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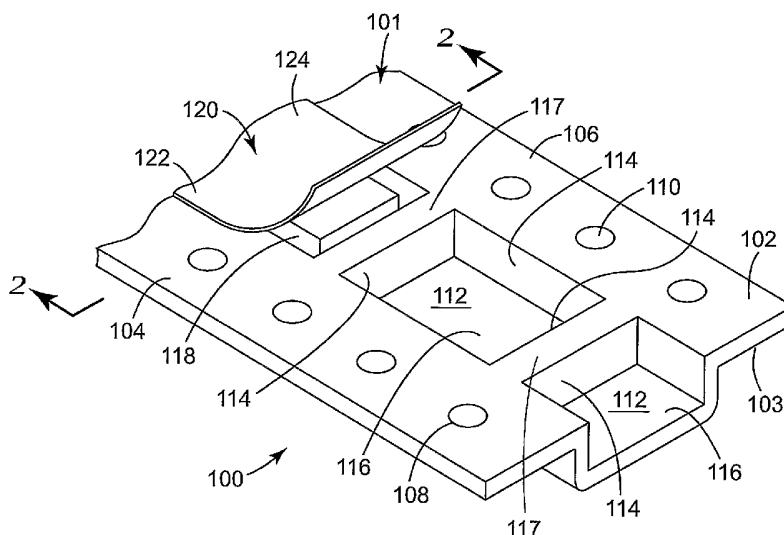
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(54) Title: COMPONENT CARRIER AND METHOD FOR MAKING



(57) Abstract: A carrier tape includes a longitudinal strip having a plurality of component receiving pockets positioned therein. The pocket depth is greater than a thickness of the longitudinal strip. Adjacent pockets are spaced apart by a distance less than approximately five times the thickness of the longitudinal strip. Sidewalls separating adjacent pockets have a height greater than the pocket depth minus a height of a component which the pockets are configured to receive. The carrier tape is produced by providing a rotatable tool and a nip roll having a conformable outer circumferential surface opposed to the tool. The outer circumferential surface of the tool includes projections for forming the pockets. A polymer web is introduced into a nip between the tool and the nip roll, and embossed with the projections on the circumferential surface of the tool.

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COMPONENT CARRIER AND METHOD FOR MAKING

Field of the Invention

The present invention relates generally to carrier tapes of the kind having a
5 plurality of pockets spaced longitudinally on the tape for accommodating components
therein. More particularly, the invention relates to carrier tapes for very small
components, and a method for producing such carrier tapes.

Background

10 In general, carrier tapes that are used to hold and transport components are well
known. For example, in the field of electronics circuit assembly, electronic components
are often carried from a supply of components to a specific location on a circuit board for
attachment thereto. The components may be of several different types, including surface
mount components. Particular examples include memory chips, integrated circuit chips,
15 resistors, connectors, processors, capacitors, gate arrays, etc.

Rather than manually affixing each individual electronic component to a circuit
board, the electronics industry makes extensive use of robotic placement machines,
sometimes known as "pick-and-place" machines, that grasp a component at a specific
location (i.e., from the carrier tape) and place it at another specific location (i.e., on a
20 printed circuit board). Grasping of the components is commonly accomplished with a
vacuum pick-up device that grasps the top of the component by suction. Robotic
placement equipment is typically programmed to repeat a precise sequence of movements
in every cycle. For electronic component assembly, the robotic equipment may be
programmed to grasp a memory chip, for example, and place it in a specific location on a
25 circuit board. To ensure the sustained operation of the robotic placement machine, a
continuous supply of electronic components must be furnished to the machine at a
predetermined rate and location. It is therefore important that each component be located
in the same position (i.e., the point at which the robotic placement machine grasps the
component) as each preceding and succeeding component.

30 A common way to provide a continuous supply of electronic components to
robotic placement equipment is to use a carrier tape. Conventional carrier tapes generally
comprise an elongated strip that has a series of identical pockets formed at predetermined,

uniformly spaced intervals along the length of the tape. The pockets are each designed to receive an electronic component therein. Frequently, the pockets are sized to match a particular component. The component manufacturer typically loads components into the series of pockets. After components are placed in the pockets, a cover tape is applied over the elongated strip to retain the components in their respective pockets. The loaded carrier tape is wound into a roll or onto a reel, and then transported from the component manufacturer to another manufacturer or assembler, where the roll of carrier tape may be mounted within some type of assembly equipment. The carrier tape is typically unwound from the roll and automatically advanced toward a robotic pick-up location. Advancement of the carrier tape is commonly accomplished using a series of through-holes uniformly spaced along one or both edges of the elongated strip forming the carrier tape. The through-holes receive the teeth of a drive sprocket that advances the tape toward the robotic placement machine. Eventually, the cover tape is stripped from the carrier tape, the components are removed from the pockets and then placed onto the circuit board.

