

ANISOTROPIC CONDUCTIVE SHEET

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This application claims the benefit of Korean Patent Application No. 10-2007-0014566,
5 filed on February 12, 2007, in the Korean Intellectual Property Office, the disclosure of
which is incorporated herein in its entirety by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

10 The present invention relates to an anisotropic conductive sheet, and more particularly,
to an anisotropic conductive sheet having conductor units that can be sufficiently
compressed in the direction of the thickness of the anisotropic conductive sheet.

2. Description of the Related Art

15 In general, when manufacture of an electronic device is completed, an electrical test is
conducted in order to test the performance of the electronic device. For the electrical
test, an anisotropic conductive sheet is placed between test equipment and the
electronic device in order to electrically connect the test equipment to the electronic
device. Next, electric current is sent from a terminal of the test equipment to a lead
20 terminal of the electronic device via the anisotropic conductive sheet. Then the test
equipment analyzes a signal received from the lead frame of the electronic device in
order to determine whether the electronic device has a defect.

Such an anisotropic conductive sheet has been disclosed in Korean Patent Laid-Open

25 Gazette No. 2001-0050489. Referring to FIG. 1, a conventional anisotropic
conductive sheet 100 includes an elastic polymeric sheet 110 made of an elastic
polymer that has insulating properties and can be elastically deformed; and a plurality
of conductor units 120 that are separated from one another in the elastic polymeric
sheet 110 perpendicularly to the direction of the thickness of the elastic polymeric
sheet 110. Each of the conductor units 120 extends in the direction of the thickness of
30 the elastic polymeric sheet 110.

Each of the conductor units 120 includes a plurality of spherical conductors 121.

When the anisotropic conductive sheet 100 is pressurized in the direction of the
thickness thereof, the conductors 121 contact one another, thus permitting current to
flow into the anisotropic conductive sheet 100 in the direction of the thickness of the

elastic polymeric sheet 110.

However, such a conventional anisotropic conductive sheet has the following disadvantage.

5 The diameters The diameters of the conductors 121 are several tens of μm . Such a small size conductor can contact only a small part of an elastic polymer included in an elastic polymeric sheet and thus, it is difficult for the conductor to be sufficiently supported by the elastic polymer. If pressure is repeatedly applied (more than several thousand times) to the anisotropic conductive sheet 100 by terminals of an electronic device (not shown), the conductors 121 are likely to be separated from the
10 elastic polymer or the elastic polymer may be depressed, thereby degrading the overall performance of the anisotropic conductive sheet 100. The terminals of electronic devices that have been recently manufactured are formed of lead-free material with a high degree of hardness. However, the higher the degree of hardness of an electronic device, the more a conductor unit is likely to be damaged.

15 In order to solve this problem, as illustrated in FIG. 2, Korean Patent Laid-Open Gazette No. 2001-0090778 has introduced an anisotropic conductive sheet 100 employing conductor units having linear fibrous conductors 122 instead of spherical conductors. The anisotropic conductive sheet 100 includes an elastic polymeric sheet 110 made of an elastic polymer, and a plurality of conductor units 120 consisting
20 of the linear fibrous conductors 122. Each of the linear fibrous conductors 122 is composed of a conductor body formed of carbon material, and a nickel layer covering the conductor body.

The fibrous conductors 122 can contact a large part of the elastic polymer and are thus stably supported by the elastic polymer. Thus, even if pressure is repeatedly
25 applied (more than several thousand times) to the anisotropic conductive sheet 100 by the terminals of an electronic device (not shown), a probability that the fibrous conductors 122 will be separated from the elastic polymer is low.

However, the fibrous conductors 122 in the anisotropic conductive sheet 100 are linear and thus are not easily bent in the direction of the thickness of the anisotropic
30 conductive sheet 100. Thus, if the anisotropic conductive sheet 100 is pressurized by terminals of an electronic device, it is not easily compressed. Furthermore, since the conductor body of each of the fibrous conductors 122 is formed of carbon material having few toughness or malleability, the fibrous conductors 122 are broken when a large amount of pressure is applied onto the anisotropic conductive sheet 100 by the

electronic device.

