

TITLE OF THE INVENTION

Method of and Apparatus for Manufacturing Ceramic
Green Sheet for Laminated Ceramic Electronic Component
BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to a method of and an
apparatus for manufacturing a ceramic green sheet which is
employed for a laminated ceramic electronic component.

Description of the Background Art

- 10 A laminated ceramic electronic component such as a
laminated ceramic capacitor, a laminated inductor or a
multilayer circuit board, for example, is obtained by
stacking ceramic green sheets. A laminated ceramic
capacitor, which is the most typical example of such a
15 laminated ceramic electronic component, has generally been
manufactured in the following manner:

(1) A mother sheet of green ceramic is punched into a
rectangular form, to obtain a ceramic green sheet for
stacking.

- 20 (2) Internal electrodes are printed on the
rectangular ceramic green sheet.

(3) The printed internal electrodes are dried.

- (4) A plurality of such ceramic green sheets, which
are provided with internal electrodes of a first pattern,
25 are alternately stacked with those provided with internal

electrodes of a second pattern, which is different from the first pattern.

(5) The stacked green sheets are aligned on the basis of the outlines thereof.

5 (6) The as-formed laminate of the ceramic green sheets is introduced into a die assembly and pressurized.

 (7) The laminate is cut into a chip for independently forming a laminated ceramic capacitor. Then steps of firing the chip and forming external electrodes thereon
10 are carried out to obtain a desired laminated ceramic capacitor.

 In the aforementioned method of manufacturing a laminated ceramic capacitor, however, the internal electrodes are printed in the step (2) after the
15 rectangular ceramic green sheet is obtained in the step (1). If misregistration is caused in the step of printing the internal electrodes, therefore, such misregistration is carried over to the final product, since such ceramic green sheets are stacked on the basis of the outlines
20 thereof in the step (5). Thus, the as-formed laminated ceramic capacitors are pronely dispersed in acquired capacitance.

 In the step (5), the ceramic green sheets are registered in the stacked state through vibration etc. so
25 that the outlines thereof are aligned with each other.

However, it is impossible to improve stacking accuracy since the ceramic green sheets are relatively inferior in mechanical strength. This also leads to dispersion of acquired capacitances, particularly in laminated ceramic capacitors.

Further, the capacitance acquired by each laminated ceramic capacitor is substantially determined at the step (2). In the step (2), the internal electrodes are printed on the ceramic green sheet which has already been punched into a rectangular outline, and such ceramic green sheets are aligned in the stacked state on the basis of the outlines in the step (5). Thus, it is impossible to arbitrarily change the capacitance acquired by the as-formed laminated ceramic capacitor, so far as the ceramic green sheets are provided with internal electrodes having the same types of patterns. In order to obtain a plurality of types of laminated ceramic capacitors having different capacitances, it is necessary to prepare a plurality of types of ceramic green sheets having different patterns of internal electrodes in the step (2).

While it is necessary to directly handle the ceramic green sheet in the steps (2) to (5), difficulty of such handling is increased as the thickness of the ceramic green sheet is reduced.

SUMMARY OF THE INVENTION

Accordingly, it would be desirable to provide a method of and an apparatus for manufacturing a ceramic green sheet for a laminated ceramic electronic component, which can solve the aforementioned problems.

In a first aspect, the invention provides a method of preparing a laminate of ceramic green sheets for a laminated ceramic electronic component, comprising the steps of:

forming an elongate ceramic green layer on a carrier;

continuously guiding said carrier successively to a conductor forming station, a drying station, and a cutting station;

depositing conductive material onto the surface of the elongate ceramic green layer at the conductor forming station;

drying said conductive material at the drying station;

cutting said elongate ceramic green sheet at the cutting station at a predetermined position on the green ceramic layer with respect to the conductor to define a conductor bearing sheet section whilst leaving the carrier intact;

separating the cut section of the elongate ceramic green layer from the carrier at the cutting

station and stacking a predetermined number of such cut sections at a stacking station whilst providing support for the cut sections during separation and stacking.

5 In a related aspect, the invention also provides apparatus for preparing a laminate of ceramic green sheets for a laminated ceramic electronic component, comprising:

 means for providing an elongate composite
10 including an elongate green ceramic layer on a carrier;

 a conductor forming station for depositing conductive material onto the surface of the elongate ceramic green layer;

15 a drying station for drying said conductive material on said elongate green ceramic layer;

 a cutting station for cutting said elongate green ceramic layer after drying, at a predetermined cutting position on the green ceramic layer relative to the
20 conductor to define a cut section of a conductor bearing ceramic green sheet whilst leaving the carrier intact; and

 means for separating the cut sheet section from the carrier at the cutting station and for stacking
25 cut sheet sections at a stacking station while providing support for the cut sections during

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separation and stacking.

