. A wide variety of primers may be suitable. If used, the composition of the primer layer will depend upon the composition of the polymeric substrate 12 as well as the composition of the adhesive layer 14. For example, a number of primer technologies that have been used to provide improved adhesion between polyester-based substrates and functional coatings, such as adhesive layers, applied to them are: the use of aminosilane coatings to improve the adhesion at subfreezing temperatures as described in US Patent No. 5,064,722 (Swofford et al.); PET (polyethylene terephthalate) films primed with polyallylamine coatings to improve adhesion to the PET film of a polyvinyl butyral or ionoplast resin layer, as described in US Patent No. 7,189,457 (Anderson); glass laminates for reduction of sound transmission that may include 3-layer laminates of polyester film positioned between two dissimilar polymer layers, as described in US Patent No. 7,297,407 (Anderson); and the primer layers for multi-layer optical films where the primer layer may include a sulfopolyester and a crosslinker, as described in PCT Publication No. WO 2009/123921.

In some embodiments, the second major surface 12B of the first polymeric substrate may include a release coating layer. A wide range of release coating layers may be suitable to be disposed upon the second major surface 12B. For example, suitable release coatings include materials such as those used on the back side of rolled tape products to permit the tape to be rolled up and remain intact and then to be unwound for use. Such materials are often referred to as low adhesion backsizes or LABs. A wide variety of LABs have been developed for use with a wide variety of adhesives. Examples of suitable LAB or release coatings that are suitable for use in the cover tape constructions of this disclosure include: the water-based fluorochemical materials described in US Patent No. 7,411,020 (Carlson et al.); the polysiloxane release coatings described in US Patent No. 5,753,346 (Leir et al.); the release compositions described in US Patent No. 7,229,687 (Kinning et al.); the polyvinyl N-alkyl carbamates (polyurethanes) described in US Patent No. 2,532,011 (Dalquist et al.); the moisture-curable materials described in US Patent No. 6,204,350 (Liu et al.); and the organopolysiloxane-polyurea copolymer release agents described in US Patent No. 5,290,615 (Tushaus et al.).

As discussed above, the antistatic film construction 18 may include an antistatic layer 24 disposed on a major surface 22B of the second substrate 22. Generally, the antistatic layer may be any layer that dissipates static charges that build-up during storage, transportation, and manufacturing of electronic parts. For example, the antistatic layer may include or be formed of long chain aliphatic amines, amides, or quaternary ammonium salts; metal oxides such as indium tin oxide (ITO), antimony tin oxide (ATO), P-doped ATO, titanium oxide (TiO₂), zinc oxide (ZnO), vanadium oxide (V₂O₅); conductive polymers such as PEDOT, PSS, polyaniline nanofibers; ionic liquids, ionic salts, or polymeric salts such as those described in U.S. Patents 6,706,920, 6,732,829, 6,740,413 and U.S. Pubs. 2010/0136265 and 2007/0141329, which are hereby incorporated by reference in their entirety; quaternary amine monomers/oligomers/polymers (e.g., ethanaminium (N,N,N-trimethyl-2-[(2-methyl-1-oxo-2-propenyl) oxy] chloride) commercially available as TEXNOL CP-81 from Nippon Nyukazai Co., LTD, Japan); metal salts such as barium sulfate (BaSO₄), or Lithium chloride (LiCl); nanoparticles such as carbon nanotubes (CNT), graphene like carbon (GLC); or combinations thereof.

In some embodiments, the antistatic layer may include an antistatic component and a resin component. Suitable antistatic components include ionic liquids, ionic salts, or polymeric salts such as those described in U.S. Patents 6,706,920, 6,732,829, 6,740,413 and U.S. Pubs. 2010/0136265 and 2007/0141329. For example, the antistatic components may include a nitrogen-containing organic cation and a weakly coordinating fluoroorganic anion. Further suitable antistatic agents include ethanaminium.

In some embodiments, the resin component may include acrylate or methacrylate monomers or oligomers and their mixtures, for example, 2-hydroxyethyl methacrylate, 2-hydroxy-3-phenoxypropyl acrylate, isobornyl acrylate, methyl methacrylate, 2-(N,N-dimethylamino)ethyl acrylate, ethylene glycol dimethacrylate, pentaerythritol pentaacrylate (available as SR 399) and dethoxylated (4) bisphenol A diacrylate (available as SR 601). Further suitable resin components include, for example, polyolefins, polystyrenes, polyacrylates, polymethacrylates, polyacrylonitriles, poly(vinylacetates), polyvinyl alcohols, polyvinyl chlorides, polyoxymethylenes, polycarbonates, polyamides, polyimides, polyurethanes, phenolics, polyamines, amino-epoxy resins, polyesters, silicones, cellulose based polymers, polysaccharides, or combinations thereof.

In some embodiments, the antistatic component may be present in the antistatic layer in an amount of between 1-50 wt. %, 1-20 wt. %, or 1-10 wt. %, based on the total weight of the antistatic component and the resin component. The resin component may be present in the antistatic layer in an amount of between 50-99 wt. %, 70-99 wt. %, or 90-99 wt. %, based on the total weight of the antistatic component and the resin component.

In various embodiments, the antistatic and resin components may be deposited onto the cover tape as a solution that includes the antistatic and resin components and a solvent. Suitable solvents may include alcohols, ketones, esters, aldehydes, chlorinated solvents, water, and combinations thereof. Suitable alcohols include, for example, methanol, ethanol, 1-propanol or 2-propanol, or 1-methoxy -2-propanol.

In some embodiments, the antistatic layer may be present on the substrate at a thickness, after removal of solvent, if any, of from 0.01 to 100 μm , from 0.05 to 10 μm , or from 0.1 to 5 μm .

The antistatic layer 24 may exhibit a wide range of desirable properties making it particularly suitable for the multi-layer cover tapes of the present disclosure. For example, in some embodiments, the antistatic layer 24 may be an optically transparent layer. In this

regard, the antistatic layer 24 may have a visible light transmission (%T) of at least 75%, at least 80%, or higher.

In order to impart antistatic properties to the multi-layer cover tape, in some embodiments, the antistatic layer 24 may have a surface resistance of less than 10^{12} Ohms/square, less than 10^{10} Ohms/square, or less than 10^7 Ohms/square; or between 10^4 and 10^{12} Ohms/square, between 10^4 and 10^{10} Ohms/square, or between 10^4 and 10^8 Ohms/square.

In some embodiments, the multi-layered cover tape constructions of the present disclosure may be sufficiently flexible to be rolled upon themselves so that the multi-layered cover tape can be supplied and used in the form of a roll.

Referring now to FIG. 2, a multi-layer cover tape construction 10' according to some embodiments of the present disclosure is depicted. As shown, the tape construction 10' may include a substrate 12' with a first major surface 12A' and a second major surface 12B', and an adhesive layer 14' and an antistatic layer 18' disposed on the second major surface 12B'. The adhesive layer 14' and antistatic layer 18' may be arranged such that the antistatic layer 18' is disposed nearest the second major surface 12B'. In some embodiments, the adhesive layer 14' may be disposed on only a portion of the polymeric substrate 12'. For example, the adhesive layer 14' may be disposed in two or more stripes of adhesive on a portion of the substrate 12' (e.g., on opposed longitudinal edges of the substrate 12') such that portions of the antistatic layer 18' remain exposed between the adhesive stripes. The tape construction 10' may also include a low adhesion backsize layer 16' disposed on the first major surface 12A'. Additionally, one or more optional priming layers may be disposed on the second major surface 12B'. For example, as shown, a first primer layer 13' may be disposed between the second major surface 12B' and the antistatic layer 18' and/or a second primer layer 13'' may be disposed between the antistatic layer 18' and the adhesive layer 14'.

Many of the elements of this second type of multi-layer cover tape construction are the same or can be the same as those described above. Specifically, the adhesive layer, low adhesion backsize layer, priming layer, and antistatic layer may be as described above. In some embodiments, the polymeric substrate 12' includes or is formed of cellulose acetate, as described above.

In some embodiments, the present disclosure is further directed to carrier tape assemblies that incorporate the cover tape constructions described above. The carrier tape assembly may include (i) a carrier tape for electronic component transportation, the carrier tape comprising parallel strip portions in a lengthwise direction, the strip portions having top and bottom surfaces, and between the parallel strip portions, a plurality of indented segments (or pockets) for accommodating electronic components formed intermittently in the lengthwise direction of the tape; and (ii) a multi-layer cover tape construction, as described above, for releasably sealing the pockets of the carrier tape.

An embodiment of a carrier tape assembly 100 of this disclosure is shown in Figure 3, and includes a carrier tape 101 and the any of the above-described multi-layer cover tapes (10 or 10'). The illustrated carrier tape assembly 100 is useful for the storage and delivery of components (especially electronic components) by an advancement mechanism. More specifically, a flexible carrier tape 101 has a carrier or strip portion 102 defining a top surface and a bottom surface opposite the top surface. Strip portion 102 includes longitudinal edge surfaces 104 and 106, and a row of aligned advancement holes 108 and 110 formed in and extending along one, and preferably both, edge surfaces. Advancement holes 108 and 110 provide a means for receiving an advancement mechanism such as the teeth of a sprocket drive for advancing carrier tape 101 toward a predetermined location.

A series of pockets 112 may be formed in and spaced along strip portion 102, the pockets opening through the top surface of the strip portion. Within a given carrier tape, each pocket may be essentially identical to the other pockets. Typically, they are aligned with each other and equally spaced apart. In the illustrated embodiment, each pocket includes side walls 114 that adjoin and extend downwardly from the top surface of the strip portion and adjoin a bottom wall 116 to form pocket 112. Bottom wall 116 may be generally planar and parallel to the plane of strip portion 102. Optionally, bottom wall 116 may include an aperture or through hole 117 that is of a size to accommodate a mechanical push-up (e.g., a poke-up needle) to facilitate removal of component 118 (such as an electronic component (e.g., a silicone encapsulated LED die)) that is stored in pocket 112. Aperture 117 may also be used by an optical scanner to detect the presence or absence of a component within any given pocket. In addition, aperture 117 may be useful in applying a vacuum to the pocket to permit more efficient loading of the pockets with components.