It is known to form carrier tapes using a rotating drum. The rotating drum has a plurality of molds disposed around its circumference. The molds may be convex (i.e., male) or concave (i.e., female) molds, and are sized to provide the desired final pocket dimensions, accounting for the thickness of the tape, the depth of the pocket, and the thermal contraction of the tape after molding. An exemplary method for producing carrier tape using a convex rotary mold is described in U.S. Patent No. 5,800,772 to Kurasawa. In the production of an embossed carrier tape using a convex rotary mold, a web of material is incrementally heated to its softening temperature, and is then guided to pass around the periphery of the drum. The softened material drapes over the molds and comes into close contact with generally the entire side surfaces of the convex molds except for those portions of the web located between adjacent convex molds. At the same time, the web is vacuum-drawn against the molds to urge the web into the spaces between adjacent molds.

Rotary molds used in vacuum forming as described above are generally constructed by stacking a plurality of drum sections as described in United States Patent No. 5,800,772. When a plurality of drum sections are assembled together, a forming tool is created. The space between the drum sections enables the use of vacuum to draw down a molten web to form pocket features.

The ongoing trend in electronics towards smaller and smaller products requires continued miniaturization of electronic components. Needs exist for packaging small electronic components on the order of 1 millimeter (0.040 inches) length by 0.5 millimeter (0.020 inches) width and smaller. One of the major challenges in producing carrier tapes for small components is to consistently meet increasingly fine dimensional accuracy and precision requirements. The current methods used to make forming tools have significant drawbacks for producing carrier tape to package small components. For example, when vacuum forming using a rotating drum it becomes increasingly difficult to draw the web into and between the smaller and more closely spaced molds. Consequently, it is more difficult to keep carrier tape feature dimensions within required tolerances, and features of the carrier tape are not always fully and accurately formed. When the dimensions of carrier tape features approach the same order of magnitude as the thickness of the web, forming the carrier tape with the necessary precision becomes increasingly problematic.

For producing very small features in a polymer sheet, it is known to emboss a polymer web of material between a mold tool and a nip roll formed of steel or chrome. The thickness of the web exceeds the height of features on the tool, such that features are formed on the side of the web in contact with the tool features, and the backside of the web (in contact with the nip roll) is completely flat and featureless. Such a construction applied to a carrier tape would not only use more polymer (leading to greater costs), but the dimensions and reduced flexibility of the thick tape would also adversely affect compatibility with many automated systems.

If carrier dimensions are not kept within fine tolerances and features of the carrier tape are not fully and accurately formed, components could be caught in the pockets, be wobbly or unstable in the pockets, migrate to an incorrect position, or turn over completely. Since it is virtually impossible to correct the attitude of a component in a pocket, a part improperly positioned in a pocket can fail to be picked out of the pocket or can be improperly picked as it is removed from the pocket. As a consequence, an improperly positioned part may not be successfully mounted on a printed circuit board or the like.

Summary

In one aspect, the invention described herein provides a component carrier tape. In one embodiment according to the invention, the component carrier tape comprises a longitudinal flexible strip having a plurality of pockets longitudinally positioned on the longitudinal strip. The pockets are configured for receiving a component therein. Each of the pockets has a depth from a top surface of the longitudinal strip that is greater than a thickness of the longitudinal strip. The side walls separating adjacent pockets are spaced apart by a distance less than approximately five times the thickness of the longitudinal strip, and the sidewalls separating the adjacent pockets have a height greater than the pocket depth minus a height of the component which the pockets are configured to receive.

In another embodiment according to the invention, the carrier tape comprises a longitudinal flexible strip having a top surface and a bottom surface opposite the top surface. A plurality of pockets for receiving components are spaced along the strip and open through the top surface of the strip. Adjacent pockets are separated from each other by a crossbar. The crossbar separates adjacent recesses by a distance less than approximately three times a thickness of the strip, and a top surface of the crossbar is substantially coplanar with the top surface of the strip. A plurality of projections extend from the bottom surface of the strip, each one of the projections corresponding to one of the plurality of pockets.

In another aspect, the invention described herein provides a method for making a component carrier tape. In one embodiment according to the invention, the method comprises providing a rotatable tool having an outer circumferential surface and a nip roll having a conformable outer circumferential surface opposed to the outer circumferential surface of the tool. The outer circumferential surface of the rotatable tool includes a series of projections for forming a plurality of longitudinally spaced component receiving pockets. A polymer web is introduced into a nip between the tool and the nip roll, and the polymer web is pressed between the tool and the nip roll to emboss the web with the projections on the circumferential surface of the tool. The embossed web is then removed from the tool.

Brief Description of the Drawings

Figure 1 is a fragmentary perspective view of one embodiment of a carrier tape according to the invention, with an optional cover thereof having been partially removed to show components stored within pockets of the carrier tape. The component has been omitted from the leading pocket to show the interior of the pocket more clearly.

5 Figure 2 is a sectional view taken along line 2—2 in Figure 1.

Figure 3 is a schematic illustration of an exemplary process according to the invention for producing the carrier tape of Figures 1 and 2.

Figure 4 is a photograph of a carrier tape produced using prior art processes, showing incompletely formed crossbar features separating adjacent pockets.