If the anisotropic conductive sheet 100 is not sufficiently compressed, it is difficult for the fibrous conductors 122 to contact the terminals of the electronic device.

Accordingly, electric current flowing from test equipment is not smoothly supplied to the electronic device, thereby lowering the reliability of an overall test.

SUMMARY OF THE INVENTION

The present invention provides an anisotropic conductive sheet in which conductors are not separated from an elastic polymer even if the anisotropic conductive sheet is pressurized many times many times, and which can be sufficiently compressed when it is pressurized by an electronic device.

change according to claims

According to an aspect of the present invention, there is provided an anisotropic conductive sheet comprising: an elastic polymeric sheet which has insulating properties and is to be elastically deformed; and a plurality of conductor units being disposed so as to be separated from one another in the elastic polymeric sheet, perpendicularly to the direction of the thickness of the elastic polymeric sheet, where each of the conductor units extends in the direction of the thickness of the elastic polymeric sheet, wherein current is permitted to flow in the direction of the thickness of the elastic polymeric sheet but is prevented to flow perpendicularly to the direction of the thickness thereof, and each of the conductor units comprises a plurality of curved fibrous conductors

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features and advantages of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

FIG. 1 illustrates a conventional anisotropic conductive sheet;

FIG. 2 illustrates another conventional anisotropic conductive sheet;

FIG. 3 illustrates an anisotropic conductive sheet according to an embodiment of the present invention;

FIG. 4 is a cross-sectional view of the anisotropic conductive sheet illustrated in FIG. 3, taken along the line IV-IV the line IV-IV;

FIG. 5 illustrates a state before a magnetic field has an effect on a sheet that is to be

molded;

FIG. 6 illustrates a state after the magnetic field has an effect on the sheet of FIG. 5;
FIG. 7 illustrates the anisotropic conductive sheet of FIG. 3 that is disposed between
an electronic device and test equipment according to an embodiment of the present
invention;

FIG. 8 illustrates the state of the anisotropic conductive sheet of FIG. 3 when the
electronic device of FIG. 7 is pressurized toward the test equipment of FIG. 7
according to an embodiment of the present invention;

FIG. 9 illustrates an anisotropic conductive sheet according to another embodiment of
the present invention; and

FIG. 10 illustrates an anisotropic conductive sheet according to another embodiment
of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will now be described more fully with reference to the
accompanying drawings, in which exemplary embodiments of the invention are shown.
FIG. 3 illustrates an anisotropic conductive sheet 1 according to an embodiment of the
present invention. FIG. 4 is a cross-sectional view of the anisotropic conductive sheet
1 illustrated in FIG. 3, taken along the line IV-IV. FIG. 5 illustrates a state before a
magnetic field has an effect on a sheet that is to be molded. FIG. 6 illustrates a state
after the magnetic field has an effect on the sheet of FIG. 5. FIG. 7 illustrates the
anisotropic conductive sheet 1 of FIG. 3 that is disposed between an electronic device
and test equipment according to an embodiment of the present invention. FIG. 8
illustrates the state of the anisotropic conductive sheet 1 of FIG. 3 when the electronic
device of FIG. 7 is pressurized toward the test equipment of FIG. 7 according to an
embodiment of the present invention.

Referring to FIG. 3, the anisotropic conductive sheet 1 can permit the flow of current in
the direction of the thickness of an elastic polymeric sheet 10 and prevent the flow of
current perpendicularly to the direction of the thickness of the elastic polymeric sheet
10. The anisotropic conductive sheet 1 includes the elastic polymeric sheet 10 and a
plurality of conductor units 20.

The elastic polymeric sheet 10 has a predetermined thickness, and is formed of an
elastic polymeric material that has insulating properties and can be elastically
deformed.

The elastic polymeric material may be polymeric material having a cross-linked structure cross-linked structure. As curable polymeric substance forming materials usable for obtaining such elastic polymeric substances, may be used various materials.