The pockets 112 may be designed to conform to the size and shape of the components that they are intended to receive. Although not specifically illustrated, the pockets may have more or less side walls than the four that are shown. In general, each pocket includes at least one side wall that adjoins and extends downwardly from strip portion 102, and a bottom wall that adjoins the side wall to form the pocket. Thus, the pockets may be circular, oval, triangular, pentagonal, or have other shapes in outline. Each side wall may also be formed with a slight draft (i.e., a 2° to 12° slant toward the center of the pocket) in order to facilitate insertion of the component, and to assist in releasing the pocket from a mold or forming die during fabrication of the carrier tape. The depth of the pocket can also vary depending on the component that the pocket is intended to receive. In addition, the interior of the pocket may be formed with ledges, ribs, pedestals, bars, rails, appurtenances, and other similar structural features to better accommodate or support particular components. Although a single column of pockets is illustrated in the drawings, two or more columns of aligned pockets could also be formed along the length of the strip portion in order to facilitate the simultaneous delivery of multiple components. It is expected that the columns of pockets would be arranged parallel to each other with pockets in one column being in aligned rows with the pockets in the adjacent column(s).

Carrier tape 101 may be formed of any polymeric material that has a sufficient gauge and flexibility to permit it to be wound about the hub of a storage reel. Preferably, carrier tape 101 is optically clear by which it is meant that it is sufficiently transparent to permit components stored within the pockets to be visually inspected without removing the multi-layer cover tape (10 or 10'). A variety of polymeric materials may be used including, but not limited to, polyester (e.g., glycol-modified polyethylene terephthalate), polycarbonate, polypropylene, polystyrene, and acrylonitrile-butadiene-styrene.

As shown in FIG. 3, the multi-layer cover tape (10 or 10') overlies part or all of pockets 112, and is disposed between the rows of advancement holes 108 and 110 along the length of strip portion 102. The multi-layer cover tape (10 or 10') may be releasably secured to the top surface of strip portion 102 so that it can be removed to access the stored components. Regarding multi-layer cover tape 10, in some embodiments, the exposed portion of the adhesive layer 14 may generally correspond to the parallel longitudinal bonding portions 122 and 124, which may be bonded to longitudinal edge surfaces 104 and 106, respectively, of strip portion 102. Regarding multi-layer cover tape

10', the stripes of adhesive layer 14 may generally correspond to the parallel longitudinal bonding portions 122 and 124, which may be bonded to longitudinal edge surfaces 104 and 106, respectively, of strip portion 102. The multi-layer cover tape (10 or 10') may be positioned on the carrier tape 101 such that for the region of the multi-layer cover tape (10 or 10') that overlies the pockets 112, the antistatic layer is the layer of the multi-layer cover tape (10 or 10') that is nearest the pockets 112.

Also disclosed herein are methods of forming multi-layer cover tape constructions. In some embodiments, the method comprises providing an adhesive tape construction comprising a first substrate with a first major surface and second major surface with a low adhesion backsize coating on the second major surface of the first polymeric substrate, and an adhesive layer coated on the first major surface of the first substrate. The method further includes forming an antistatic film construction that includes a second substrate (that includes or is formed of cellulose acetate) having a first and second major surface, and adhering the second major surface of the second substrate to the adhesive layer such that portions of the adhesive layer remain exposed on either side of the second polymeric substrate. Forming the antistatic film construction includes depositing an antistatic layer onto the second major surface of the second substrate. The antistatic layer may be deposited on the second substrate using any conventional coating technique including, for example, Meyer rod coating, knife coating, Gravure coating, Curtain coating, or slot die coating.

In some embodiments, the method of forming a multi-layer cover tape construction comprises providing a substrate with a first major surface and second major surface with a low adhesion backsize coating on the second major surface of the substrate, and forming an antistatic layer on the first major surface of the substrate, and applying an adhesive layer to a portion of the antistatic layer (e.g., in two or more stripes such that portions of the antistatic layer remain exposed between the adhesive layer). Forming the antistatic film construction includes depositing an antistatic layer onto the first major surface of the substrate. The antistatic layer may be deposited on the substrate using any conventional coating technique including, for example, Meyer rod coating, knife coating, Gravure coating, Curtain coating, or slot die coating.

In some embodiments, the methods of the present disclosure further include applying a primer layer between one or more layers of the multi-layer cover tape construction, as discussed above.

In some embodiments, in addition to or as alternative to the surface energy characteristics discussed above, the multi-layer cover tapes of the present disclosure may include microstructured projections having a width of 0.05mm-4.0mm and a depth of 0.03-0.1mm. For example, such microstructured projections may be provided on any of the substrates, on a surface of the substrate that is nearest the adhesive layer (which may be a heat activated adhesive (HAA)). The surface morphology of a cover tape without microstructured projections and with microstructured projections are shown in Figures 11A and 11B, respectively.

Stick force testing of cover tapes was carried out with silicones which are used to encapsulate the electronic components which have considerable tackiness. The stick force of a microstructured HAA cover tape (2675-wm) was tested with other commercially available cover tapes 2675, 2670 and 2671A. The lower the stick force, the lower the die-stick and therefore the better the cover tape. The cover tapes tested and the peel force required for each of the cover tapes with tacky silicone component is shown in Figure 12. Figure 12 compares the peel force requirement for different cover tapes when tested against silicone component with microstructures projected cover tape showing the lowest peel force indicating lower die-stick characteristics.

Listing of Embodiments

1. A multi-layer cover tape construction comprising:

- a first substrate with a first major surface and a second major surface;
- an adhesive layer disposed on the first major surface of the first substrate; and
- an antistatic construction disposed on the first major surface of the first substrate; wherein the antistatic construction comprises:
 - a second polymeric substrate with a first major surface and a second major surface; and
 - an antistatic layer disposed on the second major surface of the second substrate; and

wherein the second polymeric substrate has a surface energy of between wherein the second polymeric substrate has a surface energy of between 5 and 500 mN/m, and a surface roughness of between 0.1 and 5 μ m.

5 2. A multi-layer cover tape construction comprising:

a polymeric substrate with a first major surface and a second major surface;

an adhesive layer disposed on the first major surface of the first substrate; and

an antistatic layer disposed on the first major surface of the first substrate;

wherein the polymeric substrate has a surface energy of between 5 and 500 mN/m,
10 and a surface roughness of between 0.1 and 5 μ m.

3. The multi-layer cover tape construction according to any one of the previous embodiments, wherein the antistatic layer comprises an antistatic component comprising an ionic liquid, ionic salt, metal oxide, or polymeric salt.

15 4. The multi-layer cover tape construction according to any one of the previous embodiments, wherein the antistatic layer comprises an antistatic component comprising (a) a nitrogen-containing organic cation and a weakly coordinating fluoroorganic anion; or (b) ethanaminium.

20 5. The multi-layer cover tape construction according to any one of embodiments 3-4, wherein the antistatic layer further comprises a resin component.

25 6. The multi-layer cover tape construction according to embodiment 5, wherein the resin component comprises acrylate or methacrylate monomers or oligomers, or isocyanate and epoxy monomers.

30 7. The multi-layer cover tape construction according to any one of embodiments 5-6, wherein the antistatic component is present in the antistatic layer in an amount of between 1-20 wt. %, based on the total weight of the antistatic component and the resin component.

8. The multi-layer cover tape construction according to any one of embodiments 5-7, wherein the resin component is present in the antistatic layer in an amount of between 70-99 wt. %, based on the total weight of the antistatic component and the resin component.

9. The multi-layer cover tape construction according to any one of the previous embodiments, wherein the antistatic layer is present at a thickness of from 0.05 to 10 μm .

10. The multi-layer cover tape construction according to any one of the previous embodiments, wherein the first or second substrates comprise PET, BOPP, or cellulose acetate.

11. The multi-layer cover tape construction according to any one of the previous embodiments, wherein the adhesive layer comprise a pressure sensitive adhesive.

12. The multi-layer cover tape construction according to any one of the previous embodiments, further comprising a release coating layer.

13. A carrier tape assembly comprising;

a carrier tape for electronic component transportation, the carrier tape comprising:

a strip portion having a top surface, a bottom surface opposite the top surface, and a plurality of pockets for carrying the electronic components, the pockets being spaced along the strip portion and opening through the top surface thereof; and

a multi-layer cover tape construction according to any one of the previous embodiments, wherein the multi-layer cover tape construction overlies at least a portion of the pockets.

14. A method of forming a multi-layer cover tape construction comprising;

providing an adhesive tape construction comprising:

a first substrate having a first major surface and second major surface; and

an adhesive layer coated on the first major surface of the substrate;

forming an antistatic film construction comprising:

a second polymeric substrate having a first major surface and a second major surface, wherein the second polymeric substrate has a surface energy of between 5 and 500 mN/m, and a surface roughness of between 0.1 and 5 μ m; and

an antistatic layer disposed on the second major surface; and

5 adhering the second major surface of the second substrate to the adhesive layer such that that portions of the adhesive layer remain exposed on either side of the second substrate.

Examples

These Examples are merely for illustrative purposes only and are not meant to be
10 limiting on the scope of the appended claims.

Materials

For the Examples disclosed in the present application, cellulose acetate films are available from 3M Company, St. Paul, MN, and Clarifoil, UK. The BOPP material of 13 μ m
15 thickness are available from PT. Trias Sentosa, Tbk Indonesia. The PET films (ARYAPET A-491 – Matte film with one side corona treated (88% OT) and ARYAPET A391 – Super matte film with one side corona treated (69% OT)) are available from JBF Bahrain SPC, UAE.

