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(54) Title of Invention	POLYIMIDE INSULATING MULTILAYER SUBSTRATE AND PRODUCING METHOD THEREOF		
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Specification

1. Title of Invention

POLYIMIDE INSULATING MULTILAYER SUBSTRATE AND PRODUCTION METHOD THEREOF

2. Scope of Patent Claims

(1) A polyimide insulating multilayer substrate, comprising a metal thin film conductor layer and a polyimide insulating layer constituting a power plane and a ground plane, wherein a plurality of dehumidifying pores is provided through the metal thin film conductor layer, and the plurality of dehumidifying pores has an opening area of 0.001 to 0.04 square millimeters, may have any shape, and are filled and sealed with polyimide.

(2) The polyimide insulating multilayer substrate according to claim 1, wherein the plurality of dehumidifying pores forms a unit opening pattern, and the unit opening pattern is repeated in the metal thin film conductor layer.

(3) The polyimide insulating multilayer substrate according to claim 2, wherein, in portions peripheral to through holes and via holes, the unit opening pattern has a larger opening porosity than other portions.

(4) A polyimide insulating multilayer substrate production method, wherein, when producing a polyimide insulating multilayer substrate having a metal thin film conductor layer and a polyimide insulating layer constituting a power plane and a ground plane, a plurality of dehumidifying pores is formed through the metal thin film conductor layer when a conductor layer is patterned using a plating resist, a polyimide insulating layer is laminated by applying a polyimide precursor resin, and simultaneously, the dehumidifying pores are filled and sealed with polyimide.

3. Detailed Description of Invention

[Field of Industrial Applicability]

The present invention relates to a polyimide insulating multilayer having excellent heat resistance and electrical properties, and to a production method thereof.

[Conventional Art]

Polyimide is a circuit board material used as an organic insulating material having excellent heat resistance and electrical properties, and art in which a polyimide insulating layer is provided and micropatterned, art for laminating, art for terminal connection, and the like.

Recently, in conjunction with trends toward higher speeds and higher integration in LSI technology, wiring systems between elements have also continued to become denser and more multilayered, and in conjunction with such, above art has been further developed and applied, and polyimide insulating multilayer substrates having specifications that can accommodate higher speeds are becoming widespread.

There are largely two methods for producing polyimide insulating multilayer substrates. One is a so-called sequential lamination method, in which two or more inner layer boards having conductor circuit patterns formed on one or both sides of an insulating film using additive or subtractive methods are sandwiched between prepregs or the like and laminated together using an adhesive. This lamination method has the disadvantage in that the adhesive becomes conductive.

The additive method is a method for forming a conductive metal pattern on a resin substrate by depositing a thin layer of metal directly onto the resin by plating or sputtering, and then using a plating resist to build up and pattern the metal layer. The subtractive method is a method for attaching copper foil using an adhesive and then etching the copper foil to create a pattern.

Another method for producing polyimide insulating multilayer substrates is a so-called build-up method, in which metal conductor thin film layers and insulating layers are stacked one layer at a time. Namely, for the metal conductor thin film layer, metallization is performed directly on an underlying insulating layer, and then the thickness is increased to desired dimensions using a plating resist. For the insulating layer, a polyimide precursor resin is applied, in the form of a varnish, to a substrate with a conductor circuit pattern on its surface, and then cured to form an additional layer. Therefore, the build-up method has an advantage of allowing for thinner layers.

[Problem to Be Solved by Invention]

Conventionally, polyimide is a highly hygroscopic raw material. Accordingly, when using such to produce multilayer wiring boards, that is, polyimide insulating multilayer substrate, there are problems such as the following.