10 Figure 5 is a photograph of a carrier tape produced using processes according to the invention, showing completely formed crossbar features separating adjacent pockets.

Detailed Description

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

The present invention provides a component holding or transport device having a plurality of pockets formed therein that can be used in the storage or transport of a variety of types of components. More particularly, the present invention provides a holding or transport device having very small precisely formed pockets for use with very small components. In one implementation, the present invention provides a longitudinal component carrier tape having a plurality of closely spaced pockets for storing, transporting, and otherwise handling electronic or other components. Although illustrative embodiments of component carriers are described below with reference to carrier tapes for use with electronic components, it is understood that the component carriers may be adapted for use with materials or substances of any type. For example, the features and materials of the component carriers may be adapted for use with liquid sample materials (or sample materials entrained in a liquid), as may be used in sample processing devices

like those described in U.S. Patent Application Serial No. 10/682,597, filed October 9, 2003.

Referring now to the drawings, one embodiment of a carrier tape according to the invention is shown in Figures 1 and 2. The illustrated carrier tape is particularly useful for the storage and delivery of small electronic components by an advancement mechanism. For purposes of the invention, small components are those having at least one dimension on the order of 1 millimeter (0.040 inches) and smaller.

A unitary flexible carrier tape 100 has a strip portion 101 defining a top surface 102 and a bottom surface 103 opposite the top surface 102. Strip portion 101 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 (not shown) for advancing carrier tape 100 toward a predetermined location.

A series of pockets 112 is formed in and spaced along strip portion 101, the pockets opening through the top surface 102 of the strip portion. Within a given carrier tape, each pocket 112 is usually practically identical to the other pockets. Typically, the pockets 112 are aligned with each other and equally spaced apart. In the illustrated embodiment, each pocket 112 includes four side walls 114, each at generally right angles with respect to each adjacent wall. Side walls 114 adjoin and extend downwardly from the top surface 102 of the strip portion and adjoin bottom wall 116 to form pocket 112. Bottom wall 116 is generally planar and parallel to the plane of strip portion 101. The transverse side walls 114 of adjacent longitudinally positioned pockets 112 define crossbars 117 that separate adjacent pockets 112.

Pockets 112 may be designed to conform to the size and shape of the components that they are intended to receive. Alternately, pocket 112 may have a generic design to readily accommodate components of varying sizes and/or shapes. Although not specifically illustrated, the pockets may have more or less side walls than the four that are shown in the preferred embodiment. In general, each pocket includes at least one side wall 114 that adjoins and extends downwardly from strip portion 101, and a bottom wall 116 that adjoins the side wall 114 to form the pocket 112. Thus, the pockets 112 may be circular, oval, triangular, pentagonal, or have other shapes in outline. Each side wall 114

may also be formed with a slight draft (i.e., a slant toward the center of the pocket) 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 pockets 112 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 112 is illustrated in the drawings, two or more columns of aligned pockets could also be formed along the length of the strip portion 101 to facilitate the simultaneous delivery of multiple components. The columns of pockets could be arranged parallel to each other with pockets in one column being in aligned rows with the pockets in the adjacent column(s), as described in United States Patent No. 4, 298,120. Alternately, the pockets in adjacent columns may be offset from each other, as described in United States Patent No. 4,724,958.

In component carriers according to the invention, the side walls 114 of adjacent pockets 112 are separated by a distance less than about five (5) times the web thickness, preferably less than about three (3) times the web thickness; and the top edges of the walls 114 separating adjacent pockets 112 are substantially coplanar with the top surface 102 of strip portion 101. The height of the adjacent side walls 114 is greater than the pocket depth minus the component height, to prevent component migration between adjacent pockets. In some embodiments, the height of the adjacent side walls is approximately 90% of the pocket depth or greater, preferably approximately 95% of the pocket depth or greater, and more preferably equal to the pocket 112 depth. In some embodiments, the depth of the pockets 112 is greater than the thickness of the web forming strip portion 101, while in other embodiments the depth of the pockets 112 is less than the thickness of the web forming strip portion 101. In either case, the pockets 112 produce corresponding projections on the bottom surface of strip portion 101. In some embodiments, at least one of a length of the pocket and a width of the pocket is less than 2 mm, preferably less than 1 mm. In other embodiments, the strip portion has a width of less than approximately 16 mm for multi-row embodiments, and less than approximately 10 mm for single row embodiments. In still other embodiments, the plurality of pockets 112 are spaced along the longitudinal strip at a pitch of approximately 2 mm or less.

The web forming strip portion 101 may have any thickness, so long as the web has sufficient flexibility to permit it to be wound about the hub of a storage reel. In some embodiments according to the invention, strip portion has a thickness of less than about 1 mm (40 mil), preferably less than about 0.5 mm (20 mil). In some embodiments, the strip
5 portion has a thickness less than about 0.25 mm (10 mil). Strip portion 101 may be optically clear, pigmented or modified to be electrically dissipative or conductive. The electrically conductive material allows an electric charge to dissipate throughout the carrier tape and preferably to the ground. This feature may prevent damage to components contained within the carrier tape due to an accumulated static electric charge.

