

CARRIER TAPE FOR ELECTRONIC COMPONENTS

Technical Field

5 The disclosure generally relates to carrier tapes, particularly carrier tapes for electronic components.

Background

As electronic equipment become miniaturized, it has become desirable to design and
10 manufacture electronic components, such as integrated circuit (IC) chips, to be lighter in weight and smaller in size. Carrier tapes are used to transport electronic components (such as resistors, capacitors, or integrated circuits) from a component manufacturer to a different manufacturer that assembles the components carried within the carrier tape. These electronic components are mounted onto a printed circuit board (PCB) or other substrate during assembly of electronic
15 equipment, or sub-assemblies that will be used later to build electronic equipment.

Summary

In some aspects of the disclosure a flexible carrier tape for transporting a plurality of components is provided. The flexible carrier tape includes a flexible substrate
20 extending along a longitudinal axis of the carrier tape. A plurality of spaced apart pockets is formed in the flexible substrate along the longitudinal axis of the carrier tape. Each pocket is configured to receive and store a component. Each pocket is defined by a bottom wall, opposing side walls and opposing end walls. The bottom wall includes a structured top surface having a plurality of first channels extending along an in-plane first direction and forming a
25 regular pattern along an orthogonal in-plane second direction at a first pitch P1. A Fourier transform of the regular pattern has a first peak along the second direction at a first spatial frequency corresponding to the first pitch. The bottom wall includes opposing second channels formed in the bottom wall at opposite longitudinal ends of the first channels. The second channels extend along the second direction and are deeper than the first channels. In a cross-
30 section of the pocket in a plane orthogonal to the second direction, a curved region joins each

side wall to a top surface of the substrate. A radius of curvature R of a circle best fitting the curved region is less than about 200 microns.

In some other aspects of the disclosure a flexible carrier tape for transporting a plurality of components is provided. The flexible carried tape includes a flexible substrate extending along a longitudinal axis of the carrier tape. A plurality of spaced apart pockets is formed in the flexible substrate along the longitudinal axis of the carrier tape. Each pocket is less than about 200 microns deep. Each pocket includes a bottom wall and a side wall extending from the bottom wall to a top surface of the substrate. In a cross-section of the pocket in a plane orthogonal to the bottom and side walls, a first curved region joins the side wall to the top surface of the substrate and a second curved region joins the side wall to the bottom wall. A radius of curvature R of a circle best fitting the first curved region is less than about 50 microns. The side wall includes a substantially linear portion disposed and extending between the first and second curved regions. The substantially linear portion making an angle of less than about 30 degrees with a normal to the substrate.

In some other aspects of the disclosure a flexible carrier tape for transporting a plurality of components is provided. The flexible carried tape includes a flexible substrate extending along a longitudinal axis of the carrier tape. A plurality of spaced apart pockets is formed in the flexible substrate along the longitudinal axis of the carrier tape. Each pocket is configured to receive and store a component. Each pocket is defined by a bottom wall, opposing side walls and opposing end walls. For at least one pocket, the bottom wall of the at least one pocket includes a structured top surface forming first and second regular patterns. A Fourier transform of the first and second regular patterns includes respective first and second peaks at respective spatial frequencies. The spatial frequency of the first peak is different from the spatial frequency of the second peak.

Brief Description of Drawings

The various aspects of the disclosure will be discussed in greater detail with reference to the accompanying figures where,

FIG. 1 schematically shows a flexible carrier tape according to some aspects of the disclosure;

FIG. 2 schematically shows a pocket of the flexible carrier tape according to some aspects of the disclosure;

FIG. 3 shows a structured top surface of a bottom wall of the pocket of the flexible carrier tape according to some aspects of the disclosure;

5 FIG. 4 schematically shows a component disposed in a pocket according to some aspects of the disclosure;

FIGS. 5 & 6 schematically show different views of the pocket of the flexible carrier tape according to some aspects of the disclosure;

10 FIGS. 7 & 8 show cross sectional views of the laser etched pocket according to some aspects of the disclosure;

FIG. 9 schematically shows the geometrical relationship of the pocket to a substrate of the carrier tape according to some aspects of the disclosure; and

15 FIGS. 10 & 11 shows graphs of power spectral density vs. spatial frequency showing a Fourier transform analysis of the structured top surface of the bottom wall of the pocket of the carrier tape according to some aspects of the 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 labelled with the same number.

