

SHARP POCKET CARRIER TAPE

FIELD OF THE INVENTION

[001] The present invention relates generally to a carrier tape for electronic component packaging applications and more specifically to a carrier tape with a plurality of sharp angled pockets to prevent or reduce unwanted movement and damage of the electronic components in the pockets.

BACKGROUND OF INVENTION

[002] The storage, handling, and transport of electronic components such as a semiconductor package has become more important as electronic devices using such components become more prevalent. Generally, electronic components are transported to an assembly location in a carrier tape assembly that has a plurality of pockets formed therein to hold the electronic components in a secure position to prevent damage. These carrier tape assemblies can include a carrier tape and a cover tape or film placed over the carrier tape to prevent it from migrating out of the pocket. Carrier tapes are often manufactured in a thermoforming or embossing operation in which a web of thermoplastic polymer is delivered to a mold that forms the component pockets in the carrier tape. A cover film can be heat sealed along the edges of the carrier tape to seal the electronic components within the pockets of the carrier tape.

[003] As electronic components such as Bare Die and WLCSP (Wafer Level Chip Scale Package) become smaller and thinner they can more easily shift or migrate out of the pockets during shipping and handling. One of the major challenges in producing carrier tapes for electronic components is to meet increasingly fine dimensional accuracy and precision requirements. In this regard, a degree of freedom for components inside the pocket is restricted by the carrier tape pocket design and cover tape or film sealed at the top of the pocket.

[004] In conventional carrier tapes, there is typically a radius at the pocket opening portion where the top surface of the carrier tape and side wall of the pocket meet. As illustrated in FIG. 1, the curvature of the pocket opening and pocket opening radius can cause the electronic component to rest on this curved portion rather than the pocket base. This can lead to a higher likelihood of shifting and breakage of the component.

[005] It can be appreciated by those skilled in the art that this opening radius and curvature of the pocket opening portion depends on the type of pocket design and the forming process. For example, in certain forming processes it can be difficult to keep carrier tape feature dimensions within required tolerances, and features of the carrier tape may not accurately form. Thus, providing carrier tape pockets with the necessary precision can be challenging. In view of this issue, the pocket opening radius of carrier tape pockets is of particular importance for smaller or thin electronic components that are generally more fragile and susceptible to damage. Moreover, conventional carrier tapes are formed through processes that focus on the pocket cavity profile of the base surface. This can lead to an indistinct pocket opening because of natural stretching.

[006] Recent efforts have focused on solving this issue to reduce the possibility of component shifting/migration and damage. For example, one can reduce the sealing line distance closer to the pocket opening and apply extra sealing on the area in between two pockets. However, the effectiveness of such attempts depends on the sharpness of the pocket opening and the component thickness. Another important factor to consider is the high peel-back force performance that can cause component instability for SMT (Surface Mount Technology) pick and place processes. Specifically, as the sealing line is adjusted closer to the pocket opening, an occurrence of thin-sealing and/or an open sealing may arise which would require an increase of sealing pressure and sealing temperature to prevent such issues. For extra sealing on the area between two pockets (rib), additional bonding can be introduced so that additional peeling force is necessary to separate the cover tape and carrier tape.

[007] As such, the present disclosure is aimed at providing a carrier tape and pocket design that overcomes, or at least ameliorates, one or more of the disadvantages of

conventional designs. In particular, the carrier tape includes a pocket design for securing small or thin electronic components and preventing shifting, migrating or incorrect positioning therein from the space created by the pocket opening radius and other pocket dimensions.

SUMMARY OF THE DISCLOSURE

[008] In one aspect, the present disclosure provides a carrier tape for carrying electronic components, comprising a longitudinal strip with a top surface; and a plurality of pockets positioned longitudinally along the strip, each being configured to receive an electronic component, wherein each pocket having one or more side walls extending from the top surface of the longitudinal strip to a flat bottom base surface of the pocket, wherein each pocket having a depth in the range of 0.10 to 2mm; wherein the one or more side walls have a draft angle of less than 5°; and wherein each pocket having an opening radius of less than 0.1 mm.

[009] In another aspect, the pocket comprised in the carrier tape disclosed herein may be any shape with a width of at least 0.80mm and a length of at least 0.80mm. In another aspect, the pocket is square shaped.

[0010] In another aspect, the pocket comprised in the carrier tape disclosed herein may further comprises one or more corner reliefs. In this aspect, the pocket may have a width of at least 1mm and a length of at least 1mm.

[0011] In another aspect, the depth of the pocket disclosed herein is about 0.2mm.

[0012] In another aspect, the draft angle of the pocket disclosed herein is less than 2°.

[0013] In another aspect, the draft angle of the pocket disclosed herein is about 0°.

[0014] In another aspect, the width, length and depth of the pocket disclosed herein are 0.8mm, 0.8mm and 0.2mm respectively.

[0015] In another aspect, the pocket disclosed herein may further comprises a continuous lip portion that surrounds the perimeter of the pocket.

[0016] In another aspect, the carrier tape may be an embossed carrier tape.

