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PRINTED CIRCUIT BOARDS WITH VIA AND METHOD OF PRODUCING THE SAME

FIELD OF THE INVENTION

The present invention is related to printed circuit boards. In particular, the present invention is related to methods of producing vias and microvias in single or multiple layer printed circuit boards or substrates.

BACKGROUND OF THE INVENTION

Printed circuit boards (PCB's), including rigid, flexible, single, double and multilayer boards have found important uses in the semi-conductor and electronic industry. A PCB typically contain at least one dielectric layer with one or both sides metallized to form circuitry. For boards which have multiple dielectric layers insulating layers of metallic circuitry, interconnections between the various metallic layers are often required.

Conventional methods of fabricating a PCB board with interconnects includes laser drilling, mechanical drilling, sand blasting, and the use of plasma and photodielectric technologies. The mechanical method is useful for drilling interconnecting holes which span the entire depth of the layers, and is also useful for drilling through dielectric layers containing woven glass.

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In the laser method, a laser beam is used to drill the hole in a dielectric layer to form a via before plating is performed on the via such that electrical connection is formed between the metallic layers next to the opposing surfaces of the dielectric layer. A similar process is used to drill a blind via with metal at one end, if the laser used is effective in cutting through the dielectric layer, without cutting through metal.

Many of the conventional lasers, such as excimer, Nd:YAG and UV lasers are effective in cutting holes through polymeric resin but not effective in cutting through dielectric layers containing woven glass fibers. The Transverse Excitation Atmospheric (TEA) CO_2 laser is well known in the art to be effective in drilling vias through woven glass fibers. However, even with the TEA CO_2 laser, the efficiency of drilling through woven glass is only approximately half the efficiency of drilling through polymeric resin alone. Therefore, it is common practice in the art to use dielectric layers without woven glass when a via needs to be drilled by laser techniques. This is especially true for blind vias, in which mechanical drilling is not an effective technique.

There are, however, disadvantages to the above-mentioned prior art laser method for creating vias. If a resin layer without woven glass fibers is used as a dielectric layer, for example using a copper coated resin layer, it becomes very difficult to control the thickness and uniformity during the lamination process such that an effective insulating layer is created. This is because the polymeric layer alone without the woven glass support tends to flow excessively, often resulting in a dielectric layer with non-uniform thickness. In certain sections, the cured resin layer may be so thin that they

become unreliable as an insulating layer between the two metallic layers. This problem is particularly serious in high frequency signal applications, which are very sensitive to the thickness of the dielectric layer, such as in mobile telephone circuitries. Therefore, although laser drilling into the resin layer gives smooth, straight edges, the above-described disadvantages render the technique undesirable for many application. Using dielectric layers with woven glass, however, reduces the efficiency of the via drilling process, thereby increasing cost of production. Furthermore, the via created through the woven glass has a jagged edge and rough wall, which is undesirable for the subsequent plating process.

There is therefore a need to provide a new method of creating vias through dielectric layer which have reliable insulating properties. In particular, these vias should have straight-edges such that metallic plating may be performed easily and effectively.

OBJECT OF THE INVENTION

It is an object of the present invention to provide a PCB interconnect to overcome the shortcomings as stated above.

It is another object of the present invention to provide a PCB with a reliable insulating layer having at least one straight-walled via.

It is a further object to provide a method of making a printed circuit board with a reliable insulating layer with a straight-walled via.

SUMMARY OF THE INVENTION

The present invention provides a printed circuit board which includes a first and second metallic layers and at least one dielectric layer therebetween. This dielectric layer contains resin and reinforcement fibers such as glass, and at least one metal plated via or channel therethrough for electrical connection between the first and second metallic layer. According to the present invention, the reinforcement fiber in said dielectric layer is pulled back from the via, such that no fibers are in direct contact with the wall of the via. The via has a straight wall along its channel with a smooth metal plating, giving the via effective and reliable electrical conductivity between the first and second dielectric layer. The via may be a blind via, in which the second metallic layer covers one end of the via.

In one embodiment, a single reinforced dielectric layer is sandwiched between the first and second metallic layers. In another embodiment, the first and second metallic layers have additional metallic and dielectric layers provided therebetween. Each of these dielectric layers may also contain both reinforcement fiber and resin and may be cured to form a multilayered PCB board. One or more straight-walled vias are provided through one or more of these dielectric layers to electrically interconnect various metallic layers.