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Detailed Description of Illustrative embodiments

25 In the following description, reference is made to the accompanying drawings that form a part hereof and in which various embodiments are shown by way of illustration. It is to be understood that other embodiments are contemplated and may be made without departing from the scope or spirit of the present description. The following detailed description, therefore, is not to be taken in a limiting sense.

30 Carrier tapes according to the present disclosure are generally used in combination with components, particularly electronic components. Carrier tapes include a number of pockets formed within the carrier tape at regular intervals. The pockets have a geometry that is

compatible with the components to be carried and the components rest within the defined pockets. In a shallow pocket design, such as 100 microns, the component may flip away from the defined pocket due to large radius at the top and/or bottom surface of the pocket. Embodiments described herein address these and other challenges with regard to electronic components disposed in carrier tapes.

Referring to FIG. 1, a flexible carrier tape (200) is configured to transport a plurality of components (10). The flexible carrier tape (200) includes a flexible substrate (20) extending along the longitudinal axis (x-axis) of the carrier tape (200). In certain aspects, the substrate (20) has a substantially flat surface (22) as shown in FIG. 6. A plurality of spaced apart pockets (30) is formed in the flexible substrate (20) of the carrier tape. The pockets (30) are spaced apart along the longitudinal axis (x-axis) of the carrier tape (200). In some aspects, the plurality of pockets (30) may be formed in a row in the flexible substrate (20). Each pocket (30) is configured to receive and store a component (10). Further, each pocket is defined by a bottom wall (31), opposing side walls (32) and opposing end walls (33). The bottom wall (31) of the pocket (30) is lower than a top surface (21) of the substrate (20) as is best shown in FIG. 5. The side walls (32, 33) extend from the bottom wall (31) to the top surface (21) of the substrate (20). As illustrated in FIG. 6, the substrate (20) has an average thickness T_s and the bottom wall (31) has an average thickness T_w . The pockets (30) have an average depth D_p , wherein $D_p < T_s$. In some aspects, each pocket may have a depth of less than about 200 microns, or less than 150 microns.

A series of optional sprocket holes (40) are provided in carrier tape (200) as shown in FIG. 1 to facilitate mechanical handling of the carrier tape. In some embodiments, other structures (e.g., notches or printed indicia) may be used in place of, or in addition to, sprocket holes (40). The sprocket holes (40) may be disposed, for example, along one or both longitudinal edges of the carrier tape (200). The sprocket holes (40) can engage with teeth on a sprocketed drive (not shown) as may be present in the drive assemblies of a precision placement equipment used to remove the components from the pockets of the carrier tape. The sprocket holes (40) are used to advance the carrier tape (200) to a prescribed location such that the component (10) can be placed in or removed from the pocket (30) of the carrier tape (200).

For at least one pocket, the bottom wall (31) of at least one pocket (30) includes a structured top surface (34) as shown in FIGS. 2 and 3. The structured top surface (34) includes a plurality of first channels (35) extending along an in-plane first direction (x-axis). In some aspects, the first direction (x-axis) may be substantially perpendicular to the opposing end walls (33). The plurality of first channels (35) forms a regular pattern along an orthogonal in-plane second direction (y-axis) at a first pitch P1. In some aspects, the second direction (y-axis) may be substantially perpendicular to the opposing side walls (32). In some embodiments, a laser source may be applied to the substrate (20) to selectively ablate one or more portions of the substrate to obtain the pocket (30) and the structured top surface (34) having the first channels (35) in the bottom wall (31) of the pocket (30). In some aspects, each pocket may have a depth of less than about 200 microns, or less than 150 microns. In some embodiments, for at least one pocket, the structured top surface (34) of the bottom wall (31) may have an average surface roughness Sa of greater than about 2 microns, or, greater than about 3 microns. In other embodiments, in each of the plurality of spaced apart pockets, the structured top surface (34) of the bottom wall (31) may have an average surface roughness Sa of greater than about 2 microns, or, greater than about 3 microns.