Various hardening polymeric materials may be available as cross-linked polymeric material. For example, the cross-linked polymeric material may be conjugated diene-based rubber, such as poly-butadiene rubber, raw rubber, poly-isoprene rubber, styrene-butadiene copolymer rubber, acrylonitrile-butadiene copolymer rubber, or hydrogenated compounds thereof; a block copolymer rubber, such as styrene-butadiene-diene copolymer rubber, styrene-isoprene block copolymer, or hydrogenated compounds thereof; chloroprene; urethane rubber; polyester-based rubber; epichlorohydrin rubber; silicon rubber; ethylene-propylene copolymer rubber; or ethylene-propylene-diene copolymer rubber.

If the anisotropic conductive sheet 1 needs to be durable, material other than conjugated diene-based rubber is preferably used, and particularly, silicon rubber is preferably used due to its moldability and electrical characteristics.

Silicon rubber is preferably obtained by cross-linking or condensing liquid silicon rubber. The liquid silicon rubber preferably has a viscosity not higher than 10^5 poises as measured at a shear rate of 10^{-1} . The liquid silicon rubber may be condensation type rubber, addition type rubber, or rubber containing material of a vinyl group or a hydroxyl group. In detail, the liquid silicon rubber may be dimethyl silicon raw rubber, methyl vinyl silicon raw rubber, or methyl phenyl vinyl silicon raw rubber.

The conductor units 20 are arranged in the elastic polymeric sheet 10 while extending in the direction of the thickness of the elastic polymeric sheet 10. In detail, the conductor units 20 are separated from one another in the elastic polymeric sheet 10, perpendicularly to the direction of the thickness of the elastic polymeric sheet 10.

In the conductor units 20, a plurality of curved fibrous conductors 21 are formed of one selected from the above group of elastic polymeric material. In each of the conductor units 20, the fibrous conductors 21 are randomly arranged but at least two from among them are preferably arranged in the direction of the thickness of the elastic polymeric sheet 10 for easy electrical connection in the direction of the thickness of the elastic polymeric sheet 10. FIG. 3 illustrates that three fibrous conductors 21 are arranged in each of the conductor units 20 in the direction of the thickness of the elastic polymeric sheet 10 but the present invention is not limited to this and more than three fibrous conductors 21 may be arranged.

As illustrated in FIG. 4, each of the fibrous conductors 21 includes a metallic conductor body 22, a nickel layer 23 covering the conductor body 22, and a plated layer 24 covering the nickel layer 23, where the plated layer 24 is plated with one of gold, silver, rhodium, and palladium.

5 The fibrous conductors 21 have a thickness of several tens of μm , and are manufactured by cutting a single fibrous conductor into lengths ranging from 0.1 mm to several mm by using a predetermined cutting machine.

The conductor body 22 may be formed of various materials but is preferably formed of a metallic material, such as piano wire, tungsten, or brass, which has good conductivity and magnetism.

10 For example, the conductor body 22 may be covered with the nickel layer 23 by using chemical plating or electroplating. Also, precious metal, such as gold, silver, rhodium, and palladium, has high oxidation resistance and high electrical conductivity, and thus, the nickel layer 23 is plated with the precious metal by using chemical plating or electroplating.

15 Both ends of each of the fibrous conductors 21 are pointed, and particularly, are preferably formed to a 'Λ' shape in order to improve the degree to which the fibrous conductors 21 can contact terminals of an electronic device.

Each of the fibrous conductors 21 is formed in a convex-shaped curve, perpendicularly to the direction of the thickness of the elastic polymeric sheet 10, and is preferably formed in a '<' shape.

20 A method of manufacturing the above-described anisotropic conductive sheet will now be described with reference to FIGS. 5 and 6. First, an upper mold 30 and a lower mold 34 are prepared so as to face one another. In the upper mold 30, a plurality of ferromagnetic layers 31 are deposited according to the arrangement of the conductor units 20, and the resultant structure is covered with a non-magnetic layer 32. In the lower mold 34, a plurality of ferromagnetic layers 35 and a non-magnetic layer 36 are formed so as to respectively correspond to the ferromagnetic layers 31 and the non-magnetic layer 31 in the upper mold 30.

25 30 A pair of electromagnets 33 and 37 are respectively deposited on the top of the upper mold 30 and on the bottom of the lower mold 34.