The resins such as acrylate/methacrylates CD9053 (Trifunctional acid ester), SR351NS
20 (Trimethylolpropane triacrylate, SR740A (Dimethacrylate ester), SR340 (2-Phenoxyethylmethacrylate), CN9062 (acrylic esters urethane acrylate) are available from Sartomer Company, Exton, PA, Isobornyl acrylate from Sigma Aldrich Pte Ltd, Singapore and Desmodur 3300 and Desmodur 3800 isocyanates from Bayer Materials, Germany.

A commercially available anti-static coating solution Texnol – CP81, an acrylic
25 copolymer emulsion are available from Nippon Nyukazai Company., Ltd, Japan. The FC4400 and FC5000i ionic liquids are available from 3M Company, St. Paul, MN, and nano ZnO is available from Nanomaterials Technology (NMT), Singapore. The acrylate based polymer solution PMH-8899 which is used as LAB material for cellulose acetate is available from 3M Company, St. Paul, MN.

30 The solvent Methyl Ethyl Ketone (MEK), Ethyl acetate and 1-methoxy 2-propanol, cross-linker 1,4 butane diol and catalyst di-butyl tin dilaurate (DBTDL) are available from Sigma-Aldrich Pte Ltd, Singapore.

Coating Application Method

The antistatic coating solutions were coated on substrates (PET, BOPP and cellulose acetate) using Meyer rod (obtained from R.D. Specialties, Webster, N.Y.) of number 2 to get a wet film thickness of about 5 μm . The coatings were cured either at room temperature or at 100°C as required. In the case of acrylate/methacrylates UV curing was utilized. Typically the dry film thickness of the coatings after thermal curing is around 1-2 μm depending on the solid content of the coating solutions.

Surface Resistivity, Surface Energy, Surface Roughness and Die-stick Measurements

The surface resistivity of the coatings was measured using a HIRETA UP MCP HT 450 surface resistivity meter at an applied voltage of 10V. For each coating condition, three surface resistivity measurements were taken randomly over an area of 20cm x 30cm.

The surface roughness of the as obtained films and anti-stat coated films were measured using a Mitutoyo surface profiler.

The surface energy was measured as per ASTM D7490 – 13, Standard Test Method for Measurement of the Surface Tension of Solid Coatings, Substrates and Pigments using Contact Angle Measurements. For this water and di-iodomethane contact angles were measured using a Goniometer from Attension, Finland.

The LED die-stick was measured using a 3M internal test method, for which twenty silicone encapsulated LED dies were used. The LED dies were placed on a smooth glass surface with silicone encapsulated dome facing upwards. The surface of the film which needs to be tested was placed over the silicone encapsulated dome and allowed to stay in that position for 15mins by placing a glass plate of 70g weight. After 15mins, the glass plate and the films were removed and the number of LED dies sticking onto the film was recorded.

Example 1

The anti-static coating formulations were prepared with different acrylate/methacrylate monomers/oligomers or their mixers (CD9053 – SR351NS 1:1 mixture, Sartomer CD9053 - Trifunctional acid ester, Isobornyl acrylate, SR740 Dimethacrylate ester (with 5, 10 and 20% FC4400), Phenoxyethylmethacrylate, CN9062 acrylic ester urethane acrylate) with FC4400 ionic liquid as an antistatic agent and are listed in Table 1. The

acrylate/methacrylate monomers/oligomers or their mixtures were prepared in 1-methoxy-2-propanol solvent to have a resin content of 20wt%. The FC4400 ionic liquid was added to obtain coating solutions with FC4400 loadings of 5, 10 and 20wt% to the resin weight. The Irgacure 158 initiator was used for UV crosslinking. The cellulose acetate film was coated with the above formulation using a 5µm Meyer rod. Typically, with 20wt% solid content in the coating formulation, a dry film thickness of about 1µm was obtained after curing. The curing was carried out in a two steps process (i) in the first step the solvent was expelled by exposing the coated substrate to 100°C for 2mins in an oven and (ii) exposing under a UV light.

The effect of acrylate/methacrylate monomers/oligomers or their mixers on the coating characteristics such as adhesion and surface resistivity are listed in Table 1. The initial formulations were tested with 10wt% FC4400 content were tested to select a suitable monomer/oligomer for cellulose acetate film. The monomer/oligomer formulations which gave rise to good adhesion were further optimized with different FC4400 contents to attain the required surface resistivity.

Table 1 shows the effect of oligomers/monomers on coating adhesion and surface resistivity.

Table 1

Description	Cellulose Acetate Film-Matte Surface	Sartomer CD9053	CD9053-SR351NS 1:1 mixture	Isobornyl acrylate	CN9062 Acrylic ester-Urethane acrylate	SR340A Phenoxyethylmethacrylate	SR740A Dimethacrylate esters
FC4400 Content (wt%)	0%	10%	10%	10%	10%	10%	10%
Observation – Coating on Cellulose Acetate film dried at 100C for 2min and UV cured	Not Coated	Poor Adhesion. Coating can be removed with paper wipes.	Poor Adhesion. Coating can be removed with paper wipes.	Uniform adherent coating. SR above range.	Stable adherent coating.	Stable adherent coating. FC4400 – 10% and below good.	Stable adherent coating.
Sample Identification	Control	A2	B2	C2	D2	E2	F2
Surface Resistivity (ohms/sq)	5.99E+13	3.74E+07	6.14E+07	Over Range (Higher than 10E+13)	2.15E+10	4.38E+10	4.97E+10
	9.94E+13	2.60E+07	5.70E+07		6.93E+09	3.29E+10	2.72E+10
	6.56E+13	4.25E+07	4.00E+07		9.59E+09	8.38E+10	7.96E+10
	9.90E+13	3.07E+08	5.65E+07		1.27E+10	6.87E+10	5.36E+10
	6.26E+13	2.79E+07	4.90E+07		9.81E+09	4.42E+10	1.05E+10

5 The following observations were made from the above results.

The surface resistivity of the cellulose acetate film prior to antistatic coating was in the range of 5.99E+13 to 9.94E+13, closer to a non-conductor.

10 The antistatic coatings with Sartomer CD9053 trifunctional acid ester and with Sartomer CD9053 – SR351NS 1:1 mixture, both exhibited a very poor adhesion to cellulose acetate substrate. However, both the coating showed surface resistivity in the static dissipative range (E7-E8 ohms/sq).

15 In the case of isobornyl acrylate, the coating was uniform and adherent on the cellulose acetate substrate. However with 10wt% FC4400 the surface resistance of the coating was above the SR measurement range (>E14 ohms/sq). So, no further studies were carried out using isobornyl acrylate.

The use of SR340 (phenoxyethylmethacrylate) resulted in coatings with very good adhesion, but the surface resistivity was higher at about E10 ohms/sq with 10wt% of FC4400. The increase in FC4400 loadings to 20wt% or more, did not bring down the surface resistivity.

The use of CN9062 (acrylic esters of urethane acrylate) with FC4400 ionic liquid formed very stable and adherent coatings on cellulose acetate film. The coating with 10wt% FC4400 showed a surface resistivity of E9-E10 ohms/sq range making it suitable for the cover tape applications.

5 Among all the acrylate/methacrylate oligomer formulations the SR740A (dimethacrylate ester oligomers) formed a very adherent and stable coating on cellulose acetate film. So, the effect of FC4400 anti-static ionic liquid was tested with 5, 10 and 20wt% additions in the coating solution. While the 5wt% FC4400 additions showed surface resistivity in the range E8-E9 ohm/sq, with increase in FC4400 content to 10wt% brought down the surface
10 resistivity to E6-E7 ohms/sq range. However, further increase in FC4400 content to 20wt% did not bring down the surface resistivity, indicating the optimum FC4400 content that is required to bring down the surface resistivity to E6-E7 ohms/sq range to be 10wt%.

Figure 4 shows the effect of FC4400 content on the surface resistivity of coatings formed
15 with SR740A dimethacrylate ester oligomers.

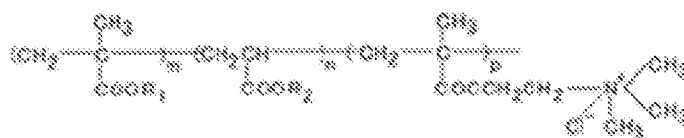
(i) Anti-static coatings based on FC4400 ionic liquid and a variety of acrylate/methacrylate oligomers can be formed on cellulose acetate films.

(ii) The surface resistivity of the anti-static coatings can be tuned in the range of $10E7 - 10E11$ ohms/sq, with changes in the FC4400 ionic liquid content.
20

(iii) The anti-static coated cellulose acetate films, exhibited non-stick property with silicone casted parts and silicone encapsulated LED dies, confirming its suitability for applications to handle silicone encapsulated/silicone parts.

25 **Example 2**

The Texnol-CP81 is a mixture of Ethanaminium, N,N,N-trimethyl-2-[(2-methyl-1-oxo-2-propenyl)oxy] chloride, polymer with butyl-2-propenoate(n-butyl acrylate) and methyl 2-methyl 2-propenoate (methyl methacrylate) in a solvent mixture of methanol (MeOH), ethanol (EtOH), Propanol (PrOH) and water.



The coating was applied on the cellulose acetate film and was heat dried in an oven at 100°C for 2mins. The anti-static coating of Texnol - CP81, formed a uniform and adherent coating on the cellulose acetate film. The surface resistivity of the coatings were in the range of 3.72E7 – 9.82E7 ohms/sq. To test coating adherence tape peel test was carried out on the coating using magic tape. The surface resistivity of the coatings showed a slight increase to the range of 8.52E7 – 2.53E8 ohms/sq. However, the coatings remained adherent without peel-off indicating its durability.