In yet another embodiment, the first and second metallic layers is sandwiched between additional dielectric or metallic layers. The straight-walled vias may run through the reinforced dielectric layer between the first and second metallic layers, or through the additional dielectric layers. As in

the previous embodiments, one or more of these straight-walled vias may be blind vias with one end closed by a metallic layer.

One method for producing such straight-walled vias in a reinforced dielectric layer involves the precutting of the dielectric layer to create a hole before the curing or drilling process. The traverse cross sectional area of the hole should be larger than that of the via in the final board. During the conventional lamination process to cure the dielectric layer, the resin in the dielectric layer flows into the hole and fill it to form a resin plug, which does not contain the reinforcement fiber. This is because the reinforcement fibers within the dielectric layer such as glass fibers do not flow. The cured dielectric layer, on the other hand, forms a reliable and effective insulating layer due to the presence of the reinforcement fibers. A conventional laser drilling process can then be employed to drill the via at the resin plug. Since the resin plug does not contain glass because the woven glass has been removed during the precutting process, the laser drilling process is quick and effective in creating a straight-walled via.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1A is a photograph to show a longitudinal cross-section of a metal plated via with a jagged wall through a glass-containing dielectric layer produced by a laser drilling process as found in the prior art.

Figure 1B is a photograph to show a longitudinal cross-section of a metal plated via with a straight wall through a resin dielectric layer which does not contain glass produced by a laser drilling process as found in the prior art.

Figures 2A - F are a schematic diagram to illustrate a method for producing a straight-walled via through a reinforced dielectric layer according to the present invention.

Figures 3A - D are a schematic diagram to illustrate another method for producing a straight-walled via through a reinforced dielectric layer according to the present invention.

DESCRIPTION OF THE INVENTION

Figure 1A and B shows two prior art metal plated vias. The via shown in Fig. 1A is produced by CO_2 laser drilling through a glass-reinforced dielectric layer **40** which is laid over a metallic layer **42**. The u-shaped via is plated with a metallic layer **44**. The wall of the via has a rough, jagged edge, with the substantially horizontal glass fibers clear shown to be causing the roughness of the via wall.

Figure 1B shows the cross-section of a metal-plated via produced by CO_2 laser drilling through a resin dielectric layer **50** which does not contain any glass fibers. In this example, dielectric layer **50** is laminated on top of a metallic layer **52**, and the via is plated with metallic layer **54**. It can be clearly seen that without the presence of the reinforcement glass fibers, the wall of the vias is straight and smooth. This is due to the absence of the reinforcement fibers. However, as mentioned previously, a dielectric layer without reinforcement fibers tend to run excessively during heat pressing, resulting in thin and/or uneven insulation between the metallic layers.

Figures 2A - F show one method of producing a straight-walled blind via through a dielectric layer according to the present invention. In this example, two metallic layers **20** and **22** are prepared on opposing surfaces of dielectric layer **24** by a conventional method, as shown in Figure 2A. An additional resin- and glass-containing bond film **26**, as shown in Figure 2B, is layered onto metallic layer **20**. This bond film has precut hole **28**, which is registered with layers **26** and **20** to corresponding to a via in the final product. During the heat-press lamination process, the resin in bond film **26** flows into hole **28** to form cured resin plug **30**, as shown in Figure 2C. A conventional laser drilling process (as shown by the dotted arrow **31**) is performed to create via **32** through resin plug **30**, as shown in Figures. 2D and E. A standard plating process is then performed to produce a metal plating **34** on the surface of via **32** as shown in Fig. 2F. Additional metallization may then be produced on the exposed surface of layer **26** according to conventional processes (not shown).

It is clear that since the glass fibers are cut away during the precutting of hole 28, there is no reinforcement fibers in the immediate vicinity of the via, nor is there any fibers in direct contact with the wall of the via created according to the present invention. Furthermore, although glass-reinforced dielectric material is used in this example, it is clear that other reinforcement fibers may also be used, such as aramic, and the same method applied.

The vias produced by the process shown in Figure 2 has a straight edge, since the laser drilling process is actually performed through the resin layer, which does not contain any glass fibers. This facilitates the subsequent plating process, and gives superior plating results compared to the jagged walls in the prior art as shown in Fig. 1A. Furthermore, dielectric layer **26** remains a reliable and effective insulating layer, since it contains glass fibers, which gives good support to the bond film during the lamination process.