Material for sheet molding 2 is filled between the upper mold 30 and the lower mold 34 in order to manufacture the anisotropic conductive sheet. In the material for sheet molding 2, fibrous conductors 21 having magnetic and conductive properties are

scattered in fluid elastic polymeric material. FIG. 5 illustrates a case where the material for sheet molding 2 is filled between the upper mold 30 and the lower mold 34.

Next, the electromagnets 33 and 37 operate in order to form a strong magnetic field in the direction of the thickness of the anisotropic conductive sheet. Then the material for sheet molding 2 is arranged in such a manner that the fibrous conductors 21 can be located between the ferromagnetic layers 31 in the upper mold 30 and the ferromagnetic layers 35 in the lower mold 34. FIG. 6 illustrates that the fibrous conductors 21 are arranged in the material for sheet molding 2 in the direction of the thickness of the anisotropic conductive sheet 1. If the material for sheet molding 2 is heated so as to be hardened, the anisotropic conductive sheet 1 is completed.

The anisotropic conductive sheet 1 manufactured as described above is used as illustrated in FIGS. 7 and 8.

First, the anisotropic conductive sheet 1 is placed on test equipment 50. More specifically, the anisotropic conductive sheet 1 is placed on the test equipment 50 so that the conductor parts 20 of the anisotropic conductive sheet 1 can be located on terminals 51 of the test equipment 50. Next, an electronic device 40 is placed on the anisotropic conductive sheet 1 so that terminals 41 of the electronic device 40 can be located on the conductor parts 20 of the anisotropic conductive sheet 1. The resultant structure is illustrated in FIG. 7. Thereafter, as illustrated in FIG. 8, the electronic device 40 is pressed downward in order to allow the terminals 41 of the electronic device 40 to be securely electrically connected to the conductor parts 20 of the anisotropic conductive sheet 1.

If the electronic device 40 is pressed downward, the fibrous conductors 21 in the conductor parts 20 of the anisotropic conductive sheet 1 contact one another. Since the fibrous conductors 21 are curved, they can be sufficiently bent when the electronic device 40 is pressed downward.

Both ends of each of the fibrous conductors 21 are pointed. Thus even if a foreign substance adheres to the terminals 41 of the electronic device 40, the fibrous conductors 21 can contact the terminals 41 while penetrating the foreign substance.

The anisotropic conductive sheet 1 according to the present embodiment has the following advantages.

First, the anisotropic conductive sheet 1 can contact a larger part of an elastic polymer than the conventional spherical conductors 121, since the conductor 21 of the anisotropic conductive sheet 1 is fibrous. Thus even if pressure is repeatedly applied

(more than several thousand times) to the anisotropic conductive sheet 1 by the terminals 41 of the electronic device 40, a probability that the fibrous conductors 21 will be separated from the elastic polymer is low.

Also, since the fibrous conductors 21 of the anisotropic conductive sheet 1 are curved, they bend easily, thus allowing the anisotropic conductive sheet 1 to be compressed when the anisotropic conductive sheet 1 is pressurized by the electronic device 40. In contrast, when the conventional anisotropic conductive sheet 100 having the linear fibrous conductors 122 is pressurized by the electronic device, the fibrous conductors 122 are not easily bent, thus preventing the anisotropic conductive sheet 100 from being sufficiently compressed.

Also, in the case of the anisotropic conductive sheet 1 according to the present embodiment, two or more fibrous conductors 21 are included in each of the conductor units 20 in the direction of the thickness of the elastic polymeric sheet 10. Thus it is easy to control the extent of compression of the anisotropic conductive sheet 1. However, in the case of the conventional anisotropic conductive sheet 100, only one linear fibrous conductor 122 is included in each of the conductor units 122 in the direction of the thickness of the conventional anisotropic conductive sheet 100, which is not enough to absorb pressurization energy generated by an electronic device. Furthermore, the fibrous conductors 122 of the conventional anisotropic conductive sheet 100 are linear and thus cannot easily absorb the pressurization energy.

However, in the present embodiment, two or more fibrous conductors 21 are included in each of the conductor units 20 in the direction of the thickness of the elastic polymeric sheet 10, and are enough to absorb the pressurization energy, thereby allowing the anisotropic conductive sheet 1 to be sufficiently compressed. Although FIG. 7 illustrates that three fibrous conductors 21 are included in each of the conductor units 20 in the direction of the thickness of the elastic polymer sheet 10, the total number of the fibrous conductors 21 can be increased in order to increase the extent to which the anisotropic conductive sheet 1 can be compressed.