Figure 5 shows the surface resistivity of the (1) as obtained anti-static coating and (2) after the tape peel test.

To test the effect of Texnol-CP81 coated cellulose acetate film on the die-stick issue, a cover tape construction using the Texnol-CP81 coated cellulose acetate film was placed on the carrier with dome shaped silicone encapsulated LED dies. The dome shaped silicone encapsulated parts are seen nicely placed in the carrier without die-stick issue. This further confirms the suitability of cellulose acetate based cover tapes with anti-static agent in solving the die-stick issue.

The cellulose acetate film coated with a commercially available anti-static coating Texnol – CP81, exhibited non-stick property with silicone encapsulated LED dies. The Texnol-CP81 coated cellulose acetate film when tested as a cover tape over silicone encapsulated LED dies in a carrier, showed the absence of die-stick phenomena, with all the LED dies retained in the carrier.

Example 3

1. FC5000i ionic liquid and nano ZnO in acrylate polymer solution PMH-8899:

The acrylate polymer solution PMH-8899, was tested at 5wt% loading by diluting it with ethyl acetate and toluene. To the 5% solution of PMH-8899, the FC5000i ionic liquid and nano ZnO particles were added as antistatic agents and tested for surface resistivity and

die-stick. The anti-static ionic liquid FC5000i was tested at 2.5, 5, 7.5, 10, 20 and 30wt% loadings to the acrylic resin weight. The nano ZnO was tested at loadings of 5, 7.5 and 10wt% in 5% PMH-8899 solution. The PMH-8899 solution with the antistat additions were mixed in a vortex mixture and coated on cellulose acetate and BOPP substrates using a 5µm Meyer rod on both the matte and non-matte surfaces. The coatings were dried for 15mins at 80°C in an oven.

The surface resistivity of the coated surfaces were measured and the results of coatings with FC5000i content of 10wt% and above are shown in Figure 6. Below 10wt% FC5000i, the surface resistivity of the coatings were over E11 ohm/sq which was above the useful range and therefore not shown in this Figure. With FC5000i content of 10wt%, the surface resistivity was in the E11 ohms/sq range, which decreased to E10- E11 range with increase in FC5000i loading to 20wt%. Further, increase in FC5000i content to 30wt%, brought down the surface resistivity to E10 ohm/sq, range. The change in the surface morphology of the surfaces namely matte and un-matte did not considerably influence the surface resistivity.

Figure 6 shows the effect of FC5000i content on surface resistivity of the cellulose acetate and BOPP films.

The nano ZnO under the loadings of 5, 7.5 and 10wt% in 5% PMH-9900 solution were coated on cellulose acetate and BOPP films. The coated substrates were dried at 80°C for 15mins. The surface resistivity of the coatings formed on the matte surface of cellulose acetate film under different nano ZnO loadings is shown in Figure 7.

Figure 7 shows the effect of ZnO loading on the surface resistivity of the cellulose acetate substrate.

The surface resistivity of the coatings showed a steady decrease with increase in ZnO content from 5wt% to 10wt%. The nano ZnO – PMH-8899 coatings formed on cellulose acetate film after drying was clear and transparent. The coated cellulose acetate and BOPP films showed an optical transmittance of 95% which was similar to that of the uncoated film.

Example 4

This example describes a multilayer cover tape construction based on PET substrate to solve the die-stick issue encountered with silicone encapsulated LED dies and components. In the multilayer construction, the antistatic coating layer is formed by the polymerization of isocyanate oligomers (Desmodur 3300 and Desmodur 3800) using a cross linker with FC4400 ionic liquid as an antistatic agent.

This example shows the effect surface finishing of the PET substrates (non-matte, matte and super matte) on die-stick.

For this, a two pot system was prepared with the use of Desmodur 3300 and Desmodur 3800, 1,4 – butane diol cross linker, ionic liquid FC4400 and the catalyst Di-butyl tin di-laurate (DBTDL).

The Part 1, consisted of Desmodur 3300/3800 along with the FC4400 which was diluted by 1.5gm of MEK. The solid content of part 1, was around 50%. The Part 2, consisted of the 1,4-butane diol with the catalyst (Di-butyl tin di-laurate DBTDL) which was diluted by 0.5 gm of MEK. The solid content of part 2, was around 45%. Prior to coating the part 1 and part 2 were mixed in a Vortex mixture to obtain a homogeneous solution.

The solution after mixing was used immediately for coating on non-matte, matte and super matte PET substrates using Meyer rod (obtained from R.D. Specialties, Webster, N.Y.) of number 2 to get a wet film thickness of 5 μ m. The coatings were cured at 100°C for 2mins in an oven.

Table 2 gives the effect of surface roughness and surface energy on die-stick issue of three different PET substrates.

Table 2

Substrate	Surface Energy (mN/m)	Surface Roughness (μm)	Test Result with Silicone Encapsulated LED Die
PET – Clear – Corona treated	46.57	0.117	Die-stick
PET – Clear – Corona treated with Antistatic coating	58.38	0.127	Die-stick
PET – Matte – Corona treated	49.71	0.312	No Die-stick
PET – Matte - Corona treated with Antistatic coating	51.14	0.319	No Die-stick
PET – Super Matte – Corona treated	40.91	0.359	No Die-stick
PET – Super Matte - Corona treated with Antistatic coating	41.64	0.381	No Die-stick

5

The following observations are made from the results.

With the use of matte and super matte PET substrates the die-stick issue was absent. It was observed that the matte and super matte surfaces had a surface roughness in the range of 0.31 – 0.36 μm which was much higher than the un-matte surface (0.11 μm). On the other hand the surface energy of these PETs varied only by about 10-20%. So, it can be said the substrates with surface energy in the range of 40 – 60 mN/m, the higher surface roughness of the substrates have a prominent role in deciding the die-stick property.

10

The ionic liquid FC4400 was mixed at 2.5, 5 and 10wt% loadings to with Desmodur 3800 isocyanate, solvent, cross linker and coated on the non-matte, matte and super matte PET surfaces. Since, the surface resistivity values were higher than E11 ohms/sq with 2.5wt% FC4400 additions, the results are shown for 5 and 10wt% loading of FC4400. As the shiny PET showed die-stick issue, the results of surface resistivity of antistat coated matte and super matte surfaces are compared in Figure 8.

15

Figure 8 shows the effect of FC4400 loading on the surface resistivity of the matte and super matte PET surfaces.

With 5wt% FC4400 loadings, the surface resistivity of coated surfaces was about E10 ohms/sq and the increase in FC4400 loading to 10wt%, decreased the surface resistivity to E9 ohms/sq range. However, the die-stick was not affected with change in FC4400 loadings.

Example 5

Effect of Surface Energy and Surface Roughness of Films on Die-stick Issue

As the surface energy and surface roughness of the substrates were found to have a major role in determining the die-stick property, a variety of substrates (cellulose acetate, BOPP and PET), with un-matte, matte and super matte surface finishes were tested for these two parameters. These substrate some with antistatic coatings and some in the as obtained condition were tested for die-stick with silicone encapsulated LED dies. The type of films tested, their surface energy and surface roughness values and the corresponding effect on die-stick issue are given in Table 2.

Table 3 shows the effect of surface roughness and surface energy on die-stick issue of different substrates.

Table 3

Substrate	Surface Roughness (μm)	Surface Energy (mN/m)	Test Result with Silicone Encapsulated LED Die
Clarifoil CA- Non-matte	0.0282	51.719	Die-stick
Clarifoil CA- Matte	0.3322	38.086	No Die-Stick
3M CA - Non-matte	0.0352	51.017	Die-stick
3M CA - Matte	0.4438	47.967	No Die-Stick
Magic Tape - Matte CA film	0.364	31.345	No Die-Stick
3M CA - Non-matte 7.5%ZnO	0.0968	38.987	Die-Stick
3M CA - Matte 7.5%ZnO	0.347	36.919	No Die-Stick
3M CA - Non-matte 20%FC5000i	0.08	28.161	Die-stick
3M CA - Matte 20% FC5000i	0.263	30.098	No Die-Stick
3M CA - Non-matte 15%FC5000i	0.064	28.539	Die-stick
3M CA - Matte 15% FC5000i	0.225	28.007	No Die-stick
3M CA - Non-matte 5%FC5000i	0.049	27.304	Die-stick
3M CA - Matt 5% FC5000i	0.295	27.394	No Die-stick
PET - Fluoropolymer coated-Non-matte	0.016	18.053	Die-stick
PET - Without Fluoropolymer-coating - Non-matte	0.0198	36.955	Die-stick
PET - Super Matte - Corona treated	0.359	40.91	No Die-stick
BOPP - Non-matte	0.0634	30.103	Die-stick
BOPP - Matte	0.357	38.513	No Die-stick
PET Film - Non-matte	0.0208	42.455	Die-stick

To further understand the surface energy and surface roughness ranges of films on the die-stick issue, the results are shown in the form of a contour plot in Figure 9.

5

Figure 9 shows the surface energy and surface roughness ranges on die-stick issue.

The following observations are made from the plot.

1. In the surface roughness range of 0.20 – 0.50 μ m and surface energy range of 22 – 60mN/m, the die-stick issue is absent or minimal. Within this range, with increase in surface energy, a similar increase in surface roughness is required to solve the die-stick issue. For a film with a surface energy of 25mN/m, a surface roughness of 0.22 μ m is good enough to solve the die-stick issue. With increase in surface energy to 50mN/m, it requires an increase in surface roughness to about 0.35 μ m.
2. While it is generally said that a low surface energy surface is a good choice to solve the sticking issue (e.g., use of low surface energy fluoropolymer coated liners for adhesive coated films/tapes), the low surface energy per se does not solve the die-stick issue. In addition to surface energy, the surface roughness plays an important role. It is observed that at surface roughness values below 0.22 μ m, even the films having lower surface energies of 25mN/m or lower exhibit the die-stick issue. So, a minimum surface roughness of 0.22 μ m can be said as a necessity to solve the die-stick issue irrespective of the surface energy value (20-50mN/m).
3. Similarly, a minimum surface energy requirement needs to be met to solve the die-stick issue, in addition to the surface roughness value. It is observed that at surface energy values below 22mN/m, the films exhibit die-stick issue irrespective of the surface roughness (0.01-0.4 μ m).