Carrier tape 100 may optionally include an elongate cover tape 120. Cover tape
10 120 is applied over the pockets 112 of the carrier tape 100 to retain the components therein. An exemplary component 118 is schematically illustrated in Figures 1 and 2. Cover tape 120 can also protect the components from dirt and other contaminants that could invade the pockets. As best shown in Figures 1 and 2, cover tape 120 is flexible,
15 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 101. Cover tape 120 is releasably secured to the top surface of strip portion 101 so that it can be subsequently removed to access the stored components. As illustrated, cover tape 120 includes parallel longitudinal bonding portions 122 and 124 that are bonded to longitudinal edge surfaces 104 and 106,
20 respectively, of strip portion 101. For example, a pressure sensitive adhesive such as an acrylate material, or a heat-activated adhesive such as an ethylene vinyl acetate copolymer, may be used to adhere the cover to edge surfaces 104 and 106. Alternatively, cover tape 120 could be secured to strip portion 101 by other means. Cover tape 120 could also be omitted, and components retained in the pockets 112 by an adhesive, for
25 example.

In one exemplary embodiment, the carrier tapes according to the present invention are made by shaping the pockets 112 in a sheet of polymeric material and winding the carrier tape onto a reel to form a roll. Figure 3 schematically shows an apparatus and manufacturing process used in the production of a component carrier tape according to the
30 present invention. A rotatable tool 200 has a structured outer circumferential surface 202. The surface 202 includes projections 204 extending therefrom that correspond to the various features to be formed in a component carrier tape 100, e.g., component pockets

112, alignment features within the pockets, bosses for sprocket or alignment holes, etc. For purposes of illustration, projections 204 have been greatly enlarged in the schematic representation of Figure 3.

5 A nip roll 210 having a conformable outer circumferential surface 212 is in contact with and opposes the outer circumferential surface 202 of the rotatable tool 200, such that the projections 204 press into and deform the surface 212 of the nip roll 210. The circumferential surface 212 of the nip roll 210 is preferably covered with an elastomeric material. Suitable elastomeric materials include, but are not limited to, rubbers, silicones, ethylene propylene diene monomers (EPDM), urethanes, Teflon®, nitriles, neoprenes, and
10 fluoroelastomers. In some embodiments, the conformable outer surface 212 of the nip roll 210 has a Shore A hardness in the range of 30 to 100, preferably in the range of 50 to 90, depending upon the material being formed.

A melt-processable polymer is delivered from an extruder 220 to a slot die apparatus 222. The melt-processable polymer is delivered to the slot die apparatus 222 at
15 or above its melting temperature (i.e., the temperature at which it can be formed or molded). A web 230 of polymer is discharged from the die apparatus 222 into the nip 240 between the rotatable tool 200 and the nip roll 210. In some implementations, it may be preferred that the polymer web 230 be drop cast onto the rotatable tool 200 just before the nip 240 formed with the nip roll 210. The conformable outer surface 212 of the nip roll
20 210 deforms as the polymer web 230 is pressed between the rotatable tool 200 and the nip roll 210 and embossed with the features of the rotatable tool 200. The pressure applied to the web 230 by the conformable nip roll 210 is sufficient to force molten resin of web 230 into small crevices between projections 204 (forming features of the carrier tape 100 such as narrow pocket crossbars 117) of the rotatable tool 200, and to provided backside feature
25 definition to the web 230 (i.e., features are defined on bottom surface 103 of strip portion 101). The pressure applied by the conformable nip roll 210 will depend upon a plurality of factors, including process speed, material viscosity, web thickness, and dimensions and spacing of projections 204 on rotatable tool 200.

The dimensions of the incoming polymeric web 230 will be determined by the
30 gauge and width of the carrier tape 100 that is to be formed. It is preferred that the thickness of the polymer web 230 and the pressure between the rotatable tool 200 and the nip roll 210 be controlled such that the thickness of the web 230 exiting the nip 240 is less

than the height of the projections 204 that form the component pockets 112 of the carrier tape 100. In a preferred embodiment, the polymer web 230 is delivered to the nip 240 at a thickness in the range of 5 mils to 20 mils.

In some implementations, it may be preferred that the polymer web 230 be delivered from the die apparatus 222 to the rotatable tool 200 at a temperature that is at or above its melt processing temperature. By providing the polymer web 230 to the rotatable tool 200 at or above its melt processing temperature, the polymer can adequately form or be replicated to the shape of the projections 204 on the rotatable tool 200. The temperature at which the polymeric web 230 must be delivered from the die apparatus 222 varies over a broad range (i.e., about 200° to over 630° F) depending upon the gauge and type of material that is being formed, as well as the speed of the manufacturing line. Although the tool 200 is depicted and described herein as a roll, it should be understood that the tool 200 may alternatively be provided as any other rotatable structure amenable to continuous web-form processing, such as a continuous belt.