[0017] In one aspect, the present disclosure provides a method of manufacturing a carrier tape disclosed herein.

[0018] Further objects of the invention will appear in the description and accompanying figures.

[0019] To the accomplishment of the above and related objects, this invention may be embodied in the form illustrated in the accompanying drawings, attention being called to the fact, however, that the drawings are illustrative only, and that changes may be made in the specific construction illustrated and described within the scope of the appended claims.

DEFINITIONS

[0020] The following words and terms used herein shall have the meaning indicated:

[0021] In the following Detailed Description, 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. In this regard, directional terminology, such as “top,” “bottom,” “front,” “back,” “leading,” “forward,” “trailing,” etc., is used with reference to the orientation of the Figure(s) being described. Because components of embodiments of the present invention can be positioned in a number of different orientations, the directional terminology is used for purposes of illustration and is in no way limiting. 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.

[0022] The word “substantially” does not exclude “completely” e.g. a composition which is “substantially free” from Y may be completely free from Y. Where necessary, the word “substantially” may be omitted from the definition of the invention.

[0023] Unless specified otherwise, the terms "comprising" and "comprise", and grammatical variants thereof, are intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, unrecited elements.

[0024] As used herein, the term "about", in the context of concentrations of components of the formulations, typically means +/- 5% of the stated value, more typically +/- 4% of the stated value, more typically +/- 3% of the stated value, more typically, +/- 2% of the stated value, even more typically +/- 1% of the stated value, and even more typically +/- 0.5% of the stated value.

[0025] Throughout this disclosure, certain embodiments may be disclosed in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

[0026] The invention illustratively described herein may suitably be practiced in the absence of any element or elements, limitation or limitations, not specifically disclosed herein. Thus, for example, the terms "comprising", "including", "containing", etc. shall be read expansively and without limitation. Additionally, the terms and expressions employed herein have been used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the

features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed. Thus, it should be understood that although the present invention has been specifically disclosed by preferred embodiments and optional features, modification and variation of the inventions embodied therein herein disclosed may be resorted to by those skilled in the art, and that such modifications and variations are considered to be within the scope of this invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] Various other objects, features and attendant advantages of the present invention will become fully appreciated as the same becomes better understood when considered in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the several views, and wherein:

[0028] FIG. 1 depicts a top view and a cross-sectional view of a pocket opening radius of a conventional carrier tape pocket with close-up views of the pocket opening radius and measurement points.

[0029] FIG. 2A depicts a top view of the carrier tape disclosed herein.

[0030] FIG. 2B depicts an isometric view of the carrier tape of FIG. 2A.

[0031] FIG. 3A depicts a top view of the carrier tape disclosed herein.

[0032] FIG. 3B depicts a perspective view of the carrier tape disclosed herein.

[0033] FIG. 3C depicts a side view of the carrier tape disclosed herein.

[0034] FIG. 4A depicts a top view of the carrier tape disclosed herein with the inclusion of a lip portion.

[0035] FIG. 4B depicts a perspective view of the carrier tape disclosed herein with the inclusion of a lip portion.

[0036] FIG. 4C depicts a side view of the carrier tape disclosed herein with the inclusion of a lip portion.

[0037] FIG 5A depicts a cross-section view of a pocket opening and draft angle (θ) of the carrier tape disclosed herein.

[0038] FIG 5B depicts a cross-section view of a pocket opening and draft angle (θ) of the carrier tape disclosed herein with a lip portion.

[0039] FIG. 6A depicts a top view of the carrier tape disclosed herein with discontinuous lip portions on opposite sides of the pocket opening and a sloped wall (A) adjoining the top surface of the carrier tape.

[0040] FIG. 6B depicts a perspective view of the carrier tape with discontinuous lip portions on opposite sides of the pocket and a sloped wall adjoining the top surface of the carrier tape.

[0041] FIG. 6C depicts a side view of the carrier tape with lip portions on opposite sides of the pocket opening and a sloped wall (A) adjoining the top surface of the carrier tape.

[0042] FIG. 7A is an image of a cross-sectional view of the pocket opening and draft angle disclosed herein.

[0043] FIG. 7B is an image of a cross-sectional view of the pocket disclosed herein of 0.2 mm depth and a 92-degree angle (2 degree draft angle).

[0044] FIG. 7C is an image of a cross-sectional view of the pocket disclosed herein of 0.66 mm depth and a 92-degree angle (2 degree draft angle).

[0045] FIG. 8A is an image of a cross-sectional view of a first type of pocket design (termed a rotary tape) with a draft angle.

[0046] FIG. 8B is an image of a cross-sectional view of a first type of pocket design (termed a rotary tape) with an opening radius.

[0047] FIG. 9A is an image of a cross-sectional view of a second type of pocket design (termed Japanese tape) with a draft angle.

[0048] FIG. 9B is an image of a cross-sectional view of a second type of pocket design (termed Japanese tape) with an opening radius.

[0049] FIG. 10A is an image of a cross-sectional view of a third type of pocket design (termed PTT tape) with a draft angle.