In comparison to the unmatte surface, the matte surface of both cellulose acetate and BOPP substrates showed a better non die-stick performance with silicone encapsulated LED dies.

The surface roughness and surface energy values of the substrates had a definite role on die-stick issue with minimal or no die-stick observed in the surface roughness range of 0.20 – 0.50 μ m and surface energy range of 22 – 60mN/m.

The utility of matte BOPP in making heat activated adhesive (HAA) and pressure sensitive adhesive (PSA) cover tape were tested. The heat activated adhesive was applied at the edges of the BOPP substrate and tested over a carrier to know its suitability as a HAA cover tape. Similarly, to test the use of matte BOPP as a PSA cover tape, PET

substrate with adhesive was laminated over the matte BOPP such that the adhesive layer of the PET can be adhered to the carrier. The cover tape constructions with matte BOPP with antistatic coating was tested with silicone encapsulated LED dies for die-stick and no die-stick was observed. Further, the testing was carried out as a cover tape over a carrier with stacked with silicone encapsulated LED dies. With the use of matte BOPP film, no die-stick was observed and it is shown in Figure 10.

Figure 10 shows the testing of matte BOPP substrate as a cover tape over a carrier with silicone encapsulated LED dies.

What is claimed is:

1. A multi-layer cover tape construction comprising:

a first substrate with a first major surface and a second major surface;

5 an adhesive layer disposed on the first major surface of the first substrate; and

an antistatic construction disposed on the first major surface of the first substrate;

wherein the antistatic construction comprises:

a second polymeric substrate with a first major surface and a second major surface; and

10 an antistatic layer disposed on the second major surface of the second substrate; and

wherein the second polymeric substrate has a surface energy of between wherein the second polymeric substrate has a surface energy of between 5 and 500 mN/m, and a surface roughness of between 0.1 and 5 μ m.

15

2. The multi-layer cover tape construction according to claim 1, wherein the antistatic layer comprises an antistatic component comprising an ionic liquid, ionic salt, metal oxide, or polymeric salt.

20

3. The multi-layer cover tape construction according to claim 1, wherein the antistatic layer comprises an antistatic component comprising (a) a nitrogen-containing organic cation and a weakly coordinating fluoroorganic anion; or (b) ethanaminium.

4. The multi-layer cover tape construction according to claim 1, wherein the antistatic layer further comprises a resin component.

5. The multi-layer cover tape construction according to claim 4, wherein the resin component comprises acrylate or methacrylate monomers or oligomers, or isocyanate and epoxy monomers.

6. The multi-layer cover tape construction according to claim 5, wherein the antistatic component is present in the antistatic layer in an amount of between 1-20 wt. %, based on the total weight of the antistatic component and the resin component.

7. The multi-layer cover tape construction according to claim 6, wherein the resin component is present in the antistatic layer in an amount of between 70-99 wt. %, based on the total weight of the antistatic component and the resin component.

8. The multi-layer cover tape construction according to claim 1, wherein the antistatic layer is present at a thickness of from 0.05 to 10 μm .

9. The multi-layer cover tape construction according claim 1, wherein the first or second substrates comprise PET, BOPP, or cellulose acetate.

10. The multi-layer cover tape construction according to claim 1, wherein the adhesive layer comprise a pressure sensitive adhesive.

11. The multi-layer cover tape construction according to claim 1, further comprising a release coating layer.

12. A carrier tape assembly comprising;

a carrier tape for electronic component transportation, the carrier tape comprising:

a strip portion having a top surface, a bottom surface opposite the top surface, and a plurality of pockets for carrying the electronic components, the pockets being spaced along the strip portion and opening through the top surface thereof; and

a multi-layer cover tape construction according to claim 1, wherein the multi-layer cover tape construction overlies at least a portion of the pockets.

13. A method of forming a multi-layer cover tape construction comprising;

5 providing an adhesive tape construction comprising:

a first substrate having a first major surface and second major surface; and

an adhesive layer coated on the first major surface of the substrate;

forming an antistatic film construction comprising:

10 a second polymeric substrate having a first major surface and a second major surface, wherein the second polymeric substrate has a surface energy of between 5 and 500 mN/m, and a surface roughness of between 0.1 and 5 μ m; and

an antistatic layer disposed on the second major surface; and

15 adhering the second major surface of the second substrate to the adhesive layer such that that portions of the adhesive layer remain exposed on either side of the second substrate.

14. A multi-layer cover tape construction comprising:

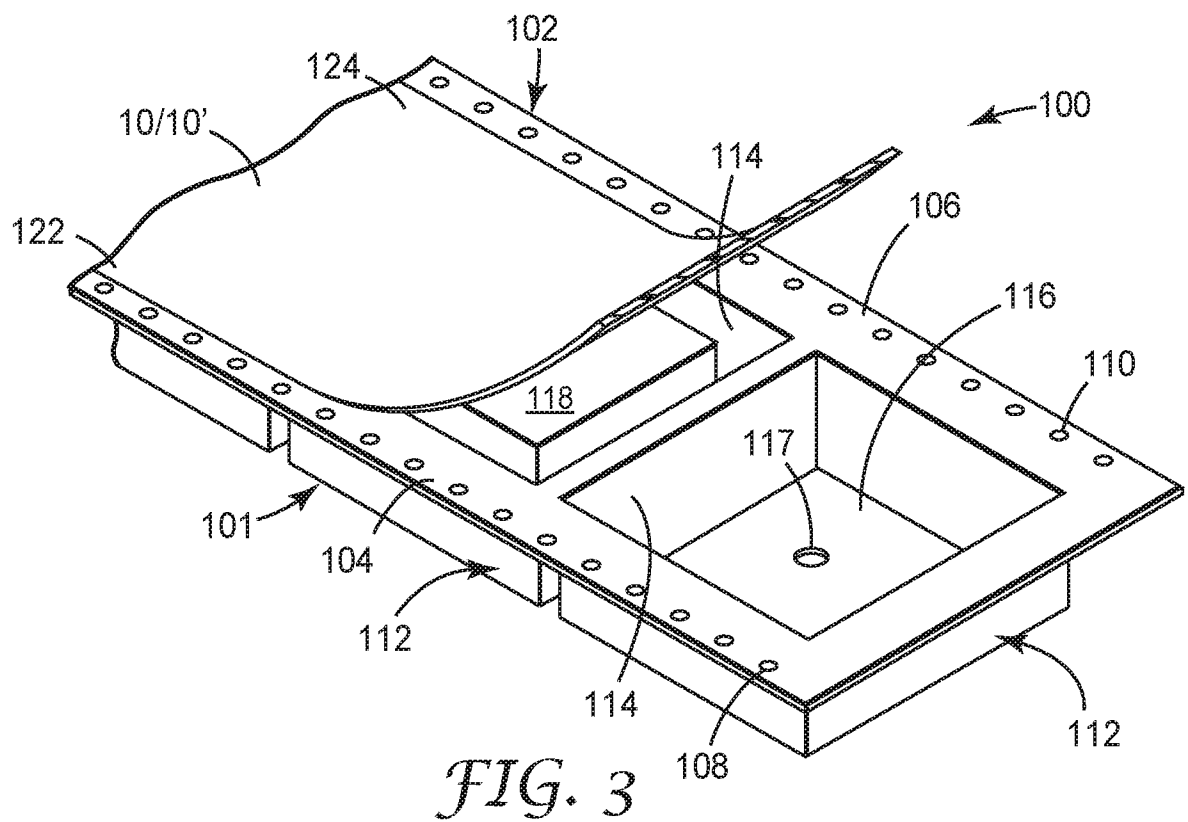
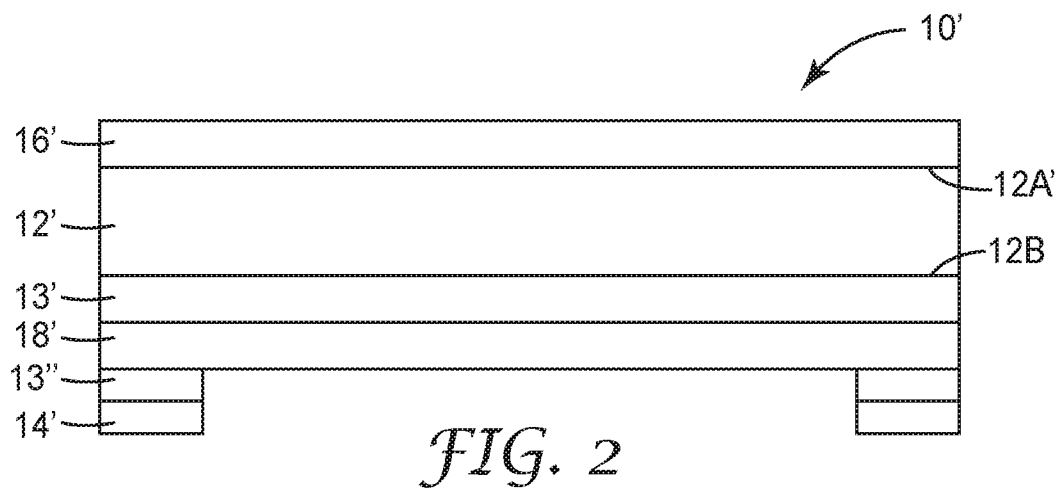
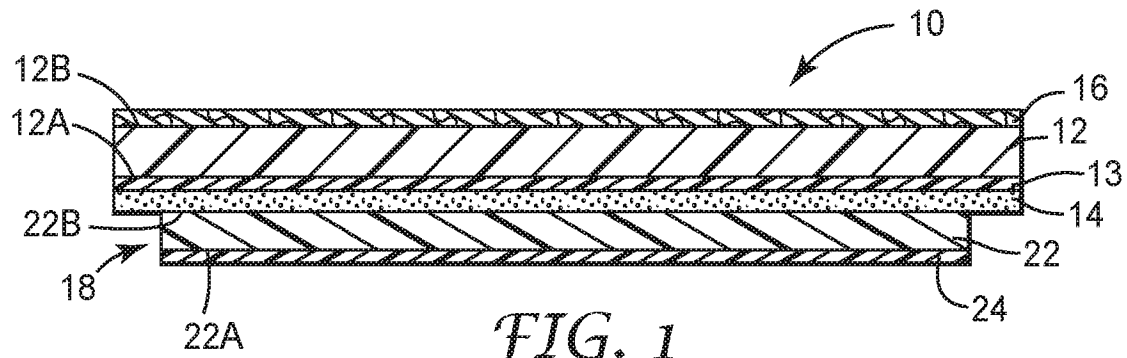
a polymeric substrate with a first major surface and a second major surface;

an adhesive layer disposed on the first major surface of the first substrate; and