Conventionally used polyimide films have a saturated moisture absorption of approximately 3% and contain approximately 1% moisture even at normal temperature and normal humidity (25°C, 50% RH). For this reason, when a polyimide-insulated multilayer board is exposed to high temperatures (250 to 300°C), such as during soldering, absorbed moisture contained in the polyimide rapidly vaporizes and expands, easily causing voids and large swelling at the interface between the polyimide and the conductor layer, and in some cases causing peeling or cracks at the interface between the metal conductor thin film layer and the polyimide insulating layer where stress is likely to concentrate.

In addition, even when voids and swelling do not occur during the heating process, some moisture remains in the polyimide of the board product, so depending on the usage environment after the board is incorporated into the final product, when repeatedly exposed to environmental changes, there is a high possibility that peeling will occur, as described above.

This problem is present whether the sequential lamination method or the build-up method is used, but it is particularly severe with the build-up method, in which metal conductor thin film layers and insulating layers are stacked alternately one by one.

Furthermore, it is expected that wiring boards using polyimide as an insulating material will become increasingly multilayered in the future, resulting in an increase in the number of interlayer connections, and therefore in the number of closed areas where voids and swelling are likely to occur.

Therefore, there is a need for an effective method for preventing damage to the substrate and deterioration of its characteristics due to the evaporation and expansion of the internal moisture.

Countermeasures that have been taken up until now have been to dry the entire substrate at a temperature of around 100°C before carrying out work that involves heating the substrate, such as soldering, to bring the substrate close to an absolute dry state and prevent the occurrence of voids and swelling. However, as the number of layers in a board increases, the number of via holes also increases dramatically, making it difficult to achieve a substantially absolute dry state in every part of the polyimide in the board using this method alone.

Attempts have been made to reduce the moisture absorption of polyimide films to some extent by partially modifying their molecular structure. However, although the dimensional stability of these polyimide films has been improved, the water absorption rate and gas permeability of the films have been significantly reduced, so these polyimide films are not suitable for use in polyimide insulating multilayer substrates, which involve the application of polyimide precursor resins or polyimide adhesives that release moisture during imidization.

Also, polyimide films having reduced hygroscopicity or water absorption rate tend to have higher chemical resistance than conventional films. Accordingly, it becomes more difficult use chemical etching to provide polyimide opening portions for interlayer connection in multilayer substrates.

[Means for Solving Problem]

In order to solve this problem, the polyimide insulating multilayer substrate of the present invention

is a polyimide insulating multilayer substrate having a metal thin film conductor layer and a polyimide insulating layer constituting a power plane and a ground plane, wherein a plurality of dehumidifying pores is provided through the metal thin film conductor layer, and the plurality of dehumidifying pores has an opening area of 0.001 to 0.04 square millimeters, may have any shape, and are filled and sealed with polyimide.

In addition, in the polyimide insulating multilayer substrate of the present invention, the metal thin film conductor layers constituting the power plane and the ground plane have an opening pattern region acting as a moisture-conducting portion, which is composed of through pores of any shape having an opening area of 0.001 to 0.04 square millimeters, these through pores are filled with polyimide, and moisture absorbed in the polyimide insulating layer is absorbed evenly from every part of the polyimide, and thus it is possible to escape the substrate through these moisture-conducting portions.

Preferably, in order to prioritize the escape of absorbed moisture near the via holes and through holes, the open void ratio of the opening pattern near the via holes and through holes is made larger than the open void ratio of the opening pattern in parts other than the via hole and through hole parts. This is because, near the via holes and through holes, there are many parts surrounded by a non-permeable metal layer, making it more difficult for moisture and gas to escape accordingly.

Furthermore, in the polyimide insulating multilayer substrate production method of the present invention, when producing a polyimide insulating multilayer substrate having a metal thin film conductor layer and a polyimide insulating layer constituting a power plane and a ground plane, a plurality of dehumidifying pores is formed through the metal thin film conductor layer, the plurality of dehumidifying pores is formed at the same time as patterning a metal conductor thin film layer by a method using a plating resist such as an active plating, and these dehumidifying pores are filled with the same polyimide at the same time as laminating the polyimide insulating layer by applying a polyimide precursor resin.