The temperature of the polymer web is preferably lowered to below the melt processing temperature at some point after the nip 240 between the rotatable tool 200 and the nip roll 210 to retain the structures formed in the polymer web 230 and provide mechanical stability to the web. To aid in temperature control of the web 230, the rotatable tool 200 and/or the nip roll 210 may be heated or cooled, as necessary. The result of the processing depicted in Figure 3 is an embossed web 250 that can be used to form the carrier tapes 100 according to the present invention.

In the case of extrusion of thermoplastic resins, a web of molten material is guided to pass through the nip 240. As the embossed web 250 exits the nip 240, any suitable cooling means may be employed to cool the web and sufficiently harden the material such that it may be removed from the rotatable tool 200. Cooling can be accomplished, for example, by convective air cooling, direct impingement of air jets by high-pressure blowers, a water bath or spray, or a cooling oven until the thermoplastic polymer sufficiently solidifies.

In the case of polymerizable resins, the resin may be poured or pumped directly into a dispenser that feeds the slot die apparatus 222. For embodiments wherein the polymer resin is a reactive resin, the method of manufacturing the web further comprises curing the resin in one or more steps. For example, the resin may be cured upon exposure

to a suitable radiant energy source such as actinic radiation, ultraviolet light, visible light, etc., depending upon the nature of the polymerizable resin to sufficiently harden the resin prior to removal from the rotatable tool 200. Combinations of cooling and curing may also be employed in hardening the web as it comes off the tool 200.

5 Suitable resin compositions for component carrier tapes of this invention are dimensionally stable, durable, and readily formable into the desired configuration. Suitable materials include, but are not limited to, polyesters (e.g., glycol-modified polyethylene terephthalate, or polybutylene terephthalate), polycarbonate, polypropylene, polystyrene, polyvinyl chloride, acrylonitrile-butadiene-styrene, amorphous polyethylene
10 terephthalate, polyamide, polyolefins (e.g. polyethylene, polybutene, or polyisobutene), modified poly (phenylene ether), polyurethane, polydimethylsiloxane, acrylonitrile-butadiene-styrene resins, and polyolefin copolymers. In some embodiments, the material has a melt temperature in the range of 400° to 630° F. The material may be modified to be electrically dissipative or conductive. In the latter case, the material may include an
15 electrically conductive material, such as carbon black or vanadium pentoxide, that is either interspersed within the polymeric material or is subsequently coated onto the web. These materials may also include dyes, colorants, pigments, UV stabilizers, or other additives.

 In general, the rotatable tool 200 may be comprised of any substrate suitable for forming by direct machining. Suitable substrates machine cleanly with minimal or no burr
20 formation, exhibit low ductility and low graininess, and maintain dimensional accuracy after machining. A variety of machinable metals or plastics may be utilized. Suitable metals include aluminum, steel, brass, copper electroless nickel, and alloys thereof. Suitable plastics comprise thermoplastic or thermoset materials such as acrylics or other materials. In some embodiments, the material forming rotatable tool 200 may comprise a
25 porous material, such that a vacuum can be applied through the material of rotatable tool 200, in combination with nip roll 210.

 The rotatable tool 200 is preferably formed as a unitary sleeve having projections 204 for all of the desired carrier tape 100 features on the unitary sleeve. The sleeve may include projections for forming the pockets, alignment features thereof, and protuberances
30 for skiving to form sprocket holes, for example. The method includes simultaneously thermoforming the pockets and the protuberances to provide excellent registration therebetween.

Projections on the outer circumference 202 of the rotatable tool 200 are preferably cut directly onto the sleeve using either a carbide or diamond tooling machine that is capable of shaping each projection with fine precision. Moore Special Tool Company, Bridgeport, CT; Precitech, Keen, NH; and Aerotech Inc., Pittsburgh PA, manufacture
5 suitable machines for such purposes. Such machines typically include a laser interferometer-positioning device, a suitable example of which is available from Zygo Corporation, Middlefield CT. The diamond tools suitable for use are those such as can be purchased from K&Y Diamond, Mooers, NY, or Chardon Tool, Chardon, OH.

The sleeve can be machined using techniques and methods known in the art to
10 form the desired projections 204 thereon. For example, the projection surfaces corresponding to the component pocket sidewalls 114 can be formed by turning the sleeve in a typical lathe operation in which the sleeve is turned and the cutter is in a fixed position. The projection surfaces corresponding to the component pocket crossbars 117 can be formed by holding the sleeve stationary and cutting slots parallel to the axis of the
15 sleeve. Additional projections, such as those for forming posts for skiving, can be formed in a manner similar to the formation of the projections used to shape the pockets. Beneficially, projections 204 on the sleeve can be formed to simultaneously produce a plurality of carrier tapes. Specifically, pockets and other features for a plurality of carrier tapes can be produced on a single sleeve, and the web 250 slit after forming to isolate the
20 individual carrier tapes.