5 In order to obtain a ceramic green sheet for a laminated ceramic electronic component according to the present invention, the green ceramic layer which is formed on the long carrier film can be continuously handled in a state being held on the long carrier film and maintained in the long configuration, from the step of printing a conductor film, such as an internal
10 electrode, on the green ceramic layer to the step of punching the same for extracting a ceramic green sheet.

In the preferred embodiments, the green ceramic layer, which is subject to various processes for

obtaining a ceramic green sheet punched into prescribed dimensions and configuration, is handled in a state backed by the carrier film. Thus, the carrier film advantageously makes up for small mechanical strength of the green ceramic layer. Therefore, even if the green ceramic layer has a small thickness of not more than 30 μm , for example, it is possible to manufacture a ceramic green sheet in high reliability, substantially with no deformation or breakage in handling.

Further, since the green ceramic layer is continuously subjected to desired processes while keeping the long configuration, it is easy to maintain cleanliness of the green ceramic layer. Thus, it is possible to easily obtain a high-quality ceramic green sheet.

Further, in the preferred embodiment since the conductor film is printed on the green ceramic layer in the state of the long composite and the green ceramic layer is punched in the later step to provide a ceramic green sheet having a desired geometry, it is possible to compensate for misregistration of the conductor film, which may be caused in the printing step, in the later punching step. Thus, the punched ceramic green sheet has no undesired misregistration of the conductor film. Such punched ceramic green sheets are stacked while being maintained in the states of registration attained in the punching step, whereby no

misregistration is caused in the conductor films, such as internal electrodes, in the as-formed laminated ceramic electronic component.

5 An advantageous feature of the preferred embodiment resides in the ceramic green sheet being punched and extracted from the green ceramic layer after the conductor film is printed on the green ceramic layer. Therefore, it is possible to easily obtain a plurality of types of laminated ceramic electronic components, such as laminated ceramic
10 capacitors having different opposite areas of internal electrodes, i.e., different acquired capacitances, for example, by making adjustable at least either a position for printing the conductor film on the green ceramic layer or that for punching and extracting the ceramic green
15 sheet from the green ceramic layer.

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

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates an apparatus for preparing a ceramic green sheet for a laminated ceramic electronic component according to an embodiment of the present
25 invention;

Fig. 2 is an enlarged sectional view showing an apparatus provided in a punching station 13 shown in Fig. 1; and

Fig. 3 is an enlarged sectional view showing an apparatus which is substituted for the apparatus shown in Fig. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 illustrates an apparatus for manufacturing a ceramic green sheet for a laminated ceramic electronic component according to an embodiment of the present invention.

This apparatus comprises a supply reel 2, which is adapted to supply a long composite 1 of a long carrier film and a green ceramic layer continuously formed thereon along its longitudinal direction. The composite 1 is drawn out from the supply reel 2 and guided to subsequent stations while upwardly directing the green ceramic layer. It is preferable to control tension and a cross-directional position of the composite 1, which is drawn out from the supply reel 2.

The composite 1 is then guided to a green ceramic layer defective detecting part 3. A defective portion of the green ceramic layer is detected by visual observation or an optical detector 4, and information of such a defective portion is transmitted to a controller 5.

Then the composite 1 is guided to a printing station 6. The printing station 6 is provided with a conveyor 7 for carrying the composite 1, a reciprocable slider having a suction mechanism, a suction roll, or the like. In this printing station 6, a conductor film is printed on the surface of the green ceramic layer, which is contained in the composite 1, with conductive paste at a constant pitch. Therefore, a screen 8, a scraper 9 for spreading the conductive paste on the screen 8 and a squeegee 10 for applying the conductive paste onto the surface of the green ceramic layer through the screen 8 are arranged above the conveyor 7. If the green ceramic layer defective detecting part 3 detects a defective portion of the green ceramic layer, it is preferable to print no conductor film on such a defective portion. In this printing station 6, a registration mark may be printed simultaneously with printing of the conductor film.