[0050] FIG. 10B is an image of a cross-sectional view of a third type of pocket design (termed PTT tape) with an opening radius.

[0051] FIG. 11A is an image of a cross-sectional view of a fourth type of pocket design (termed Mini-Press tape) with a draft angle.

[0052] FIG. 11B is an image of a cross-sectional view of a fourth type of pocket design (termed Mini-Press tape) with an opening radius.

DETAILED DESCRIPTION OF THE INVENTION

[0053] In a following description, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration a specific example in which the invention may be practiced. It is to be understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the present invention.

Carrier Tape

[0054] A carrier tape assembly includes a carrier tape and a cover film bonded to a top surface of the carrier tape. The carrier tape assembly is used to transport and store electronic components typically used in assembling electronic devices. The electronic components are disposed in pockets formed in the carrier tape. These pockets can be positioned longitudinally along the length of the carrier tape and spaced equidistantly apart from one another. Each of the pockets can be spaced apart from one another such that the number of pockets per meter is defined by the pocket pitch. For example, the range of pocket pitches can be 2 to 56 mm. So, the number of pockets per meter of tape can range from 17 to 500. In one embodiment, the distance between adjacent pockets (pocket pitch) along the longitudinal axis of the carrier tape is about 5mm to 5cm, but can be greater. In one embodiment, the pocket pitch (P1) can be at least 2mm. In another embodiment, the pocket pitch can be 2mm, 4mm, 8mm, 12mm, 16mm, 20mm, 24mm, 28mm, 32mm, 36mm or 40mm.

[0055] Due to the diversity of electronic components in size and physical requirements, the carrier tape width can vary from 4mm to 56mm. More specifically, the carrier tape can have a width of 4mm, 8mm, 12mm, 16mm, 24mm, 32mm, 44mm, or 56mm. In one embodiment, the carrier tape width is 8mm or 12mm. Moreover, the thickness of the carrier tape can be 0.20mm, 0.25mm, 0.30mm, 0.35mm, 0.40mm or 0.50mm.

[0056] In one embodiment, the electronic component can be thin with a thickness of 0.08mm to 2.00mm. In another embodiment, the electronic component can be any integrated circuit, Die or wafer. For example, the electronic component can be a bare Die, WLCSP (Wafer Level Chip Scale Package) or Die Prep. In terms of size with respects to length and width, the electronic component can be, for example, as small as 0.20mm x 0.40mm or as large as 39.00mm x 47.00mm.

[0057] FIG. 2A depicts a top view of the carrier tape and FIG. 2B depicts a perspective view. The carrier tape assembly **100** can include a carrier tape **101** and a cover film (not shown). The carrier tape **101** can include a longitudinally extending central portion **101A**

having a plurality of pockets **103** formed therein and two side portions **101B** and **101C**. The side portions are disposed on opposite sides of the central portion and extend longitudinally therewith and define the longitudinal axis of the carrier tape. The central and side portions **101A**, **101B** and **101C** can be formed in a flat configuration with their top surface being parallel to each other along the same plane (coplanar) and at the same height. Alternatively, one or more of the central and side portions can be at an elevated or raised level with respect to one another at differing planes and heights.

[0058] The cover film can be applied over the pockets **103** of carrier tape **101** to retain the electronic components therein. The cover film can be adhered to a sealing area. In one embodiment, one or both of the side portions **101B** and **101C** can comprise an adhesion portion that defines the attachment region for cover film. The cover film can be continuously adhered to the carrier tape within the adhesion portion along the longitudinal length of the carrier tape. A pressure sensitive adhesive such as an acrylate material, or a heat-activated adhesive such as an ethylene vinyl acetate copolymer, can be used to adhere the cover film to the top surface of side portions **101B** and **101C**. The width of the bond area between the cover film and the carrier tape on both side portions can be the same, smaller or greater with respect to one another. In one embodiment, both side portions **101B** and **101C** comprise an adhesion portion. The two continuous bond areas allow for a stable and even separation of the cover film from the carrier tape during removal of the component from each pocket during assembly operations. In one embodiment, the adhesive is a heat activated adhesive for providing a heat seal cover tape.

[0059] In one embodiment, the cover film can comprise an adhesive layer such as a pressure sensitive adhesive coated onto a backing layer, or a heat-activated adhesive coated on a support layer. The adhesive layer can be used to adhere the cover film to top surface of side portions **101B** and **101C** of carrier tape **101**.

[0060] In one embodiment, one or both side portion **101B** and **101C** can comprise a row of aligned advancement structures **104**, as depicted in FIGS. 2 to 6. In one embodiment, the carrier tape can comprise a single row of advancement structures formed on one of

the side portions of the carrier tape. The advancement structures are configured to engage with drive assemblies of placement equipment used to remove the electronic components from the pockets of the carrier tape. In this regard, the advancement structures **104** are used to advance the carrier tape to a prescribed location such that the electronic component can be placed in or removed from the pocket of the carrier tape. In one embodiment, the advancement structures are circular holes.

