

A Method of Manufacturing Ceramic
Multilayer Electronic Component

Field of the Invention

5 The present invention relates to a method of
manufacturing a ceramic multilayer electronic
component such as a ceramic multilayer circuit board,
a hybrid IC having a ceramic multilayer structure or
an LC composite part having a ceramic multilayer
structure.

10 Description of the Background Art

Fig. 4 shows some steps which are included in a
conventional method of manufacturing a ceramic
multilayer circuit board as an exemplary ceramic
multilayer electronic component.

15 First, a ceramic green sheet 2 is formed on a
carrier film 1 and then dried, as shown at (1). In
order to form such a ceramic green sheet 2, ceramic
slurry is applied to one surface of the carrier film
1 by a doctor blade or the like.

20 Then, the carrier film 1 is separated from the
ceramic green sheet 2, as shown at (2).

Then, the ceramic green sheet 2 is punched into
prescribed dimensions, as shown at (3).

25 Then, holes 3 for serving as via holes are
provided

in the ceramic green sheet 2 with a punch, a drill or the like, as shown at (4).

Then, the holes 3 are filled up with conductive paste 4, as shown at (5). Fig. 5 shows a concrete example of the step of applying such conductive paste 4. The conductive paste 4 is applied by screen printing through a screen 5. The ceramic green sheet 2 provided with the holes 3 is placed on a suction stage 7 through an air-permeable sheet 6. The suction stage 7 is supplied with vacuum suction as shown by arrow 8, thereby applying negative pressures into the holes 3 through the air-permeable sheet 6. The screen 5 is provided with patterns 9 in positions corresponding to the holes 3 provided in the ceramic green sheet 2. These patterns 9 are slightly larger in diameter than the holes 3. The conductive paste 4 is spread on the screen 5 by a squeegee 10, to be filled up in the holes 3. Then the conductive paste 4 is dried.

Then, an interconnection pattern 11 is formed by screen printing, for example, as shown at (6) in Fig. 4. Thereafter the interconnection pattern 11 is dried.

The steps shown at (5) and (6) in Fig. 4 may be simultaneously carried out. Then the ceramic green sheet 2 shown at (6) is stacked on other ceramic green sheets along prescribed order. At this time, it is necessary to align the ceramic green sheet 2 with the other ones on the

basis of its end surfaces, or through alignment holes provided in the ceramic green sheet 2 and pins inserted in such holes.

However, the aforementioned conventional method of manufacturing a ceramic multilayer circuit board has the following problems:

(A) The ceramic green sheet 2, having a small thickness of about 50 to 200 μ m in general, is undulated, swollen, warped or dispersed in contraction when the same is dried with the interconnection pattern 11 printed thereon. Thus, the ceramic green sheet 2 is displaced from the other ones in the stacking step to cause defects of characteristics such as capacitance and inductance.

(B) The aforementioned problem may further lead to a critical defect such as imperfect conduction of the via holes defined by the holes 3.

(C) While extension parts 12 shown at (5) in Fig. 4 are increased in size in order to prevent the problem (B), high-density interconnection cannot be attained and it is difficult to miniaturize the circuit board in this case.

(D) When the ceramic green sheet 2 is reduced in thickness, rigidity thereof is so reduced that it is difficult to handle the same. This also promotes the aforementioned problem (A). Thus, the ceramic green sheet 2 is restricted in applicable thickness.

Summary of the Invention

The present invention aims to provide a method of manufacturing a ceramic multilayer electronic component which can solve the aforementioned problems (A) to (D).

According to the present invention there is provided a method of manufacturing a ceramic multilayer electronic component, comprising: forming a ceramic green sheet on a carrier film; creating a hole for serving as a via hole in said ceramic green sheet on said carrier film; filling up said hole in said ceramic sheet on said carrier film with conductive paste; forming an interconnection pattern on said ceramic green sheet on said carrier film; separating said ceramic green sheet from said carrier film; and stacking said ceramic green sheet on other ceramic green sheets once said ceramic green sheet has been separated from said carrier film.

Thus, at least the creation of a hole for serving as a via hole, the filling up of the hole with conductive paste and the forming of an interconnection pattern are carried out on the ceramic green sheet while it is backed with the carrier film, so that the ceramic green sheet is separated from the carrier film immediately before the same is stacked on other ceramic green sheets. In this way it

is possible to prevent the ceramic green sheet from inconvenience such as undulation, swelling, warping or dispersion in contraction. While a ceramic green sheet which is backed with no carrier film is contracted by 0.3
5 to 0.5%, for example, such contraction can be suppressed to about 0.05% when the ceramic green sheet is backed with the carrier film.

Therefore,
accuracy is improved in stacking of ceramic green sheets.
10 Thus, electric characteristics such as capacitance and inductance are improved in the ceramic multilayer electronic component. Further, reliability in conduction through via holes is improved. Consequently, it is possible to reduce the via holes and extension parts
15 thereof in diameter, thereby enabling high density interconnection and miniaturization.