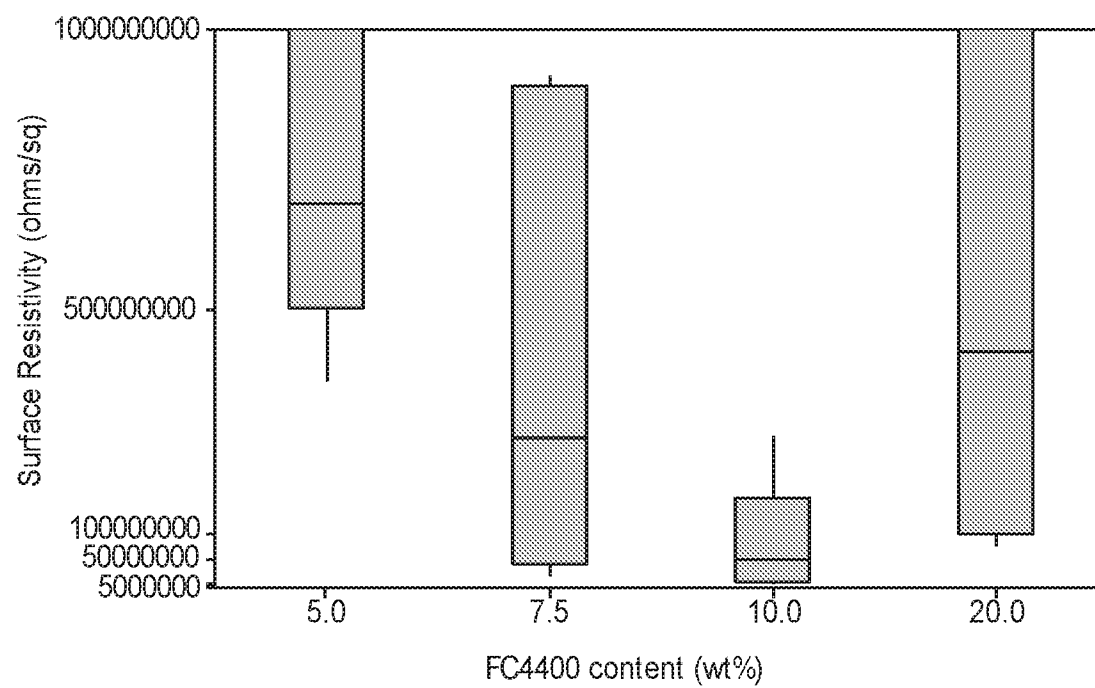
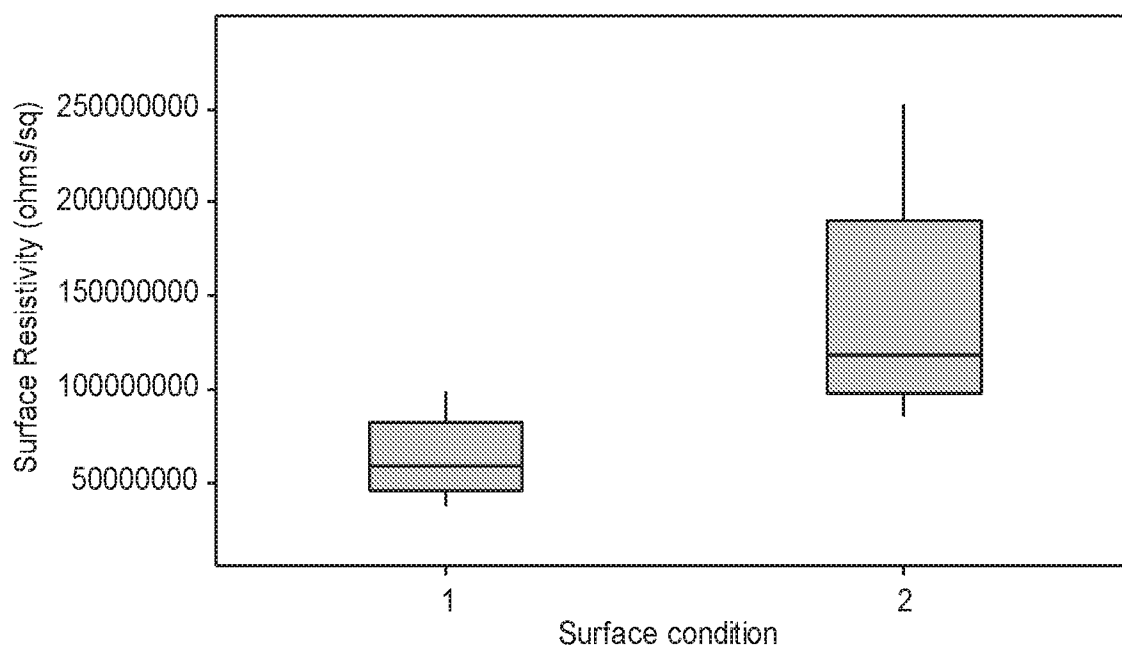
20 an antistatic layer disposed on the first major surface of the first substrate;

wherein the polymeric substrate has a surface energy of between 5 and 500 mN/m, and a surface roughness of between 0.1 and 5 μ m.