The plurality of first channels (35) forming the regular pattern on the top surface (34) may have a topography characterizable by a Fourier power spectrum associated with the orthogonal in-plane first and second directions. The spatial frequency content may be determined by calculating a Fourier power spectrum for each in-plane direction. The resulting power spectra plotted on graphs of power spectral density (PSD) versus spatial frequency for several samples are shown in FIGS. 10 and 11. In some aspects, a Fourier transform of the regular pattern on the top surface (34) of the bottom wall (31) includes a first peak (50) along the second direction at a first spatial frequency (SF1) corresponding to the first pitch P1. In some embodiments, the first pitch P1 may be less than about 100 microns, or less than about 75 microns, or less than about 50 microns.

In some other aspects, the structured top surface (34) of the bottom wall (31) may form first and second regular patterns. As graphically represented in FIG. 11, the Fourier transform of the first and second regular patterns may include respective first (51) and second (52) peaks at respective spatial frequencies SF1 and SF2, wherein SF1 is different from SF2. In some

embodiments, SF1 is different from SF2 by at least 20%, or by at least 30%, or by at least 40%. In some embodiments, SF1 may correspond to the first regular pattern having an average pitch P1 less than about 75 microns, or less than about 50 microns.

5 In some aspects, a first curved region (60) joins each side wall (32, 33) to a top surface (21) of the substrate (20) as viewed in a cross-section of the pocket (30) in a plane (CS) orthogonal to the second direction (y-axis) best illustrated in FIG. 9. In some embodiments, a radius of curvature R of a circle (61) best fitting the curved region (60) may be less than about 200 microns. In other embodiments, the radius of curvature R of a circle (61) best fitting the
10 curved region (60) may be less than about 150 microns, or less than 100 microns, and, in other embodiments, may be less than about 50 microns.

 The bottom wall (31) of the pocket (30) includes opposing second channels (36) formed in the bottom wall (31). The second channels (36) may be formed at opposite longitudinal ends (35a, 35b) of the first channels (35). The second channels (36) extend along
15 the second direction (y-axis) and are deeper than the first channels. In some embodiments, the second channels (36) are deeper than the first channels (35) by at least 1 micron, and, in some instances, by at least 2-3 microns. In some aspects, a second curved region (70) joins the side wall (33) to the bottom wall (31). The second curved region (70) may be substantially U-shaped as best shown in FIGS. 8 & 9.

20 In some aspects as illustrated in FIG. 7, the side wall includes a substantially linear portion (80) disposed and extending between the first (60) and second (70) curved regions. The substantially linear portion (80) makes an angle (α) with a normal (23) to the substrate. The angle (α) may be less than about 30 degrees, or may be less than 25 degrees, or may be less than 20 degrees, or, in other instance, may be less than 15 degrees.

25 Carrier tapes of the present disclosure may be made of any suitable material including thermoplastic polymeric materials that have sufficient thickness and flexibility to permit it to be wound about the hub of a storage reel. Suitable thermoplastic polymeric materials include, but are not limited to, polyesters (e.g., glycol-modified polyethylene terephthalate, or polybutylene terephthalate), polycarbonate, polypropylene, polystyrene, polyvinyl chloride, acrylonitrile-
30 butadiene-styrene, amorphous polyethylene 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 may have a melt temperature in the range of about 400°F (204°C) to about 630°F (332°C). Carrier tapes can be manufactured in a thermoforming or
5 embossing operation, for example, in which a web of thermoplastic polymer is delivered to a mold that forms the pockets in the carrier tape. The carrier tape may be optically clear, pigmented or modified to be electrically dissipative. In such cases, the carrier tape may include an electrically conductive material, such as carbon black.

Various modifications and alterations will be apparent to those skilled in the art and it
10 should be understood that this scope of this disclosure is not limited to the illustrative embodiments set forth herein.