Then the composite 1 is guided to a defective print detecting part 11. In this part, a defective print portion is detected by visual observation or an optical detector 12, and information of such a defective print portion is inputted in the controller 5. The controller 5 controls an operation in a punching station 13, which is described later, so that the defective print portion is not used in a step of stacking ceramic green sheets. In

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this case, a short of printing caused by the non-used defective print portion is automatically corrected by additional printing.

Then the composite 1 is guided to a drying station 5 14. The drying station 14 is provided with a drying furnace 17, which comprises a hot air nozzle 15 for supplying hot air to the upper surface of the composite 1 from above and a heating panel 16 for heating the lower surface of the composite 1 by heat transfer. Infrared 10 radiation may be employed in the drying station 14, which is adapted to dry the conductor film printed in the printing station 6.

Then the composite 1 is extended along a dancer roller 18. Thus, the tension of the composite 1 is 15 controlled between the printing station 6 and the punching station 13, which is described later, while difference between the feed rates of the composite 1 in the printing and punching stations 6 and 13 is absorbed. Such difference of the feed rates is not accumulated since the 20 green ceramic layer is punched in the punching station 13 on the basis of the printed conductor film and the registration mark.

Then, the composite 1 is guided to the punching station 13. The punching station 13 is provided with a 25 conveyor 19 for carrying the composite 1, and a pickup 20

which is arranged above the conveyor 19 through the composite 1. The pickup 20 comprises a cutting edge 21 for forming a cutting line in the green ceramic layer. Fig. 2 or 3 shows the punching station 13 in detail.

5 Fig. 2 shows a composite 1, which comprises a carrier film 22 and a green ceramic layer 23 formed thereon on the left side. The composite 1 is placed on a conveyor belt 24, which is provided in the conveyor 19 shown in Fig. 1. A large number of pores (not shown) are preferably formed
10 in the conveyor belt 24 to supply negative pressure through such pores, in order to position the green ceramic layer 23 on the conveyor belt 24 through the carrier film 22.

 The aforementioned pickup 20 is so provided above the
15 conveyor belt 24 that the same can be approached to and separated from the conveyor belt 24, as shown by an arrow 25. The pickup 20 is provided with a head 28 defining a contact surface 27, which comes into contact with one major surface of a ceramic green sheet 26 to be stacked.
20 The aforementioned cutting edge 21 is arranged around the head 28 to enclose the contact surface 27 while projecting from the same. The head 28 is provided with a plurality of air holes 29 in the contact surface 27. The cutting edge 21 is fixedly mounted on a slider 30, which is
25 vertically slidable in a prescribed range on the

peripheral surfaces of the head 28. Compression springs 31 regularly apply downward force to the slider 30.

When the pickup 20 is approached to the conveyor belt 24, the cutting edge 21 forms a cutting line 32, defining a closed loop, along a prescribed region of the green ceramic layer 23. At this time, the cutting edge 21 is relatively upwardly moved with respect to the head 28 so that the degree of projection from the contact surface 27 is reduced to an extent sufficient for forming the cutting line 32 in the green ceramic layer 23, following sliding movement of the slider 30 against elasticity of the compression springs 31. Namely, the cutting line 32 is exclusively formed in the green ceramic layer 23, while the carrier film 22 is provided with no such cutting line at least passing through the same.

Then the pickup 20 is separated from the conveyor belt 24. Thus, the ceramic green sheet 26, which is defined by the region enclosed by the cutting line 32, is extracted from the green ceramic layer 23 as shown on the left side of Fig. 2. At this time, negative pressure is supplied to the air holes 29, which are provided in the head 28, for attracting the ceramic green sheet 26 to be stacked onto the contact surface 27.

In order to form the cutting line 32 with the cutting edge 21, it is necessary to correctly register the

position of the conductor film, printed on the green ceramic layer 23, to which the cutting edge 21 is applied. Therefore, the aforementioned registration mark, which has been printed simultaneously with the conductor film, is
5 detected by an optical sensor, for example, to obtain information for adjusting the position of the pickup 20. The means for carrying the composite 1 is not restricted to the conveyor belt 24, but a suction slider or a suction roller may alternatively be employed. In this case, the
10 composite 1 may be positioned on a surface plate or the like, in order to cut out the ceramic green sheet 26.

Then, the pickup 20 is moved above a stacking table 34, as shown by an arrow 33.

The stacking table 34, which contains a heater 35, is
15 vertically movable by a vertical driving unit 36, also serving as a pressure device, along an arrow 37. A lamination base 38 is arranged on the stacking table 34.