According to an experiment, it has been confirmed possible to handle a ceramic green sheet of about 10 μ m in thickness. Thus, the ceramic green sheet is substantially
20 unlimited in design of thickness.

Further, most of the series of steps of handling the ceramic green sheet are carried out on the ceramic green sheet which is maintained in the state backed with the carrier film, the ceramic green sheet can be easily
25 handled to facilitate automation of the steps.

In addition, the accuracy in stacking of ceramic green sheets is so improved as described above that it is possible to increase dimensions of handleable ceramic green sheets while maintaining prescribed accuracy, whereby productivity of the ceramic multi-layer electronic component is improved.

Since the creation of a hole for serving as a via hole and the filling up of the hole with conductive paste are carried out on the ceramic green sheet while it is backed with the carrier film, the conductive paste which is filled up in a hole also provided in the carrier film may be partially transferred to the ceramic green sheet. In this case, the transferred part of the conductive paste piles up on an end surface of the hole for serving as a via hole, leading to further improvement in reliability of conduction through the via hole.

During the forming of an interconnection pattern, further, it is possible to prevent the ceramic green sheet from contamination caused by rubbing in the equipment since one surface of the ceramic green sheet is masked with the carrier film. Thus, it is possible to keep the ceramic green sheet clean, thereby contributing to improvement in quality of the as-obtained ceramic multilayer electronic component.

During the filling up of the hole of the ceramic

green sheet with conductive paste, it is possible to directly supply the conductive paste onto the carrier film in place of a screen, for applying the conductive paste into hole with a squeegee. In this case, no screen is
5 required for filling up the hole with conductive paste and hence no step is required for aligning such a screen with the hole. Thus, both of the operation and the equipment therefor are simplified.

After the ceramic green sheet has been formed on
10 the carrier film, these elements may be cut into prescribed dimensions along with each other so that the ceramic green sheet is then subjected to the following steps. In this case, it is easier to employ a method, which is further suitable for multi-item small-quantity
15 production, of carrying the ceramic green sheet through the steps as compared with a case of directly handling a long ceramic green sheet.

The foregoing and other objects, features, aspects and advantages of the present invention will become more
20 apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows sectional views successively
25 illustrating some steps which are included in a method of

manufacturing a ceramic multilayer circuit board according to an embodiment of the present invention;

Fig. 2 is a sectional view showing a concrete example of an apparatus for carrying out the step shown at (4) in Fig. 1;

Fig. 3 is a sectional view showing a step of stacking a ceramic green sheet 22 which is carried out after the step shown at (5) in Fig. 1;

Fig. 4 shows sectional views successively illustrating some steps which are included in a conventional method of manufacturing a ceramic multilayer circuit board; and

Fig. 5 is a sectional view showing a concrete example of an apparatus for carrying out the step shown at (5) in Fig. 4.

Description of the Preferred Embodiments

An embodiment of the present invention will now be described with reference to a method of manufacturing a ceramic multilayer circuit board.

Fig. 1 successively illustrate some steps which are included in the method according to the embodiment.

First, a ceramic green sheet 22 is formed on a carrier film 21 of polyethylene terephthalate, for example, and then dried, as shown at (1). The ceramic green sheet 22 is formed by applying ceramic slurry to one

surface of the carrier film 21 by a doctor blade or the like, for example.

Then, the ceramic green sheet 22 is cut into prescribed dimensions with the carrier film 21, as shown at (2). This step is carried out through punching with a die, or cutting with a blade, for example.

Then, holes 23 for serving as via holes are provided in the ceramic green sheet 22, which is maintained in the state backed with the carrier film 21, with a punch, a drill or the like, as shown at (3). The holes 23 pass through not only the ceramic green sheet 22 but the carrier film 21. At this time, reference holes may be formed in the ceramic green sheet 22 for use in printing and stacking steps described below.

Then, the holes 23 are filled up with conductive paste 24, which is then dried, as shown at (4). Fig. 2 shows a concrete example of the step of applying the conductive paste 24.

As shown in Fig. 2, the ceramic green sheet 22 which is backed with the carrier film 21 is placed on a suction stage 25 through an air-permeable sheet 26. At this time, the carrier film 21 is preferably upwardly located so that the ceramic green sheet 22 is in contact with the air-permeable sheet 26. In this state, the suction stage 25 is supplied with vacuum suction as shown by arrow 27,

thereby applying negative pressures into the holes 23 through the air-permeable sheet 26. The conductive paste 24 is supplied onto the carrier film 21, and a squeegee 28 is driven to fill up the holes 23 with the conductive
5 paste 24.