[Action]

Conventionally, commercially available polyimide films are highly hygroscopic materials, but from another perspective, they can also be said to have the property of easily allowing moisture to pass through.

Thus, in polyimide insulating multilayer substrates, in areas surrounded by metal planes such as power planes and ground planes that cover the entire surface, polyimide moisture-conducting portions or water-conducting sections composed of many dense dehumidifying pores are provided to allow moisture stored in the polyimide to escape without delay. This is also effective for dehumidifying when the polyimide moisture-conducting sections penetrate upper and lower metal planes.

When voids or swelling occurs at interface between a polyimide and a metal thin film conductor layer, and such particularly markedly occurs at the interface around via holes and through holes. Reasons for this include the fact that internal gas pressure is likely to increase in these areas and that adhesion strength at the interface around via holes and through holes is often originally lower than in other areas, and stress tends to concentrate there, making them the most susceptible to the effects of increased pressure, such as cracking. Therefore, it is particularly important to prevent defects from occurring in the areas around via holes and through holes. Therefore, in these areas, it is desirable to provide an opening pattern with a higher opening porosity than the opening pattern in other areas.

In the present invention, the reason the opening area of the dehumidifying pores is set to 0.001 to 0.04 square millimeters is that when the opening area is less than 0.001 square millimeters, moisture-conducting portions do not function well enough, and conversely, when the opening area is larger than 0.04 square millimeters, the number of dehumidifying pores must be reduced due to limitations on the overall area of the moisture-conducting portion, resulting in areas of insufficient dehumidifying. In other words, it is better to increase the number of dehumidifying pores rather than increasing the opening area of each pore.

The dehumidifying pores may have any shape and may be curved as long as they are through pores and can maintain their function as moisture-conducting portions.

[Examples]

As a specific production method for actually forming the opening pattern of the dehumidifying pores filled with polyimide in the present invention, the following method is preferable.

When forming a metal thin film conductor layer pattern on a resin substrate, the opening area of the dehumidifying pores in the present invention is minute at 0.001 to 0.04 square millimeters, so it is difficult to finely pattern in the subtractive method, and an active method is an easy method for forming such small holes; therefore, it is suitable to adopt the active method.

Specifically, as illustrated in FIG. 1, a copper thin film 2 is provided on a polyimide film 1, and as illustrated in FIG. 2, a photoresist 3 is used to form a plating resist on the copper thin film 2 by exposure and development, thereby forming an outline of a conductor circuit pattern (not illustrated).

At this time, at the same time as forming the outer shape of the conductor circuit pattern, a protruding plating resist 3a is formed in accordance with a predetermined opening pattern of dehumidifying pores, as illustrated in FIG. 3.

Therefore, the only particular effort required to add the pores is to simply add a predetermined opening pattern for the dehumidifying pores to a photomask used when exposing the photoresist, which is very simple.

As illustrated in FIG. 4, a copper metal thin film conductor layer 4 is formed in the space around the protruding plating resist 3a, and then, as illustrated in FIG. 5, the protruding plating resist 3a in the dehumidifying pores is dissolved and removed.

Furthermore, as illustrated in FIG. 6, the copper thin film 2 between the metal thin film conductor layers 4 is dissolved and removed. Thus, a plurality of dehumidifying pores 5 is formed through the metal thin film conductor layers 4 according to the opening pattern.

Next, as a method for filling and sealing the formed dehumidifying pores 5 with polyimide, a simple method is to apply a polyimide precursor resin 6 in a varnish state to the metal thin film conductor layer 4, heat it to form the polyimide insulating layer 7, and then fill the dehumidifying pores 5 with the same polyimide, as illustrated in FIG. 7 and FIG. 8.