Also, both ends of each of the fibrous conductor 21 of the anisotropic conductive sheet 1 according to the present embodiment are pointed and thus can directly contact the terminals of an electronic device even if a foreign substance adheres to the terminals. However, both ends of each of the conventional anisotropic conductive sheet 100 having the linear fibrous conductors 122, which contact the terminals of the electronic device, are stubby and thus are not easily electrically

connected to the electronic device when a foreign substance adheres to the terminals of the electronic device. In contrast, even if a foreign substance adheres to the terminals of the electronic device, since both ends of each of the fibrous conductor 21 of the anisotropic conductive sheet 1 according to the present embodiment are pointed,
5 they can contact the terminals of the electronic device while penetrating the foreign substance and thus can be securely electrically connected to the terminals of the electronic device.

Modifications can be made to the anisotropic conductive sheet 1 according to the present embodiment as described below.

10 First, the fibrous conductors 21 can be bent into an 'S' shape. FIG. 9 illustrates an anisotropic conductive sheet 1 having fibrous conductors 21 formed in an 'S' shape. However, the fibrous conductors 21 are not limited to being formed in a 'C' shape or an 'S' shape, that is, they can be formed in variously curved shapes.

15 In the above embodiments of the present invention, the conductor units 20 consist of only the fibrous conductors 21 having a curved shape but the conductor units 20 are not limited to this and may also consist of curved fibrous conductors and linear fibrous conductors.

Alternatively, the conductor units 20 can further include spherical conductors. FIG. 10 illustrates an anisotropic conductive sheet 1 that includes not only fibrous
20 conductors 21 but also spherical conductors 25. In this case, the spherical conductors 25 preferably form on a lower part of each of the conductor units 20, so that the fibrous conductors 21 can be located on an upper part of the anisotropic conductive sheet 1 in order to allow the anisotropic conductive sheet 1 to be easily compressed, since the upper part thereof is generally pressurized by an electronic
25 device.

As described above, an anisotropic conductive sheet according to the present invention is advantageous in that conductors are not separated from an elastic polymer even if pressure is repeatedly applied (many times) to the anisotropic conductive sheet, and the anisotropic conductive sheet can be sufficiently pressurized
30 by an electronic device.

While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following

claims.

What is claimed is:

1. An anisotropic conductive sheet comprising:

an elastic polymeric sheet which has insulating properties and is to be elastically deformed; and

5 a plurality of conductor units being disposed so as to be separated from one another in the elastic polymeric sheet, perpendicularly to the direction of the thickness of the elastic polymeric sheet, where each of the conductor units extends in the direction of the thickness of the elastic polymeric sheet,

10 wherein current is permitted to flow in the direction of the thickness of the elastic polymeric sheet but is prevented to flow perpendicularly to the direction of the thickness thereof, and

each of the conductor units comprises a plurality of curved fibrous conductors.

15 2. The anisotropic conductive sheet of claim 1, wherein at least two of the fibrous conductors of each of the conductor units are disposed in the direction of the thickness of the elastic polymeric sheet.

20 3. The anisotropic conductive sheet of claim 1, wherein each of the fibrous conductors comprises a metallic conductor body and a nickel layer that covers the conductor body.

25 4. The anisotropic conductive sheet of claim 3, further comprising a plated layer covering the nickel layer, where the plated layer is formed of one selected from a group consisting of gold, silver, rhodium, and palladium.

5. The anisotropic conductive sheet of claim 1, wherein both ends of each of the fibrous conductors are pointed.

30 6. The anisotropic conductive sheet of claim 1, wherein the fibrous conductors are formed in a convex shaped curve, perpendicularly to the direction of the thickness of the elastic polymeric sheet.

7. The anisotropic conductive sheet of claim 6, wherein the fibrous conductors are curved in a '<' shape or an 'S' shape.

8. The anisotropic conductive sheet of claim 1, wherein each of the conductor units further comprises spherical conductors.