Once the pockets 112 of the carrier tape 100 have been prepared, the advancement holes 108, 110 are subsequently formed in a separate operation such as by punching the strip portion 101, or by skiving off protuberances formed on one or both of longitudinal edge surfaces 104 and 106 as described, for example, in United States Patent No.
25 5,738,816. The carrier tape 100 is then wound (either concentric or level windings) about a reel 260 to form a supply roll for storage until the carrier tape is loaded with components.

Figure 4 is a photograph of a typical vacuum formed carrier tape formed on male-featured tooling using a conductive black polycarbonate resin. The low pocket crossbars
30 result from the restricted flow of resin into the narrow crevices between the pockets in the tooling.

Figure 5 is a photograph of a carrier tape formed using a static dissipative black polystyrene resin in an extrusion replication process with a conformable nip roll 210 according to the invention. The crossbars of the carrier are fully formed. Clearly, the production method and apparatus of the present invention produces significantly higher pocket crossbars than the standard vacuum formed pocket crossbars.

In experimental results, where a fully formed crossbar has a height of 0.631 mm, average crossbar heights obtained using conductive black polycarbonate in a standard vacuum forming process pockets were 0.107 mm, while average crossbar heights obtained using identical material in the extrusion replication process of the invention were 0.607 mm. Thus, a standard vacuum forming process produced a crossbar height equal to approximately 17% (0.107 mm / 0.631 mm) of a fully formed crossbar height, while the extrusion replication process of the invention produced a crossbar height equal to approximately 96% (0.607 mm / 0.631 mm) of a fully formed crossbar height.

Process Example

A component carrier tape according to the invention was prepared using a static dissipative polystyrene resin filled with carbon black. The resin was fed into a single screw 2.5-inch Davis Standard extruder with a length/diameter (L/D) ratio of 30:1. A rising temperature profile was used in the extruder die zones, reaching a final temperature of 450° F. The molten polymer was passed through a heated neck tube into a 10-inch wide film die block shimmed to a nominal gap of 0.070 inches. The web melt emerging from the extruder die block was drop cast into a nip formed by an aluminum forming tool and a silicone rubber covered nip roll. The silicone rubber had a Shore A hardness of 75. The tool roll temperature was maintained at 100° F, while the nip roll temperature was maintained at 70° F. After exiting the nip, the web continued around the curved surface of the tool as it was cooled by contact with a chilled forming tool, and also by external compressed air cooling until a temperature of less than the glass transition temperature of the material (approximately 212°F) was reached. The web was then removed from the tool and wound into a roll.

Although specific embodiments have been illustrated and described herein for purposes of description of the preferred embodiment, it will be appreciated by those of ordinary skill in the art that a wide variety of alternate and/or equivalent implementations calculated to achieve the same purposes may be substituted for the specific embodiments

shown and described without departing from the scope of the present invention. Those with skill in the art will readily appreciate that the present invention may be implemented in a very wide variety of embodiments. This application is intended to cover any adaptations or variations of the preferred embodiments discussed herein. Therefore, it is
5 manifestly intended that this invention be limited only by the claims and the equivalents thereof.

What is claimed is:

1. A component carrier tape comprising:
a longitudinal flexible strip;
a plurality of pockets longitudinally positioned on the longitudinal strip and
configured for receiving a component therein, each of the pockets having a
depth from a top surface of the longitudinal strip that is greater than a
thickness of the longitudinal strip;
wherein side walls separating adjacent pockets are spaced apart by a distance less
than approximately five times the thickness of the longitudinal strip, and
wherein the sidewalls separating the adjacent pockets have a height greater
than the pocket depth minus a height of the component which the pockets
are configured to receive.
2. The component carrier tape of claim 1, wherein the longitudinal strip has first and
second parallel longitudinal edge surfaces, and at least one of the edge surfaces includes a
plurality of equally spaced advancement holes for receiving an advancement mechanism.
3. The component carrier tape of claim 1, further comprising a cover releaseably
secured to a top surface of the longitudinal strip, extending along the strip, and covering
the plurality of pockets.
4. The component carrier tape of claim 1, wherein the longitudinal strip has a width
of less than 10 mm.
5. The component carrier tape of claim 1, wherein the plurality of pockets are spaced
on the longitudinal strip at a pitch of about 2 mm or less.
6. The component carrier tape of claim 1, wherein side walls separating adjacent
pockets are spaced apart by a distance less than approximately three times the thickness of
the longitudinal strip.