Another method of creating the straight-walled via in the dielectric layer according to the present invention is shown in Figures 3A - D. In this example, a fiber-reinforced B-stage dielectric layer **60** with a precut hole **61**, such as FR4 from Nelco is laid on top of metallic layer **62** as shown in Fig. 3A. The position of hole **61** corresponds to the position of the via to be created, and the diameter of hole **61** is larger than the diameter of the final via. This is followed by heat pressing such that the resin flows into hole **61** to form resin plug **63** as shown in Fig. 3B. Then laser drilling is performed in resin plug **63** as shown by arrow **64** to generate via **66** in Fig. 3C. Via **66** has a straight wall since the laser beam does not have to cut through the reinforcement fibers. Conventional plating such as electroless plating can

performed to generate the desired metallic coating **68**. Further photolithography and other processes can then be performed on the two metallic layers to generate the desired circuitrized metallic layers. Additional dielectric and metallic layers can also be added according to conventional methods to generate further layers.

The traverse cross-sectional area of the precut hole (i.e. the diameter for a circular hole) should be larger than that of the via in the final board. This is to ensure that no glass is present to interfere with the laser drilling process. For example the diameter of the precut hole may be 0.1 to 0.8 mm larger than the via to be created. A larger margin will make the registration process easier. The preferred diameter is 0.2 to 1.6mm larger than the diameter of the via to be created. Therefore, the immediate vicinity where no fibers are present may be defined as 0.8 to 0.1mm from the wall of the via, preferably 0.1 to 0.2 mm from the wall of the via. Bond film such as FR4 may be used.

While the present invention has been described particularly with references to Figs 1 and 3, it should be understood that the figures are for illustration only and should not be taken as limitation on the invention. It is contemplated that many changes and modifications may be made by one of ordinary skill in the art without departing from the spirit and the scope of the invention described. In particular, it is clear that straight-walled vias of numerous kind through one or more glass-containing dielectric layers may be produced on the same board connecting various metallic layers based on the teachings provided herewith.

CLAIMS

1. A printed circuit board comprising :

a first metallic layer, a second metallic layer and at least one fiber-reinforced dielectric layer therebetween, said first and second metallic layers further interconnected by a metal plated via through said dielectric layer, said via having a straight wall, with no reinforcement fiber in direct contact with said wall.

2. A method for producing a printed circuit board with at least one via comprising :

a) cutting a hole in an uncured or semi-cured fiber-reinforced dielectric layer with a first and second surface, the position of said hole corresponding to said via, the diameter of said hole larger than the diameter of said via;

b) lamination pressing said dielectric layer such that said hole is filled up with cured resin to form a resin plug; and

c) drilling said via by a laser beam through said resin plug such that a straight-walled via is created.

3. A printed circuit board according to claim 1 wherein no fiber is within a 0.1mm vicinity of said wall of said via.

4. A printed circuit board according to claim 3 wherein said via is a microvia with diameter of less than 0.2 mm.

5. A printed circuit board according to claim 1 wherein no fiber is within a 0.1 mm vicinity of said wall of said via.

6. A printed circuit board according to claim 1 wherein said first and second metallic layers are laminated with at least two fiber-reinforced dielectric layers therebetween, said board further having at least one additional metallic interlayer disposed between said dielectric layers.

7. A printed circuit board according to claim 1 wherein additional dielectric layers with metallic interlayers are provided next to said first metallic layer on the surface opposite said dielectric layer.

8. A printed circuit board according to claim 1 wherein said reinforcement fiber is glass.

9. A printed circuit board according to claim 1 wherein said reinforcement fiber is aramic.

10. A method according to claim 2 wherein said dielectric layer has opposing first and second surfaces, said lamination step performed such that said first surface is laminated onto a metallic surface; and said method further comprising the step of :

(d) electroplating said second surface such that a second metallic layer is formed on said second surface and said via, and electrical connection established between said first and second metallic surfaces.

11. A method according to claim 10 wherein said first metallic layer is a circuitrized layer.

12. A method according to claim 11 further comprising the step of

(e) creating a circuitry pattern on said second metallic layers.

13. A method according to claim 10 further comprising the step of

(e) creating a circuitry pattern on said first and second metallic layers.

14. A method according to claim 2 wherein said dielectric layer is coated with a first metallic layer on said first surface; said method further comprising the steps of :

(d) electroplating a second metallic layer onto said second surface of said dielectric layer after said drilling step is performed such that said via is also plated, and electric connection is established between said first and second metallic layers; and

(e) creating a circuitry pattern on said first metallic layer;

15. A method according to claim 14 further comprising the steps of

creating a circuitry pattern on said second metallic layer.