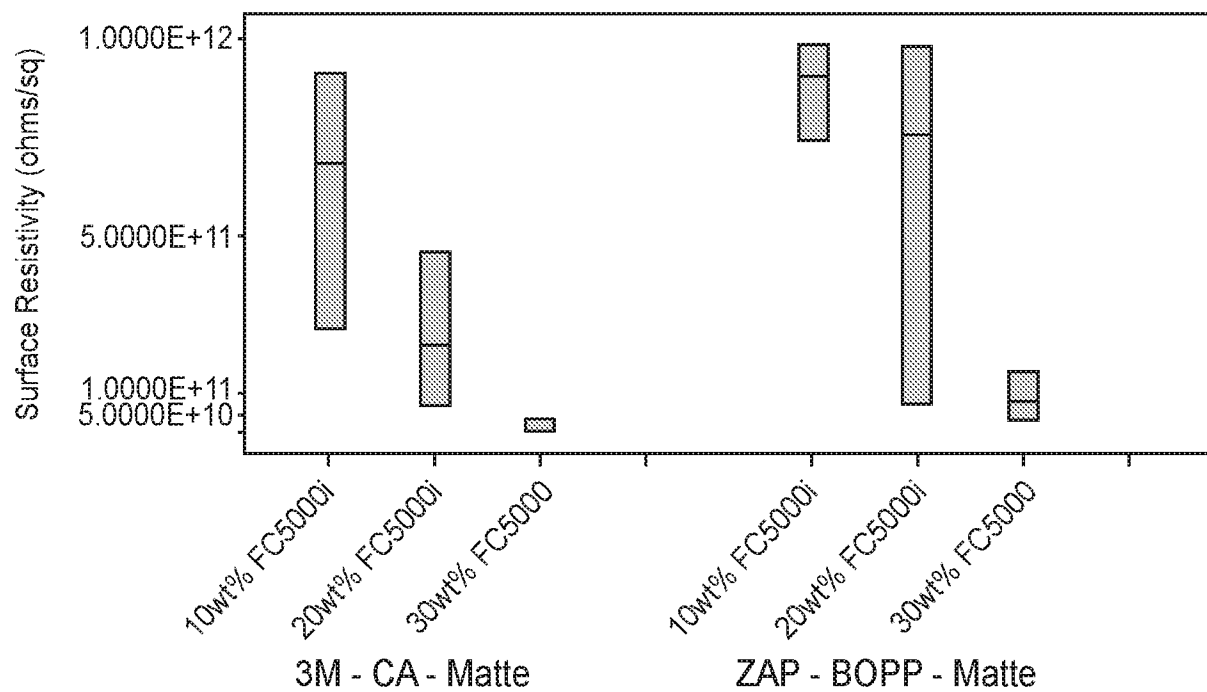
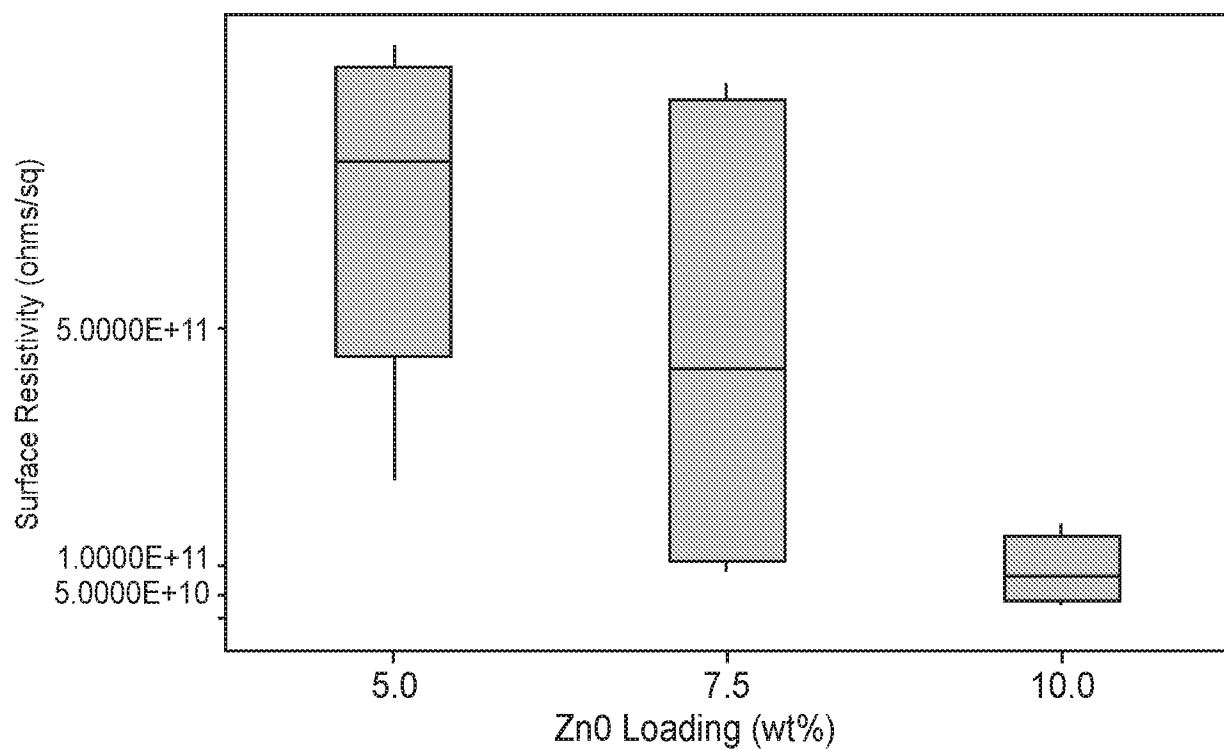
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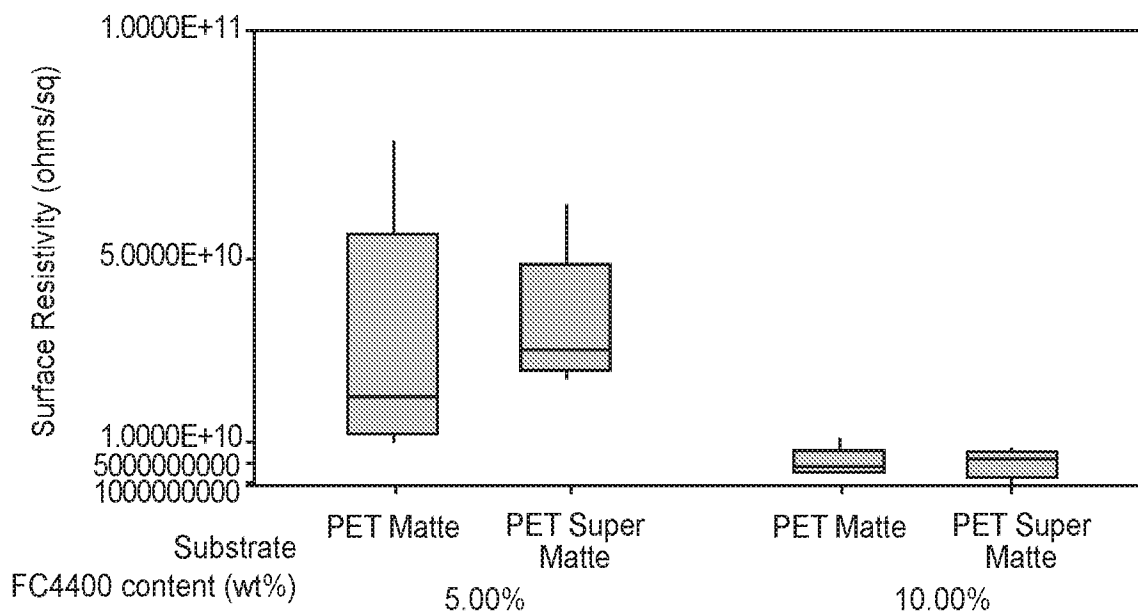
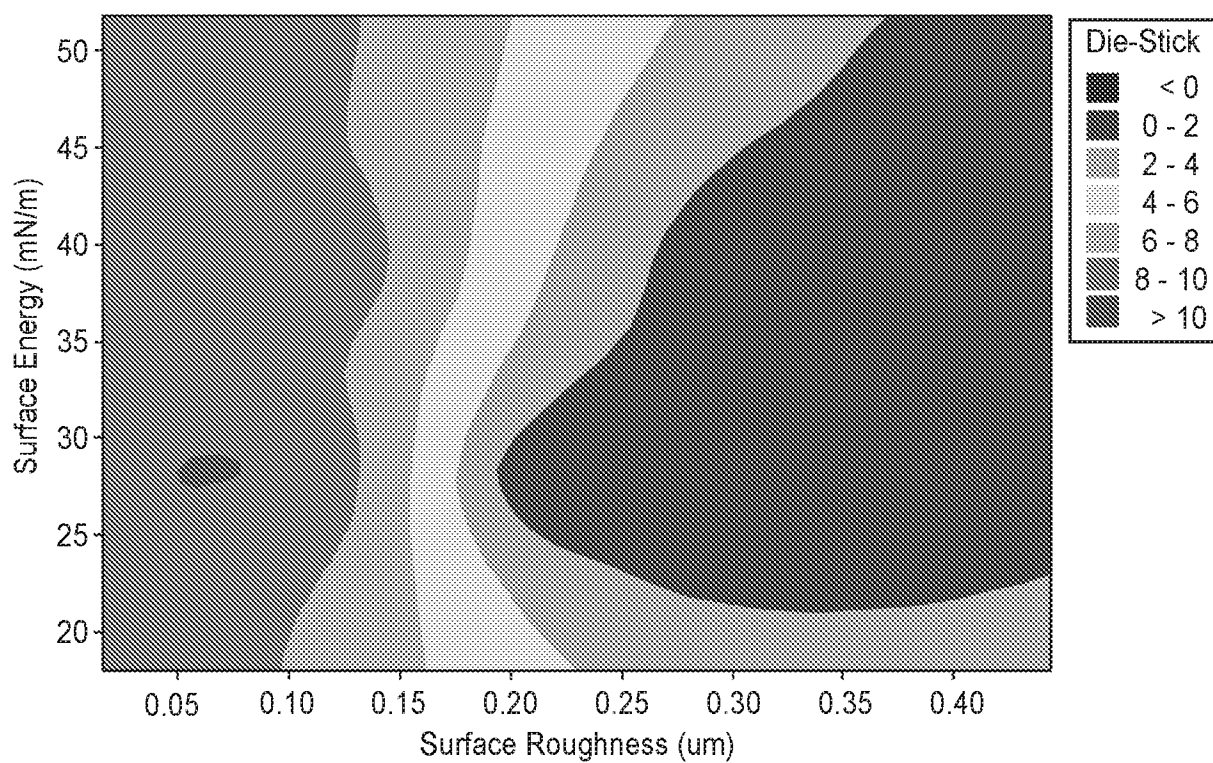
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*FIG. 4**FIG. 5*