[0061] In one embodiment, the carrier tape **101** is an embossed carrier tape. The embossed carrier tape contains embossed pockets **103** that are made by blistering to create the pocket **103** on the carrier tape. This forming process of the pockets and resulting carrier tape is in contrast to a punched carrier tape, with penetrated cavities or pockets made through die cutting methods that form punched or semi-punched pockets on the tape. In one embodiment, the carrier tape is formed by conventional thermal forming and embossing methods, wherein the advancement structures are formed using heat through an embossed method which integrates an extra forming action in the forming tool design.

[0062] The carrier tape **101** can be comprised of a longitudinal strip that is made of a flexible material. In one embodiment, the carrier tape and longitudinal strip may be made from any polymeric material that has a sufficient thickness and flexibility to permit it to be wound about the hub of a storage reel. The polymeric material that can be used for the carrier tapes can be dimensionally stable, durable, and readily formable into the desired configuration. A variety of polymeric materials may be used including, but not limited to, polyester (for example, glycol-modified polyethylene terephthalate), polycarbonate, polypropylene, polystyrene, polyvinyl chloride, and acrylonitrile-butadiene-styrene, amorphous polyethylene terephthalate, polyamide, polyolefins (for example, polyethylene, polybutene, or polyisobutene), modified poly(phenylene ether), polyurethane, polydimethylsiloxane, acrylonitrile-butadiene-styrene resins, and polyolefin copolymers. In one embodiment, the carrier tape **101** may be formed from polycarbonate or polystyrene.

[0063] In one embodiment, the manufacturing material of the carrier tape can have a melt temperature in the range of 400° F to 630° F. The carrier tape can be optically clear, pigmented or modified to be electrically dissipative. In the latter case, the carrier tape can include an electrically conductive material, such as carbon black or vanadium pentoxide, either dispersed within the resin material or coated onto the surface(s) of the formed carrier tape. The electrically conductive material helps dissipate an electric discharge that can occur during removal of the cover film or unwinding of the carrier tape assembly from a storage spool thus helping to prevent damage to the electronic components contained within the pockets of the carrier tape. In addition, dyes, colorants, pigments, UV stabilizers, or other additives may be added to the resin material before forming the carrier tape.

Carrier Tape Pocket

[0064] The present disclosure is aimed at the provision of a carrier tape with a pocket profile and design to avoid shifting/migration of the electronic component in the pocket and prevent damage to the component. Component migration refers to movement of the component out from the pocket. Alternatively, the component can get trapped at the pocket opening between the cover tape and pocket edge. This is a particularly important consideration when the electronic component is thin and fragile and is more vulnerable to damage from being incorrectly positioned when a force is biased on one or more edges or corners of the component.

[0065] The present disclosure provides a sharp pocket opening carrier tape (SPOT) with a shallow pocket depth, sharp pocket opening radius and small pocket draft angle with either flat or raised profile at sealing level to avoid the aforementioned issues associated with component migration, especially with thin electronic components.

[0066] FIG. 3A depicts a top view of the carrier tape assembly. FIG. 3B depicts a perspective view and FIG. 3C depicts a side view. The pockets of the carrier tape can comprise one or more side walls **105** and a flat base or bottom wall **106** (depicted in

greater detail in FIG. 5A). The one or more side walls each extend downward from the top surface **107** of the carrier tape to adjoin to the bottom or base **106** of the pocket. Each side wall is adjoined to any adjacent side wall at a corner in forming the pocket, whereby each side wall starts/ends at a corner. As depicted in greater detail in FIG. 5A, the pocket base **106** is planar and defines a first reference plane R_1 . The pocket base and hence the first reference plane are parallel to the top surface of the carrier tape side portions that define a second reference plane R_2 . The distance between the two reference planes defines a first reference height, H_1 . The reference height H_1 can be referred to as the pocket depth (K_0).

[0067] FIG. 4A depicts a top view of the carrier tape assembly with the inclusion of a lip portion **111**. FIG. 4B depicts a perspective view and FIG. 4C depicts a side view. The lip portion **111** can improve the seal of the cover film over the pockets and achieve a desired tension of the cover film.

[0068] In some conventional carrier tape designs, to aid in avoiding component migration an adhesive layer or substance is applied to the bottom wall of the pocket. However, the present disclosure and pocket design does not require any adhesive layer or substance being applied to the pocket base. Thus, in one embodiment, the carrier tape pocket disclosed herein does not comprise any adhesive layer, material or substance for affixing the electronic component within the pocket.

[0069] The pockets of the carrier tape disclosed herein are designed to accommodate the size and shape of the electronic components that they are intended to receive. Thus, the pockets can be square, rectangle, circular, oval, triangular, pentagonal, or have other shapes in outline dependent upon the electronic component size and shape. In one embodiment, the pocket is a square shape as shown in FIGS. 2 to 6, whereby each pocket **103** includes four side walls **105**, each side wall formed at a right angle with respect to each adjacent wall and the side walls **105** adjoin and extend downward from the top surface of the central portion of the carrier tape and adjoin bottom wall **106** to form the pocket.