7. The component carrier tape of claim 1, wherein the sidewalls separating adjacent pockets have a height greater than approximately 90% of the pocket depth.
8. The component carrier tape of claim 1, wherein the sidewalls separating adjacent pockets have a height greater than approximately 95% of the pocket depth.
9. The component carrier tape of claim 1, wherein the sidewalls separating the adjacent pockets have a height approximately equal to the pocket depth.
10. The component carrier tape of claim 1, wherein the pockets have a length and a width, and wherein at least one of the pocket length and pocket width is less than 2 mm.
11. The component carrier tape of claim 10, wherein the pockets have a length and a width, and wherein at least one of the pocket length and pocket width is less than 1 mm.
12. The component carrier tape of claim 1, wherein the longitudinal strip has a thickness of less than about 0.5 mm.
13. The component carrier tape of claim 12, wherein the longitudinal strip has a thickness of less than about 0.25 mm.
14. A flexible carrier tape for storage and delivery of components by an advancement mechanism, the carrier tape comprising:
 - a longitudinal flexible strip having a top surface and a bottom surface opposite the top surface;
 - a plurality of pockets for receiving components spaced along the strip and opening through the top surface thereof, wherein adjacent pockets are separated from each other by a crossbar, the crossbar separating adjacent recesses by a distance less than approximately three times a thickness of the strip, and wherein a top surface of the crossbar is substantially coplanar with the top surface of the strip; and

a plurality of projections extending from the bottom surface of the strip, each one of the projections corresponding to one of the plurality of pockets.

15. A method for producing an embossed carrier tape having a plurality of longitudinally spaced component receiving pockets in a front side thereof, comprising:
providing a rotatable tool having an outer circumferential surface, the outer circumferential surface including a series of projections for forming a plurality of longitudinally spaced component receiving pockets;
providing a nip roll having a conformable outer circumferential surface opposed to the outer circumferential surface of the tool;
introducing a polymer web into a nip between the tool and the nip roll;
pressing the polymer web between the tool and the nip roll to emboss the web with the projections on the circumferential surface of the tool; and
removing the embossed web from the tool.

16. The method of claim 15, wherein providing a rotatable tool having an outer circumferential surface including a series of projections comprises providing projections having a height greater than a thickness of embossed web removed from the tool.

17. The method of claim 15, wherein providing a rotatable tool having an outer circumferential surface including a series of projections comprises providing projections separated by a distance less than about five times the thickness of the embossed web removed from the tool.

18. The method of claim 17 wherein providing a rotatable tool having an outer circumferential surface including a series of projections comprises providing projections separated by a distance less than about three times the thickness of the embossed web removed from the tool.

19. The method of claim 15, wherein providing a rotatable tool having an outer circumferential surface including a series of projections comprises providing projections to form a plurality of individual carrier tapes in the embossed web.

20. The method of claim 15, wherein providing a nip roll having a conformable outer circumferential surface comprises providing a conformable circumferential surface having a Shore A hardness in the range of 30 to 100.
21. The method of claim 15, wherein providing a nip roll having a conformable outer circumferential surface comprises covering a circumferential surface of the nip roll covered with an elastomer.
22. The method of claim 15, wherein pressing the polymer web between the tool and the nip roll includes deforming the conformable surface of the nip roll with the projections of the rotatable tool to form features on a back side of the web.
23. The method of claim 15, wherein providing a rotatable tool comprises providing a unitary tool.