When the pickup 20 is moved above the stacking table 34 as shown on the right side of Fig. 2, the stacking
20 table 34 is upwardly moved. Thus, ceramic green sheets 26, which have already been placed on the lamination base 38, are brought into pressure contact with the ceramic green sheet 26, which has been carried by the pickup 20, while being heated by the heater 35.

25 Then, the stacking table 34 is downwardly moved so

that the ceramic green sheet 26, which has been held by the pickup 20, is in turn held by the stacking table 34. At this time, positive pressure may be supplied to the air holes 29, in order to easily separate the ceramic green sheet 26 from the contact surface 27 of the pickup 20.

Thereafter similar steps are repeated by desired times, to stack a desired number of ceramic green sheets 26 on the lamination base 38.

When the ceramic green sheet 26 carried by the pickup 20 is placed on the ceramic green sheets 26 which have already been placed on the lamination base 38 in the aforementioned step of stacking the ceramic green sheets 26, a solvent may be applied to the peripheries of the ceramic green sheets 26 simultaneously with supply of positive pressure to the air holes 29, in order to fix the ceramic green sheets 26 in the stacked state. In order to further strongly fix the ceramic green sheets 26 in the stacked state, a heating iron may be applied in the peripheral edge portions of the stacked ceramic green sheets 26, thereby applying a pressure in relation to the direction of stacking.

Fig. 3 shows an apparatus, which is substituted for the apparatus for punching and stacking the ceramic green sheet 26 shown in Fig. 2. The apparatus shown in Fig. 3 is similar to that shown on the left side of Fig. 2.

Therefore, corresponding elements are indicated by similar reference numerals, to omit redundant description.

A pickup 20 shown in Fig. 3 is adapted to not only punch a ceramic green sheet 26 but stack such ceramic green sheets 26 by itself. Thus, the degree of projection of a cutting edge 21 from a contact surface 27 is selected to be larger than that of the cutting edge 21 from the contact surface 27 in the apparatus shown in Fig. 2.

An operation of the apparatus shown in Fig. 3 is now described. First, the pickup 20 is approached to a conveyor belt 24, so that the cutting edge 21 forms a cutting line 32, defining a closed loop, along a prescribed region of a green ceramic layer 23. At this time, the cutting edge 21 is relatively upwardly displaced with respect to a head 28 so that the degree of projection thereof is sufficient for forming the cutting line 32 in the green ceramic layer 23, with sliding movement of a slider 30 against elasticity of compression springs 31.

Then, the pickup 20 is separated from the conveyor belt 24. Thus, a ceramic green sheet 26, which is defined by the region enclosed by the cutting line 32, is cut out from the green ceramic layer 23 following retraction of the pickup 20. At this time, negative pressure is supplied to air holes 29 which are provided in the head 28, so that a first ceramic green sheet 26(a) to be

stacked is attracted onto the contact surface 27 and separated from the carrier film 22.

Thereafter similar steps are repeated to stack a desired number of ceramic green sheets 26 in the space enclosed by the cutting edge 21.

When the pickup 20 is approached to the conveyor belt 24 in order to punch second and following ceramic green sheets 26 from the green ceramic layer 23, i.e., to form cutting lines 32 in the green ceramic layer 23 for punching the second and following ceramic green sheets 26, a pressure of about 20 kg/cm², for example, is applied between the pickup 20 and the conveyor belt 24. The conveyor belt 24 is heated by a heater (not shown), to be maintained at a temperature of about 90°C, for example. Thus, the stacked ceramic green sheets 26 are brought into contact with each other by thermocompression bonding.

The heat applied to the conveyor belt 24 is adapted to melt a binder contained in the ceramic green sheet 26, and to increase its viscosity. Such melting of the binder contributes to improvement in degree of joining of the stacked ceramic green sheets 26, as well as to separation of the ceramic green sheets 26 from the carrier film 22.

After a desired number of ceramic green sheets 26 are stacked on the contact surface 27 of the pickup 20 in the aforementioned manner, the laminate of the ceramic green

sheets 26 is extracted from the pickup 20. At this time, it is preferable to supply positive pressure to the air holes 29, in order to facilitate such extraction.

When the defective print detecting part 11 etc. detects a defective portion such as a defective print portion of the conductor film caused in the printing station 6, for example, the controller 5 controls the punching station 13 to carry out no punching operation on such a defective portion, as hereinabove described.