[0070] FIG. 5A depicts a cross-section view of a pocket opening and draft angle (θ) of the carrier tape assembly. Similarly, FIG. 5B depicts a cross-section view of a pocket opening and draft angle (θ) of the carrier tape assembly with (B) a lip portion.

[0071] As shown in FIG 5A and 5B, each pocket side wall can have a slight draft angle, that refers to the deviation or slant of the side wall away from the centre of the pocket as it extends upwards from the pocket base **106**. In other words, the draft angle refers to an obtuse angle above 90° and does not refer to an acute angle below 90° relative to the planar surface of the pocket base. In one embodiment, the draft angle Θ of the side wall is in the range of 0° and 5° , preferably the draft angle may be less than 5° , more preferably less than 2° . In one embodiment, the draft angle may be 1° . In one embodiment, the draft angle may be 0° . As will be appreciated, when the draft angle is 0° the side wall extends directly perpendicular to the plane and surface of the flat base **106** along a vertical axis Y with no deviation or slanting of the side wall away from the centre of the pocket. If the side wall is slanted away from the centre and hence vertical axis Y, this will produce a distance that the top or edge of the side wall deviates from the vertical axis Y. In this context, the top or edge of the side wall is the opposite point from where the side wall adjoins the pocket base.

[0072] The top surface of the carrier tape and side wall of the pocket meet/join/intersect with one another in forming the opening corner of the pocket, whereby the forming process of the pocket and transition of the material from the top surface to side wall will form a curvature or arching portion of varying size. The curved or arched portion of the pocket opening corner determines the pocket opening radius. The curved or arched portion of the pocket opening can be defined as the portion between points where the planar surface of the side wall and planar surface of the top surface begin to curve towards one another. As illustrated in FIG. 1, to measure the opening radius of a pocket a cross section of the pocket cavity is used to select points along the curved or arched

portion (112) of the pocket. Conventional contact measurement equipment known to those skilled in the art can be used to calculate the opening radius to scale. In particular, the points placed on the curved or arched portion of the opening corner can be used to form a circle of which the radius may be derived, whereby the radius of the circle corresponds to the pocket opening radius. It will be appreciated that the sharper the pocket opening and reduction in the curvature of the opening, the smaller the pocket opening radius will be. The opening radius of the pocket described herein will be identical or substantially identical around the entirety of the pocket opening and all top edge corners. In one embodiment, the pocket opening radius of the pocket described herein may be equal or less than 0.10mm. In another embodiment, the pocket opening radius is selected from any one of 0.10mm, 0.09mm, 0.08mm, 0.07mm, 0.06mm, 0.05mm, 0.045mm, 0.04mm, 0.035mm, 0.03mm, 0.025mm, 0.02mm or 0.01mm.

[0073] The depth (K_o) of the pocket can be considered as the distance from the bottom of the pocket to a top surface **108** of the carrier tape or from the bottom of the pocket to the top or edge of the pocket side wall regardless of sealing level. The sealing level can be the same level as the top surface **108** of the carrier tape **107**. In one embodiment, the depth (K_o) of the pocket may be the first reference height H_1 . In one embodiment, the first reference height H_1 is greater than the sealing level. The depth of the pocket may vary depending on the component that the pocket is intended to receive and more specifically, the thickness of the electronic component to be placed within the pocket. In one embodiment, the depth (K_o) of the pocket may be in the range of about 0.5mm to 5mm and preferably no greater than about 2mm. In another embodiment, the pocket depth may be selected from any one of 5mm, 4mm, 3mm, 2mm, 1mm, 0.9mm, 0.8mm, 0.7mm, 0.6mm, 0.5mm, 0.4mm, 0.3mm, 0.2mm or 0.1mm. In one embodiment, the pocket depth may be in the range of about 1mm to 0.1mm. In one embodiment, the pocket depth may be about 0.2mm.

[0074] The width (B_o) and length (A_o) defining the pocket cavity can be dictated in part by the size of the electronic component to be placed within the pocket. In one embodiment, the pocket width (B_o) is anywhere in the range of 56mm to 0.2mm. In one

embodiment, the pocket width is greater than 0.8mm. In another embodiment, the pocket width is selected from any one of 56mm, 50mm, 45mm, 40mm, 35mm, 30mm, 25mm, 20mm, 15mm, 10mm, 5mm, 1mm, 0.9mm, 0.8mm, 0.7mm, 0.6mm, 0.5mm, 0.4mm, 0.3mm or 0.2mm. In a preferred embodiment, the pocket width is about 0.8mm. In one embodiment, the pocket length (Ao) is anywhere in the range of 56mm to 0.2mm. In one embodiment, the pocket length is greater than 0.8mm. In another embodiment, the pocket length is selected from any one of 56mm, 50mm, 45mm, 40mm, 35mm, 30mm, 25mm, 20mm, 15mm, 10mm, 5mm, 1mm, 0.9mm, 0.8mm, 0.7mm, 0.6mm, 0.5mm, 0.4mm, 0.3mm or 0.2mm. In a preferred embodiment, the pocket length is about 0.8mm. In one embodiment, the pocket width and length are both about 0.8mm. In another embodiment, the pocket width and length are both about 1mm.