(Example 1)

As illustrated in FIG. 9, a 50 μm polyimide film 10 ("Kapton 200H" made by Toray DuPont) was prepared, a signal conductive layer 12 composed of a wiring pattern of 25 μm thick copper foil was formed on one side thereof, a 10 μm thick copper foil ground conductive layer 16 having an opening pattern composed of circular through holes 14 having a diameter of 40 μm was formed via additive plating on the other side, and a via hole 18 connecting the signal conductive layer 12 and the ground conductive layer 16 was formed.

Furthermore, a precursor of polyimide resin "PI2545" made by DuPont was applied to both sides of the conductive layer and heated to form polyimide insulating layers 20 and 22, each having a thickness of 30 μm , among which, a chemical copper plating was formed on the surface of the polyimide insulating layer 20 formed upon the ground conductive layer 16 using the same additive plating as in the formation of the ground conductive layer 16, a 10 μm thick power conductive metal layer 26 having an opening pattern composed of 40 μm circular through holes 24 was formed, and the via hole 18 connecting the signal conductive layer 12 and the power conductive metal layer 26 through the ground conductive layer 16 was formed. Then, a portion of the polyimide was selectively chemically dissolved to produce a polyimide insulating multilayer substrate. When this polyimide insulating multilayer substrate is used, for example, the ground conductive layer 16 serves as a ground plane, and the signal conductive metal layer 12 and power conductive metal layer 26 serve as power planes.

This substrate was soldered near the via hole 18 and the presence or absence of expansion of the substrate was checked. This procedure was repeated 100 times, but no voids were observed in any of the cases.

[Effect of Invention]

The polyimide insulating multilayer substrate of the present invention is configured as above, and thus the following effects can be obtained.

The impact of absorbed moisture contained in the polyimide can be reduced.

Furthermore, it is also possible to effectively mitigate swelling problems of plating deposit films caused by absorbed gasses other than water, for example, hydrogen gas, a byproduct of the chemical plating reaction in chemical plating of the polyimide surface.

4. Brief Description of Drawings

FIG. 1 to FIG. 8 are schematic cross-sections illustrating the steps of forming the dehumidifying pores in the polyimide insulating multilayer substrate of the present invention and the steps of filling and sealing the dehumidifying pores with polyimide.

FIG. 9 is a schematic cross-section illustrating an example of the polyimide insulating multilayer substrate of the present invention.

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In the drawings, reference numerals indicate the following elements.

- 1...Polyimide film
- 2...Copper thin film
- 3...Resist
- 4...Copper
- 5...Dehumidifying pore portion
- 6...Polyimide precursor resin
- 7...Polyimide solid layer
- 10...Polyimide film
- 12...Signal conductive layer
- 14...Through hole
- 16...Ground conductive layer
- 18...Via hole
- 20, 22...Polyimide insulating layer
- 24...Through hole
- 26...Power conductive metal layer

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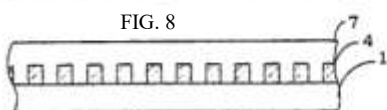
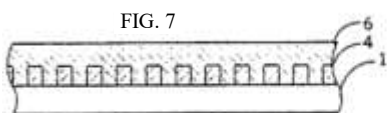
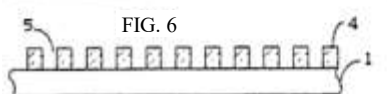
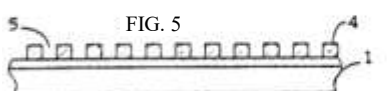
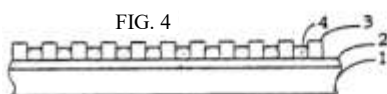
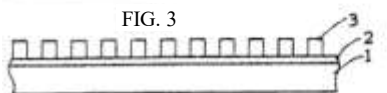
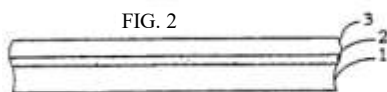
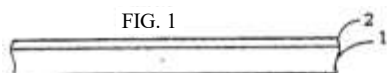


FIG. 9