The aforementioned air-permeable sheet 26, which is prepared from a filter material such as paper, for example, is also adapted to prevent the suction stage 25 from contamination by the conductive paste 24. This sheet
10 26 is replaced by a new one when the same is contaminated. If the air-permeable sheet 26 is mechanically soft, the suction stage 25 may be provided with a member for supporting the lower surface of the air-permeable sheet 26.

15 The step of filling up the holes 23 with the conductive paste 24 may alternatively be carried out by screen printing as shown in Fig. 5, and in this case, the ceramic green sheet 22 may be upwardly located in the step shown in Fig. 2.

20 Then, an interconnection pattern 29 is formed on the ceramic green sheet 22 by screen printing, for example, and then dried, as shown at (5) in Fig. 1.

Then, the as-obtained ceramic green sheet 22 is separated from the carrier film 21, and stacked on other
25 ceramic green sheets along prescribed order. Fig. 3 shows

concrete examples of these steps.

As shown in Fig. 3, employed is a suction head 31 which is provided with cutting blades 30 around the same. The cutting blades 30, which are vertically movable in a prescribed range with respect to the suction head 31, are
5 downwardly urged by springs 32.

These cutting blades 30 are downwardly moved with the suction head 31 toward the ceramic green sheet 22, thereby cutting the ceramic green sheet 22 into prescribed
10 dimensions. At this time, the cutting blades 30 may slightly bite into the carrier film 21. The as-cut ceramic green sheet 22 is slightly smaller in dimension than the ceramic green sheet 22 cut with the carrier film 21 at the step (2) shown in Fig. 1.

15 Immediately after such cutting, the suction head 31 sucks the ceramic green sheet 22 to separate the same from the carrier film 21 following upward movement thereof. Immediately after such separation, the suction head 31 is moved along arrow 33 to stack the ceramic green sheet 22
20 on other ceramic green sheets at a prescribed position in order. At this time, the ceramic green sheet 22 may be partially coated with an adhesive, or pressed against the other ceramic green sheets with a hot plate to be provisionally compression-bonded thereto, so that the same
25 is not displaced from the other ceramic green sheets in

later steps.

In the aforementioned stacking step, the ceramic green sheet 22 can be aligned with the other ones on the basis of end surfaces thereof, through alignment holes provided in the ceramic green sheet 22 and reference pins inserted therein, with a frame for serving as the basis of alignment, or by image processing of alignment marks (or holes), for example.

Although an embodiment of the present invention has been described with reference to a method of manufacturing a ceramic multilayer circuit board, it will be appreciated that the invention is widely applicable to ceramic multilayer electronic components such as a hybrid IC and an LC composite part, so far as the components have ceramic multilayer structures and via holes.

While the ceramic green sheet 22 is cut into prescribed dimensions with the carrier film 21 in the step shown at (2) in Fig. 1 in the aforementioned embodiment, the carrier film 21 may be replaced by that previously having prescribed dimensions, so that the ceramic green sheet 22 is formed thereon.

Further, the ceramic green sheet 22 being in the state shown at (5) in Fig. 1 may be directly separated from the carrier film 21 through no cutting step shown in Fig. 3, to be stacked on other ceramic green sheets.

Although an embodiment of the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken
5 by way of limitation, the scope of the present invention being limited only by the terms of the appended claims.



CLAIMS:

1. A method of manufacturing a ceramic multilayer electronic component, comprising:

forming a ceramic green sheet on a carrier film;

5 creating a hole for serving as a via hole in said ceramic green sheet on said carrier film;

filling up said hole in said ceramic sheet on said carrier film with conductive paste;

10 forming an interconnection pattern on said ceramic green sheet on said carrier film;

separating said ceramic green sheet from said carrier film; and

15 stacking said ceramic green sheet on other ceramic green sheets once said ceramic green sheet has been separated from said carrier film.

2. A method of manufacturing a ceramic multilayer electronic component in accordance with claim 1, wherein the creating of a hole for serving as a via hole includes forming said hole to pass through said ceramic green sheet and said carrier film.

20

3. A method of manufacturing a ceramic multilayer electronic component in accordance with claim 2, wherein said filling up of said hole with conductive paste includes supplying said conductive paste onto said carrier film and driving a squeegee toward said carrier film thereby filling up said hole (23) with said

25

conductive paste.



4. A method of manufacturing a ceramic multilayer electronic component in accordance with claim 3, wherein said filling up of said hole with conductive paste
- 5 includes placing an air-permeable sheet to be in contact with said ceramic green sheet and applying vacuum suction into said hole through said air-permeable sheet.
5. A method of manufacturing a ceramic multilayer electronic component in accordance with claim 4, wherein
- 10 said air-permeable sheet is made of paper.
6. A method of manufacturing a ceramic multilayer electronic component in accordance with claim 4, further comprising replacing said air-permeable sheet by a new one.
- 15 7. A method substantially as described herein with reference to Figures 1 to 3 of the accompanying drawings.