[0075] In the context of the pocket dimensions of width, length and depth, there exists tolerances that account for variations in the measurements to the degree of around +/- 0.03mm or +/- 0.05mm. In a preferred embodiment, the pocket may have the following dimensions: a width (Bo) of 0.8mm, length (Ao) of 0.8mm and depth (Ko) of 0.2mm. In another preferred embodiment, the pocket may have the following dimensions: a width (Bo) of 1mm, length (Ao) of 1mm and depth (Ko) of 0.2mm. In another preferred embodiment, the pocket may have the following dimensions: a width (Bo) of 0.50mm, length (Ao) of 0.50mm and depth (Ko) of 0.10mm.

[0076] As shown in FIG. 3, 4 and 6, in one embodiment the pocket base **106** can comprise a vacuum hole **109** which is used in applying a vacuum to the pocket to permit more efficient loading of the pockets with the electronic components. In addition, the vacuum hole **109** can be used for visual inspection, that is to confirm that the electronic component is present and properly positioned in the pocket.

[0077] In one embodiment, the pocket is a shape with two or more corners. In such instances, the pocket can comprise one or more corner reliefs **110**. Corner reliefs **110** represent an expanded area or an additional cut out area of the carrier tape in the pocket corner and, as the name suggests, creates relief for the electronic component corner dropped into pocket for a reduced likelihood that the component will become trapped,

captured or otherwise obstructed from its corner being incorrectly positioned within the pocket. In this regard, the sidewalls **105** of the pocket can sufficiently hold and capture the electronic component in place for improved loading and removal efficiency of the component with the addition of the corner reliefs **110**. In one embodiment, the pocket can be a square pocket comprising corner reliefs **110** at each corner, whereby the dimensions of the pocket can be at least 1mm in width and at least 1mm in length.

[0078] The corner relief **110** can be shaped in various forms in order to improve the loading efficiency of electronic components into and out of the pockets. Thus, any type of corner relief can be incorporated into the pocket that may be round or square “mouse ears” or “H” or “工” (I-shape) or any shape that provides the same function in creating an area or space in the pocket for the corners of electronic components to be received. In one embodiment, the pockets comprise corner reliefs **110** in the form of “mouse ears” as shown in FIG. 3, 4 and 6 with a radius dimension of 0.50mm. As will be appreciated, the bridge or gap (i.e. pocket pitch) between adjacent pockets is reduced by the introduction of the corner reliefs **110**.

[0079] In order to improve the sealing of the cover film over the pockets and achieve a desired tension of the cover film, a rim or lip portion **111** can be added adjacent to the pocket edge. In one embodiment, the entire pocket edge comprises a rim or lip portion **111** such that the rim or lip portions surrounds the entire perimeter of the pocket opening. In another embodiment, portions of the pocket edge comprise a rim or lip portion **111** such that the rim or lip portion surround only a portion of the perimeter of the pocket opening. For example, with a pocket of square or rectangle shape, one, two or three edges or sides of the pocket can be bordered by discontinuous lip portions, thus enclosing at least a portion of one, two or three edges of the pocket, as shown in FIG. 6 with two discontinuous pairs of lip portions on opposite sides of the pocket. In yet another example, the lip portion **111** can be continuous and completely surround the pocket perimeter and opening, as illustrated in FIG 4 and 5B.

[0080] As shown in FIG. 5B, the side wall **105A** of the elevated lip portion **111** facing the pocket opening can be an extension of the side walls **105** of the pocket, such that side

walls **105A** and **105** adjoin and extend downward from the top of the elevated lip portion and adjoin base **106** to form the pocket. The base **106** defines a first reference plane R_1 parallel to the second reference plane R_2 of the top surface (**108**) of the carrier tape side portions **101B** and **101C**. In one embodiment, the top surface of the lip portion **111** is elevated above the top surface of the side portions **101B** and **101C** and defines a third reference plane R_3 running parallel to both R_1 and R_2 . Thus, the distance between the reference planes R_1 and R_3 defines a second reference height, H_2 , wherein the second reference height is greater than the first reference height H_1 . Essentially, the inclusion of the lip portions **111** increases the depth of the pocket through increasing the first reference height H_1 . However, the total depth (K_0) remains within the range of 0.10mm to 5.00mm described herein.

[0081] The top surface of the lip portion **111** can extend longitudinally outward away from the pocket opening for a predetermined distance (X_1) dependent on the proximity of the adjacent pockets and width of the carrier tape itself. After the predetermined extended distance, the top surface of the lip portion **111** can extend downward to adjoin the top surface of the carrier tape, as illustrated in FIG 5B and FIG 6C. In one embodiment, the lip portion **111** can extend longitudinally outward away from the pocket opening for a distance of 0.05mm to 0.20mm, whereby the top surface of the lip portion **111** to the surface of the carrier tape is defined by a third reference height (H_3). The lip portion may extend downwards to the carrier tape surface forming a wall (A) directly perpendicular to said carrier tape surface or forming a wall (A) with a slope that may be angled between 0° to 45° for a distance of 0.10mm to 2.00mm. The lip portion and downward extending wall together can define a predetermined distance (X_2). In one embodiment, (X_2) is the same as (X_1) when the wall (A) extends directly perpendicular, as in FIG 5B.

