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54 Low resistance elastic connector and preparation of the same.

57 The present invention relates to a low resistance elastic connector in which electro-conductive filaments isolated from each other are allowed to penetrate an electric insulating elastomer in its thickness direction, and consist of a ferro-magnetic material coated with good conductors.

The present invention provides a connector capable of connection of minute pitches and having a lower resistivity than that of conventional connectors, which consequently is adapted for use in the field in which low resistivity is required.

LOW RESISTANCE ELASTIC CONNECTOR AND PREPARATION
OF THE SAME

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an elastic connector, and particularly to an improved elastic connector which is used in a variety of precision electronic circuits and which is suitable for use in circuits requiring a low conduction resisting value.

Description of the Prior Art

In recent years, concurrently with the minimization of electronic parts and circuits, connectors are being widely used in watches, cameras and desk top calculators, such as laminate type connectors in which an electro-conductive rubber and an insulating rubber are laminated alternately or other connectors in which electro-conductive filaments are arranged isolated from each other in an insulating rubber and penetrate the insulating rubber in its thicknesswise direction. These connectors each has delicate

characteristics involved in conduction resisting value or in minuteness of connectable electrode group. The resistance value varies with the dimension of electrode to be connected and the distance between electrodes. A laminate type connector for use in watches has a conduction resisting value of 50 to 5000 Ω per electrode to be connected and an electro-conductive filament penetrating type connector used for connection between circuits in cameras or the like has a conduction resisting value of 0.2 to 10 Ω per electrode to be connected.

The objects of these connectors are achieved to some extent in connection between liquid crystal display and circuit plate or in connection between circuit plates for small current signal use. However, these connectors does not yet fulfill demands in the field in which low conductance resistance is needed, such as connection of circuit plates used for driving, connection of circuits in which LSI (Large Scale Integrated Circuit) high speed operators are used, and inspection of performances of LSI chip carrier or flat pack products.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a connector capable of connection of minute pitches and having a lower resistivity than that of conventional connectors, which consequently is adapted for use in the field as stated above in which low resistivity is required.

The object of the present invention can be attained by the following:

1. In a low resistance elastic connector in which electro-conductive filaments isolated from each other are allowed to penetrate an electric insulating elastomer in its thickness direction, said filaments consisting of a ferro-magnetic material coated with good conductors.

2. A method of preparing a low resistance elastic connector, which comprises at least:

- (a) arranging a plural of ferro-magnetic materials in a definite direction, hardening them with a resin, cutting the resultant product into a predetermined length and then removing the resin to provide filaments,
- (b) coating all over the surfaces of said filaments with good conductors by means of electroless plating or vacuum evaporation,

- (c) adhering an unhardened elastomer to the filaments coated with good conductors and
- (d) applying a magnetic field to said mixture, orientating the filaments in the thickness direction and then hardening said unhardened elastomer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The reason for the use of conductors having ferro-magnetism and high electro-conductivity is that with making use of the ferro-magnetism, conductors dispersed in an unhardened elastomer are given orientation for arrangement by applying magnetism. This makes possible the embedding of electro-conductive filaments in as high a density as not less than 3 pieces per 1 mm².

In order to obtain high electro-conductivity, iron, nickel and cobalt may be used as the electro-conductive filament. More preferably, however, these ferro-magnetic materials may be coated with gold, copper or silver, which has good electro-conductivity. Further preferably these ferro-magnetic materials have their surfaces coated with a thick film layer of not less than 1 μ of copper which is relatively inexpensive and has superior

electro-conductivity. Most preferably the electro-conductive filament is used in which iron, used as the core material because of its high mechanical strength, has its entire surface including its edges coated with a thick layer of copper of not less than 1μ and the resulting thick layer of copper is further coated with gold having excellent weather resistance. There is no problem when the core has a thickness of not larger than 50μ and a core having a thickness of not larger than 25μ is preferred as the elastic connector from a view point of compression characteristic. Of course the present invention is not limited thereto and thereby. From the view point of connection density and resistance value, density of embedding filaments is generally not less than 3 filaments per 1 mm^2 , preferably not less than 8 filaments per 1 mm^2 and more preferably not less than 15 filaments per 1 mm^2 . The length of filaments is preferably substantially equivalent to or somewhat longer than the length of an insulating matrix. In order to assure reliability of electric connections, it is more preferable that filaments protrude by 3 to 50μ from the surface of an elastomer. The thickness of insulating elastomer which is generally employed is of the order of 0.3 to 5 mm, taking into

consideration absorption of tolerances of related parts, compactness, etc.

When noble metals such as gold are used for coating the electro-conductive filament in the present invention, it is economical that portions to be coated with said metal are limited to the portions of filaments exposed outside of an insulating elastomer. When using filaments of about 25μ , the density of orienting and embedding the ferro-magnetic material by using magnetism is not larger than 200 filaments per 1 mm^2 and preferably not larger than 100 filaments per 1 mm^2 from a view point of entangling of filaments. On the other hand, the field in which low resistance connectors are needed as mentioned above requires at least a resistance of not more than 0.1Ω per connection electrode, preferably a resistance of about 0.02Ω . The level of a volume resistivity R of $0.02\Omega\cdot\text{cm}$, more preferably of $0.005\Omega\cdot\text{cm}$ can satisfy the above-mentioned demands and the conductivity level cannot be achieved until the present invention.

It is necessary in general that electric connectors based on mechanical contact of conductors such as elastic connector have surface resistances of the contact areas kept low. The elastic connector using filaments of multi-structure according to the present invention is also advantageous from the above-stated view point. It is

preferable that portions which come to contact with other parts consist of soft materials such as gold, platinum, soldering materials, etc. It is particularly preferred to use good conductors having a Brinell hardness of not higher than 70.