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*FIG. 6**FIG. 7*

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*FIG. 8**FIG. 9*

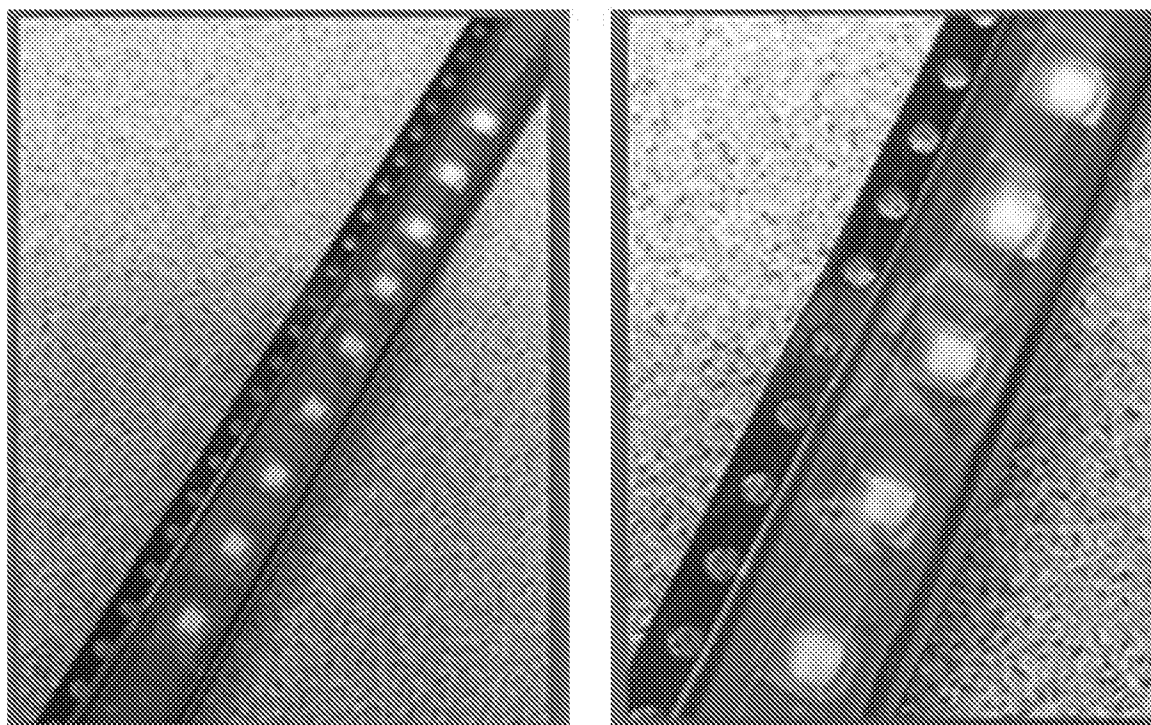


FIG. 10

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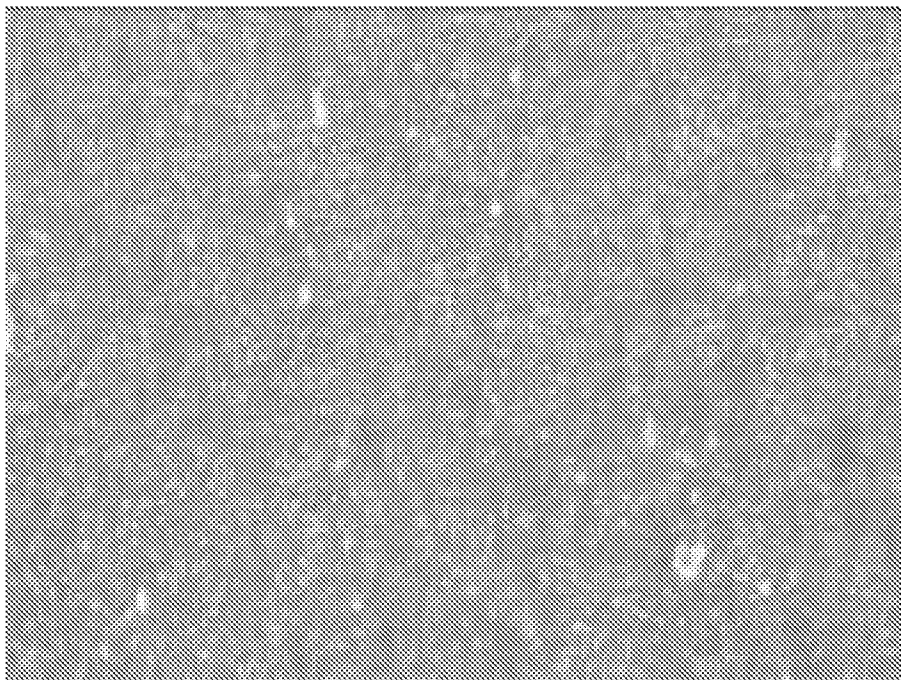


FIG. 11A

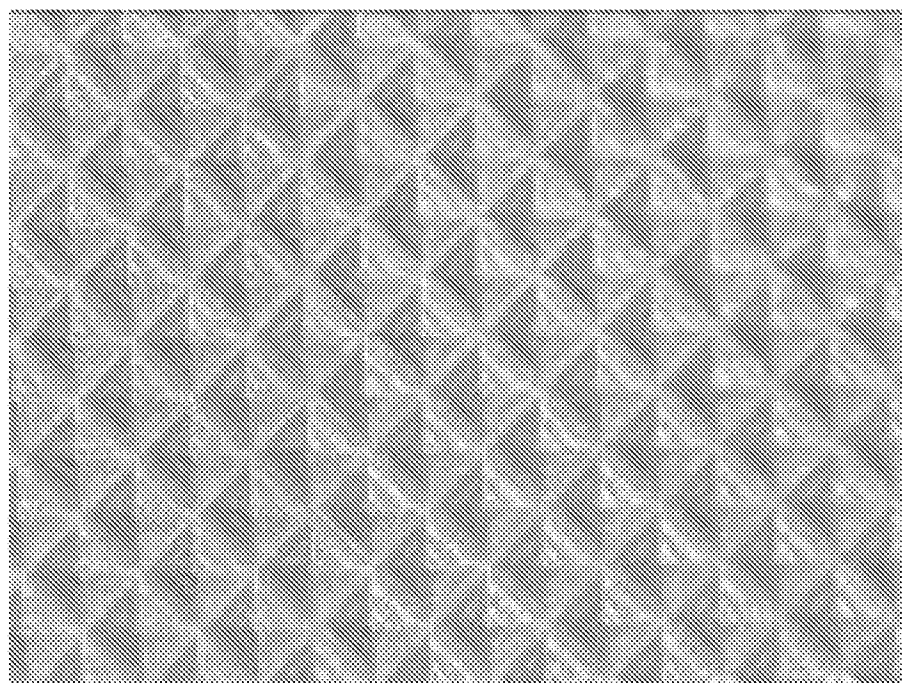


FIG. 11B

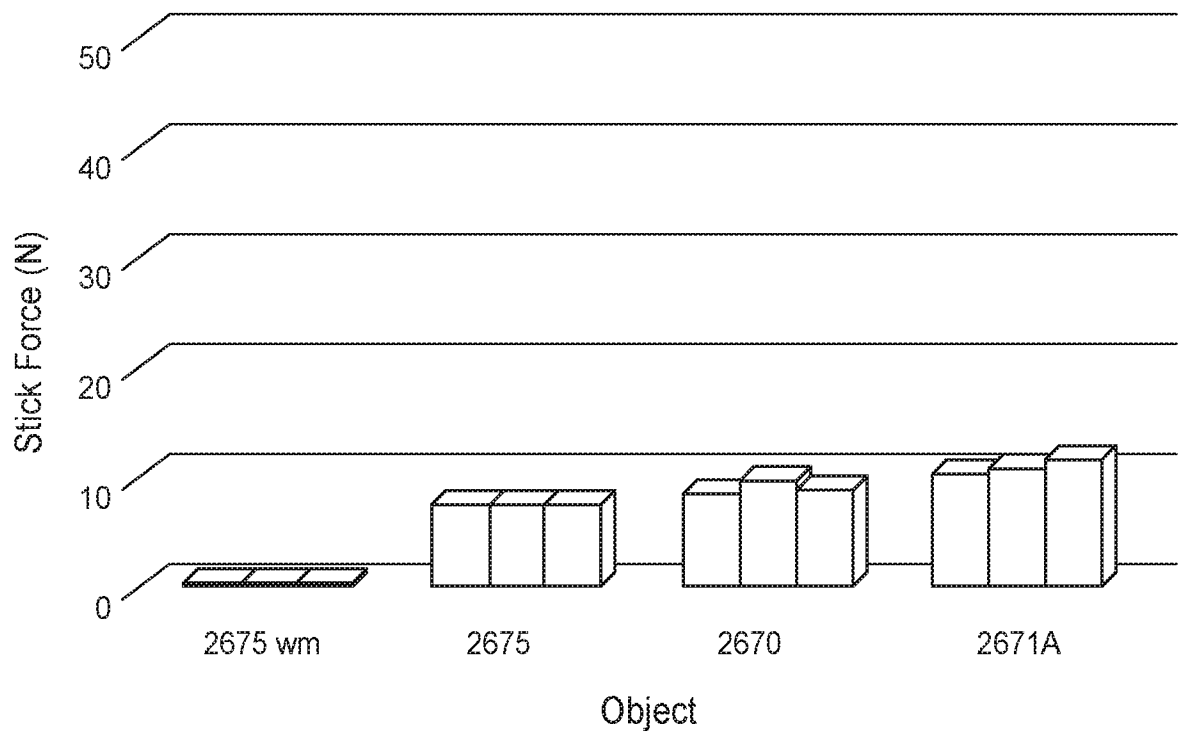


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 16/62169

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B05D 5/02, B05D 5/10, B05D 5/12, B32B 27/08, C09J 7/02 (2016.01)

CPC - B05D 5/02, B05D 5/10, B05D 5/12, B05D 7/56, B32B 27/08, B32B 2405/00, C09J 7/025

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)

IPC(8)- B05D 5/02, B05D 5/10, B05D 5/12, B32B 27/08, C09J 7/02 (2016.01);

CPC- B05D 5/02, B05D 5/10, B05D 5/12, B05D 7/56, B32B 27/08, B32B 2405/00, C09J 7/025

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC- 156/60, 264/639, 264/171.21, 427/208.8, 427/393.1, 428/343-354;

Patents and NPL (classification, keyword; search terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Pub West (US EP JP WO), Pat Base (AU BE BR CA CH CN DE DK EP ES FI FR GB IN JP KR SE TH TW US WO), Google Patent, Google Scholar, Google Web, FPO; search terms: tape, adhere, construction, structure, backing, strip, cover, film, coating, carrier, antistatic, inhibit, static, charge, triboelectric, without, surface, energy, tension, roughness...

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2014/0134365 A1 (TANAZAWA et al.) 15 May 2014 (15.05.2014), para [0013]-[0016], [0021]-[0026]	1-14
Y	US 2014/0030519 A1 (MORIMOTO et al.) 30 January 2014 (30.01.2014), para [0017], [0098], [0099], [0101], [0107], [0124], [0141], [0159], [0167]-[0171], [0179], [0184], [0185], [0192]	1-14
Y	US 2003/0183553 A1 (FUJIMURA et al.) 02 October 2003 (02.10.2003), Figs. 4, 6; para [0006]-[0009], [0016], [0018], [0034]	12
Y	US 2007/0184243 A1 (ONO et al.) 09 August 2007 (09.08.2007), para [0011]-[0088]	1-14
Y	US 2006/0251892 A1 (HUSEMANN et al.) 09 November 2006 (09.11.2006), para [0010]-[0130]	1-14

☐ Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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