[0082] In one embodiment, the pocket disclosed herein may comprise at least one side wall that extends down from a top surface of at least one of the elevated lip portions and is adjoined to the pocket base. In another embodiment, the pocket disclosed herein may comprise one, two, three, four, five, six, seven or eight side walls or more, dependent upon the shape of the pocket.

[0083] FIG. 7A – FIG. 7C are images of a pocket design of the present invention obtained by 3D digital microscopy. The cross-sections were obtained through epoxy moulding then slicing to the middle of the cavity / pocket and an image captured via 3D digital microscope. FIG. 7A-C is an image of a pocket with sharp pocket opening radius of 43-44 μ m and draft angle of 2°. FIG. 7B is an image that shows the angle of a 0.2mm depth pocket and FIG. 7C shows a pocket of 0.66mm depth with a lip portion. FIG. 7A-C shows the sharpest pocket opening tape (SPOT) in shallowest pocket depth (Ko), sharp opening radius and stiffness pocket draft angle with either flat or lip portion at the sealing level. These characteristics of the depth, opening radius and draft angle prevent migration of electronic components at the pocket opening from space and damage to the component.

[0084] FIG. 8A and FIG. 8B are images of a cross-section of a first conventional pocket design (termed a rotary tape) with a draft angle and opening radius. The depth of these pockets is between 0.37mm to 0.70mm. The cross-sections were obtained through epoxy moulding then slicing to the middle of the cavity / pocket and an image captured via 3D digital microscope. As indicated, this pocket design provides a large opening radius of more than 210 μ m and a draft angle of greater than 5° that will cause the component to rest on the arched portion rather than the pocket base leading to a higher likelihood of shifting and breakage of the component.

[0085] FIG. 9A and FIG. 9B are images of a cross-section of a second conventional pocket design (termed Japanese tape) with a draft angle and opening radius. The cross-sections were obtained through epoxy moulding then slicing to the middle of the cavity / pocket and an image captured via 3D digital microscope. As indicated, this pocket design provides a large opening radius of more than 55 μ m and a draft angle of greater than 15° that will lead to a higher likelihood of shifting and breakage of the component.

[0086] FIG. 10A and FIG. 10B are images of a cross-section of a third conventional pocket design (termed PTT tape) with a draft angle and opening radius. The depth of these pockets is between 0.6mm to 1mm. The cross-sections were obtained through epoxy moulding then slicing to the middle of the cavity / pocket and an image captured via 3D digital microscope. As indicated, this pocket design provides a large opening radius of

more than 205 μ m and a draft angle of greater than 9° that will cause the component to rest on the arched portion rather than the pocket base leading to a higher likelihood of shifting and breakage of the component.

[0087] FIG. 11A and FIG. 11B are images of cross-section of a fourth conventional pocket design (termed Mini-Press tape) with a draft angle and opening radius. The cross-sections were obtained through epoxy moulding then slicing to the middle of the cavity / pocket and an image captured via 3D digital microscope. As indicated, this pocket design provides a large opening radius of more than 215 μ m and a draft angle of greater than 10° that will cause the component to rest on the arched portion rather than the pocket base leading to a higher likelihood of shifting and breakage of the component.

Working Example

[0088] Embossed carrier tapes of the present disclosure were formed of a molded sheet of commercially available polycarbonate or polystyrene material with a thickness of 0.2mm to 0.3mm. The carrier tape formed (Example 1) was either 8 or 12 mm in width, 4 mm in pitch between receiving pockets thereof. Square pockets were formed in the carrier tape in a size of 0.80mm in length and width with an inner depth of the pocket at 0.20 mm or 0.66mm. The draft angle was less than 5° and the pocket opening radius was less than 0.1mm, specifically less than 0.05mm. The carrier tape formed (Example 1) corresponds to such an embossed carrier tape illustrated in FIGS. 3 to 7. It is important to appreciate the distinction of the pocket opening radius versus pocket depth (K_o), whereby in conventional designs (as represented by FIG 8-11), the shallower the depth (K_o) a pocket has the rounder or least sharp the pocket opening will form and larger draft angle. Accordingly, the problem of conventional designs is attaining a sharp pocket opening in combination with shallow pocket depths (K_o) and small draft angle, since there is a technical difficulty in attaining such pockets in practice.

[0089] In the present invention, despite a shallow pocket depth (K_o), the pocket opening still remains sharp with a pocket opening radius of less than 0.1mm, specifically less than

0.05mm. In this context, the shallow pocket depth (Ko) is referring to 0.20mm depth regardless of the width or length size (Ao x Bo).