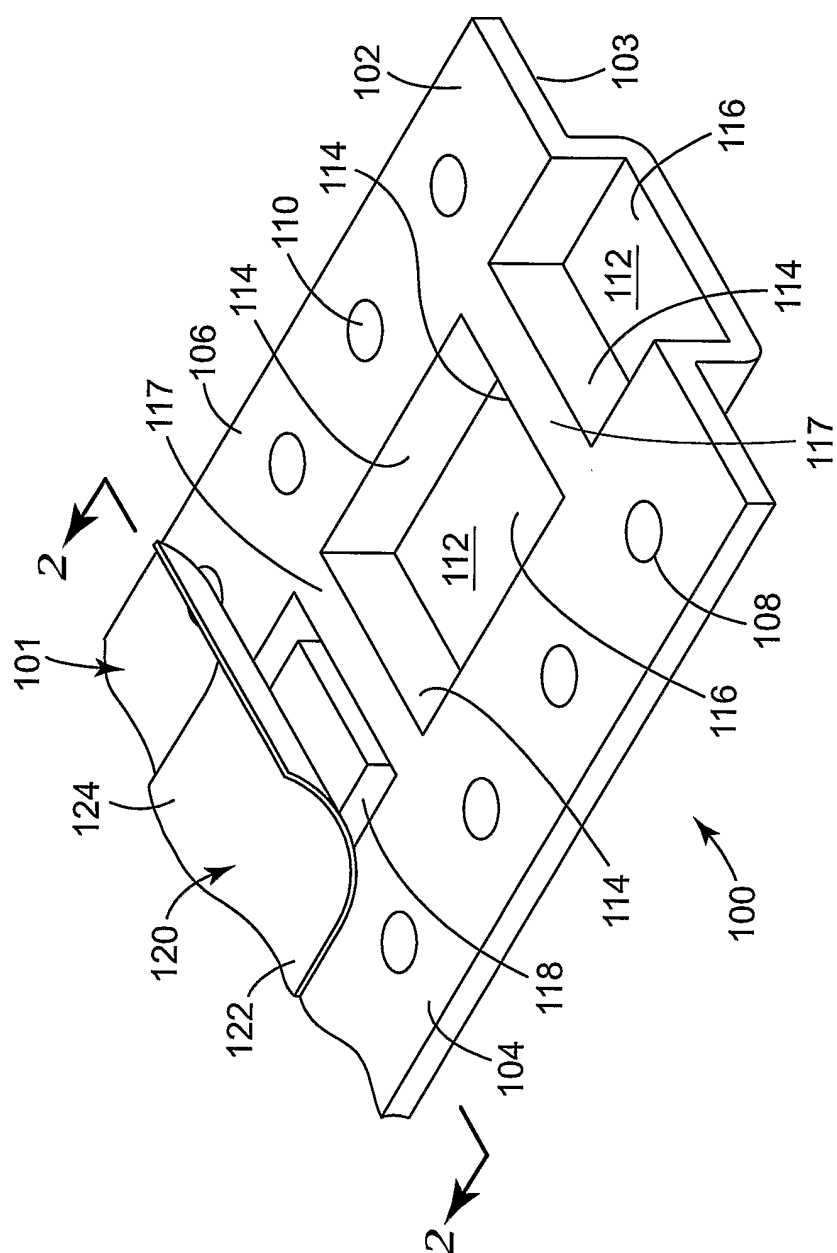


FIG. 1

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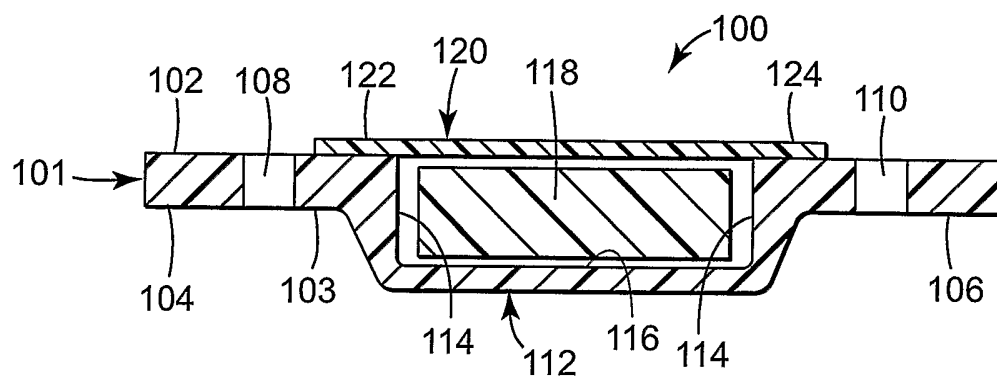


FIG. 2

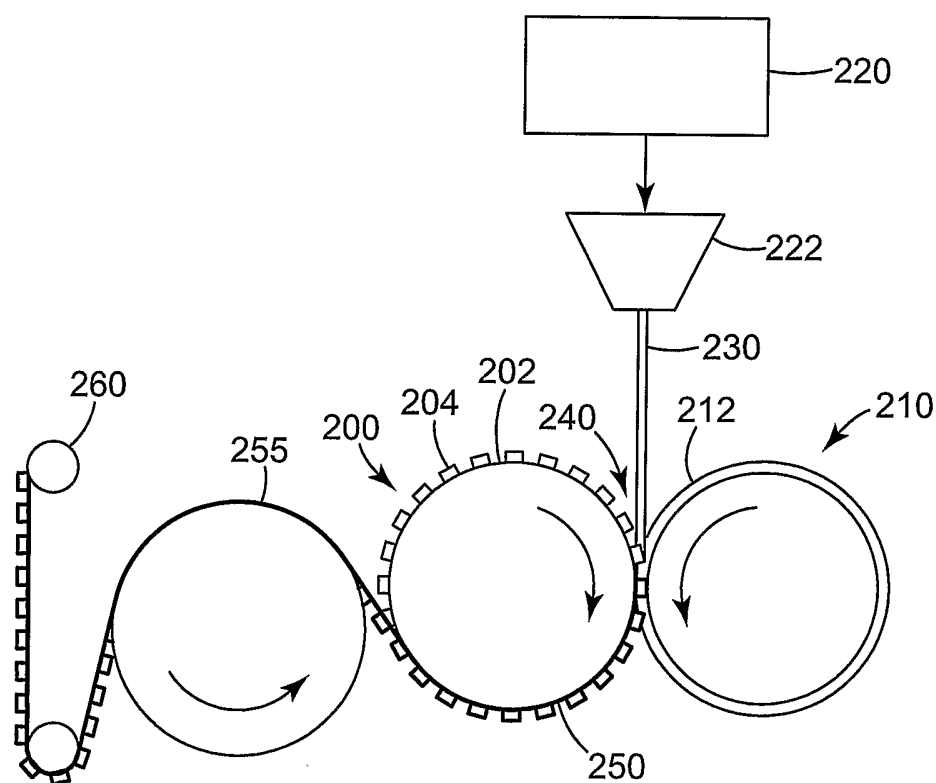


FIG. 3

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FIG. 4
Prior Art



FIG. 5

SUBSTITUTE SHEET (RULE 26)