Claims

1. A flexible carrier tape for transporting a plurality of components, comprising a flexible substrate extending along a longitudinal axis of the carrier tape, and a plurality of spaced apart
5 pockets formed in the flexible substrate along the longitudinal axis of the carrier tape, each pocket configured to receive and store a component and defined by a bottom wall, opposing side walls and opposing end walls, the bottom wall comprising:
a structured top surface comprising a plurality of first channels extending along an in-plane first direction and forming a regular pattern along an orthogonal in-plane second direction at a first
10 pitch, such that a Fourier transform of the regular pattern comprises a first peak along the second direction at a first spatial frequency corresponding to the first pitch; and
opposing second channels formed in the bottom wall at opposite longitudinal ends of the first channels, the second channels extending along the second direction and deeper than the first channels, wherein in a cross-section of the pocket in a plane orthogonal to the second direction,
15 a curved region joins each side wall to a top surface of the substrate, a radius of curvature of a circle best fitting the curved region being less than about 200 microns.
2. The flexible carrier tape of claim 1, wherein the first direction is substantially perpendicular to the opposing end walls, wherein the second direction is substantially perpendicular to the
20 opposing side walls.
3. The flexible carrier tape of claim 1, wherein the radius of curvature of the circle best fitting the curved region is less than about 150 microns, or less than about 100 microns.
- 25 4. The flexible carrier tape of claim 1, wherein each pocket is less than about 200 microns deep, and wherein the second channels are deeper than the first channels by at least 1 micron.
5. The flexible carrier tape of claim 1, wherein the first pitch is less than about 100 microns, or less than about 75 microns, or less than about 50 microns.

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6. The flexible carrier tape of claim 1, wherein the substrate has a substantially flat surface, and wherein the substrate has an average thickness T_s and the pockets have an average depth D_p , and wherein $D_p < T_s$.

5 7. The flexible carrier tape of claim 1, wherein for each pocket, the structured top surface of the bottom wall has an average surface roughness of greater than about 2 microns, or greater than about 3 microns.

8. A flexible carrier tape for transporting a plurality of components, comprising a flexible
10 substrate extending along a longitudinal axis of the carrier tape, and a plurality of spaced apart pockets formed in the flexible substrate along the longitudinal axis of the carrier tape, each pocket less than about 200 microns deep and comprising a bottom wall and a side wall extending from the bottom wall to a top surface of the substrate, such that in a cross-section of the pocket in a plane orthogonal to the bottom and side walls, a first curved region joins the
15 side wall to the top surface of the substrate and a second curved region joins the side wall to the bottom wall, wherein a radius of curvature of a circle best fitting the first curved region is less than about 50 microns, and wherein the side wall comprises a substantially linear portion disposed and extending between the first and second curved regions, the substantially linear portion making an angle of less than about 30 degrees with a normal to the substrate.

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9. The flexible carrier tape of claim 8, wherein the second curved region is substantially U-shaped.

10. The flexible carrier tape of claim 8, wherein the substantially linear portion makes an angle
25 of less than about 20 degrees with the normal to the substrate.

11. A flexible carrier tape for transporting a plurality of components, comprising a flexible
substrate extending along a longitudinal axis of the carrier tape, and a plurality of spaced apart
pockets formed in the flexible substrate along the longitudinal axis of the carrier tape, each
30 pocket configured to receive and store a component and defined by a bottom wall, opposing

side walls and opposing end walls, such that for at least one pocket, the bottom wall of the at least one pocket comprises a structured top surface forming first and second regular patterns such that a Fourier transform of the first and second regular patterns comprises respective first and second peaks at respective spatial frequencies SF1 and SF2, SF1 different from SF2.

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12. The flexible carrier tape of claim 11, wherein SF1 is different from SF2 by at least 20%.

13. The flexible carrier tape of claim 11, wherein SF1 corresponds to the first regular pattern having an average pitch P1 less than about 75 microns.

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14. The flexible carrier tape of claim 11, wherein the structured top surface of the bottom wall of the at least one pocket has an average surface roughness greater than about 2 microns.