[0090] The technical difficulty in attaining the abovementioned combination of features of a shallow pocket depth with sharp pocket angle in practice is outlined in the below table with accompanying illustration in Figs. 8-11 of examples of conventional pocket designs. In Table 1, the relevant dimensions and features of the opening radius and draft angle for these conventional pocket design have been measured in comparison to an embodiment of the present invention as represented by Fig. 7.

Table 1

Tape Type	Pocket Opening Radius (microns - μm)	Draft Angle (Degree)
Comparative Example -Rotary	213 and 231	> 5
Comparative Example -Japanese Tape	57 and 65	> 5
Comparative Example -PTT	206 and 224	> 5
Comparative Example -Mini-Press	218 and 259	> 5
Example 1	43 and 44	< 5

[0091] In addition to the foregoing, Table 2 below compares the dimensions of a conventional mini-press pocket design to a representative embodiment (Example 2) of the carrier tape disclosed herein.

Table 2

		Mini-Press (Comparative example)	Example 2
Pocket Opening Radius		0.25mm	Maximum 0.10mm
Pocket Draft Angle		10°	0° to 5°
Pocket Size	Ao	1.50mm	0.80mm
	Bo	1.50mm	0.80mm
	Ko	0.70mm	0.20mm
Pocket Pitch (P1)		4.00mm	4.00mm

[0092] As shown in the Tables 1 and 2 above, the industrial needs and issues faced in providing a sharp pocket opening tape (SPOT) in shallowest pocket depth (K_o) and with a stiff pocket draft angle (i.e. smallest angle) are achieved by the present disclosure. This highlights an advantage of the present disclosure. The sharp pocket opening tape disclosed herein can prevent thin electronic components from becoming trapped in the pocket opening from space created by the pocket opening radius and / or cover tape curve up after sealing. In contrast, conventional pockets lack a sharp pocket opening especially for shallow depth pockets (K_o). This is highlighted in tables 1-2 and the accompanying illustrative figures (FIG. 8 – FIG. 11).

[0093] With respect to the above description then, it is to be realized that the optimum dimensional relationships for the parts of the invention, to include variations in size, materials, shape, form, function and manner of operation, assembly and use, are deemed readily apparent and obvious to one skilled in the art, and all equivalent relationships to those illustrated in the drawings and described in the specification are intended to be encompassed by the present invention.

[0094] Therefore, the foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

[0095] The foregoing has described the principles, embodiments and. modes of operation of the present invention. However, the invention should not be construed as being limited to the particular embodiments discussed. The above described embodiments should be regarded as illustrative rather than restrictive, and it should be appreciated that variations may be made in those embodiments by workers skilled in the art without departing from the scope of the present invention as defined by the following claims.

[0096] The invention has been described broadly and generically herein. Each of the narrower species and subgeneric groupings falling within the generic disclosure also form part of the invention. This includes the generic description of the invention with a proviso or negative limitation removing any subject matter from the genus, regardless of whether or not the excised material is specifically recited herein.

[0097] Other embodiments are within the following claims and non-limiting examples. In addition, where features or aspects of the invention are described in terms of Markush groups, those skilled in the art will recognize that the invention is also thereby described in terms of any individual member or subgroup of members of the Markush group.

What is claimed is:

1. A carrier tape for carrying electronic components, comprising:
 - a longitudinal strip with a top surface; and
 - a plurality of pockets positioned longitudinally along the longitudinal strip, each pocket configured to receive an electronic component,wherein each pocket has one or more side walls extending from the top surface of the longitudinal strip to a flat base surface of the pocket,
wherein each pocket has a depth in the range of 0.10 to 2mm;
wherein the one or more side walls have a draft angle of less than 5°; and
wherein each pocket has an opening radius of less than 0.1 mm.
2. The carrier tape of claim 1, wherein each pocket is square shaped.
3. The carrier tape of claim 2, wherein each pocket further comprises one or more corner reliefs.
4. The carrier tape of claim 1, wherein each pocket has a depth of about 0.2mm.
5. The carrier tape of claim 1, wherein the draft angle is less than 2°.
6. The carrier tape of claim 1, wherein the draft angle is about 0°.
7. The carrier tape of claim 1, wherein each pocket has a width of 0.8mm; length of 0.8mm and depth of 0.2mm.
8. The carrier tape of claim 1, wherein each pocket further comprises a continuous lip portion that surrounds the perimeter of the pocket.
9. The carrier tape of claim 7, wherein the draft angle is less than 2°.

10. The carrier tape of claim 3, wherein each pocket has a width of at least 1mm and a length of at least 1mm.

11. The carrier tape of claim 1, wherein the carrier tape is an embossed carrier tape.

12. The carrier tape of claim 1, wherein each pocket further comprises one or more corner reliefs.

13. The carrier tape of claim 1, wherein the pocket has a pocket opening radius of less than 0.05mm.

14. A method of manufacturing a carrier tape according to claim 1, comprising thermally forming the carrier tape through an embossing method.