Referring again to Fig. 1, the composite 1 is wound on a take-up reel 39 under tension control after prescribed portions of the green ceramic layer 23 are extracted as the ceramic green sheets 26 in the punching station 13, as hereinabove described.

In the punching station 13, the cutting edge 21 may be registered with the conductor film which is provided on the green ceramic layer by numerical control etc. and the registered state may be appropriately displaced on the basis thereof, so that it is possible to arbitrarily change the acquired capacitance in a laminated ceramic capacitor, for example.

Although 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 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 preparing a laminate of ceramic green sheets for a laminated ceramic electronic component, comprising the steps of:

5 forming an elongate ceramic green layer on a carrier;

continuously guiding said carrier successively to a conductor forming station, a drying station, and a cutting station;

10 depositing conductive material onto the surface of the elongate ceramic green layer at the conductor forming station;

drying said conductive material at the drying station;

15 cutting said elongate ceramic green sheet at the cutting station at a predetermined position on the green ceramic layer with respect to the conductor to define a conductor bearing sheet section whilst leaving the carrier intact;

20 separating the cut section of the elongate ceramic green layer from the carrier at the cutting station and stacking a predetermined number of such cut sections at a stacking station whilst providing support for the cut sections during separation and
25 stacking.

2. A method according to claim 1, wherein a cut



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section of the elongate ceramic green layer is separated from the carrier by lifting the cut section.

3. A method according to claim 2, wherein the cutting operation and the lifting operation are performed by a punch head.

4. A method according to claim 3, wherein cut sections are stacked by operation of the punch head.

5. A method according to any preceding claim, wherein the conductive material is deposited on the surface of the elongate ceramic green layer by printing.

6. A method according to any preceding claim, wherein a registration mark in prescribed positional relation to said conductive material is printed on the surface of the elongate ceramic green sheet simultaneously with the printing of said conductive material.

7. A method in accordance with claim 6, wherein said green ceramic layer is cut at said cutting station at a position in accordance with said registration mark.

8. A method according to any preceding claim, wherein said composite is guided to defect detecting means for detecting presence/absence of a defective portion in said green ceramic layer, and wherein conductive material is not deposited on a portion of



said ceramic green layer which is detected to be defective.

5 9. A method in accordance with any preceding claim, wherein said composite is guided to a defective conductive material detecting means between said conductor forming station and said cutting station, for detecting presence/absence of a defective conductor portion so that a detected portion of said green ceramic layer having a defective conductor is not cut at the cutting station.

10 10. Apparatus for preparing a laminate of ceramic green sheets for a laminated ceramic electronic component, comprising:

15 means for providing an elongate composite including an elongate green ceramic layer on a carrier;

a conductor forming station for depositing conductive material onto the surface of the elongate ceramic green layer;

20 a drying station for drying said conductive material on said elongate green ceramic layer;

a cutting station for cutting said elongate green ceramic layer after drying, at a predetermined cutting position on the green ceramic layer relative to the conductor to define a cut section of a conductor bearing ceramic green sheet whilst leaving the carrier



intact;

and means for separating the cut sheet section from the carrier at the cutting station and for stacking cut sheet sections at a stacking station while providing support for the cut sections during separation and stacking.

11. Apparatus according to claim 10, further comprising means for controlling tension of said composite between said printing station and said punching station.

12. Apparatus according to claim 10 or 11, wherein said cutting station comprises a punching station for performing the cutting operation.

13. Apparatus according to claim 12, wherein said punching station is provided with a head having a contact surface for contacting said green ceramic layer, and a cutting edge arranged to project from said contact surface while enclosing said head for punching said green ceramic layer.

14. Apparatus according to claim 13, wherein said cutting edge is urged by a spring to project from said contact surface.

15. Apparatus according to claim 13 or 14, wherein the means for separating a cut sheet section from the carrier comprises said punch head.

16. Apparatus according to claim 15, wherein



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said contact surface of said head is provided with a plurality of air holes for supplying suction force to said ceramic green sheet.

5 17. Apparatus according to claim 13, 14, 15 or 16, wherein said means for stacking cut sheets comprises said punch head.

10 18. Apparatus according to claim 17, wherein the punch head includes a space defined by said cutting edge and said contact surface and the space has a capacity for receiving a plurality of ceramic green sheets to form a stack thereof.

15 19. A method or apparatus substantially as herein described with reference to the accompanying drawings, for preparing laminates of green ceramic sheets for laminated ceramic electronic components.

20. An electronic component manufactured by or by use of a method or apparatus as claimed in any of the preceding claims.