The electric insulating elastomer used in the present invention includes various types of elastomers such as silicone rubber, nitrile rubber, butyl rubber, natural rubber, etc., and silicone rubber among them is most preferably used from the view point of temperature stability, weather resistance, secular deterioration, etc.

The industrial method of preparation according to the present invention is as follows:

Filaments of the same length having ferro-magnetism and high electro-conductivity are admixed in an original solution of unhardened elastomer; a sheet-like capsule having a predetermined thickness is prepared.

The capsule thus obtained has a space formed by a thin polyester film which covers the upper and lower sides thereof and a frame material which surrounds its periphery and the space is filled with the above-mentioned mixture. Said capsule is allowed to harden by applying to it a magnetic field substantially vertical thereto, whereby an

anisotropic electro-conductive sheet in which filaments are oriented in its thickness direction is obtained. In order to obtain a sheet having a thickness of high accuracy, it is preferable to conduct pressure molding while applying magnetic field.

The method of preparing filaments having the same length comprises hardening core materials arranged in an definite direction using a resin, cutting it, then melting the resin to make short filaments and subjecting them to electroless plating to provide the predetermined filaments. Electroless plating is suitable for plating all over the surface of short filaments with a good conductor. It is also preferable to conduct coating with a good conductor by means of vacuum evaporation instead of electroless plating.

The volume resistivity in the present invention is measured as follows.

The electrode plate used is an electrode of 1 mm x 1 mm in which copper electrode (thickness 35μ) is formed on an epoxy base plate mixed with glass fiber and its surface is gold plated (thickness 0.3μ). A sample which is compressed by 5% of the thickness of the matrix is interposed between the opposing electrodes. Then, by applying a d.c. voltage of 1 mv between the electrodes, the resistance value is measured using a digital multimeter.

The present invention makes it possible to obtain an extremely low resistance elastic connector and can make thereby a contribution to improvements in the field where connections by bonding are carried out instead of elastic connectors because conventional elastic connectors have high resistance values.

Particularly, a large contribution is made by the present invention in cases where problems arise in connections by bonding, for example, a case where in inspection of performances of LSI products, it is required to remove again bonding after the inspection or a case where since ceramic carriers and resin circuit plates are greatly different from each other in coefficients of thermal expansion, the reliability with respect to changes in temperature is low.

Example 1

Stainless steel fibers (diameter 25μ), which had been cut to a length of 1 mm, was subjected to the surface activation treatment with palladium, after which the resulting surface was entirely copper plated by a thickness of 1μ , further coated with nickel and still further gold plated by 0.3μ . These platings all were conducted by electroless plating. As for copper plating, a chemical solution containing 12.5 weight % of Cu and 12.5 weight % of

caustic soda was used for the treatment at ordinary temperatures. For nickel plating, a chemical solution containing 0.5 weight % of Ni was used at 80°C and for gold plating a chemical solution containing 0.3 weight % of Au at 95°C. Then, 3 weight % of said filaments based on the weight of silicone was admixed in an original solution of silicone rubber and molded by applying to it a magnetic field of 5000 gauss. Thus, there was obtained an anisotropic conductor of 1 mm in thickness in which said filaments were oriented and embedded with a density of 15 filaments per 1 mm². The product was cut to provide elastic connectors of a width of 2 mm x a length of 20 mm x a thickness of 1mm. As a result of the measurements of said connector conducted using an electrode of 1mm² by the above-mentioned method, it was found that the elastic connector having a resistance value equivalent to bonding such as $R_0 = 0.010\Omega$ and $R = 0.0010\Omega.cm$ was obtained.

WE CLAIM

1. In a low resistance elastic connector in which electro-conductive filaments isolated from each other are allowed to penetrate an electric insulating elastomer in its thickness direction, said filaments consisting of a ferro-magnetic material coated with good conductors.

2. A low resistance elastic connector as claimed in Claim 1, wherein of the outmost surfaces of said filaments, such portions that come to contact with other parts on electric connection are coated with good conductors having a Brinell hardness of not more than 70.

3. A low resistance elastic connector as claimed in Claims (1) or (2), wherein the volume resistivity is not more than $0.02\Omega\cdot\text{cm}$.

4. A low resistance elastic connector as claimed in any of Claims (1), (2) or (3), wherein said filaments protrude from both surfaces of an electric insulating elastomer.

5. A low resistance elastic connector as claimed in Claim (4), wherein the length of protrusions is 3 to 50μ .

6. A low resistance elastic connector as claimed in any of Claims (1), (2), (3), (4) or (5), wherein said good

conductors are allowed to cover all over the surface of a ferro-magnetic material.

7. A low resistance elastic connector as claimed in Claim (6), wherein said ferro-magnetic material is coated with copper, further coated or not coated with nickel and still further coated with gold.

8. A method of preparing a low resistance elastic connector, which comprises at least:

- (a) arranging a plural of ferro-magnetic materials in a definite direction, hardening them with a resin, cutting the resultant product into a predetermined length and then removing the resin to provide filaments,
- (b) coating all over the surfaces of said filaments with good conductors by means of electroless plating or vacuum evaporation,
- (c) adhering an unhardened elastomer to the filaments coated with good conductors and
- (d) applying a magnetic field to said mixture, arranging the filaments in the thickness direction and then hardening said unhardened elastomer.

9. A method of preparing a low resistance elastic connector as claimed in Claim (8), wherein the electroless

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plating is conducted with copper and gold in two layers in that order.